Use of Recycled Materials in Pavement Construction

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Abstract: The use of recycled materials commonly plastic bottle increasing rapidly and disposal of waste plastic bottle has become a serious problem and waste plastics are burnt for apparent disposal which cause environmental pollution. Utilization of waste plastic in bituminous mixes has proved that these enhance the properties of mix in addition to solving disposal problems. This study project has been developed to discuss in detail as how the plastic waste can be handled and used successfully in the construction of roads thus mitigating the environmental problems and economize the cost of construction of road with in the country. The aim of this study is to reduce the waste plastic material and reuse in flexible road construction. These plastic wastes are used in bitumen as a modifier. In the study laboratory test result show the improvement in engineering property like Penetration value, Ductility test, Flash point test, and Softening point test, Marshall Stability test of modified bituminous mixes for different percentage of plastic i.e. 8%, 12%, and 16% of plastic mix and using plastic contents 5%, 7%, 9% with bitumen as compared to unmodified mix. Utilization of waste plastic bags in bituminous mixes has proved that these enhance the properties of mix in addition to solving disposal problems. Plastic waste which is cleaned is cut into a size such that it passes through 2-3mm sieve using shredding machine. Generally a bituminous mixture is a mixture of coarse aggregate, fine aggregate, filler and binder. A Hot Mix Asphalt is a bituminous mixture where all constituents are mixed, placed and compacted at high temperature. HMA can be Dense Graded mixes (DGM) known as Bituminous Concrete (BC) or gap graded known as Stone Matrix Asphalt (SMA). SMA requires stabilizing additives composed of cellulose fibbers, mineral fibres or polymers to prevent drain down of the mix

Keywords: Aggregates, Bitumen, Shredded Plastic, Waste, Bitumen, Aggregates, Plastic Roads, Penetration test, Flow value, Marshal Stability test

1. Introduction

Transport infrastructure asset productivity and efficiency are significantly dependent upon pavement networks' structural and functional results, including roads, airports and ports. Good quality components and modern technologies are also often utilized for the building of new pavement.

The floor design involves environmental materials that are not sustainable, including processed mixed products and carbon-fueled transporters such as diesel and oil binder fossil fuels.

Sustainability of paving products and building technology is needed to mitigate the environmental effect of paving design and development.

A variety of environmental evaluation methods, including life-cycle analysis (LCA), and resources and environmental leadership, determine the positive environmental potentials of pavement development on the basis of ISO 14044. One of the most important strategies for the production of sustainable paving is utilizing marginal materials, such as reclaimed, recycled and waste items. They must keep in mind that a variety of waste products are usable and may be found in different layers of paving.

However, in determining the usage of waste materials on paving projects there are several considerations that must be taken into consideration.

In fact it is very profitable to use the waste materials, instead of incurring another cost of disposal, due to the scarcity of simulated resources and their costs are now that. The use of recycled materials in pavements has many advantages, including cost reductions, less raw materials use, decrease of renewable energy consumption and ease of manufacture. The use of recycled materials will vary from renovation of the existing floor to the use of it in new floor.

In the disposal of flexible pavement, rigid paving recycling and recycling of solid residues such as glass, fly ash, plastic and steel slags are three major categories of products to be used. To compliance with the DOT requirements, the cost analysis of the life cycle should be done to identify which products are better used and the form to be recycled.

A. Material Type and Content

The optimal quality for each margin will be calculated on the basis of laboratory testing as the structural efficiency of the paving method can be improved by different processes with any marginal substance. The marginal material's ideal form and quality will, where necessary, also be checked by field analysis and full-scale testing.

Pavement type

Three main classes of floors are available: rigid (betons), versatile (asphalt) and hybrid (cement stabilized and asphalt surfaced). While versatile floorings typically involve asphalt surfaces, sprayed seals and fasteners are viable surface solutions as well. It is important to remember that the loading power cycle of the concrete packaging system relies on horizontal, vertical and rotating interlocks, whereas for concrete paving it depends on a concrete plate service.

Meanwhile, asphalt rotting and progressive locking are factors impacting the load-bearing capability of asphalted areas due to compaction and field exposure.
Pavement strength
Negative products forming the flooring would be equal to structural quality in conventional structures otherwise identical. Under other terms, the marginal components are intended to satisfy the structural quality specifications of existing paving norms.

Initial cost
The prices of the procurement and distribution of goods must be taken into consideration. For example, a shortage of material recycling and distribution facilities may raise the initial costs.

Life cycle cost
There are four main phases of the construction cycle: raw materials, infrastructure, and utilities and recycling. As paving existence is to be seen as a loop mechanism that improves sustainability, the marginal material’s effects are evaluated in each step. In addition, it is necessary to determine environmental and socio-economic costs of paving alternatives. It is critical that the paving schemes incur two separate kinds of costs; the expense for contractor and customer for paving. These included raw materials, repairs and refurbishment (utility stage) and the recovery of goods (Huang 2004), while vehicle service, delays and incident costs are the normal costs of the pavement users (Daniel and Rietveld 1999).

Durability
Intermediate products would have ample resilience, equivalent to modern technologies, in the face of environmental hazards and chemical assaults. For starters, floors designed using airport marginal materials will last for exhausting jet aircraft.

Practicability
Products comprising intermediate components must follow the functional tolerances usually specified by building codes.

Constructability
It is crucial to determine how the crews of buildings and pavings requires specific training or facilities to reach appropriate content tolerances for design, repair and restoration.

Safety
Across all aspects of pavement life, protection must be discussed. Of starters, any harmful impacts on the safety of the paving workers will be measured on specific products. Moreover, the pavement constructed with margins will insure that passengers and commodities are transported safely. For starters, surfaces comprising marginal materials should provide appropriate resistance to skidding.

Climate change effect
The impacts of climate change can be separated into two major parts; the results direct and the results indirect (Austroad 2004). Specific environmental impacts, such as temperatures, pollution, wind intensity and aquifer depth, affect traffic shifts induced by population adjustments triggered by climatic change (Koetse and Rietveld, 2009). The impact of these conditions is clear.

II. Data Collection And Its Analysis

A. General
• Similar field training and laboratory testing are needed for recoverable (aggregates of recycled waste) and bitumen work. Each segment describes in depth materials obtained from the following location for treated plastic aggregates. Three key parts separated the present portion. The first segment includes the aggregates and bitumen physical specifications. Chapter 2 displays the plastic features. Third segment introduces plastic waste storage products for bulk shredding.

Site Details
• Based in Anantnag, this location is situated. The flooring beneath PMGSY is versatile. The NIT Srinagar and the Awantipora Islamic University of Cashmere performed scientific research.

Aggregates
• The chemicals are mixed with the ingredients of bituminous or cement. In certain situations it creates slurry, which is mixed with water, as the binding agent.

The aggregates may be categorized as normal and artificial. The existing aggregates are again known as gross aggregates composed of broken earth, gravels and fine sand aggregates. The by-product of the blast furnace slag collected is the one widely used as a substitute for the road building. Stone formulations for road work for bituminous surfaces should be rough, durable, long-lasting and hydro-phobic. Gravel will be well graded, with an aperture of no less than 5.75 (6.4mm to 38mm). It should be free of all silts, clay and organic matter, clean, well graded, and smoothing. A gross sum will be 0.15 m3 for each 10 m2 region of 12 mm nominal size in the first surface paint. In comparison, 0.15 m3 for every 10 m2 of surface area and 10 mm of nominal measurements are required to be included in the second coat of surface dressings.

B. Methodology
Procedure for maintaining marshall bituminous blend stability
• Choose an overall ranking to be used for the MoRTH table instant binder blend
• Determine the ratio of each scale to create the product
• Identification.
• The exact gravity of the mixture and asphalt cement shall be calculated.
• Pack research experiments of varying amounts of asphalt.
• Determine a small specimen’s basic gravity

Application of surplus products in the building of floors replacing traditional materials
• Carry out material integrity checks.
• Calculate in each experiment a proportion of vacuums and vacuum loaded with bitumen.
• Choose from the data obtained the optimal binding material.
• Evaluate specification specifications appropriately.

C. Experimental Work
Find out if the samples produced by the laboratory produce the optimal (OBC) bitumen quality, bitumen and bituminous blend, and remove the substance with other pvc, recycled and GGBS amounts of bitumen (AGBS) and fillers. The load distribution efficiency of floors is strongly determined by the aggregates. Therefore, before use for building, it is important to thoroughly test them. They should not only be solid and robust, but must have the right structure and scale in order to render the pavement monolithic. Power, durability, stiffness, shape, and water absorption are studied for aggregates. Bitumen specifications have been addressed as a binding medium and its different types.
Various experiments on bitume are carried out in order to determine its durability, gradation, viscosity, susceptibility to temperature and safety. Basic bitumen check procedures have also been documented in the above-mentioned code books.

Sample Preparation
The construction of the mixtures was carried out by grinding and compacting samples with 0.5 percent content variances according to the ASTM check system for plastic flow resistance in oil mixtures. Bitumen rating 60/70. Samples have been compacted on either hand with 75 strikes. For through bitumen material, three samples were made. The best amount of Bitumen was defined as Bitumen material containing 4% air vacuum. Still, two lightweight sample vacuums were determined: the mineral aggregate vacuum (VMA), the VCA, in combinations of percent of the coarse compound in a way similar to the calculation of VMA, by substituting the aggregate percentiles.

Marshall mix design
The stability and flow check of Marshall includes the assessment of the efficiency of the system of Marshall. The stability component of the study tests the full load with a load rate of 50.8 mm / minute assisted by the research specimen. The load is added to the specimen and is defined as stability by the full capacity. Once packing, the plastic flow of the specimen (deformation) is determined by an connected dial gauge as a function of charge. At a period when the full load is registered, the flow value shall increase by 0.25 mm (0.01 inch). These are the essential measures taken in the creation of the marshal combination.
Marshall Mix’s concept is a common laboratory procedure used internationally to assess the intensity and flow properties of bitumen packaging mixes and record them on them. In India, the method for characterizing bituminous mixtures is very common. Many researchers have even examined bituminous blends with this method. Thanks to its simplification and low expense, this research approach is commonly recognized. In view of the various advantages of the Marshall method, this was chosen to determine the optimum binder content (OBC) for mixes and also to analyze different characteristics of Marshall, such as Marshall stability, flow value, unit weight, air vacuum, etc.

Specimen preparation
Heat up to around 1200 gm of the aggregates and filler at a temperature about 1750C and 1900C. Bitumen is calorified to 1210C-1250C and the first regulation percentage of bitumen (specifically 3.5% or 4% by measuring add-ons) is fully diluted with 50 blows at the temperature of 1380C and 1490C on either side.
The mixture is compacted by the roaster with 50 blows on all sides. In order to achieve a compacted thickness of 63,5+/−3 mm, weight of the mixed aggregates taken to prepare the specimen can better be modified. In the next check, change the bitumen content by +0:5% and perform the process above.

Determine the properties of the mix
The characteristics of importance are Gt’s specific theoretical magnitude, Gm’s real mixing mass, Vv air vacuum percentage, Vb bitumen percentage, VMA vacuum percentage and VFB vacuum percentage.

III. Results and Discussion
A. Assessments on Aggregates
Table 1 displays the materials used to analyze the design of pavement, and contrasts the related quality requirements as described below.

<table>
<thead>
<tr>
<th>Tests</th>
<th>Aggregates (0.3)</th>
<th>Impact Value 10-20 (Good)</th>
<th>Specific Gravity 2.5-3</th>
<th>Water Absorption 0.1-4%</th>
<th>Los Angeles Abrasion Test (0.3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.252</td>
<td>0.193</td>
<td>2.6</td>
<td>0.33</td>
<td>0.356</td>
<td></td>
</tr>
</tbody>
</table>

B. Tests on Bitumen
Bitumen used to evaluate paving design are issued under Table 2 and are contrasted according to their specific code defined in Chapter 2.2 above with normal appropriate values. Bitumen

Figure 2: Tests

Figure 3: Ductility

Figure 4: Ring and Ball Test
C. Tests on Recycled Aggregates

Table 3.3 below offers the aggregates used to research the pavement’s architecture, comparing the required minimum values with the IRC specifications.

<table>
<thead>
<tr>
<th>Sr. no</th>
<th>Mix name</th>
<th>Percentage of natural aggregates</th>
<th>Percentage of recycled aggregates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C-type</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>M1-type</td>
<td>80</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>M2-type</td>
<td>75</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>M3-type</td>
<td>70</td>
<td>23</td>
</tr>
</tbody>
</table>

Mixed proportions of the various types of plastic composition variation are derived from this project coupled with the disparity in the composition.
**Figure 1:** Mix Design Proportions

**Figure 2:** Avg. Marshall Stability

**Figure 3:** Flow
Differences in durability qualities relative to traditional and non-conventional products

**Figure Avg. Marshall Stability**

Mix flow performance variance for traditional and non-conventional distinction Substances

**Flow**

Comparison of traditional and non-conventional commodity Variety of void filled bitumen (VFB) content.
Comparison of traditional and nonconventional products with the prices with void aggregates (VA).

Unit weight variance combination characteristics relative to traditional and non-conventional products.
Penetration Table Penetration values for original and modified bitumen 60-70 shown in Table IV.

<table>
<thead>
<tr>
<th>% Plastic waste by weight</th>
<th>Penetration (dmm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>35</td>
</tr>
<tr>
<td>7</td>
<td>28</td>
</tr>
<tr>
<td>9</td>
<td>24</td>
</tr>
</tbody>
</table>

As per MoRTH, the findings were found to be within the defined limits. By raising the amount of waste plastic in the blend, the stability benefit of Marshall is improved and optimum stability by weight of bitumen is observed for the blend that comprises 5 percent plastic. The stability benefit has declined at 9 percent plastic content. So in 2nd attempt the optimal plastic content is identified as 9 percent.

With the inclusion of plastic material in the mix, the flow intensity goes up constantly.

It can be inferred from the following test results that applying plastic waste to the semi-dense bituminous concrete mix greatly increases efficiency in the product. The intensity and voids metric have exceeded the MORTH quality criterion. The maximum plastic quality by weight of the bitumen material in ist attempt was obtained as 12 per cent.

- In contrast to conventional aggregates, recycled aggregates are fairly flexible and can be used, even in clothes, as a base material. Here Recycled aggregates are contained below the Standards in compliance with the MoRTH specifications.
- The application of plastic additives improves the bitumen properties that we see in the experimental works and findings above.
- GGBS as filler were found to have exactly the same properties as traditional filler products.
- They achieve 27,78 percent higher stability values compared with the conventional content used for optimum replacement of traditional plastic for non-standard plastic items (waste materials) as GGBS, recycled aggregates aggregates aggregate aggregate applied and fill aggregates aggregates.

Throughout our trial, the normal bitumen products were compared with other concentrations of synthetic bitumen. We also found from our experiments that the optimal quantity is 7%. Waste plastic bitumen has 20% better performance. The scheme is also a form of extracting plastics from waste and helps to facilitate the recycling of plastics. LDPE plastics produces acceptable performance at 7 per cent.

- As contrasted with standard bitumen, LDPE inserted plastic is more compact and robust.
- LDPE plastics have reduced bitumen and a healthy recycling of plastics by implementing them.
- It can be shown from the table that as the plastic waste content rises from 5% to 9%, the penetration amount slowly decreases from 35% to 24%. This ensures plastic waste has a major impact on rising the penetration benefit by growing the rigidity of the bitumen binder for plastic waste. Render the binder less sensitive, so it should aid in deformation tolerance such as rutting.

The use of recycled plastic waste in asphalt paving provides a beneficial market for these products. The usage of adjusted bitumen with the inclusion of recycled waste plastic of around 5-10 percent by bitumen weight tends to dramatically increase the durability, strength, fatigue life and other favorable properties of bituminous concrete mix, resulting in increased resilience and pavement efficiency with limited savings in bitumen usage.

The process is eco-friendly. For road building and laminated roofing, disposable materials are also used to contain huge amounts of waste materials. And such systems are strongly important economically, ensuring improved services.
References