COMPARATIVE ANALYSIS OF BITUMEN MIX PROPERTIES USING LOW DENSITY POLYETHYLENE AND POLYPROPYLENE IN ROADWAY CONSTRUCTION

Prem Nandan[1], Dr Kapil Kumar Soni[2], Dr Sharad Kumar Soni[3]
[1] Research Scholar, [2] Associate Professor, [3]Associate Professor
Department of Civil Engineering, Rabindranath Tagore University, Raisen (M.P)

ABSTRACT

Roads are crucial in the current situation since they link various towns and rural areas to the major state or federal routes. But building a road comes at a hefty price. In order to lower the overall cost without sacrificing the material's actual characteristics, it is necessary to suggest an alternate material in place of the more traditional ones. India ranks 12th in terms of garbage production and has the second-largest road network after China. As a result, using waste materials to create flexible pavement will turn out to be both economical and environmentally efficient. The most often utilized materials for flexible pavement construction worldwide are bituminous mixtures. It is made up of mineral aggregate and asphalt or bitumen (used as a binder), which are combined, spread out in layers, and then compacted. When properly designed and implemented, standard bituminous pavements function rather well in most scenarios. However, in other instances, bituminous mixes perform very poorly.

This study looks into the possibility of improving the properties of asphalt mixtures using a polymer i.e polyethylene, one type of polymer. Determining the ideal kind of polyethylene to use and how much of it to use is another goal. The aggregate was coated with two different kinds of polyethylene: low density polyethylene (LDPE) and polypropylene (PP).For testing, five weight percentages of polyethylene of each kind and state with the ideal binder concentration were chosen (5, 10, 15, 20 and 25%). The tests involve determining ductility, flash and fire point, penetration, softening point tests and marshall stability test. Determining the proportions of air spaces and air voids of mineral aggregate is necessary for Marshall mix design. According to the findings, PP polyethylene modifier that has been ground offers superior engineering qualities.

Keywords: Bituminous pavement Mix Design, low density polyethylene, polypropylene, Marshall test, Powder filler, sustainability, asphalt, flexible pavement, pavement efficiency, environment efficient pavement.

1. INTRODUCTION

There are new advance researches into new and innovative techniques for utilising waste materials. There are many private companies and highway agencies completed many advance researches and projects for utilising the waste polymers for road construction which are environmentally suitable and by using it performance will also increase. These studies are done for trying to match safe and economical disposal of waste material or for more cost efficiency in road construction.

Bitumen is defined by Indian standard institution that it is black or dark brown in colour. It is crystalline and having adhesive properties. It is mainly coming from crude oil by naturally or by refinery processes. Mainly bitumen is adhesive in nature and mixture of hydrocarbons which are generally found in tar, asphalt etc. Bituminous binders are widely used by paving industry. In general pavements are categorized into 2 groups, i.e. flexible and rigid pavement. Flexible Pavement Flexible pavements are those, which on the whole have low flexural strength and are rather flexible in their structural action under loads. These types of pavement layers reflect the deformation of lower layers on-to the surface of the layer. Rigid Pavement If the surface course of a pavement is of Plain Cement Concrete then it is called as rigid pavement since the total pavement structure can't bend or deflect due to traffic loads.

2. DETAILED METHODOLOGY

1. Selection of Materials:

- Bitumen: Choose a standard bitumen grade (e.g., VG30) and determine its initial properties through standard tests like penetration, softening point, ductility, and viscosity.
- Polyethylene (PE) and Low-Density Polyethylene (LDPE): Select PE and LDPE materials, considering their properties and potential for bitumen modification. LDPE is commonly used due to its flexibility and compatibility with bitumen.

2. Preparation of Modified Bitumen:

- Mixing Process: Employ either a dry or wet process for incorporating the plastic into the bitumen.
- Dry Process: Involves mixing pre-heated aggregates with shredded plastic and then adding them to the hot bitumen.
- Wet Process: Involves directly mixing the shredded plastic into the hot bitumen.
- Mixing Ratio: Determine the optimal ratio of PE or LDPE to bitumen based on literature and preliminary trials. Common ratios range from 2% to 8% by weight of bitumen, but can be higher for certain applications.
- Mixing Temperature: The mixing temperature is crucial and should be optimized to ensure proper dispersion of the plastic within the bitumen. Temperatures typically range from 160°C to 180°C for bitumen and 130°C to 170°C for plastic.
- Mixing Time: Optimizing the mixing time is important for achieving good adhesion between the plastic and bitumen. Mixing times can range from 1 to 2 hours.

3. TESTING OF MODIFIED BITUMEN

- Penetration Test: Measures the hardness of the bitumen by determining the depth to which a standard needle penetrates under specified conditions.
- Softening Point Test: Determines the temperature at which the bitumen softens and begins to deform under specified conditions.
- Ductility Test: Measures the ability of the bitumen to deform without breaking under tension.
- Viscosity Test: Measures the resistance of the bitumen to flow under specified conditions.
- Other Tests: Depending on the specific research objectives, other tests like Marshall stability and flow, or Superpave mix design may be employed.

4. ANALYSIS AND INTERPRETATION

- Comparison: Compare the test results of modified bitumen samples with those of the original bitumen to assess the impact of PE and LDPE modification.
- Statistical Analysis: Use statistical methods to analyze the data and determine the significance of the observed changes in properties.
- Optimization: Based on the analysis, optimize the mixing ratio, temperature, and other parameters to achieve the desired properties for the intended application.

- Interpretation: Relate the changes in bitumen properties to the performance characteristics of pavement or other applications, such as rutting resistance, fatigue resistance, and low-temperature performance.

5. REPORTING

- Document the entire methodology, including the materials used, the mixing process, the test procedures, and the results obtained.
- Clearly present the findings, including tables and graphs, and discuss the implications of the results.
- Make recommendations for future research or practical applications based on the findings.

Materials Used

Bituminous mix consists of a mixture of aggregates continuously graded from maximum size, typically, less than 25 mm, through the fine filler that is smaller than 0.075mm. Sufficient bitumen is added to the mix so that the compacted mix is effectively impervious and will have acceptable dissipative and elastic properties. The bituminous mix design aims to determine the proportion of bitumen, filler, fine aggregates, and coarse aggregates to produce a mix which is workable, strong, durable and economical.

The basic materials used are as follows:

- Aggregates
- Fly Ash
- Bituminous Binder
- Polyethylene
- LDPE

6. RESULTS AND DISCUSSION

Physical tests on aggregate

The following tests were conducted in order to determine the physical properties of aggregates.

• Specific gravity

• Water absorption

• Aggregate impact test

• Los-angeles abrasion test

7. CONCLUSION & FUTURE SCOPE

In this study, three types of mixes i.e. Plain bitumen, bitumen with LDPE and bitumen wit polypropylene are prepared with VG30 grade bitumen used as a binder. The effect of addition of waste polyethylene and LDPE in form of locally available pipes and cement bags in the bituminous mixes has been studied by varying concentrations of polyethylene and LDPE from 0% to 25% at an increment of 5%.

1. Using Marshall Method of mix design, the optimum bitumen content (OBC) and optimum LDPE and polypropylene content have been determined for different types of mixes. It has been observed that addition of 20% of LDPE and polypropylene for BC mixes results in optimum Marshall Properties.
2. Using the same Marshall specimens prepared at their by using both stone dust as filler and it is observed that the retained stability increases with addition of LDPE and polypropylene in the mixes, and BC with 20% results in highest retained.
3. In this study, testing of bitumen with waste LDPE and polypropylene has been used and the result shows that, utilizing of waste LDPE is lowering the penetration value but when we are increasing the waste content in bitumen then penetration value is also increasing and giving best results in 20% replacement.
4. In softening point test result, the result shows that the increasing of LDPE and polypropylene in bitumen is increasing the softening point of modified bitumen.
5. In ductility test result the result shows, decrease in value of ductility but values are more than 50cm so can be used for road construction.
6. Flash and fire point values are also increasing with the increase in percentage of LDPE and polypropylene.
7. Considering these factors, we can assure that we can obtain a more stable and durable mix for the pavements by polymer modifications. This small investigation not only utilizes beneficially, the waste non-degradable plastics but also provides us an improved pavement with better strength and longer life period.

8. Polymer modified pavements would be a boon for India's hot and extremely humid climate, where temperatures frequently rises past 50°C and torrential rains create havoc, leaving most of the roads with heavy distresses. This adversely affects the life of the pavements. The polymer modified bitumen show improved properties for pavement constructions. This also can reduce the amount of plastics waste which otherwise are considered to be a threat to the hygiene of the environment.
9. In this modification process plastics-waste is coated over aggregate. This increases the surface area of contact at the interface and ensures better bonding between aggregate and bitumen. The polymer coating also reduces the void spaces present in the mix. This prevents the moisture absorption and oxidation of bitumen by entrapped air. The road can withstand heavy traffic and show better service life.
10. This study will have a positive impact on the environment as it will reduce the volume of plastic waste to be disposed off by incineration and land filling. It will not only add value to plastic waste but will develop a technology, which is eco-friendly.

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