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Sustainable Use of Mine Waste and Iron Ore Tailings in Flexible Pavement

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Abstract

Rapid growth of infrastructure in road construction need natural resources. There is a need to explore the feasibility of use of iron ore tailings and mine waste in road construction. Utilization of mine waste rocks and iron ore tailings in bitumen as aggregates will help in sustainable & greener development. This literature shows the potential use of iron ore tailings as a replacement of natural fine aggregates &mine waste as a replacement of coarse aggregates. As natural resources are depleting day by day, there is a need for substitution for aggregates in bitumen. A comprehensive overview of the published literature on the use of iron ore tailings & mine waste in bitumen is being presented. The various effects of various properties such as penetration, softening point, ductility, specific gravity, flash &fire point of bitumen have been presented here. In this paper the properties of fine aggregates, properties of coarse aggregates, and marshal stability values are determined.

Keywords: - *Mine waste; iron ore tailings; fine aggregates; coarse aggregates; marshal stability.*

INTRODUCTION

Mining is a fundamental industry in the development of human society, playing an important role in the economies of many countries around the world. Most of the Highways in India constructed with

flexible pavement having wearing course/surfacing course with bituminous concrete. This BC should be constructed to satisfy the recommendation and requirements of MORTH Section 509. This clause specifies the construction of Bituminous Concrete, for use in wearing and profile corrective courses. This work shall consist of construction in a single or multiple layer of bituminous concrete on a previously prepared bituminous bound surface.

A single layer shall be 25 mm to 100mm in thickness. As per MORTH Section 500 clause 509 BC should be made with Bitumen Grade 60/70 (VG 30) for nominal aggregate size 19 mm with bitumen content 5-6% has layer thickness 50-65 mm and for nominal aggregate size 13 mm with bitumen content 5-7% having layer thickness 30-45mm.

BITUMINOUS CONCRETE

- Bituminous concrete is a type of construction material used for paving roads, driveways, and parking lots. It's made from a blend of stone and other forms of aggregate materials joined together by a binding agent. ... Despite its name, this material is quite different than standard concrete, and contains no cement.

IRON ORE TAILINGS

- Iron is the world's most commonly used metal –steel, for which iron ore is the raw material representing almost 95% of all metals used per year.
- Iron ore is a metal of universal use and it is the backbone of modern civilization.
- It is the foundation of our basic industry and it is used all over the world and Iron is taken out from mines in form of iron ore.
- There are 4 types of iron ore:
- They are:
  1. Magnetite: 72% pure iron.
  2. Hematite: 62-70% pure iron.
  3. Limonite: 40-60% pure iron.
  4. Siderite: 40-50% and many impurities.

MINE WASTE

- The quantity of waste produced (shale and sandstone) in coal mines is in terms of millions of cu.m per year.
- The main condition of mine waste utilization is that the materials should satisfy all the geotechnical criteria and is environmentally friendly.
- These waste materials can be used as fill for subsided land (or) as aggregate in embankment dams, roads, pavements foundations and building constructions.

The different types of mine waste are:

1. Waste rock: Blasting, crushing, grinding.
2. Tailings: Flotation, thickening, drying/ filtering.

OBJECTIVES

a) To study the physical properties of bitumen (Ordinary bitumen of 60/70 grade) by adding mine waste and iron ore tailings at the various percentages.
b) To find out an optimum percentage of waste materials in the bituminous mix
c) To improve the properties of bituminous mix and to provide the solution for disposal in a useful way.
d) 4.To increase the Marshall Stability Value
e) Improving the volumetric properties of BC mix.
f) To utilize iron ore tailings as filler material in bituminous mixes.

LITERATURE REVIEW

In 1956, Prof. Ladis Csanyi, Lowa State University, realized the potential of foamed bitumen for use as a soil binder. Since then, foamed asphalt technology, which allows lower mixing temperatures, has been used successfully in many countries.

In the early 1970s, Chevron developed mixture design and thickness design methodologies for paving mixtures (base, open-graded, and dense-graded) stabilized with Emulsified asphalt.

In 1977, Chevron published their "Bitumuls Mix Manual" as a practical guideline, which contains much valuable information for specifying, designing , and producing emulsion-stabilized mixtures. Kuennen reported that emulsified asphalt mixes are popular in rural settings where distances from HMA plants and lower traffic volumes may preclude HMA.

In 1994, Maccarone and others, studied cold-mixed asphalt-based foamed bitumen and very high binder content emulsions and concluded that the use of cold mixes for use on was gaining acceptance worldwide due to energy efficiency and lower emissions.

In 1995, Shell Bitumen filed a patent to cover a warm-mix asphalt technique that used a two-component technique, of Shell Global Solutions, described an innovative WMA process that was tested in the laboratory and evaluated in large-scale field trials (in Norway, the United Kingdom, and the Netherlands) with particular reference to the production and

placement of dense-graded wearing courses Jenkins and others, introduced a new process involving a half- warm foamed bitumen treatment. They explored the concepts and possible benefits of heating a wide variety of aggregates to temperatures above ambient but below 212°F before the application of foamed Bitumen.

MATERIALS

- Bituminous concrete (BC)
- Mine waste as replacement of coarse aggregate.
- Iron ore tailings replacement of fine aggregate.
- Water

METHODOLOGY

- The purpose of this study was to evaluate the laboratory performance for Dense bituminous macadam (DBM) Grade-2.
- After the determination of gradation, Marshall Stability tests were conducted to determine the volumetric properties of the specimens.
- The iron ore tailings passing 2.36mm sieve is used as filler material. The mine waste passing above 20mm is also used as filler material.
- Various tests conducted to determine basic properties of aggregates and the tests conducted to determine the basic properties of bitumen.
- The coarse aggregates used in the present study are crushed hard rock passing 16mm, 12.5mm, 10mm and 6mm sieve sizes.

Table 1: Physical properties of Coarse aggregates

SI.No	Properties	Test Method	Range as Per IRC	Obtained Values
1	Crushing value	IS-2386 part IV	Less than 30%	24.9%
2	Abrasion value	IS-2386 part IV	Less than 30%	17%
3	Impact value	IS-2386 part IV	Less than 30%	16.8%
4	Combined Flakiness and elongation index	IS-2386 part I	Less than 15%	14%
5	Water absorption test	IS-2386 part III	Less than 2%	0.375%

Table 2: Physical properties of Bitumen

SI. No .	Properties	Test method	Obtained Values
1	Penetration (mm) (100g, 25 ℃, 5 sec)	IS: 1203 -1978	65
2	Softening point (℃)	IS: 1205 -1978	120
3	Ductility at 25 ℃ (mr	IS: 1208 -1978	75
4	Specific gravity of bitumen	IS: 1202 -1978	1
5	Flash point test (℃)	IS: 1209 -1978	175°c
6	Fire point (℃)	IS: 1209 -1978	175°c+5°c

Table 3: Physical properties of Fine aggregates

SI. NO.	Properties	Test method	Range as per IRC	Obtained values
1	Fineness modulus test	IS-2386 part I	2.0-3.5	2.449%
2	Bulking of sand	IS-1963 part III	20-40%	30%
3	Specific gravity test	IS-1963 part III	2.5-3	2.65

EXPERIMENTAL RESULT

SI. NO.	Test conducted	Test method	Range	Values obtained	Values obtained after replacement
1.	Crushing value	IS-2386 part IV	Less than 30%	24.9%	22.7%

2.	Abrasion value	IS-2386 part IV	Less than 30%	17%	15.7%
3.	Impact value	IS-2386 part IV	Less than 30%	16.8%	16.1%
4.	Combined Flakiness and elongation index	IS-2386 part I	Less than 15%	14%	12%
5.	Water absorption test	IS-2386 part III	Less than 2%	0.375%	0.325%
6.	Bulking of sand	IS-2386 part I	20-40%	30%	25%
7.	Specific gravity test	IS-1963 part III	2.5-3	2.63	2.5

CONCLUSION AND FUTURE ENHANCEMENT

- From Marshall Stability test, it can be concluded that there is an increase in stability using the % mix at 120°c for 60/70 grade bitumen.
- The max stability for the 60/70 grade bitumen is achieved at 120°c temperature with 35% mixing dosage rate.
- Waste material (iron ore tailings / waste) can be used as filler material in bituminous concrete mixture for road construction.
- Use of this innovative technology not only strengthened the road construction but also increased the road life.
- Help to improve the environment.
- This small investigation not only utilizers beneficially, the waste semi-degradable iron ore tailings and mine waste but also provides us an improved pavement with better strength.
- Deformation on pavement takes place due to the application of heavy loads can also rectifies by use of mine and iron ore tailings.
- Water percolation through layers of surface, base and sub base from grain can also be corrected by using mine waste and iron ore tailings.
- By using mine waste and iron ore tailings, the life period of flexible pavement can be enhanced.
- Workability can also be achieved using iron ore tailings / mine waste.
- By the application of this new technology the strength of pavement also increases.
- Soil properties also increases using mine waste /iron ore tailings.

- It is an environment friendly project and it is economically adoptable.

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