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Comparative Study on Asphalt Mixture with Nano Materilas and Nano Particles Review

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ABSTRACT

Pavement materials are crucial factors affecting pavement durability. Now-adays, there is dire necessity for roads which are more stable and stronger. Due to weathering conditions and heavy traffic, the pavement surfaces are getting deteriorated by rutting, pot holes etc. Among them asphalt is the most sustainable pavement material for construction pavements and can be used for many applications including highways, airport runways, parking lots and drive ways. In order to provide effective durability than that of asphalt, in its original form it has been modified using Nano-materials known as modified asphalt.

This research will deal with the advances in Nano-materials in hot mix asphalt and also addition of recronfibre and the comparison was made. With the addition of this Recronfibre, there is an improvement in the properties of bitumen like increase in stability value and decrease in the flow value, % of air voids etc. Recronfibre is an artificial material obtained from the polyester and which is also used as a secondary reinforcement for attaining tensile strength. It helps to resist the cracks obtained by the improper laying of pavement surface and heavy loaded vehicles. But whereas, the clay Nano-particles are the primary materials applying in asphalt construction adding Nano- particles like Nano clay, Nano silica and nanotubes in asphalts normally increase the viscosity of asphalt binders and improves the rutting and fatigue resistance of asphalt mixtures. From this the performance of asphalt when treated with Nano-particles and its sustainability compared to that of other pavement materials is examined and studied.

Keywords : Modified Bitumen, Flexible Pavement, Polyester [Recron 3s] Fibber, Nano-materials, Rutting, and fatigue resistance.

I. INTRODUCTION

Generally, roads are basic requirement for transportation facilities. The pavement should be stronger and more stable. But flexible pavements are generally affected to heavy traffic, weathering and geological conditions of the pavement which causes a reduction of quality and performance. In order to overcome from the effects like rutting, pot holes, shrinkage cracks etc., properties of bitumen are improved with addition of fiber and Nano silica.

The fibers used is Polyester (Recron-3S) Fibber. This is an artificial material obtained from polyester. This Fibre helps to resist the cracks obtained by heavy loaded vehicles and any changes occurred due to varying temperatures. This also helps to increase in flexural strength and tensile strength to the pavement. Bitumen is viscous fluid material which consists of binding and adhesive property (which binds all the components in it without any changes in their properties and it is insoluble and acts as a sealant). During the construction of flexible pavements, the bitumen binder is added to increase the life span of the pavement surface. While layingof road, the bitumen and coarse aggregate are mixed together providing good bonding and frictionbetween vehicle wheels and road surface. But the major problem in the bitumen pavements is due to rising high temperatures, the volatile compounds present in the bitumen are evaporated and the bitumen will become hard.

Silicon dioxide (SiO2) is a compound of Silicon and Oxygen, commonly called silica and the elements are linked by the covalent bond. It is one of the components of the sand and can be found naturally in Quartz. It is usually white or colorless and is not soluble in water or ethanol. By associating with minerals, it forms the silicate family. Silicon dioxide (SiO2) has several industrial applications such as an additive in the food industry. Its function is to act as an anti-binder, anti-foaming agent, viscosity controller, desiccant, beverage clarifier and as an excipient of medications and vitamins. Due to its insolubility in water, silica has little biological availability and is not considered a source of silicon. Silicon found in other more soluble forms contributes to the formation and maintenance of bones and cartilage.

Properties of Nano Silica

Silicon dioxide is a solid and colorless crystalline substance. Silicon dioxide does not react with water and is resistant to acids. The molecular formula of the substance is SiO2. Silicon oxide, a member of the group of acidic glass-forming oxides, interacts with increasing temperature with alkalis and basic oxides, soluble in hydrofluoric acid, tends to form a supersonic fusion, that is, glass is an excellent dielectric. The main properties are stated below:

- SiO2 Nanoparticles is transparent and its density is 2634 kg/m3.
- The molar mass of SiO2 is 60.0843 g/mol.
- The melting point is 1986 K, whereas the boiling point is 2503 K.
- Its crystal structure is Quartz, cristobalite or tridymite.

Silica (SiO2) nano powder is used to make flat glass, glass products, molten sand, cement, fiberglass, ceramic enamel, sandblasting for antioxidants, filter sand, flux, refractory and light concrete. Silicon dioxide (SiO2) Nanoparticles is widely used in many industrial products. Rare crystals in nature can be used to create important parts of the electronics, optical instruments and crafts industry. Silicon dioxide (SiO2) nano powder is an important raw material for the manufacture of optical fibers. Generally, pure quartz can be used to make quartz glass. The coefficient of expansion of quartz glass is very small. It is equivalent to 1/18 of ordinary glass.

II. LITERATURE REVIEW

Arun Kumar et.al (2022) research paper presented comparative analysis between the healing techniques such as induction heating, nano-technology, micro-capsules, direct application of bacteria. In induction method, external temperature is provided for melting of asphalt and filling the cracks. In nanotechnology, nanomaterials are used for the self-healing process, whereas in the microcapsules method, micro capsules are embedded in the mix, and these capsules break when cracks appear, and heal the fracture.

Results stated that the replacement of half the amount of aggregate with bacteria gives higher stability to the pavement. After a comparative study of all the methods, it was found that the direct application of the bacteria method was found to be the most promising method. The direct application of bacterial-based self-healing technology is an effective method for healing the cracks in deteriorated pavement.

Francesca Russo et.al (2022) research paper presented a case study on an asphalt pavement containing an asphalt concrete modifier composed of recycled hard plastics and graphene nanoplatelets that is compared with its counterpart made of SBS Polymer-modified Bitumen (PmB). This research was divided as mix design and pre-qualification, post production tests, and two years of monitoring of the trial section.

As per the results, the mixtures modified with recycled-plastic additives showed higher stiffness and tenacity and as expected though, a higher resistance to permanent deformation in line with the literature. As far as the fatigue is concerned, a similar fatigue endurance was observed for both of the studied asphalt concrete.

Talaat Abdel-Wahed et.al (2022) research paper aimed to evaluate the performance of nano-modified binders with two different types of nanomaterials, which are Nano-Silica (NS) and Nano-Clay (NC). Each of them was added to a 60/70 penetration grade bitumen at concentrations ranging from 1% to 4% by asphalt binder weight using a high shear mixer at a speed of 4000 rpm and a mixing temperature of 145 °C for 60 minutes. A number of basic tests were carried out on the binders, such as penetration grade, softening point, rotational viscosity, and stability storage tests. Moreover, Scanning Electron Microscope (SEM) and Fourier Transform Infrared (FTIR) tests were utilized to ensure the quality of the mixing process and investigate the modified binder's internal composition. Furthermore, an additional laboratory study was carried out to characterize the performance properties of the corresponding asphalt concrete (AC) mixtures based on the Marshall stability, indirect tensile strength, moisture susceptibility, double-punch, and static creep tests.

Results stated that the best performance was attained when incorporating 3- 4% nanoparticles with a neat asphalt binder. The addition of NS or NC particles positively affected the asphalt binder and AC mixture in terms of stability, debonding, moisture damage, and rutting. However, NC was more effective compared to NS and can be used to build sturdy pavements.

Objectives behind the research

This study mainly deals about the properties of Bituminous Concrete (BC) mix produced using zydex warm mix technology and to compare them with that of HMA.

a) To compare the properties of WMA to that of HMA for the BC grade specified by MORT&H.

b) To know whether the WMA produced by zydex warm mix products meets the requirements and will it be used as the alternative for HMA. To achieve this objective, the scope included the following:

- Testing of engineering properties on bitumen, coarse aggregates and fine aggregates.
- Determination of Marshall stability test
- Determination of Indirect tensile strength test
- Determination of Aging test
- Determination of stripping test

III. MATERIAL AND THEIR PROPERTIES

It is a term for the mineral materials, for example, sand, rock and pulverized stone that are utilized with a coupling medium for example, water, bitumen, Portland Concrete, lime and so forth to shape compound materials. The aggregate utilized for this study are acquired from a local store from mandideep industrial area. The aggregates chosen for this study have sufficient strength, toughness and hardness.

Tests	Results
Aggregate impact value	22.25%
Aggregate crushing value	24.80%
Los Angeles abrasion value	33.80%
Specific gravity	2.76
Apparent specific gravity	2.88

Bitumen Mixture using Polyester (Recron-3S)fiber

With the utilization of various proportions of aggregates of various sizes, the voids in the mix got reduced giving more stability to the mixture. The various sieve sizes taken for getting the required quantity of aggregate and weights are as follows: e.g.: for 5% of bitumen.

Sieve SIze	Considered Aggregate Weight		
	5% of	5.5% of	6%of
10	60	120	60
8	120	120	120
6.3	240	180	120
4.75	240	180	240
2.36	300	300	360
Filler	240	300	300
Total Weight	1200	1200	1200

Marshal Test on Various Mixes

Various Mix types, their propositions and the obtained values of unit weight, stability, flow, percentage of air voids and percentage of voids filled by bitumen are as follows

Mix	Bitumen (%)	Flow (mm)	Marshal stability (KN)	Unit wt. (g/cm2)	% of Air Voids	% of voids filled
C	5	4	10.35	2.56	5.72	68.39
	5.5	3.9	12.07	2.57	5.5	76.46
	6	4.1	11.65	2.56	5.64	71.73
M1	5	3.9	13.36	2.54	4.9	71.59
	5.5	3.6	14.58	2.56	4.2	80.07
	6	3.7	12.76	2.54	4	78.21
M2	5	3.5	11.73	2.53	4	75.68
	5.5	3.3	13.57	2.54	3.8	80.32
	6	3.5	12.67	2.53	3.9	76
M3	5	3.2	15.66	2.5	3.01	80.7
	5.5	3	16.79	2.52	2.66	86.79
	6	3.1	16.16	2.47	2.9	83.83
M4	5	4	14.76	2.52	3.4	78.67
	5.5	3.7	15.33	2.54	3.2	83.1
	6	4.2	13.2	2.53	3.3	81.14

IV. CONCLUSION

The conclusion derived from the research are listed below:

a) The unit weight is more for nominal mix as compared to the modified bitumen whereas in modified bitumen, the unit weight is least for the mix-3proportion.

b) The void percentage is more for the nominal bitumen mix when compared to the modified bitumen mix. The least percentage value of voids is2.66%.

c) Void in the nominal mix is mostly filled by bitumen where as in modified bitumen; the voids are filled by bitumen and fiber. Hence, the bitumen percentage for filling voids is less when compared to nominal mix.

d) The flow value is more for the nominal mix whereas the modified bitumen is having much lesser flow value. In nominal mix, the maximum flow value is 4.1mm where as in modified bitumen mix flow value is3.1mm.

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