PERFORMANCE ANALYSIS OF BITUMEN MIXTURES USING NANO-SiO_2 POWDER

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ABSTRACT

Nano-particles are widely used to improve the high temperature performance of bituminous binders. However, the influence of humidity on performance at high temperatures is not clear. Therefore, the water absorption capacity of nano-SiO2 modified asphalt concrete is examined. Based on, Bitumen with a black surface faces problems, especially cracks and ruts. These deformations occur in Bitumens due to defects in the mix attributes and increased traffic loads. They occurred due to the lack of black cover and, in addition, due to mixing. This article focuses on how to improve the qualities of superior black mixes using Nano-SiO_2 Powder (NSP). The exploration includes the study of the properties of mixtures modified using NSP. The NSP substances tested represent 2, 4, 6, 8 and 10% of the weight of the bitumen. Marshall, Retention Marshall, Indirect Tensile Test (ITS) and penetration and softening point tests are used to evaluate the properties obtained. The results show that the most suitable NSP content is 6% by weight of the black tip. A 6% NSP variation in the Black-Top compound increases Marshall strength by 33.56%, decreases penetration by 8.32%, and creates conditioning by 11.22%, providing a ratio of unit weight to approximately similar air gap and other properties of the mixture are maintained as much as possible. possible. The broad inclusion of NS results in the improvement of the properties of the black coating compounds.

Keywords: - *Nano-particles, engineering characteristics, Black-top Bitumen, traffic loads, Nano-SiO_2, indirect tensile strength, Marshall Strength.*

INTRODUCTION

Bitumen causes several problems during its useful life, e.g. B. grooves, wear and moisture damage. Such frustrations reduce the workability of bitumen and the need for ongoing maintenance, increasing overall life cycle costs. Specialists have tried to create additives, eg polymers, rubber bands, etc., to improve the presentation of black roof coverings in the prevailing weather and stacking conditions. While the use of polymeric and elastic additives for black sheet modification has been known for a long time, it is associated with various difficulties, such as (a) poor storage safety at high temperatures and (b) little resemblance to sealed black. . mesh. In this way, the scientists not only sought to overcome these difficulties related to these modifiers, but also studied different approaches to improve, for example, the display of unmodified black sheets using innovative materials and the use of different types of nanomaterials.

Nano-SiO_2 materials

Nano materials are characterized by the fact that "materials with any external dimension in the nanoscale or with internal structure or surface structure in the nanoscale and nanoscale are characterized by the fact that" the lengths are between 1 nm and 100 nm " This includes both nanoobjects, which are discrete pieces of texture, and nanostructured materials, which have internal or surface structure on the nanoscale.SiO2 nano-particles (nano-SiO2) are discrete particles of silicon dioxide, an oxide of inorganic metal, spaced less than 100nm apart Nano-SiO2 has been successfully applied in various fields such as medicine, silent transportation, and design.Lower production costs and better components are the many advantages of nano- silica, nano-SiO2 has been used effectively as a rheological solute to strengthen elastomers and improve the mechanical quality of cem compounds.Nano-SiO2 is considered a moderately new inorganic nanomaterial with excellent diffusion properties, higher specific surface area, constant adsorption and brilliant stability. Nano-SiO2 has a tetrahedral crystal structure with Si inside and 4 surrounding oxygen atoms.

Figure - Nano-SiO_2 Powder

Objectives of research

Followings are the objective of this study-

- Study of the influence of nanomaterial additives on the properties of bituminous mixtures.
- Evaluation of an bitumen pavement modified with nanosilica and improvement of bitumen pavement performance using fillers such as nanosilica on VG30.

LITERATURE REVIEW

This chapter deals with the context of the use of nanosilica in bituminous mixtures. This gives an idea of the method to perform a search in the right direction. After the reform and opening up, Rroad construction changed rapidly and developed rapidly [1, 2], but the pavement has always been a major disease of China's asphalt road pavement [3, 4]. Ruts will seriously affect driving safety and road aesthetics, and greatly affect road operations [5]. Improving the strength of asphalt pavements has been a hot topic in recent years, and improving the stability of asphalt at high temperatures is one of the most effective ways [6-8]. In recent years, nanomaterials have been widely used to improve the performance of bituminous binders due to their large specific surface

area, high surface free energy, and good dispersibility [9-12]. Hasaninia and Haddadi studied asphalt rutting and fatigue damage caused by nano-SiO2 and found the correlation between the technical performance of modified binder and asphalt [13]. Wu et al. studied the temperature sensitivity of cement mortar nanoparticles, the influence of nano-SiO2 on the strength of asphalt-cement mortar, and the performance of nano-SiO2-cement bituminous mortar at different temperatures [14]. Rezaei et al. asphalt modified with nano SiO2 and SBS polymer and its performance at high temperature was analyzed [15]. Chen and Li performed technical index tests on emulsified SiO2 nanoasphalt. The addition of nano-SiO2 has been shown to improve stability, permeability and softening point [16]. Shafabakhsh and Jafari Ani found that the addition of nano-TiO2 and nano-SiO2 improved the rheological properties of asphalt, increasing toughness and viscosity by an average of 30% and 109% respectively, while reducing the level of permeability. In addition, the road resistance and durability of asphalt have been improved [17]. Saltan et al. measured the groove and fatigue properties of modified asphalt materials at the nanometric scale [18]. Che et al. studied the effect of SiO2 phase change compounds on the internal temperature of porous asphalt concrete [19]. Shafabakhsh et al. investigated the effects of nano-SiO2 on low-temperature cracking in bituminous mixtures using a semicircular curvature (SCB) test under mixture I/II load [20].

METHODOLOGY

The figure below shows the detailed workflow as well as the study intent to complete this research paper. The work began with the bibliographic search of the various literatures available for this work. The gaps in the study were listed, which served to define the work objectives that will be pursued to carry out the research. Once the gaps and objectives were identified and understood, the necessary materials for the work were obtained from the local market and the necessary tests were carried out according to IRC standards to determine the suitability of these materials to carry out the investigation. Various tests in the form of aggregates. Impact strength, refractive index, elongation and spalling, Los Angeles abrasion were measured on aggregate and softening point and penetration value were measured on bitumen.

Aggregates

"Aggregate" is a term for any particulate matter. Contains rock, crushed stone, sand, and slag, recycled concrete and geo-synthetic aggregates. The set can be characteristic, produced or reused. The total amount is somewhere in the range of 60-80% of the solid mix. They add an impression quality and imprint to the concrete. • Aggregates in a particular cement mix are selected for their strength, quality, utility, and ability to form complete mixes. For a decently strong grout, the assembly should consist of solid, hard, pristine particles free of retained synthetic compounds or layers of dirt and other fine materials that could cause disintegration of the concrete. Sums are divided into "gross" or "fine" classes. Coarse hums are particles more noticeable than 4.75mm. The standard range used is 9.5mm to 37.5mm wide. Fine sums are generally sand or crushed stone less

than 9.55mm in size. Typically, the most commonly used overall size in development is 20mm. A larger dimension, 40 mm, is becoming more regular in solid concrete. Greater total distances reduce the amount of concrete and water needed.

Figure: AGGREGATES

The procedure of Aggregate Crushing Value Test:

Take the empty barrel load measured as W1 and fill the full 12.5mm example and hold it on a 10mm IS screen in the estimating chamber in 3 equal layers with the ultimate goal of each layer using 25 rounds exposed in the packing station. Take the total gravity with the estimation chamber as W2. Then find the total W= V2 - V1. Currently filling the entire example with a diameter of 15cm. in addition, a 13 cm high steel chamber and carefully level the exterior assembly and complete the plunger so that it rests evenly on a level surface. Locate a steel chamber with a release device on the stacking plate of the compression testing machine. Compressing machine working with the ultimate goal of applying 40 tons of pile in about 10 minutes in total. Unload the load and remove the steel chamber from the machine. Remove the crushed bulk sample and continue sieving with a 2.36mm IS sieve taking care to maintain a strategic distance between the loss of fine particles and the last weight fraction carried by the 2.36mm sieve and the W3 mark.

Procedure for Los Angeles Test

- The test consists of clean whole pieces that have been oven dried at 105° - 110°C.
- Select the assessment to be used in testing with the end goal that aligns as closely as possible with the control to be used in development.
- Take 5 kg of evidence for grades A, B, C and D and 10 kg for grades E, F and G.
- Choose the lattice load according to table 2 according to the evaluation of the sums.
- Find the hum and raw load on the camera and adjust the dispersion.
- Rock the machine at a speed of between 30 and 33 cycles at this time. The number of lifts is 500 for Classes A, B, C and D and 1000 for Classes E, F and G. The machine must be set up and flown with the

ultimate goal of having a constant speed limit.

- The machine stops after the ideal number of turns and the material has been released on a plate.
- All rock debris is protected in a 1.70mm IS screen.
- Materials thicker than 1.7mm are measured to the nearest gram.

Figure: Los Angeles Abrasion Apparatus

Observations of Los Angeles Test Original weight of aggregate sample = W_1 g Weight of aggregate sample retained = W_2 gWeight passing 1.7mm IS sieve = $W_1 – W_2$ gAbrasion Value = $(W_1 – W_2) / W_1$ X 100

Test on bitumenPenetration

The bitumen penetration test is a measure of the hardness or consistency of the bituminous material. A grade of 80/100 for bitumen indicates that its infiltration grade is between 80 and 100.

Penetration is the vertical separation navigated or introduced with a standard needle in the bituminous material under explicit conditions of stress, time and temperature. This distance is estimated to be one tenth of a millimeter.

Apparatus required

Compartment: - A flat bottom tubular metal tray 55mm wide and 35mm inside and out is required. In the event that the input requires a minimum of 225, a tank 70mm wide and 45mm deep is required.

Needle: A hollow, straight, carefully cleaned, round, hard steel bar.

Shower of water: shower of water maintained at 25° ± 0.1°C and containing at least 10 liters of water, the sample is immersed to a depth of at least 100 mm from above and is supported on a support perforated with holes at least 50 mm from the shower base.

Move the bowl or plate: - You must use the tray and not shake it. It should be constrained enough to completely overwhelm support during testing.

Entry device: - It must be of a size that allows the entry of the needle without too much friction and aligned with

a precision of tenths of a millimeter.

Thermometer: - Range 0-44°C and touch at 0.20°C. Time Calculator: - Accurate to within 1 second.

Figure: Penetration Apparatus

Marshall mix design

A mixture of bituminous solids is generally designed according to the Marshall method. This test is commonly used in routine cleaning proof-of-work programs. The strength of the mix is characterized as the maximum stress imparted by a compacted specimen at a standard test temperature of 600°C. The current is estimated as the distortion in units of 0.25mm between no build-up and maximum load. promoted by example when testing continuity (the current value can also be estimated in 0.1mm torque units). This test attempts to achieve the ideal binder content for the overall mix type and volume of traffic.

RESULT & DISCUSSION

Specific Gravity of Aggregates (IS 2386 PART 3)

Table: Specific Gravity Value of 30mm Size Aggregates

Determination	Sample
Wt. Of pynometer W1(gm)	714
Wt.of pynometer+sample W2(gm)	1284
Wt.of pynometer+sample+water W3(gm)	1970
Wt.of pynometer+water W4(gm)	1600
Specific gravity = (W2-W1)/[(W2-W1)+(W4-W3)]	2.76

Table: Specific Gravity Value 15mm Size Aggregates

Determination	Sample
Wt. Of pynometer W1(gm)	714
Wt.of pynometer+sample W2(gm)	1136

Wt.of pynometer+sample+water W3(gm)	1870
Wt.of pynometer+water W4(gm)	1600
Specific gravity = (W2-W1)/[(W2-W1)+(W4-W3)]	2.77

Above tables shows the data of specific gravity value test performed for 30mm and 15mm size of theaggregates are 2.76 and 2.77 for 30mm and 15mm size of the aggregates respectively.

Los Angeles Abrasion Test (IS 2386 PART 4 1963)

Table: Los Angeles Abrasion Test

S no.	Sieve size		Wt.taken (gm) A	No. Of ball	Fraction Retained On ISSIEVE 1.7 MM	Passing (Gm) B	Abrasion Value (B/A)*100	Remarks
	Passing (mm)	Retained (mm)						
1	30	18.75	2500	11	4286	695	13.9	MAX.=30%
2	18.75	15	2500					
15MM								
1	15	9.45	2500	8	4026	812	16.2	MAX.=30%
2	9.45	7.12	2500					

Table shows Los Angeles Abrasion Test value results data for 30mm size of aggregates taken 2500gm passing through IS Sieve size 30mm and retained on 18.75mm and 2500gm passing through 18.75mm and retained on 15mm., And using 11 ball for 30mm size of aggregates and 8 for 15mm size and got the value 13.9 and 16.2 percent for 30mm and 15mm aggregates which is less than the permissible limit set by IS 2386 Part 4. Permissible limits value for pavement is maximum 30%.

Penetration test on Modified Bituminous Mix

Table: Penetration Value at 6% NS

Reading	No.of trails(NS AT 6%)				
	1	2	3	4	5
Initial reading A	0	68	0	66	10
Final reading B	58	128	56	122	62
Difference Value	58	60	56	56	52
PENETRATION VALUE	AVG. OF TRAILS 57				

Softening Point Test of Modified Bituminous Mix

Table: Softening Value at 6% NS

Temperature When The Ball Touches Bottom, ℃	Sample	
	1	2
Softening value	64	64
	Avg. of two = 64 ℃	

Table shows the penetration value and the softening value of 6% NS modified Bituminous Mix at OBC. And result found to be 57 as penetration value and 64 ℃ as softening point value.

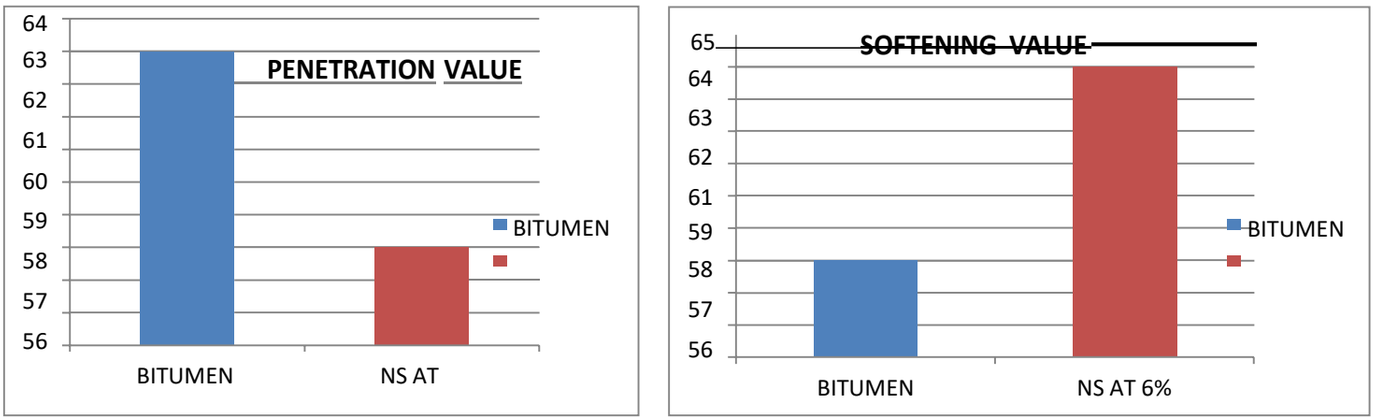

Figure: Penetration Value And Softening Value between Control MI AND NS AT 6%

In the show that mixing NS with bitumen improves the penetration and softening properties. The penetration value decreases 6.3mm to 5.7mm by 9.52%. Softening value increases 58℃ to 64℃ which represents 11.22% increment. This is happening because of mixing of NS with VG30 as it increases the stiffness properties of Modified Bituminous Mix by increasing their bond strength between the aggregates and binder.

CONCLUSIONS

In this study nanomaterial were used to modify the bituminous mixes of grade-II. Nano silica was adopted for modified the bituminous mix and various mechanical properties like Marshall Stability, Flow, Retained Stability were calculated

- Optimum Bitumen Content found at 5.62% of bitumen content.
- While adding NS to bitumen binder, It improves the physical properties of the binder by decreasing thepenetration value and increasing the softening point value of the bitumen binder.
- Maximum stability occurred at 6% NS added to the bitumen binder and stability value is 31.22% greaterthan unmodified bitumen binder. Optimum NS content is 6%
- Maximum density occurred at 4% NS added to the bitumen binder and density value is slightly greaterthan unmodified bitumen binder.
- Retained stability found to be 82%.

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