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Research Paper

Nanotechnology in Flexible Pavement

Engineering

KEYWORDS : Nanotechnology, Soil Waterproofing, New Innovation in Road construction, Improving C.B.R in wet conditions.

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ABSTRACT

Benefits of using Nano technology to make soil water proof are like increment in California Bearing Ratio (C.B.R) results in wet conditions, decrement in maintenance or negligible maintenance, increase in life span of road, less materials required for construction of road because reduction in thickness required of pavement.

I. Introduction

Nanotechnology is one of the most active research areas that encompass a number of disciplines including civil engineering and construction materials.

Traditionally, nanotechnology has been concerned with developments in the fields of microelectronics, medicine and materials sciences. However, the potential for application of many of the developments in the nanotechnology field in the area of construction engineering is growing.

After more than a decade of progress in other industrial sectors, the nanotechnology revolution has just begun to impact highway, road, and bridge materials and construction. Right now, under the Federal Highway Administration's Advanced Infrastructure Research program, study is under way on a variety of nanotechnology applications to the highway and bridge industries.

Nanotechnology-based improvements to pavement performance will result in significant cost savings to pavement agencies around the globe. Ultimately, nanotech improvements to asphalt will result in longer-lasting, more durable pavements for highways, airfields, ports, and other applications.

II. Soil Waterproofing

Nanotechnology chemicals based on organosilicon chemistry which forms clear solution with water for spray application. It reacts and converts 3 – 5 mm deep compacted soil layer to waterproofed layer. Nanotechnology chemicals has been developed to prepare in-situ waterproofed soil layer, to act like a nano breathable membrane on the compacted soil layer during pavement construction.

The technology addresses the critical subsurface drainage problems in road making. It also resolves the following issues like , Loss in strength and expansion in wet conditions for soil sub grade (CBR values and plasticity), Reduced water absorption through road shoulders and sides, Utilization of in-situ soils.

The soil waterproofing procedure is carried out in two cycles with diluted chemical solution using Spray – Dry – Spray technique. The first spray application resulted in 90 to 95% waterproofing of the soil surface. Then the soil is allowed to dry in sunlight for completing the reaction with soil.

The second spray application ensured 100% saturation of micro-cracks and soil surface. Diluted chemical solution penetrated deep into the micro-cracks of the road surface and formed perfect waterproofed Nano membrane.

Figure 1.Chemically treated Water proofed soil

III. New innovations

Roads Without and With Nano- Technology

a. Water Sensitivity

Asphalt Surfaces are water sensitive due to inadequate cleaning of dirt & dust. Milling generates micro cracks in the asphalt layer allowing higher water permeation. Water sensitivity causes bonding failures.

Water Resistance :

Nanotech converts water loving dust / dirt / aggregates to asphalt loving surfaces. Ensures excellent bonding & water resistance.

b. Poor Wetting

Cationic bitumen emulsion has poor wetting properties. Results into poor coverage of tack coat

Excellent Wetting

Nanotech lowers the surface tension of the cationic bitumen emulsion , leads to excellent wetting & complete coverage.

c. Nozzle Clogging

Cationic bitumen emulsion has poor mechanical stability. Results into clogging of nozzles and non-uniform application.

Clean Nozzles

Nanotech keeps nozzles clean by improving stability of cationic bitumen emulsion. Ensures uniform spraying at room temperature. Heating of the emulsion not required, saving energy & time

d. Excess Bitumen

Cationic bitumen emulsion particles size range from 5 - 10 microns. A 10 micron layer requires 10 gm / m2 of residual asphalt

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150 - 250 gm / m2 is specified world over as residual asphalt for tack coat application .Excess deposition of 15 - 25 times needs to be optimized.

Bitumen Optimized
Allows substantial reduction in asphalt thickness due to better wetting & spraying.

e. Tire Pick Up
Cationic Bitumen Emulsion has poor drying & it is tacky, Bonds superficially causing Tire Pick Up.

No Tire Pick Up
Wets, penetrates & sets quickly (5-10 minutes). Reduces tackiness on the surface. Eliminates Tire Pick-Up.

IV. Improving C.B.R in wet conditions
Table 1: Soil classification

Sr no.	Test	Results
1	Liquid Limit	29.59%
2	Plastic Limit	Non plastic
3	Differential Free Swell	15%
4	Maximum Dry Density	1.86 gm/ml
5	Optimum Moisture Content	15.2%

Sieve analysis:
Gravel = 3.29%
Sand = 41.06%
Silt and clay = 55.65%
Soil type: (ML-CL)

C.B.R Test:
A comparative C.B.R tests for simple untreated soil and soil treated with one of the nanotechnology chemicals were carried out by us to see variations in results.

Table 2: Observations

Sr no	Control mould		Treated mould	
	Penetration (mm)	Load (kg)	Penetration (mm)	Load (kg)
1	0	00.00	0	0.00
2	0.5	09.20	0.5	13.5
3	1.0	17.20	1.0	22.2
4	1.5	24.80	1.5	31.4
5	2.0	32.40	2.0	40.5
6	2.5	39.20	2.5	50.2
7	4.0	56.80	4.0	70.40
8	5.0	65.60	5.0	85.60
9	7.5	90.80	7.5	99.20
10	10.0	110.40	10.0	118.00
11	12.5	128.80	12.5	136.40

Figure 2. C.B.R test

Results:
For control mould:
Corrected load at 2.5 mm = 39.9 kg.
C.B.R at 2.5 mm = (load/1370) ×100
= 2.19%
Corrected load at 5.0 mm = 66.1 kg.
C.B.R at 5 mm = (load/2055) ×100
= 3.22%

For treated mould:
Corrected load at 2.5 mm = 51.1 kg.
C.B.R at 2.5 mm = (load/1370) ×100
= 3.73%
Corrected load at 5.0 mm = 86.2 kg.
C.B.R at 5 mm = (load/2055) ×100
= 4.19%

Result observation: Improvement in C.B.R results can be obtained for treated soil.

V. Conclusions

a. Reduction of materials used
As we know pavement based design and thickness of sub- base depends upon CBR value so increment in CBR value results in reduction of thickness of sub-base, which means materials require for sub-base are having less quantity

b. Cost Comparison
Conventional method of pavement making is having less initial cost but it requires the high maintenance costs. Roads are very susceptible to water hazards every year, which is a huge headache to all contractors and developers, on the other hand pavement making using nano technology may have high initial cost but it has nearly no maintenance costs which will affect the economy of road long-time.

c. Durability
As we know the conventionally made roads are not very long lasting, they hardly remain in good conditions for 10 years. But having Nano-technology as all problems due to water are eliminated, the roads life for good conditions increases up to 20-25 years.

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