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BASIC SOLUTIONS FOR THE CONSTRUCTION AND MAINTENANCE OF ROAD CORRIDORS IN PERU

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Abstract: Design and Build economic pavements made up of stabilized bases with various types of soils, and bituminous coatings with the application of nanotechnology(chemically bonded organisolane compound for soil and asphalt); in road corridors (lengths greater than 150 km) of low and high volume of traffic, in Peru. Describe the procedure and technical specifications for the application of nanotechnologies to stabilize various types of soils without considering: granulometric spindle, percentage of fines, from low to high plasticity; for use as a stabilized base, without using conventional material sources such as granular pavement layers; establishing parameters of resistance, expansion and sensitivity to humidity. Comparison of conventional asphalt mix and with application of the adhesion improver, by measuring resistance parameters, volumetric properties, adhesion, processing and compaction temperature, dosage. Through non-destructive evaluations for Road Management, the incidence of nanotechnology is determined in: useful life for road corridors with low volume of traffic, frequency of periodic maintenance, level of serviceability and comfort during its useful life, cost of pavement per kilometer, feasibility to expand the alternative sources of materials, socio-economic-environmental impact on the development of the country.
Keywords: Basic solutions, bituminous surface, road corridor and nanotechnology.

BASIC SOLUTIONS

The methodologies applied in Latin America specify that the sources of materials used for the granular layers that make up the pavement structure are soils that must meet certain characteristics such as: low percentage of fines, zero to low plasticity, comply with some granulometric zone, present gravel, among others; in order to reduce the susceptibility of modifying its resistance and mechanical properties in the presence of water.

Also in our environment, cement or lime stabilizations known as semi-rigid pavements have been applied, presenting cracks in the stabilized layer after concluding the construction process, affecting the level of road serviceability.

The application of nanotechnology for the stabilization of bases in pavements affects their flexibility and the use of soils as sources of materials that exist on the sides adjacent to the path or axis of the highway.

DESIGN

The soils used for stabilization are those indicated in Table 1 and Table 2, which belong to two regions of Peru. The soils in these regions are known as: fine sand, and silty and clayey soils; that represent soils that are discarded due to their physical-mechanical characteristics to be used as part of the pavement structure, according to conventional methodologies.

The incidence of the soil stabilizer in the increase in resistance depends on the structure of the clay, being measured indirectly by its expansion. The stabilized samples were compacted by the Marshall method, using 75 blows per face, in order to obtain compacted and reshaped samples, to be placed in a container with water, as shown in figure 1. After four days of being in the presence of of the water, the expansion of the stabilized clays can be observed according to their structure as shown in figure 2. Sample B-1 represents a clay not suitable for stabilization and sample B-2 represents a favorable clay for stabilization.

When applying nanotechnology for stabilization, the resistance or support value (CBR) of the samples increases significantly, obtaining resistances (CBR) greater than 100% and expansion or swelling are generally less than 0.5% [1], as shown in Table 3.

ID	(% what's happening) No. 40	(% what's happening) No. 200	Limit Liquid (%)	Index plastic (%)	Classification SUCS	Classification AASHTO
Highway: Zungarococha, Km 02+000	100	93	48	twenty-one	CL	A-7-6 (23)
Highway: Zungarococha, Km 09+500	100	83	fifty	twenty-one	MH	A-7-6 (19)
Road: El Paujil, Km 00+300	100	87	53	24	CH	A-7-6 (31)
Highway: Palo Seco, Km 00+100	94	23	fifteen	NP	YE	A-2-4 (0)
Highway: Santa Clara, Km 04+500	100	96	67	33	MH	A-7-5 (39)
Quarry: El Varillal, Km 14+050	78	10	-.-	NP	SP-SM	A-3 (0)

Tabla 1 - Soils that exist in the Loreto region

ID	(% what's happening) No. 40	(% what's happening) No. 200	Limit Liquid (%)	Index plastic (%)	Classification SUCS	Classification AASHTO
Highway: La Joya – Infierno, Km 15+800	100	89	40	twenty	CL	A-6 (18)
South Interoceanic Highway, Km 423+750, Madre de Dios River Quarry	16	1	NP	NP	GP	A-1-a (0)
South Interoceanic Highway, Km 598+000, Saboya Quarry	100	2	NP	NP	SP	A-3 (0)
Road: Dv 166 – Tropezón, Km 06+800	100	67	32	fifteen	CL	A-6 (8)
Highway: Dv 166 – Tropezón, Km 08+800	97	69	Four. Five	18	ML	A-7-6 (12)
Highway: Iñapari – Belgium, Km 00+800	100	5	-.-	NP	SP-SM	A-3 (0)
Highway: Iñapari – Belgium, Km 01+500	98	73	30	12	CL	A-6 (7)

Tabla 2 - Soils that exist in the Madre de Dios region

Figure 1: Stabilized and compacted clays.

Figure 2: Expansion of stabilized clays according to the structure of the clay.

ID (km)	Additive	CBR (0.1", 100% MDS) (%)	Expansion (%)
Mixture II: Clay (65%) - Fine sand (35%)	TO	156.2	0.53
	B.	102.2	0.80
Mixture III: Clay (65%) - Fine sand (35%)	F	149.9	0.28
	B.	141.4	0.54
Mix II: Clay (65%) - Gravel (35%)	F	167.7	0.00
	B.	90.4	0.11
Mixture I: Clay (70%) - Fine sand (30%)	C.	90.9	0.00
	F	193.6	0.00
	B.	136.2	0.00
Mixture II: Clay (65%) - Fine sand (35%)	C.	82.9	0.00
	F	162.8	0.00
	B.	103.5	0.00

Tabla 3 - Resistance and expansion of tropical soil mixtures

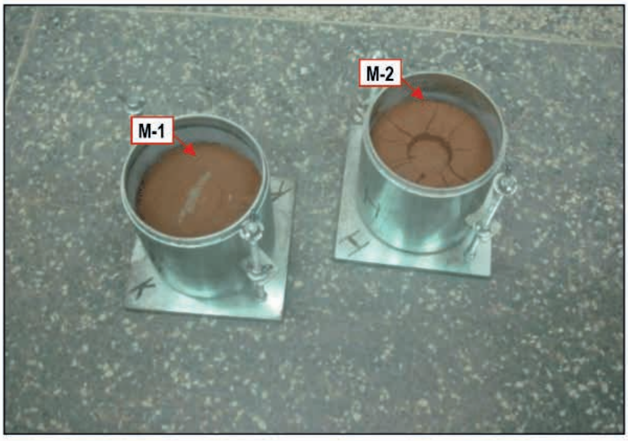

Figura 1 - Verification of flexibility (M-1) and stiffness (M-2)

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For the CBR test, after compacting the samples, they must be subjected to a seven-day curing period at room temperature, and then submerged in water for four days.

The verification of the flexibility or rigidity of the stabilized base is carried out after executing the CBR test, as shown in figure 3. Sample M-1, after executing the penetration, recovers its initial shape, for which reason a mark, which is due to the flexibility of the stabilized material. Sample M-2 presents deformation and cracks, which is due to the rigidity of the material.

CONSTRUCTION

This stage begins with the execution of the test section with a length between 100 and 300 m in order to achieve the work formula and establish the execution conditions, such as dosage, mixing procedure, frequency of irrigation for curing.

The equipment used for construction was conventional: front loader, motor grader, dump truck, tanker truck, smooth vibratory roller; this does not restrict the use of other technologies for adequate mixing and homogenization of the stabilized material.

The control of the resistance in situ is carried out eight days after the stabilized base was built, using the dynamic cone penetrometer, as shown in Figure 3.

BITUMINOUS COATING WITH NANOTECHNOLOGY

The aggregates for bituminous coatings present variability in their properties depending on their origin and region where the project is carried out, requiring to improve their affinity with asphalt cement, and the properties of resistance, workability and susceptibility of the resulting mix.

In the test method for the resistance of compacted asphalt mixtures to damage induced by humidity, according to AASHTO T-283, known as Lottman; It is a test that is more adjusted to the work conditions, quantifying the adhesiveness. It has made it possible to determine the tensile strength of the specimens, measuring the loss of cohesion of a compacted mixture as a result of the effects of accelerated saturation in water, allowing to measure the resistance of the mixture together with the addition of nanotechnology (0.075% by weight of asphalt), as shown in Table 4.

The technical specifications for asphalt mixtures establish 80% as a minimum value for the stress to tension ratio [2], from the result obtained we verify that it is satisfactorily fulfilled.

The Adhesiveness test of bituminous binders to fine aggregates (Riedel Weber procedure), according to MTC 220, allows determining the adhesiveness of bituminous binders to fine, natural or crushed aggregates, as shown in Table 5.

The technical specifications for asphalt mixtures establish grade 4 as a minimum value for adherence in fine aggregates [3], from the result obtained we verify that it is satisfactorily fulfilled.

The test to evaluate the effect of water on aggregates with bituminous coatings using boiling water, according to ASTM D 3625; allows observing the loss of adhesion, as shown in Table 6.

The technical specifications for asphalt mixtures establish 95% as a minimum value for the adherence in the mixture [4], from the result obtained we verify that it is satisfactorily fulfilled; considering that the natural aggregate is not suitable for use in bituminous coatings.

PERFORMANCE OVER TIME OF NANOTECHNOLOGY

The pavement condition index, according to ASTM D 6433; after three years made in the section: emp. Pe 5 n (Nueva Cajamarca) - Yuracyacu and sm - 114 section: emp.

Figura 2 - Verification of flexibility (M-1) and stiffness (M-2)

sample conditioning	Dry	in wet
Average air voids (%)	7.0	7.2
Degree of saturation (%)	-.-	73.6
Tensile Strength (psi)	70.34	60.68
Moisture damage (visual)	1	2
Fractured aggregates (visual)	does not present	does not present
Stress to Tension Ratio – TSR	86.3	

Tabla 4 - Resistance of compacted asphalt mixes to moisture induced damage

Sample identification	Additive(% by weight of asphalt)	Result (Grade) Partial detachment - total
25% crushed sand 35% natural sand	0.066	6 - 10

Tabla 5 - Adhesiveness of bituminous binders to fine aggregates

Description	Covering(%)	Observation
natural sample	fifty	
Additive (nanotechnology) at a dose of 0.1%	99	
Additive (nanotechnology) at a dose of 0.1%	98	sea water was used
Additive (nanotechnology) at a dose of 0.05%	85	
Additive (nanotechnology) at a dose of 0.1%	96	The liquid asphalt used for the test was MC-30

Tabla 6 - Adhesiveness of bituminous binders to fine aggregates

Figura 3 - Pavement surface condition applying nanotechnology

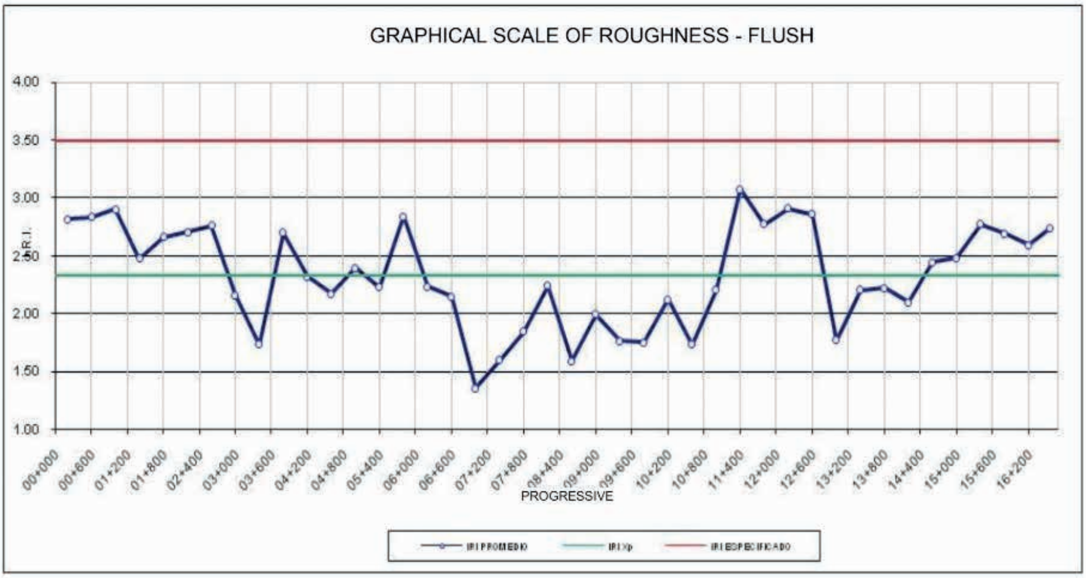

Figura 4 - Pavement surface condition applying nanotechnology

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Sm - 113(dv. Yuracyacu)- posic, Province of Moyobamba and Rioja - San Martin; demonstrates that the deterioration of the pavement using nanotechnology during the period of three years has a Very Good condition; as shown in Figure 5.

The roughness measured after three years of service is below the technical specification of the project (3.5 m/Km), as shown in Figure 6.

CONCLUSIONS

The application of nanotechnology (organisolane compound with chemical bond for soil) for stabilization is applicable to a wide range of soils, without restriction of: granulometric spindle, percentage of fines and plasticity.

The CBR of the base stabilized with nanotechnology is greater than 100% and expansion less than 0.5%, which shows that it is not susceptible in the presence of water.

The application of nanotechnology (organisolane compound with chemical bond to asphalt) in bituminous coatings substantially improves the coverage of the asphalt binder in the aggregates, ensures optimal compaction, resistance, eliminating peeling to obtain a longer useful life.

The bituminous coating plus the stabilized base during a three-year service period show no deterioration and the IRI (3.0 m/Km) is less than the technical specifications of the project, 3.5 m/Km.

Nanotechnologyit significantly affects the reduction of the cost by sources of materials in the construction of pavements.

Traffic has remained constant and safe, during and immediately after the rains.

The aforementioned technical and economic benefits have favorable social and environmental effects, which are achieved in the area of influence of the highway, embodied in the improvement of the population's quality of life, lower vehicle operating costs, lower environmental impact on water resources and air quality.

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