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MANAGEMENT OF THE PATRIMONY VIAL IN THE CONTEXT OF THE SUSTAINABLE DEVELOPMENT AND THE ADAPTATION TO THE CLIMATIC CHANGE

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ABSTRACT.

The Republic of Cuba has a total of 17815 kilometers of paved highways, in the 14 counties and the Special Municipality of the Youth's Island.

The Limits of the Program of Development of the Infrastructure Vial for next years, points out the necessity to offer preferable attention to the new investments, to the improvement of the nets road, to look after the quality of the constructions and of the works in exploitation, it is for that reason that one works in these moments in different lines, related to the environmental improvement, the energy saving and the sustainable development for what they are carried out the studies and works to achieve these objectives.

So much in the technical norms as in the design, the construction and the conservation of the infrastructure vial they are considered keeping in mind the concepts of sustainable development. In Cuba, the National Office of Normalization (ONN) has the responsibility of the elaboration of all the Cuban (NC) Norms or the adoption and adaptation of foreign norms if it is considered this way. The results of the works have facilitated to plan that for final of the year 2015, the state of the highways of interest national reach 80% of good and 20% of regulating, without having kilometers in not well state.

Until the moment in alone Cuba is possible to look after the quality of the infrastructure in the nets of highways in a sustainable way if simple teams of mensuration are applied and they are used to model posteriori of calculation to perfect the results and to be able to them to compare with decency with those of other international experiences that use in the mensuration much more modern teams of high yield. In this National Reporter he thinks about the experience of a case of study in the improvement from the pattern Index Cuban Security Comfort to which incorporated the result of the international value IRI like measure of the comfort vial in an inspected highway tract.

1. INTRODUCTION.

The Republic of Cuba according to data of the National Center of road nets, MITRANS, has a total 17 815 kilometers of paved highways, with all type of traverse section, in the 14 counties and the Special Municipality of the Youth's Island, in most of the cases with wide of rail, of concrete asphaltic variable between 3.00 and 3.50 meters and wide of the walks largely not paved and variable width from 0,00 at 1.00m.

So soon a tract of paved highway opens up to the traffic, a degradation process, of pol begins and possible oiled of the surface, what forces to conceive a System for the Design, the Management, the Construction and the Conservation of the Highways in Cuba under the principle of to assure its quality and to look after the environment in a sustainable way keeping in mind the traditions and the economic real possibilities, without neglecting the approaches and international experiences.

The Limits of the Program of Development of the Highway Infrastructure for next years in Cuba, points out the necessity to offer preferable attention to the new investments of the transport and the improvement of the road nets, as well as to increase and to look after the quality of the constructions and of the works during its years of exploitation.

All the experts outline that to reach important achievements in the studies and works are needed besides an equipment that in general it is expensive, many knowledge and it

makes aware and this last have it our specialists and Cuban scientists that are very prepared to face the challenges of the revolution scientist technique.

Nowadays, the accidents of the traffic constitute one of the first causes of death in Cuba and the first in a violent way, according to statistical of the Address of Traffic of P.N.R. and of the Institute of Legal Medicine. Keeping in mind these results, recently in August of 2010, it was approved by the National Assembly a Before Bill on The Code of Security Vial.

At the present time in Cuba, to look after the quality of the infrastructure vial teams of high yield they cannot be used for the inspection, because this not generates a financial situation sustainable in next years, keeping in mind the economic crisis for those that it crosses the World and our country doesn't escape to it.

The results of the technical inspections carried out to tracts of main highways in the Havana counties, using teams and procedures of I calculate created and developed in Cuba, they already embrace but of 1200 km - rail and they recommend measured maintenance correctives and conservation vial to increase the security and the comfort vial without neglecting the economy of the transport.

The Net of Highways of National Interest was characterized according to the Security Vial, a "New Procedure was elaborated for the Localization of Tracts and Highways of High Concentration of Accidents" and the Audits of Security Vial was begun.
It was approved recently by the National (I Converse Cuban) Assembly the Bill "Code of Safety Vial ".

2. TECHNICAL NORMS. DIRECTIVE OF THE ORGANISMS AND INSTITUTIONS.

In general, so much in the technical norms as in the design, the construction and the conservation of the infrastructure vial in Cuba are worked keeping in mind the concepts of sustainable development and, although the necessary and wanted level is not still reached, firm steps are taken to achieve it in next years.

In Cuba, the National Office of Normalization (ONN) has the responsibility of the elaboration of all the Cuban (NC) Norms or the adoption and adaptation of foreign norms if it is considered this way.

This activity is carried out for the Technical Committees of Normalization (CTN), among which CTN is #21 Highways, where in the same one he/she has a great participation and responsibility the Ministry of the Construction (MICONS).

CTN #21 is formed by 4 Subcommittees (Highways, Asphalt, Conservation and Bridges). The general strategy outlined by this CTN #21 are to achieve that in all the norms that concern him/her they are included the specific aspects on the measures to minimize the environmental impacts and other elements related with the sustainable development, that which will leave materializing in the approved norms that are in elaboration or in those that are in revision process.

This CT #21 in the last times has elaborated and several revised design norms and construction of highways, among them:

- 9 Cuban norms related with the design of roads and intersections, their equipment, and of flexible and rigid pavements.
- 12 Cuban norms on arid and asphaltic concretes in hot, in cold and superficial treatments.

Guided by the Ministry of Science, Technology and Environment (CITMA), in the country all the Organisms of the Central Administration of the State have constituted a Commission of Environment whose main function is to veil because in all the activities that are carried out it maintains the environmental appropriate protection and it is fulfilled the necessary demands for a sustainable development. The Commission of Environment of MICONS, in connection with this topic has developed, among other, the following activities:

- Elaboration of a group of Regulations of the Construction (RC) directed to the environmental protection, such as: I use of the floors in the construction. Environmental protection in the construction with temporary facilities for different types of works. Environmental protection in the plants producers of asphaltic concrete. Environmental protection in the construction. Procedure for the environmental analysis of variants of project vial. Environmental protection in the construction and Design of roads in areas ecologically sensitive.

- Elaboration of a checkup list and application guide to check the energy and environmental acting of the projects and works, with the purpose of reducing the environmental negative impacts that inevitably they take place and they are considered inside the budget of the necessary expenses for their mitigation. This checkup list has been implanted in the whole System of MICONS and in all the entities of projects / I design, engineering and investigations ingenieras applied through the National Commission of Normalization and Quality of the Address of Projects, Entity to which the main entities of this type are integrated in the country, with obligatory character, controlling its execution inside the System of Management of the Quality (SGC) that you/they have certified by the norm ISO 9001.

- A list of similar checkup was elaborated the one referred previously directed to the environmental protection in the production of construction materials, which is pending of approval and installation for the corresponding entities.

The National Commission of Energy Efficiency and Renewable Energy is inside the National Commissions of the Address of Projects, which has energetically as main objective the realization of designs efficient, included the viales and the study and application in the ways of renewable energies in all those investments in that it is possible. In this National Commission representatives participate from all the incorporate entities to the Address of Projects.

3. STRATEGY FOR THE CONSERVATION VIAL.

Applying the national construction norms or brunches and the use in some cases of advanced materials, nowadays he/she has left perfecting more and more in a sustainable way the rehabilitation and the construction of highways dedicated to always cover the multiple necessities growing of the transportation vial, what has motivated in Cuba the construction of nets of roads of 1ra, 2da, 3ra and 4ta category.

This implies the necessity to veil because the cost of the operations in the transport of passengers and loads is he/she carries out in a more and more rational and economic way. He/she stands out the strategy that for more than 12 years of work it is applied in the Highways of National Interest in Cuba with the purpose of reducing the costs of exploitation of the transport.

The results of the works have facilitated to plan that for final of the year 2015, the state of the highways of interest national reach 80% of good and 20% of regulating, without having kilometers in not well state. It is guaranteed then to reach the good condition in the cost of the operations. The financing, to maintain the state of the roads according to that foreseen previously, in fact has its source in the saving that is obtained in the costs of exploitation of the transport.

The System of Recruiting and Certification of Executed Works in the Road for Yield, it is known as: Recruiting Vial to Closed (C.V.P.C) Price.

The Law 60 Code of Vialidad and Traffic, effective in Cuba from 1987 classifies the Net Vial assisting to their interest economic partner in: national, provincial, municipal and of specific interest.

The System C.V.P.C. it is based on valuing all the necessary actions to execute in the road so that it maintains the technical state with which it was projected and I am built. These actions, varying called lines, they have official prices for their execution, those that are related in the I Classify of the Budgetary System made by the Ministry of Finances and Prices of the country (PRECONS) for the works of the construction.

Selected the highway that will be object of the conservation works is valued by PRECONS the tracts, those that should not exceed of 5 Km and you proceeds to hire the works with the company manufacturer that executed them in the foreseen term and agreed.

This approved a System of Control of the Quality, elaborated by the Ministry of Economy and Planning, where checkups settle down 3 times per month and the works are certified carried out at the end of the month. Finally, the investor, carries out the certification of the works of conservation vial finished for the payment to the company manufacturer.

4. TECHNIQUES FOR THE INSPECTION OF THE HIGHWAYS.

In Cuba one has worked during this period in achieving sustainable improvements in the Net of Highways, having as main objective the quality of service that the users and the beneficiaries of the roads expect to toast.

In the rural highways, the National Center of Vialidad of the Ministry of the group Transport with other entities of this Ministry, works in the development of a System of Administration of Highways based on a Geographical System of Information that will have the following exits:

1) State of the highways.
2) Cost of the performances
3) I Average Yearly of Daily Volumes of Traffic.
4) Indexes of Accidentalidad and Mortality.
5) Vulnerability of the Highways, effects before intense rains, hurricanes, earthquakes and the earth slips.

Until the moment in alone Cuba is possible to look after the quality of the infrastructure in the nets of highways in a sustainable way if simple teams of mensuration are applied and they are used to model posteriori of I calculate to perfect the results and to be able to them to compare with decency with those of other international experiences that use a lot in the mensurations teams but modern of high yield.

A Catalog of Damages of the Flexible Pavements of Highways is applied that includes the different families of deteriorations, even those that affect and they are associated with the structural integrity of the pavement. One works at the present time in the elaboration of an I Classify of Deteriorations for the Rigid Pavements.

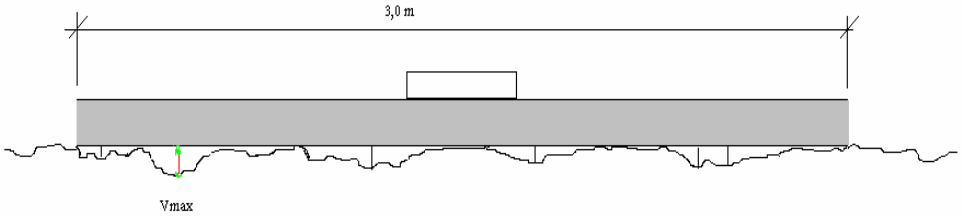
It is demonstrated in Cuba that the damages in the roads that more they affect to the security, the comfort and the funcionabilidad of the traffic, for their influence in the decrease in the circulation speed, they are those that are associated with the superficial characteristics of the pavement.

They are applied for the technical inspections of the highways portable mensuration teams and procedures of I calculate for the evaluation and the diagnosis of the highways in exploitation that you/they have been developed, positions to point, applied and some improved in the last 3 such years as it is the case the Index Security. Comfort ISC.

To assure the quality of the infrastructure vial the following techniques they are used:
The Portable GODLIKE Pendulum, Portable Marco of Texture, rigid rules and motives of 1.5, 2 and 3 m, the beam Benkelman, the rugosímetro Merlin and methods are applied of I calculate to determine IRI, the Index Security Comfort, ISC, the coefficient of longitudinal friction with the speed, the Index of State of the Vertical Signaling IES and the type and thickness of reinforcement of the structure of the flexible pavements. A methodology is also applied for the Design of the Rehabilitation of Flexible Pavements.

Figures 1, Portable DIVA Pendulum

Figures 2, Texture Marco



Figures 3, Rules Rigid of 3 m

5. CASO DE ESTUDIO. MEJORA DEL MODELO CUBANO ÍNDICE SEGURIDAD CONFORT, ISC.

In an investigation carried out in the last 3 years, he/she improved the result ISC when introducing the value IRI in the calculation of the parameter G that assists to the comfort vial. This was achieved using a lineal function of the type G = to + b (IRI), where it stops 4 intervals of speed the values they were determined for a and b.

Table 1, Value of the coefficients a and b to determine G

Intervalos de Velocidad	Coeficiente a	Coeficiente b	Ecuación
Mayor de 100 Km./h	22.00	- 6.667	G = 22.00+(-6.667 (IRI))
80 Km./h - 100 Km./h	14.25	- 1.750	G = 14.25 +(-1.750 (IRI))
60 Km./h- 79 Km./h	28.70	- 2.670	G = 28.70 +(-2.670 (IRI))
Menor de 60 Km./h	50.00	- 4.000	G = 50.00 +(-4.000(IRI))

According to the improved Pattern ISC that considers the value IRI, an inspected highway tract in the following way is qualified:

Table 2, Qualification of having been ISC according to the operation speed

Speed Km./h	Qualification of the Security. Comfort, ISC.				
	Critical	Bad	Regulate	Well	Excellent
100	2.00	2.01 – 3.10	3.11 – 4.01	4.02 – 5.40	5.41 – 6.40
90	2.90	2.91 – 3.96	3.97 – 4.84	4.85 – 6.69	6.70 – 7.30
85	3.35	3.36 -4.41	4.42 – 5.29	5.30 – 6.64	6.65 – 7.75
80	3.80	3.81 – 5.06	5.07 – 5.85	5.86 – 7.09	7.10 -8.20
75	4.25	4.26 – 5.35	5.36 – 6.12	6.13 – 7.65	7.66 – 8.65
70	4.70	4.71 – 5.80	5.81 – 6.57	6.58 – 8.10	8.11 – 9.10
65	5.15	5.16 – 6.25	6.26 – 7.02	7.03 – 8.55	8.56 – 10.0

SC is calculated solving: ISC = 0,45 and + 0,40 D + 0.15 G
And: he/she takes into account the speed of the circulation vial, km / h
D: it considers the superficial characteristics of the pavement as for their observation and the texture results there are in mm and the resistance coefficient to the slip
G: it considers the comfort vial, assisting to the result IRI in m / km.

After improving the pattern ISC it was applied to different highway tract. As case of study he/she makes an appointment a tract of main highway of the County of Havana, where the general data are:

Rural highway of 2 rails, wide of rail 3,25m and without lateral walk.
Operation Speed = 80 Km. /h.
CFD = 0.28.
The = 46.87 cm.
There is = 0.27 mm.
DV 95 = 7,81 mm
IRI = 3.83 m / Km.
t = 5.00 (result of the visual inspection of the texture of the flexible pavement)

In the technical inspection of the highway one mediated the superficial regularity with a rigid rule of 1,5m. After applying the statistical calculations a value of Percentile it was determined 95 of the mensurations (DV 95 = 7,81 mm) that I determine the value following IRI:

IRI (m / Km.) = 0.49 (7.81)
IRI = 3.83 m / Km.

Solving each variable for ISC, one has:
And = - 0.20V + 22.00
And = - 0.20 (80) + 22.00 = 6.00
D = 0.5 l + 0.3c + 0.2t (I)
l = - 0.122La + 10.049
l = 0.122 (46.87) + 10.0 49 = 4.33
c = 60CFD - 13.60
c = 60 (0.28) - 13.60 = 3.20

Substituting for D in (I), it is:
D = 0.5 (4.33) + 0.3 (3.20) + 0.2 (5.00) = 4.13
G = - 1.750 (IRI) + 14.25
G = -1.750 (3.83) +14.25
G = - 6.7025 + 14.25
G = 7.56
ISC = 0.45E + 0.40D + 0.15G
ISC = 0.45 (6.00) + 0.40 (4.13) + 0.15 (7.56)
ISC = 5.48

With the result ISC = 5.48 the qualification is reached of regulating for the highway tract whose picture is shown next and a comment of the qualification ISC.

Picture 1, See of the inspected highway tract

Comment:
The inspected highway tract requires a routine maintenance and probably an asphaltic reinforcement of the surface, with the application of thicknesses according to the traffic intensity. Fairly comfortable circulation exist irregularities in the longitudinal profile and the finish of the pavement originated by faulty meetings, not well finished repairs and located deformations that affect to the comfort without imposing restrictions to the speed and under specific conditions to the security vial, when driving motivated by the possible delays IRI 2.7 m/km.

6. NEW INVESTMENTS FOR THE CONSERVATION AND THE REHABILITATION VIAL.

For three in Cuba one works in the recovery of their main highways whose levels of deterioration had been increased considerably in the last years. For this the Cuban State with an appropriate financing has invested in diverse teams for the pavement and productive facilities.

These investments in new technologies are characterized by their demonstrated efficiency in the contributions toward a sustainable development of the activity vial in three general lines of performance:

- Teams for the fireside of pavements in cold and recycled in the place.
- Teams and pavements technology.
- You plant producers of Asphaltic Hot Concrete.

Advances have also been achieved in the design of mixtures with recycled materials and in the designs of asphaltic concretes in cold.

These performance lines have benefitted to all the regions of the country and in a special way to Havana the Capital of the country. Five plants have been acquired that produce asphaltic hot concrete: 3 stationary and 2 motives with productive capacity between 80 and 120 rhyme/h. They complete the investments new paver, vibratory compactors.
A train of having recycled in situ that he/she can work with foamy asphalt and emulsify ending up reaching depths of up to 500mm To treat them with materials that provides a

bigger stability to the structure of the pavement of the highway. It is also had a recycled, cement spacer and the traditional other teams for the works.

It is had the experience 9 years carrying out the fireside of pavements in cold and from the 2008 they have incorporated to this work 3 new milling machines W130. He/she takes advantage the recycled (RAP) material all this it allows the use of the material recycled (RAP) as component of the Asphaltic Hot Concrete in proportions of until 30% and also as Concrete Asphaltic Cold.

The 5 acquired new plants for the production of Asphaltic Hot Concrete, they have substituted more than 10 old very polluting plants of the environment and they have reduced the consumptions of fuels in 50%, for what the emissions of polluting gases to the atmosphere have diminished considerably in the last times to near places to the facilities as well as to the workers in the productive process.

They have also decreased the impacts to the environment with the use of asphaltic concretes in cold to which incorporate residual scums of the iron and steel industry, those that are crushed and classified and they are used as attaché. It is also used in these types of mixtures, in reduced scale, the asphaltic of a natural location.

7. POLITICAL THAT THEY PROMOTE AND THEY ASSURE THE DEVELOPMENT SUSTAINABLE VIAL.

One works in these moments in different lines tendentes to the environmental improvement, the energy saving and the sustainable development for what you/they are carried out the studies and works for:

- The improvement of the taking of the field data for the technical inspection of the highways to level of Project and the Net.
- To endow to each Center of road net of the country of a game of teams of low cost for the mensuration.
- The purchase of a plant producer of asphaltic emulsions.
- The introduction of the new techniques of production of concretes to smaller temperature with the possible incorporation of waxes of the cane of sugar and of the henequen like reducers of viscosity.
- Incorporation to the mixtures of the zeolite of locations in the country.
- To continue the experimentation and setting in practice of porous concretes.
- To continue perfecting variants of conservation of pavements, in the one sealed of cracks, superficial treatments, slurries, and micropavimentos where they decrease the levels of consumption of virgin more and scarcer materials.

8. CONCLUSIONS.

1. In spite of being Cuba a small, developing country and with economic limited resources, their politics for the preservation and the development of the infrastructure vial doesn't neglect the novelties in the design norms, the use and the settings in march of the new technologies, the materials and the conservation works that assure the quality of the built patrimony in a sustainable way; without neglecting the impacts, the care of the environment and the effect of the climatic change.

2. The directive orientations, the specialists and engineers road that are the technical main resource continuing with which it counts the country in this branch, they have had the necessity to create and to put to point their own tools; as well as to develop programs of I compute and models of I calculate to elevate at levels superiors the results of the work and to be able to them to compare with those of the international experience that are applied in countries but advanced without the expenditure of big supreme in convertible foreign currencies.

3. In next years the investments for the infrastructure vial should be increased, as well as the introduction in the country of new technologies in the field of laboratories, construction machineries, plants of production of materials fix and mobile, etc. However, regarding the inspection of highways in exploitation, it is possible to maintain the current techniques, keeping in mind that under the influence of the crisis economic World cup it will be not very probable the quick and sustained increment of the intensities of the I traffic, therefore they won't happen frequent sustained situations of vehicular congestion and they will be been able to continue the inspection works in the hours of the day on the roads open to the I traffic.

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