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Modelo de mantenimiento de vías, con pavimento flexible de la zona central del Ecuador

Road maintenance model, with flexible pavement in the central zone of Ecuador

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Palabras claves: Viga Benkelman, Pavimento flexible, Muestreo, Mantenimiento vial, Fallas viales, Deflexiones. SDSTs

Resumen

Introducción. Este trabajo es un estudio general del mantenimiento vial con estructura de pavimentos flexibles para conservar en eficiente estado este tipo de vías, para lo que se ha tomado como referencia las siguientes muestras: vías Montalvo-Totoras, Quero-Salasaca, Manzana de Oro-Quero, Patate-Píllaro, Patate-Baños, Pelileo-Patate, Cevallos-Mocha y Ambato-Tisaleo. Estas muestras son vías pertenecientes a la red inter cantonal de la zona central del país, misma que cumple con las mejores condiciones para un análisis de pavimentos flexibles. **Objetivo:** con este estudio se pretende establecer un modelo para el mantenimiento vial con estructura de pavimentos flexibles para conservar en eficiente estado las vías de la zona central del Ecuador. **Metodología:** para esto, se realizó un procesamiento de información compilatoria sobre el estado actual del pavimento flexible de forma visual a través del Método de Índice de condición de pavimento (PCI), en el que se identificó tipo de fallas y su severidad deflexiones generadas en la Viga de *Benkelman,* que sirvieron de base para desarrollar un plan de mantenimiento general a emplearse. **Resultados:** se obtuvieron los detalles por unidades de muestreo, resultados PCI y deflexiones por viga *Benkelman* de cada una de las ubicaciones, vías y abscisas a estudiar en la presente investigación. **Conclusiones:** se presentó una propuesta de mantenimiento vial general para las vías estudiadas, donde se encontró que la red inter-cantonal necesita mantenimiento periódico en su mayor parte y rehabilitación en las zonas más deterioradas; y, además, un mantenimiento rutinario en las vías cuyo deterioro es leve. **Área de estudio general:** Ingeniería Civil. **Área de estudio específica:** Pavimentos.

Keywords: Benkelman beam, Flexible flooring, Sampling, Road maintenance, Road failures, Deflections. SDSTs

Abstract

Introduction: This work is a general study of road maintenance with a flexible pavement structure to keep this type of roads in an efficient state, for which the following samples have been taken as reference, Montalvo-Totoras, Quero-Salasaca, Golden Apple-Quero roads, Patate-Píllaro, Patate-Baños, Pelileo-Patate, Cevallos-Mocha and Ambato-Tisaleo, which are patterns selected to guide the country's road maintenance, said sample are roads belonging to the inter-cantonal network of the central zone of the country, same that meets the best conditions for an analysis of flexible pavements.

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Objective: General study of road maintenance with flexible pavement structure to keep the roads of the middle area of Ecuador in efficient condition. Methodology. In this work, compilation information processing was conducted on the current state of the flexible pavement visually through the Pavement Condition Index (PCI) Method, in which the type of failures and their severity were identified, deflections generated in the Beam. of Benkelman, which served as a basis for developing a general maintenance plan to be used. Results. Details were obtained by sampling units, PCI results and deflections per Benkelman beam for each of the locations, tracks, and apses to be studied in this report. Conclusions. A general proposal for road maintenance of the studied roads has been presented, where it was found that the inter-cantonal network needs periodic maintenance for the most part and rehabilitation in the most deteriorated areas. And routine maintenance on roads whose deterioration is slight.

Introduction

Throughout the world, a country's development has been measured over time by the quality of its roads and traffic organization. Nowadays, it is important for large and small cities to have a high-quality road network for the benefit of end users, reducing the time and cost of vehicle circulation.(UMSS - Faculty of Sciences and Technology, 2019). In Ecuador there is great interest in improving the quality of the road network for the free circulation of rural roads and users. In 2019, Ecuador was ranked 35th out of 141 countries in the world in terms of road quality, which means that roads have great importance and impact on various related aspects such as the economy.(Abraham & Pacheco, 2020).

Methodology

With a visit to the site, the type of existing failures in the rolling layer was evaluated, as well as its road components, as well as their severity and quantity, in addition to sampling the roads, to generate feasible road maintenance plans.(Tarefder et al., 2016).

Next, a comparative analysis of the results of the Benkelman beam test was carried out, to which corrections were made per arm in relation to 1:2, seasonality and temperature; Subsequently, the characteristic, admissible and critical deflection was determined, to

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finally be able to evaluate the behavior of the grade, rolling layer and the type of deflection.(Mamani, 2010).

Finally, with the information obtained from PCI and Viga Benkelman, a general and specific road maintenance plan was made, with its respective analysis of unit prices (APUS) and items, in order to provide a viable and economic to the deterioration of the roads studied(Ministry of Transportation and Public Works [MTOP], 2013).

Table number 1 shows the types of pavement failures according to the PCI, the first column details the order of the failures, the second details the anomalies and the third column the units in which they can be measured.

Table 1

Types of pavement failures

No.	Anomalies	Unit
1	Crocodile Skin Crack	M2
2	Exudation	M2
3	Block Cracking	M2
4	Bulging and Sinking	M
5	Corrugation	M2
6	Depression	M2
7	Edge Crack	M
8	Joint Reflection Crack	M
9	Lane-Berm Difference	M
10	Longitudinal and Transverse Cracks	M
eleven	Patching	M2
12	Aggregate Polishing	M2
13	Gaps	OR
14	Railway Crossing	M2
fifteen	Rutting	M2
16	Displacements	M2
17	Parabolic Crack (Slippage)	M2
18	Swelling	M2
19	Aggregate Detachment	M2

PCI Method Analysis

The PCI method is a simple method of visual inspection of the condition of the pavement that identifies the type of damage, which is analyzed according to table number 1, its extension and the magnitude of the damage found, it does not require special tools and is also one of the complete ways to apply knowledge of professionals specialized in damages to flexible pavements to be able to evaluate them, these have standard procedures for objective evaluation by organizations such as the United States Department of Defense and the American Public Works Association (APWA) and published by the Society of Testing and Materials, for analysis and application (Standard Procedure for Pavement), inspection of the condition index of roads and parking areas(Rodriguez, 2009).

This method introduces the so-called differential values, which indicate the state of the pavement through a combination of defects, severity and quantity, which is represented through a number that varies from 0 to 100. There are value traits in which the qualitative condition of the wearing course(Coari, 2017).

By evaluating the pavement, the degree of damage can be obtained, which represents the deterioration threshold, and corrective and reparative measures can be taken depending on the degree of damage and the type of failure. Table number 2 defines the ranges. scale rating.

Table 2

PCI Qualification Range

Range	Classification
100 – 85	Excellent
85 – 70	Very good
70 – 55	Well
55 – 40	Regular
40 – 25	Bad
25 – 10	Very bad
10 – 0	Failed

Fountain:MTOP (2013)

III-A. Benkelman Beam Analysis

There are several non-destructive methods to measure the deformation resistance of the component structure of a track, being known in our half Benkelman beam, the Lacroix deflector and the impact deflector (FWD). In this case, the method used is the Benkelman beam. To perform this test, reference can be made to the AASHTO T256 - 01 or NLT 356/88 standard. The Benkelman beam consists of a rotating lever arm suspended from a reference frame and provided with a measuring disk that records the displacement of the tip of the beam.(Orozco et al., 2004).

The measurements are carried out with a metal ruler attached to a lever system that increases the deformation of the pavement due to the static load of the biaxial wheels of 81.75 kN. The point to test on the surface of the road will be marked by a horizontal line on it. This line is the test line, it must be a certain distance from the edge.

According to the average width of the road under study, pavement deflection readings should be made at a distance of 0.9 meters from the edge of the road towards the axis; data were taken at five different distances from the initial point.

Results

IV-A. Sampling

In the case of asphalt pavement roads, the sampling unit must be between230.0 ± 93.0 m², with which we obtain the following sample lengths.

In table number 3, column one shows the location of the roads in each sector, column two shows the abscissa corresponding to the road and the third column shows the length of the damage.

Table 3

Sampling unit results

Location	Abscissa	Length (M)
Quero - Salasaca	0+000 To 3+600	36
Quero - Salasaca	3+600 To 5+600	35
Quero - Salasaca	5+600 To 6+780	30
Montalvo – Totoras	0+000 To 4+000	38.30
Golden Apple - Quero	0+000 To 2+400	30
Golden Apple - Quero	2+400 To 4+770	30
Golden Apple - Quero	4+780 At 5+360	30
Golden Apple - Quero	5+460 To 5+760	30
Golden Apple - Quero	5+800 To 8+770	30
Golden Apple - Quero	8+770 At 9+040	31.5
Patate - Píllaro	0+000 TO 1+560	32
Patate - Píllaro	1+560 TO 3+800	32
Patate - Píllaro	3+800 TO 7600	32
Patate - Píllaro	7+600 TO 11+400	32
Patate - Píllaro	11+400 TO 15+320	29
Patate - Píllaro	15+320 TO 19+150	36
Patate - Píllaro	19+150 TO 23+000	32
Patate - Bathrooms	0+000 TO 2+350	35
Patate - Bathrooms	2+350 TO 4+700	35.4
Pelileo - Patate	0+000 TO 2+085	26
Pelileo - Patate	2+085 TO 4+170	30
Pelileo - Patate	4+170 TO 8+260	26
Cevallos - Mocha	0+000 TO 2+120	31.5

Table 3

Sampling unit results (continued)

Location	Abscissa	Length (M)
Cevallos - Mocha	2+120 TO 4+960	31.5
Cevallos - Mocha	4+960 TO 7+460	35
Cevallos - Mocha	7+460 TO 9+480	35
Cevallos - Mocha	9+480 TO 9+920	35
Ambato-Tisaleo	0+000 TO 3+200	twenty
Ambato-Tisaleo	3+200 TO 6+400	22
Ambato-Tisaleo	6+400 TO 9+600	25
Ambato-Tisaleo	9+600 TO 12+800	32
Ambato-Tisaleo	12+800 TO 16+200	31

IV-B. PCI of the roads

The results of the PCI of the network of the central zone of Ecuador are shown in table 4. In column one the abscissa is located, in column two the name of the road, in column three the average value of the PCI that as The first data is 94.70 Considering the state of the road and the fourth column shows the classification as Good, the different colors of the table determine the number of roads (Ramírez & Valenzuela, 2023).

Table 4

PCI Results

Abscissa	Via	PCI	Classification
0+000 TO 3+496	Quero-Salasaca	94.70	Well
3+640 TO 5+495	Quero-Salasaca	85.74	Excellent
5+360 TO 6+650	Quero-Salasaca	50.83	Very good
0+000 TO 4+000	Montalvo - Totoras	99.00	Excellent
0+000 TO 2+400	Golden Apple-Quero	35.84	Bad
2+400 TO 5+360	Golden Apple-Quero	67.92	Well
4+780 TO 5+360	Golden Apple-Quero	71.00	Very good
5+460 TO 5+760	Golden Apple-Quero	81.75	Very good
5+800 TO 8+770	Golden Apple-Quero	76.20	Very good
8+770 TO 9+100	Golden Apple-Quero	74.83	Very good
0+332 - 1+420	Patate - Píllaro	79.30	Very good
1+560 - 3+672	Patate - Píllaro	82.80	Very good
3+832 - 7+192	Patate - Píllaro	71.50	Very good
7+600 - 11+376	Patate - Píllaro	80.92	Very good
11+400 - 15+170	Patate - Píllaro	77.52	Very good
15+320 - 16+650	Patate - Píllaro	54.80	Regular
17+117 - 18+410	Patate - Píllaro	57.75	Well
18+626 - 19+165	Patate - Píllaro	36.67	Bad
19+200 - 19+232	Patate - Píllaro	30.00	Bad

Table 4

PCI Results (continued)

Abscissa	Via	PCI	Classification
19+328 - 20+544	Patate - Píllaro	79.86	Very good
20+640 - 21+184	Patate - Píllaro	70.00	Very good
21+280 - 22+688	Patate - Píllaro	58.25	Well
0+00 TO 2+350	Patate-Baths	82.77	Very good
2+350 TO 4+700	Patate-Baths	85.36	Excellent
0+000 TO 2+085	Pelileo-Patate	72.57	Very good
2+085 TO 4+170	Pelileo-Patate	83.82	Very good
4+170 TO 8+260	Pelileo-Patate	78.98	Very good
0+00 TO 2+120	Cevallos-Mocha	85.00	Very good
2+120 TO 5+000	Cevallos-Mocha	85.00	Very good
4+960 TO 7+460	Cevallos-Mocha	70.00	Very good
7+460 TO 9+480	Cevallos-Mocha	57.00	Well
9+480 TO 9+920	Cevallos-Mocha	63.00	Well
0+00 TO 3+200	Ambato - Tisaleo	69.25	Well
3+200 TO 6+400	Ambato - Tisaleo	90.38	Excellent
6+400 TO 9+600	Ambato - Tisaleo	82.27	Very good
9+600 TO 12+800	Ambato - Tisaleo	83.71	Very good
12+800 TO 16+200	Ambato - Tisaleo	84.79	Very good

IV-C. Deflections (Benkelman Beam)

Table 5 shows the results of the Benkelman beam deflections of the tracks. The first column presents the abscissa, while columns 2 contain the readings of the deflections corrected for seasonality. The third column shows the standard deviation of the data set. From column 4 to column 6, the characteristic, admissible and critical deflections are analyzed, respectively. Column 7 shows the predominant radius of curvature of the tracks. Finally, columns 8 to 10 show the results analysis of subgrade behavior and pavement behavior in percentage terms. Finally, the type of deflection is indicated. The formulas used are found in ASSHTO T-256(MTOP, 2013).

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Table 5

Deflection Results (Benkelman Beam)

RESULTADOS DEFLEXIONES VIGA DE BENKELMAN DE LAS VÍAS									
ABS	Dm ($x10^{-2}\,mm$)	σ	Dc ($x10^{-2}\,mm$)	D adm ($x10^{-2}\,mm$)	D cr ($x10^{-2}\,mm$)	Rc (m)	Comportamiento subrasante	Comportamiento pavimento	Tipo de Deflexión
QUERO - SALASACA									
0+080 - 3+540	52.30	9.33	67.65	143.39	145.32	103.57	$D_c < D_{adm}$	$R_c > 100$	I
3+620 - 5+460	95.73	17.91	125.19	137.82	140.05	97.53	$D_c < D_{adm}$	$R_c < 100$	III
5+660 - 6+660	85.57	18.19	115.50	137.82	140.05	139.65	$D_c < D_{adm}$	$R_c > 100$	I
MONTALVO - TOTORAS									
0+000 - 4+000	46.58	5	54.80	135.58	138.33	127.88	$D_c < D_{adm}$	$R_c > 100$	I
MANZANA DE ORO - QUERO									
0+000 - 2+400	84.60	6.49	95.28	144.04	144.80	100.91	$D_c < D_{adm}$	$R_c > 100$	I
2+400 - 4+600	86.55	19.70	118.95	120.47	126.47	114.43	$D_c < D_{adm}$	$R_c > 100$	I
4+600 - 5+200	83.45	18.04	113.13	120.47	126.47	61.37	$D_c < D_{adm}$	$R_c < 100$	III
5+600 - 5+800	83.80	16.50	110.95	120.47	126.47	133.91	$D_c < D_{adm}$	$R_c > 100$	I
6+000 - 8+600	91.38	14.76	115.67	122.92	128.46	95.62	$D_c < D_{adm}$	$R_c < 100$	III
8+600 - 9+100	76.80	17.61	105.77	122.92	128.46	83.64	$D_c < D_{adm}$	$R_c < 100$	III
PATATE - PÍLLARO									
0+300 - 1+500	48.00	3.23	53.30	205.09	189.05	88.37	$D_c < D_{adm}$	$R_c < 100$	III
1+800 - 3+600	47.77	3.22	53.07	205.09	189.05	87.00	$D_c < D_{adm}$	$R_c < 100$	III
3+800 -	49.26	7.78	62.09	172.34	165.79	90.33	$D_c < D_{adm}$	$R_c < 100$	III

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Table 5

Deflection Results (Benkelman Beam) (continued)

7+600									
7+600 - 11+400	51.86	7.51	64.21	279.00	238.00	109.54	$D_c < D_{adm}$	$R_c > 100$	I
11+400 - 15+320	57.44	5	65.66	133.10	136.41	149.17	$D_c < D_{adm}$	$R_c > 100$	I
15+400 - 16+400	44.91	3.37	51.87	180.67	171.80	98.30	$D_c < D_{adm}$	$R_c < 100$	III
16+600 - 17+800	46.48	3.37	52.01	180.67	171.80	94.07	$D_c < D_{adm}$	$R_c < 100$	III
18+000 - 19+000	47.50	5.63	56.67	180.67	171.80	85.80	$D_c < D_{adm}$	$R_c < 100$	III
19+100 - 20+600	40.47	2.88	45.24	194.14	181.38	98.53	$D_c < D_{adm}$	$R_c < 100$	III
20+800 - 21+200	47.15	1.32	49.39	194.14	181.38	98.18	$D_c < D_{adm}$	$R_c < 100$	III
21+400 - 22+600	42.36	3.86	48.75	194.14	181.38	97.87	$D_c < D_{adm}$	$R_c < 100$	III
				PATATE - BAÑOS					
0+000 – 2+350	52.89	21.09	87.58	180.20	170.10	223.75	$D_c < D_{adm}$	$R_c > 100$	I
2+350 – 4+700	86.35	22.42	123.23	180.20	171.46	132.43	$D_c < D_{adm}$	$R_c > 100$	I
				PELILEO – PATATE					
0+000 - 2+085	47.72	10.2	64.5	162.46	158.56	103.65	$D_c < D_{adm}$	$R_c > 100$	I
2+085 - 4+170	56.04	12.34	76.34	134.22	158.56	94.50	$D_c < D_{adm}$	$R_c > 100$	I
4+170 - 8+260	81.30	26.69	125.21	134.22	137.28	106.08	$D_c < D_{adm}$	$R_c > 100$	I
				CEVALLOS - MOCHA					
0+000 - 2+120	115.03	12.27	135.21	177.90	139.37	97.74	$D_c < D_{adm}$	$R_c < 100$	III
2+120 - 5+000	113.06	17.94	142.57	148.59	169.81	83.39	$D_c < D_{adm}$	$R_c < 100$	III
4+960 - 7+460	74.79	25.49	116.72	148.59	148.23	186.08	$D_c < D_{adm}$	$R_c > 100$	I
7+460 - 9+480	108.80	34.73	165.93	148.59	148.23	92.59	$D_c < D_{adm}$	$R_c < 100$	III
9+480 - 9+920*	42.60	5.02	50.86	148.59	148.23	146.75	$D_c < D_{adm}$	$R_c > 100$	I
				AMBATO - TISALEO					
0+000 - 3+200	105.25	5	113.48	153.34	158.15	153.39	$D_c < D_{adm}$	$R_c > 100$	I
3+200 - 6+400	57.86	9	72.66	144.02	151.80	224.49	$D_c < D_{adm}$	$R_c > 100$	I
6+400 - 9+600*	47.95	10.83	65.76	188.6	144.78	214.17	$D_c < D_{adm}$	$R_c > 100$	I
9+600 – 12+800	87.86	24.64	128.4	180.32	177.46	85.58	$D_c < D_{adm}$	$R_c > 100$	I
12+800 – 16+200	72.67	5	80.89		171.54	100.26	$D_c < D_{adm}$	$R_c > 100$	I

IV-E. General road maintenance plan

Based on the results of the PCI and the Benkelman beam, road maintenance plans were established according to the type of failure that was visualized on the site, in the different roads analyzed to prolong their duration and useful life. According to The PCI data determines the type of intervention that should be performed. Depending on the type of intervention(ASTM International, 2002), tells us that for a range of 0 -25 its classification will be “Bad” with a reconstruction intervention; For the range 55 – 25, your classification will be “regular” with a rehabilitation intervention; For the range 85 – 56, its classification will be “very good” with periodic maintenance intervention; For the range 100 – 86 your classification will be “excellent” with routine maintenance intervention.

Routine maintenance

They are preventive and permanent measures aimed at preserving the component elements of the resistance of the roads and keeping them in optimal conditions after their construction or rehabilitation. Minor repairs to the road surface, embankments and road leveling, etc. and other component elements of these, which can be made by hand. In this way, the roads are safe, reliable and usable all year round.(Chavez, 2014).

Periodic maintenance

This is a series of actions carried out over a period of one year or more, with the aim of preserving the structural integrity of the road, addressing specific major defects and preventing the development or worsening of more serious damage. This type of maintenance includes surface treatment and repair activities(Ramírez & Valenzuela, 2023).

Rehabilitation

Flexible pavement rehabilitation is the improvement of the condition of a pavement by returning it to its original state and ensuring that the pavement has sufficient structural capacity to withstand the traffic load without altering the cross-sectional geometry.(Norambuena et al., 2009).

Reconstruction

Reconstruction involves the demolition, removal and partial or complete replacement of existing asphalt pavements in the case of pavements with excessive structural problems, high rates of deterioration, lack of remaining useful life or even subgrade. Replaced pavement can handle more traffic, just like new pavement(Rondón & Reyes, 2007).

IV-F. Failure maintenance procedure

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For maintenance by type of failure, it is carried out according to its severity level Low (L), Medium (M), High (H) (UMSS - Faculty of Sciences and Technology, 2019).

Crocodile Skin:

L: Don't do anything; Surface Seal; Covering.
M: Partial or complete patching; Covering; Reconstruction.
H: Partial or complete patching; Covering; Reconstruction

Exudation or Bleeding:

L: Don't do anything.

M: Apply sand/aggregate and roller.
H: Apply sand/aggregate and roller.

Block Cracking:

L: Seal cracks over 1/8 in; Surface Seal

M: Seal cracks; Recycle surface, hot scarify and cover

H: Seal cracks; Recycle surface, hot scarify and cover

Pumping and Sinking:

L: Don't do anything
M: Cold milled, superficial longitudinal patching, partially or completely
H: Cold milled, Deep superficial patching, partial or fully (coated)

Corrugation:

L: Don't do anything.
M: Reconstruction
H: Reconstruction

Depressions:

L: Don't do anything
M: Superficial, partial or total deep patching
H: Superficial, partial or total deep patching

Edge Cracking:

L: Don't do anything; Seal cracks larger than 1/8 in.
M: Sealing cracks; Partial deep patching
H: Partial deep patching

Joint Reflective Cracking

L: Sealing cracks larger than 1/8 in.
M: Sealing cracks; Partial deep patching
H: Partial deep patching; Reconstruction of Joints

Joint Reflective Cracking

L: Sealing cracks larger than 1/8 in.
M: Sealing cracks; Partial deep patching
H: Partial deep patching; Reconstruction of Joints

External Track/Shoulder Drop

L, M, H: Fill the shoulder pads until they match the edge of the pavement.

Longitudinal and Transverse Cracking

L: Don't do anything; Sealing cracks larger than 1/8 in.
M: Crack sealing
H: Crack sealing; Partial deep patching

Patched

L: Don't do anything
M: Don't do anything; Replace the Patch.
H: Replace the Patch.

Polished Aggregates

L, M, H: Do nothing; Surface Treatment; Covering; Grind and coat.

Potholes

L: Don't do anything; Partial or total deep patching
M: Partial or total deep patching
H: Full deep patching

Railroad Crossing

L: Don't do anything
M: Close and deep patching, Superficial or Partial; Reconstruction of the Crossing
H: Close and deep patching, Superficial or Partial; Reconstruction of the Crossing,

Routing:

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L: Don't do anything; Grind and coat
M: Superficial, partial or total deep patching; Grind and coat.
H: Superficial, partial or total deep patching; Grind and coat

Pushing:

L: Don't do anything; Grind
M: Grind; Partial or total deep patching.
H: Grind; Partial or total deep patching.

Crescent Cracking

L: Don't do anything; Partial deep patching
M: Partial deep patching
H: Partial deep patching

Boss

L: Don't do anything
M: Don't do anything; Reconstruction.
H: Reconstruction

Weathering:

L: Don't do anything; Surface Seal; Surface Treatment.
M: Surface Seal; Surface Treatment; Covering.
H: Surface Treatment; Covering; Recycling; Reconstruction

Conclusions

In this research, a proposal for a general road maintenance plan for the studied roads was presented, through the processing of the conditions of the road course, which allowed data processing.

- The failures present in the running layer of the proposed roads were analyzed, which allowed obtaining an average PCI value of sections where it was determined that the Intercantonal network needs periodic maintenance for the most part and rehabilitation in the most deteriorated areas. and Routine Maintenance as a third part for roads that show slight deterioration, but in specific places.
- Using the Benkelman Beam and after making the pertinent corrections, it was possible to identify the deflections present in the pavement of the proposed roads. The critical, admissible and characteristic deflections were also determined. From these values it was identified that the deflections are “Type I and Type III”.

- In the future, the size of the database will be increased, in each proposed road since the conditions in which the road surface is evaluated are not the same. This is intended to cover two relevant aspects, the first will be to present a base of reference data from the current study of the state of the Tungurahua road course, and second, provide optimal and viable road maintenance plans.

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Conflict of interests

Authors must declare whether or not there is a conflict of interest in relation to the article presented.

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