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Continuous Visual Survey on Highway Br-010: Case Study on the Stretch between Estreito and Porto Franco – Ma.

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***Abstract*—** *Over the past decades, Brazil has exhibited economic growth in several sectors. This growth raises important questions about the quality and performance that Brazilian transportation offers the population. The road modal is the most used for transportation of cargo and people in the country. Due to the great demand of this modal, the quality of the highways is affected and end up presenting defects in the sidewalk, signaling, geometry, among others. In this context, the study aimed to evaluate the surface quality of the sidewalk of BR 010, in the stretch between the cities of Estreito - MA and Porto Franco - MA. The study was based on the application of the Continuous Visual Surveys (CVS) methodology, presented in the DNIT Procedure PRO 008/2003, which aims at identifying and quantifying the defects present on the sidewalk surface. Through the results obtained it was possible to identify that the most pertinent pathology throughout the stretch was isolated cracks found in 85.2% of the segments. On the other hand, the least present pathology was slipping, found in only 40.70% of the analyzed segments. Based on the calculations of the Surface Condition Index (SSI), it was possible to classify the stretch according to the quality of the sidewalk surface. 37% of the stretch is in good condition, 51.90% is considered regular, 7.40% is bad and 3.70% is considered to be in very bad condition. From the results obtained in the evaluation it is possible to have a basis to assist in decision making for interventions or reconstruction of critical stretches.*

I. INTRODUCTION

In Brazil, one of the first records of road construction occurred in the year 1560, located in the state of São Paulo it was called Estrada do Mar at the time, it connected São Vicente to the Piratininga Plateau and was used to drain the colony's production of wood. "In 1913 it became the first highway in Latin America to receive concrete paving," according to Bernucci et al., (2008, p.16).

Since that time, the displacement through highways is the most used in Brazil, this mode of transport is responsible for making goods and people move in an agile way, this due to the flexibility that the system offers to the user, facilitating access to boarding and alighting and door-to-door services (CNT, 2019). This availability generates comfort and convenience for users.

The National Confederation of Transport (CNT, 2019), also emphasizes that for the feasibility of the operation of the modality, the road infrastructure in Brazil is considered scarce, insufficient and of poor quality, this due to the low quality of the sidewalk and the lack of preventive maintenance in the country's road network.

Therefore, it is necessary to understand the sidewalk as a structure composed of layers, and like any other structure the sidewalk has a useful life, and the processes of

degradation, deterioration and emergence of pathologies begin as the use of the road begins. In some roads this process comes from exposure to bad weather resulting from the actions of time, and in others due to the application of excessive load on the sidewalk, resulting from overloads carried by large vehicles, according to (BERNUCCI et al., 2008).

The numerous ways of ascertaining the qualities of a road sidewalk allow information to be obtained that can be used to identify and diagnose defects in the sidewalk structure, aiming at determining possible forms of containment and prevention of defects.

The evaluation methods can be considered destructive, semi-destructive and non-destructive. The present study carried out the survey according to the technical procedure methodology of PRO-008 (DNIT, 2003), which uses the Continuous Visual Survey - CVS to obtain data and information. The sidewalk will be evaluated in a superficial way, avoiding the removal of samples, i.e., it does not damage the sidewalk surface.

Surface defects can occur due to resistance, plastic deformations, thermal shrinkage, hydraulic shrinkage, fatigue, functional ruptures and the development of cracks. According to the Highway Conservation Manual (DNIT, 2005), the Highway Operation Program (PER) has groups of services that intervene in the sidewalk infrastructure, in order to contain and prevent the emergence of defects, such as conservation, recovery, improvement and maintenance of roads.

The objective of this study was to identify and evaluate the possible causes of the pathologies found on the Bernardo Sayão Highway (BR - 010) in the stretch between the cities of Estreito and Porto Franco in the state of Maranhão, using the continuous visual survey method.

II. METHODOLOGY

This chapter presents the road selected for the study and its characteristics. The methodology used in the survey is also described.

2.1 LOCATION OF THE SURVEY

The study was based on a case study, where a continuous visual survey (CVS) of the pathologies found on BR - 010 was conducted on the stretch between the cities of Estreito and Porto Franco in the state of Maranhão. The stretch has a total length of 27.9 km and is located 124 km from the city of Araguaína in the state of Tocantins and 125 km from the city of Imperatriz in the state of Maranhão.

The stretch contemplated in the evaluation has great influence on the transportation of grains, cellulose, ore and fuel due to the location of one of the multimodal yards of the North-South Railroad (FNS), which has road access through the coinciding stretch between BR-010 and BR-226, near kilometer 1,244 of Belém-Brasília highway, with facilities of companies such as Cargill S/A, Ceval S/A, ABC Inco, Multigrain and Ceagro. The stretch makes it possible to integrate road, rail and waterway modes, thus allowing goods to be transported to the Port of Itaqui, located in the city of São Luís, capital of the state of Maranhão.

Fig. 1- Route between the two cities

Source: Google Earth, 2020.

2.2 FUNCTIONAL EVALUATION

Among the various methodologies recommended by DNIT for sidewalk surface evaluation, the one chosen for the survey was the Continuous Visual Survey (CVS) according to procedures established in standard PRO 008 (DNIT, 2003). The application of LVC is justified by the fact that it is a simple and economical method, and it is efficient for a quick and non-destructive evaluation of the sidewalk surface.

The field survey was performed in accordance with the specifications of DNIT 008/2003 - PRO, as mentioned in the bibliographic references and methodology. After the survey was completed and with the information obtained from the survey, calculations were made to present the condition of the road network between the cities of Estreito and Porto Franco - MA

For this purpose the LVC was performed in the predetermined stretch with favorable weather conditions

for viewing the defects, where in a vehicle were the driver and two passengers who had knowledge of the purpose and who were responsible for the identification, quantification, frequency and filling out the form, where all defects found were specified. The vehicle was being operated at an average speed of approximately 40 km/h, traveling along the highway in one direction only, since it is a single lane road. The survey procedure was performed by fractioning segments of 1 km in length, thus ensuring the homogeneity of the defects along the entire length of the stretch. The information was collected at the end of each kilometer traveled. With the data it was possible to classify the sidewalk based on three indexes that were calculated and used to help make decisions about possible interventions to be made, namely the Index of Consolidation of Flexible Pavements (ICPF), the Expedited Global Gravity Index (IGGE) and the Surface Condition Index (IES).

- ICPF - The calculation was estimated based on the sidewalk's visual evaluation, classifying the segment's surface according to the concepts excellent, good, fair, poor and very poor, considering the applicability of maintenance measures determined by the professional evaluator.

- IGGE - This index is calculated by taking the average of the data contained in the field survey form, where the results served as the basis for determining the IES, using the following formula:

$$IGGE = (Pt \times Ft) + (Poap \times Foap) + (Ppr \times Fpr)$$

Where:

- Pt = Weight of the crack set;
- Ft = Frequency of the crack set;
- Poap = Weight of the deformation set;
- Foap = Frequency of the deformation set;
- Ppr = Weight of the set of pans and patches;
- Fpr = Frequency (quantity per km) of the set of pans and patches.

- IES - This is the index whose values are between 0 and 10, and is evaluated according to ICPF and IGGE calculations. It is used as a basis for determining the concepts of excellent, good, regular, poor, and very poor.

The DNIT 008/2003 standard has three forms attached to assist in the development and conclusion of the Continuous Visual Survey results. The first form is in Annex "B" of the standard, which was used in the field to fill in the frequencies of defects and road data. The third form is in annex "C", and was used after the data survey to calculate the IGGE of each segment. The third form is in annex "D", and it is where the ICPF and IGGE data developed in the forms mentioned above are contained. From the determination of these data, the IES value was established, which is the index responsible for determining the legitimate state of the evaluated road.

III. RESULTS OF THE DISCUSSION

To perform the procedure the team was composed of a driver, and two technicians, one of them being the Civil Engineer Iza Eduarda Oliveira Vargas enrolled in CREA TO - No. 241604372-2, both assessed the segments reporting relevant points, identifying and quantifying the pathologies found along the road, thus totaling the 27.9 km distance between the cities.

A total of 28 segments were analyzed along the entire stretch, Table 01 specifies the defects according to the quantities found in each section evaluated, and also the frequency of defects in the network in percentages according to the severity levels that vary between low, medium and high.

Table.1: Sections with defects according to the degree of severity.

DEFEITOS	NÍVEL DE GRAVIDADE				TOTAL DE SEÇÕES COM DEFEITOS	FREQUÊNCIA DOS DEFEITOS NA MALHA AVALIADA (%)
	NÃO POSSUI DEFEITOS	BAIXO	MÉDIO	ALTO		
Panelas	7	6	2	12	20	74
TR	4	6	3	14	23	85,2
TJ	6	6	1	14	21	77,77
TB	6	6	1	14	21	77,77
Remendos	7	2	0	18	20	74
Afundamentos	14	1	4	8	13	48,14

Ondulações	10	1	4	12	17	62,1
Desgastes	4	1	5	17	23	85,2
Exsudação	13	1	4	9	14	51,9
Escorregamento	15	0	3	8	11	40,74

tr = trinca isolada, tj= trinca couro de jacaré, tb = trinca em bloco.

Source: Prepared by Brito (2021).

From this it was possible to note that the most relevant defects found were the TR (isolated cracks) present in 85.2% of the track and found in 23 of the 27 segments analyzed, this type of crack can be subdivided into transverse, longitudinal and shrinkage cracks. The main factor influencing the emergence of this pathology is temperature. In the same proportion, wear and tear was found in 85.2% of the road; this type of pathology is associated with the high traffic flow of heavy vehicles in the region.

The interconnected cracks were the second most relevant defect present in 77.77% of the track, these pathologies were observed in 21 of the 27 segments analyzed, this type of cracks is subdivided into two types. The first type is the TJ (alligator skin cracking) whose appearance is related to sidewalk degradation due to repeated traffic loads. The second type is TB (block cracking), which, according to Silva (2008), is related to shrinkage of the asphalt coating and temperature variation during the day.

The third most frequent defect was undulation, present in 62.1% of the road, observed in 17 of the 27 segments analyzed. These types of pathology result from the low stability of the asphalt mix.

The patches and potholes were found in the same proportion, being observed in 74% of the road, both defects were noted in 20 of the 27 analyzed sections. Potholes are defects derived from other defects and patches are also corrections of other defects.

Ripples were found in 17 of the 27 segments, this demonstrates that this type of defect is present in 62.1% of the evaluated stretch. According to CNT (2017), the main causes of this type of pathology are the lack of stability of the asphalt mixture, excessive moisture of the subgrade soil, and lack of aeration of the liquid asphalt mixtures.

The least frequent defects found in the evaluated segments were exudation, which was observed in 14 of the 27 segments and occurs due to excessive exposure of the sidewalk to heat. Sags, which are present in 48.14% of the road, can be classified as plastic when the sidewalk has elevations along its length and can also be classified as consolidation. And the least frequent was the slipping observed in only 11 of the 27 segments analyzed, present in only 40.74% of the road, this type of pathology is caused due to slipping of the asphalt mass that due to excess binder used

Figure 02 shows the graph that presents the results of the evaluation made by the technicians of the quality of the segments of the evaluated stretch, where they classified the sidewalk as good, fair, poor and very poor, according to the IES results.

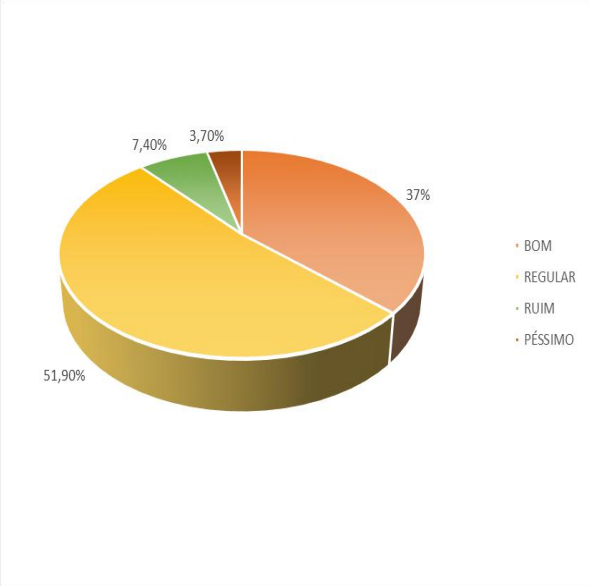

Fig. 2: Quality chart of the stretches

Source: Prepared by Brito (2021).

Figure 02 illustrates the results of the technicians' assessment of the sidewalk surface quality. Based on the application of the concepts presented in the graph, it was possible to establish the necessary corrective measures for each stretch. For the optimal concept, the DNIT (2003) standard suggests that only routine maintenance be done; on the analyzed road no section was found where this concept is applied.

In the graph it is possible to see that 37% of the analyzed stretch presents the good concept according to the application of the ICPF concept. The good concept

encompasses defects such as wear and tear, cracks that are not too serious in not very extensive areas.

The next concept is regular, present in 51.70% of the stretch. In this concept are defects such as potholes and patches.

The bad concept is present in 7.70% of the stretch, which includes defects such as surface or deep patches, in which case solutions such as resurfacing with previous corrections are indicated.

And finally, the application of the very poor concept occurred in only 3.70% of the stretch. This type of concept includes widespread defects and degradation of the coating and other layers; reconstruction of the stretch is suggested.

IV. CONCLUSION

The Continuous Visual Survey (CVS) methodology used for the survey and as a basis for the calculations succinctly met the needs of a surface survey that did not damage the sidewalk surface. Although this type of survey meets this need, it lacks important information and data such as rutting, which is permanent rutting caused by plastic and structural deformation.

However, the data made available by the survey made it possible to verify that the most relevant pathology on the sidewalk surface on the stretch between the cities of Estreito and Porto Franco - MA was isolated cracking. Afterwards it was also possible to identify that 51.90% of the stretch analyzed is in a regular situation and only 3.70% is in a terrible situation.

These results can serve as a basis to help make possible decisions to improve or recover the sidewalk surface. Furthermore, this type of survey is important because it contributes to mapping the pathologies present on the road.

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