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Flexible Pavement Analysis - Study of a critical stretch on the AM highway - 010

Bruno Ramos Pereira[1], Erika C. N. M. Pinheiro[2]

[1]Engineering Department of Civil, Faculdade Estácio do Amazonas, Brazil
[2]Civil Engineer, Work Safety Engineer, Mathematics (licentiate), Specialist in didactics in Higher education and tutoring in EAD, College Professor (Faculdade Estácio do Amazonas, Universidade Nilton Lins and UNIP)

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Abstract *— The main means of transport used in Brazil to move people and cargo are highways, making it indispensable to maintain and recover the highway network to attend the socioeconomic demands of the country. Therefore, it is essential to evaluate the need of each highway, according to the performance and durability of the pavement and according to the types of pathologies presented. This study aims to analyze the pathological problems existing in a stretch of the state highway AM - 010, between the capital of Amazonas, Manaus, and county Rio Preto da Eva, analysis to be done post photographic survey. Then the images of the pathologies were evaluated, diagnosed and classified accordingly norm of the National Department of Transport Infrastructure, DNIT. In the section evaluated the most common pathologies were: cracks, sinking, slippages, patches executed irregularly and pot holes, in addition to points without roadsides, compromised structure or obstructed, impossible to be used.*

I. INTRODUCTION

In Brazil, since the 1950s, the highways have been highlighted in the national economy as the main alternative for the movement of people and goods. The highways are the one that has the largest participation in the transport pattern, concentrating approximately 61% of the movement of goods and 95% of the passenger movement (CNT, 2019).

These data reinforce the need and importance of road infrastructure to aid the economic development of the country and for the basic safety of citizens by exercising their right to come and go with quality and comfort. However, at the moment it is possible to describe that the high demand of the highways uses and the lack of investments in maintenance of the existing roads are contributing to degradation and safety of the present structure.

In Brazil, there are 1,720,700 km of highways, 1,349,938 km are not paved, only 213,453 km are paved, that is, 12.4% of the network (CNT, 2019). In addition to the Brazilian paving mesh being small, a large part is in a state not suitable for traffic, presenting pathologies, mainly such as cracks, sinking, slippages, poorly executed patches and pot holes, among other defects.

The 2019 survey of the National Transportation Confederation (CNT), according to the extent evaluated, classified the federal and state highways of Amazonas in the general state as: 45.5% regular, 19.07% bad and 35.5% terrible; and classified the pavement as: 65.5% regular, 7.6% bad and 26.9% terrible.

Cited the problems, this article presents a case study of the AM-010, with photographic survey, the stretch is located between the state capital, Manaus, and the county Rio Preto da Eva, starting point at km 22 and end point at km 25.

The AM-010 is a state radial highway that connects the capital to the interior of the state, with a path Manaus - Rio

Preto da Eva - Itacoatiara, is approximately 252 km long, paved.

II. DEVELOPMENT

2.1 Pavement

Pavement is a structure of multiple layers of finite thicknesses, built on the final surface of earthmoving, in order to resist traffic efforts and climate actions, providing comfort, economy and safety to users (BERNUCCI, et al., 2010).

The DNIT Paving Manual (2005) defines pavement as the contact of structured layers with materials of different strengths and deformities.

2.2 Types of Pavements

Road pavements are classified according to their deformability and the materials of their composition. The choice of which pavement to use is made after taking into account the following items: flow of the traffic, the resistance of the soil and the quality of the available materials.

The National Department of Transport Infrastructure, DNIT (2005), classifies the floors into:

- Flexible, when the load is distributed in equivalent plots between layers;

- Semirigid, have the base cemented by some binder with cementitious properties;

- Rigid, when the stiffness of the coating is high in relation to the other layers, absorbing practically all the tension.

2.3 Paving situation in Brazil

The use of flexible pavement is predominant in the Brazilian road network, which is the object in this study.

According to the CNT, 2019, each of the layers that make up the floor has a specific function, that is:

• The coating is intended to withstand the actions of traffic; must be impervious in order to prevent rainwater penetration from reaching the other underlying layers; and should be comfortable to better meet rolling conditions and provide safety to the user. The coating is the only layer noticeable to the via user.

• The base is the layer that has the purpose of resisting the actions of traffic in order to relieve tensions in the coating and distribute them to the lower layers. • The sub-base is the complementary layer to the base, with the same functions as this, performed when, due to technical and economic circumstances, it is not advisable to build the floor directly on the regularization or reinforcement of the subbed.

• The reinforcement of the subbed is the layer executed on the properly compacted and regularized subbed, used when it becomes necessary to reduce high thicknesses of the sub-base layer, originated by the low support capacity of the subbed.

• The regularization layer has variable thickness, and may cease to exist in some stretches, and has the function of correcting faults of the final layer of earthmoving or an old bed of dirt road.

• The bed is the transition between the foundation ground and the pavement body.

• The subbed is the ground of the floor foundation or the original terrain, so it is not considered a layer.

Fig.1: Pavement layers (CNT, 2019)

2.3.1 Pathologies existing in the flexible pavement

The speed that a pavement will deteriorate depends on several factors, such as: environmental issues, climate, the support capacity of the pavement and subbed, the traffic, the quality of the materials used and the execution process and the loads supported by type of vehicle.

According to a CNT study conducted in 2019, these are the most common types of pathologies and their possible causes:

Fissure: there are capillary cracks in the asphalt coating that do not yet cause functional or structural problems on the highway. They are positioned longitudinally, transversely or obliquely and are noticeable in the sight of those up to 1.5 m away. The extent of the cracks is less than 30 cm. **Main causes**: poor asphalt dosage, excess fine (or filling material) in the coating; excessive compaction or at inappropriate time (CNT, 2018).

Transverse crack: isolated crack in the direction perpendicular to the axis of the track. If the extension is up to 100 cm, it is called short cross crack. When the extension is more than 100 cm, it is called a long cross crack. It is a functional defect (large cracks cause irregularity) and structural (weaken the floor covering).

Main causes: contraction of the asphalt cover caused by low temperatures or hardening of asphalt; propagation of cracks in the layers below that of the road cover (CNT, 2018).

Fig. 2: Transverse crack (CNT, 2019)

Longitudinal cracks: isolated crack in a direction predominantly parallel to the track axis. If the extension is up to 100 cm, it is called short longitudinal crack. When the extension is more than 100 cm, it is called long longitudinal crack. Functional defect (large cracks cause irregularity) and structural (weaken the floor covering). **Main causes**: poor execution of the longitudinal separation joint between the two traffic lanes; differential recalque; asphalt cover contraction due to low temperatures or asphalt hardening; propagation of cracks in the layers below that of the road cover (CNT, 2018).

Fig. 3: Longitudinal crack (CNT, 2019)

Alligator Cracks: set of interconnected cracks without defined directions, resembling the aspect of alligator leather. They're a structural defect. **Main causes**: asphalt coating collapse due to repeated traffic actions; under sizing or poor quality of the structure or one of the pavement layers; low ground support capacity; floor aging (end of life); hard or brittle asphalt (CNT, 2018).

Fig. 4: Alligator crack (CNT, 2019)

Block cracks: set of interconnected cracks forming rectangular blocks with well-defined sides. This is a functional defect (large block cracks cause irregularity) and structural (reduce the structural integrity of the pavement). **Main causes**: contraction of the asphalt cover due to alternating between high and low temperatures; low tensile strength of the asphalt mixture (CNT, 2018).

Fig. 5: Block crack (CNT, 2019)

Plastic sinking: permanent (plastic) deformation characterized by depression of the floor surface accompanied by lifting of ends (lateral volumetric compensation). When the extension is up to 6 m, it is called local plastic sinking. For extensions larger than 6 m and if it is located along the wheel track, it is called plastic wheel track sinking. **Main causes**: plastic fluency of one or more layers of the pavement or subbed; failure in asphalt mixture dosage - asphalt ligant excess; failure to select type of asphalt coating for the requesting load (CNT, 2018).

Fig. 6: Plastic sinking on wheel track

(Inova Civil,2019)

Consolidation sinking: permanent formation characterized by depression of the floor surface without being accompanied by lifting of the ends (lateral volumetric compensation). When the extension is up to 6 m, it is called local consolidation sinking. For extensions greater than 6 m and if it is located along the wheel track, it is called wheel track consolidation sinking. **Main causes**: plastic creep of one or more layers of the pavement or subbed; densification or rupture by shear of layers underlying the coating; compaction failure in construction; drainage problems (CNT, 2018).

Fig. 7: Sinking by consolidation in wheel track

(Inova Civil, 2019)

Fig. 8: Localized sinking by consolidation

(Inova Civil,2019)

Ripple or corrugation: plastic movement of the coating, characterized by ripples or corrugations (which are wrinkles) transverse on the surface of the floor. **Main causes**: lack of asphalt mixture stability; excessive subbed soil moisture; contamination of asphalt mixture; lack of aecization of liquid asphalt mixtures (CNT, 2018).

Fig. 9: Corrugation (CNT, 2019)

Slippage: movement the coating in relation to the underlying layer of the pavement with the appearance of slits in half-moon. **Main causes**: construction and bonding paint failures (CNT, 2018).

Fig. 10: Slipping (Inova Civil, 2019)

Exudation: layer of bituminous material that appears on the surface of the pavement creating a vitreous brightness, caused by the migration of the ligant through the coating. **Main causes**: excessive amount of ligant; low content of voids (CNT, 2018).

Fig. 11: Exudation (CNT, 2019)

Abrasion: effect of progressive pullout of the floor aggregate, causing surface roughness of the coating. **Main causes**: ligant-aggregate adesivity failures; presence of trapped water and overlap in voids of the coating layer, generating ligant displacement; deficiency in the content of ligant; executive problems or mixing design (CNT, 2018).

Fig. 12: Abrasion (CNT, 2019)

Pot hole: cavities of varying sizes in the floor covering. **Main causes**: fatigue cracks (process that occurs due to the accumulation of traffic requests over time); disintegration located on the floor surface; deficiency in compaction; excessive moisture in soil layers; failure to print (CNT, 2018).

Fig. 13: Pot hole reaching the base (Inova Civil,2019)

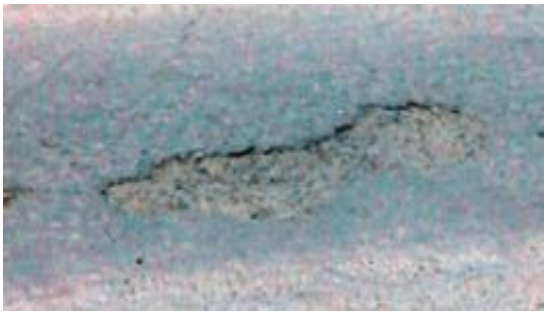

Fig. 14: Pot hole (Inova Civil, 2019)

Patch: pot holes filled with one or more layers of paving. Despite being a conservation activity, it is considered a defect because it points to a place of fragility and because it impacts the comfort in the bearing. The deterioration of patches is the set of existing damage in a patch area. **Main causes**: traffic load; use of poor quality material; environmental action; poor construction (CNT, 2018).

Fig. 15: Poorly executed patch (Inova Civil,2019)

Fig. 16: Patch well executed (Inova Civil,2019)

2.4 Conservation of highways

According to the Manual of Road Conservation of the National Department of Infrastructure and Transport (DNIT, 2005), the set of routine, periodic and emergency operations that are carried out in order to maintain the characteristics of the road system.

Conservation tasks are divided into five groups, as set out below:

1- Routine Corrective Conservation: are the conservation operations assigned to repair or remedy a defect and restore the operation of the highway providing comfort and safety to users.

2- Periodic Preventive Conservation: operations carried out periodically with the purpose of avoiding the appearance or aggravation of defects. The frequency of execution depends on traffic, topography and climate.

3- Emergency Conservation: repair operations or reconstruction of stretches or structures of the highway that have been modified and are causing interruption of traffic on the highway.

4- Restoration: set of measures aimed at adapting the highway to current and future traffic conditions, prolonging the life of the pavement.

5- Road improvements: operations that modify the characteristics of an existing highway or add new characteristics to this highway (DNIT, 2005).

It is understood that operations for road conservation, when well executed, extend the life of the roads, reducing the operational costs of vehicles, is given more safety in their traffic and keeps the operational routes in service.

III. MATERIALS

A photographic survey was carried out to record and diagnose the existing pathologies on the flexible floor.

The highway chosen to carry out this work, was the AM-010, Amazonas state highway, specifically the stretch between km 22 and km 25.

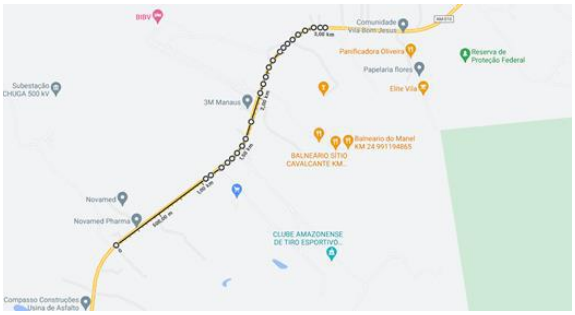

Fig. 17: Study location: AM - 010

(Google Maps, 2021)

IV. METHODS

In this work, bibliographical research was used from books, published articles, documents and field research, where it is necessary to go to the study site to collect ground-based data. The process was initiated by choosing the initial and final section, followed by the analysis of pathologies and diagnoses. All pathologies were classified and diagnosed according to DNIT/2003 Standard 005. To ensure a high-quality product, diagrams and letters must be elaborated or computer-designed using ink from India.

V. RESULTS AND DISCUSSION

The construction process of Brazilian highways is a real and significant problem. Failures in the execution process and the lack of maintenance of the structure of flexible floors can be attributed to several factors such as the deficiency in the supervision of maintenance, use of lower quality materials, incorrect use of the material quantity required in the construction process, lack of diagnoses and specialized labor, often seeking to reduce costs and increase profit margins.

The photographic survey was carried out on the afternoons of 21st and 22nd of May 2021, the stretch has an extension of 3 km, presents problems such as: cracks, pot holes, sinking, patches poorly executed, the sideways in some stretches is non-existent or is obstructed.

The cracks are common pathologies to arise, are linked to the life of the flexible pavement and are enhanced by environmental actions and the region's traffic. The following figures represent the most common types of cracks in the analyzed snippet.

Fig. 18: Longitudinal cracks (Copyright Images)

Fig. 19: Alligator cracks (Copyright Images)

The pot hole is a cavity formed on the surface of the coating that can reach the base and originates from the evolution of cracks, snooses or wear (SILVA, 2011).

Fig. 20: Pot hole reaching the base, on the pathway

(Copyright Images)

Fig. 21: Pot hole reaching the base, on the sideway (Copyright Images)

Next, it is possible to see that a patch was performed previously, the opening of the pot hole allows the view of the patch and the base.

Fig. 22: Pot hole with old patch, reaching the base (Copyright Images)

Next, the images show patches executed incorrectly, at levels higher than the pathway, some have already begun the process of deterioration in the margins of the clipping.

Fig. 23: Patch poorly executed (Copyright Images)

Fig. 24: Pot hole between poorly executed patches (Copyright Images)

In the next image we have a follow-up of patches, by a large extent of the pathway. In this case it could be evaluated the possibility of performing the full recovery of this extension, the excess of patches, poorly executed, can aggravate the emergence of new pots and still make traffic in the region more turbulent and less safe.

Fig. 25: Patch extension poorly executed (Copyright Images)

The sinking is considered a permanent deformation, the presence of a patch is visible, evidencing that there has already been an attempt to solve the problem, however, and this type of maintenance does not solve this defect.

Fig. 26: Sinking (Copyright Images)

VI. CONCLUSION

The causes of infrastructure deficiencies in Brazilian highways can be diverse or a set of factors, among them it is possible to mention: the lack of a specialized supervision on pavements, the lack of coordination between the agencies responsible for the road structure, the call of correct maintenance made with specialized labor, at the correct time. It is shown that in the present, the main problem of Brazilian highways is primarily bureaucratic. Thus, it is essential to implement a pavement management system that meets the entire road network and allows the proper planning of the maintenance interventions necessary to ensure greater durability of Brazilian highways (CNT, 2019).

After analyzing the chosen section, located in the AM-010, the critical state statement is easily verified, having evident problems of easy identification and classification. During the *in loco* evaluation, it was possible to identify longitudinal, transverse and alligator cracks, by significant extension, in addition to pot holes, of different sizes on the pathway and sideways, sinkings and patches, slippages were less seen defects. At some points the sideway was totally obstructed by vegetation, and in some others points presented major pathological problems, being pot holes the most common in the analyzed stretch.

After study, the main recommendation to solve such problems is the corrective and preventive maintenance of the highway, idealized and made by specialized professionals and with updated materials of excellent quality, this would reduce the defects in the roads, increase the quality and comfort of traffic, plus road safety.

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