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Survey of pathological manifestations in flexile pavement in the city of Manaus/AM

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***Abstract*—** *This work demonstrates a case study of pathological manifestations in a flexible pavement street, in order to point out the apparent pathologies and permanent deformations contained in an average flow road pavement in the city of Manaus-AM. Due to its important location in the south of Manaus, the stretch of Luiz Antony Street was chosen as a study, between the parallel avenues of Leonardo Malcher Avenue (at the end of the avenue, towards Aparecida neighborhood) and Ramos Ferreira Avenue. Renowned theoretical and normative references for the case study were addressed so that a visual inspection of the road could be made, diagnosing the problems encountered and defining the best solutions for them. Finally, the work reports the importance of planning and managing maintenance services on urban roads.*

I. INTRODUCTION

Currently, civil construction is debating improvements in the area of trafficability of public roads, intending to find low costs with returns in the short and long term. Every day there are several studies on the condition of paving in Brazil, since the traffic infrastructure is very deficient, added to the lack of commitment and investment by the government, causing serious damage to the economy and society.

Paving is essential in a country's infrastructure, as the displacement and flow of our products and services depend on the trafficability of our highways. Land distribution logistics is intrinsically linked to this factor, given the high volume of transported cargo, intense traffic, lack of conservation and constant maintenance. In addition to the wear mentioned above, the natural depreciation suffered by constant use entails high financial costs (operational and fuel).

Each type of pavement has its useful life, depreciated by the manifestations of defects on the road, not only because of the materials used, but also because of the structural behavior of the pavement. Thereafter, it checks that this information can help engineers to understand the technical problems detected and the best ways to perform maintenance for each type of pathological manifestation that appears on the road. Pathological manifestation is an expression used when a degradation mechanism appears, causing financial losses and accidents because they are not resolved with the correct and effective material.

II. THEORETICAL REFERENCE

Initially, this case study will address the concept and classification of pavement and its pathological manifestations in order to identify

correctly the type of anomaly in the roads and the repair techniques.

1.1. Pavement Definition

It is every structure existing on the streets where people move.

It is composed of layers of varying thickness, depending on its function. The sizing of the thickness of each layer depends on factors such as traffic studies, geotechnical studies and materials to be used (SOLANKI; ZAMAN, 2017, p. 99).

These are structures that are built on the final earthmoving surface, economically and technically designed to withstand the efforts arising from vehicle traffic and the weather, moreover, being able to offer users an improvement in rolling conditions, with safety, economy and comfort (BERNUCCI et al., 2012, p. 95).

Therefore, in all definitions, they always call the pavement as being a structure that is formed by several layers, each one performing a different function.

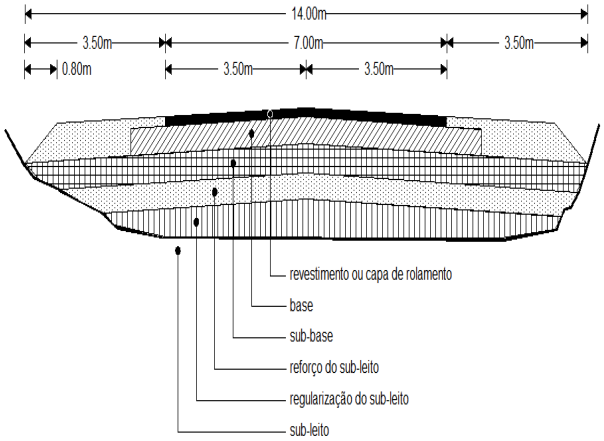

Fig 1 Pavement layer scale, Faleiros (2005).

1.2. Pavement Classification

For DER/SP (apud SIAN, 2007, p. 22) pavements are classified into three types: Flexible, rigid, and semi-rigid, as detailed. Flexible pavement is composed of a layer of bituminous material, which one of its functions is to serve as a coating, which is superimposed on one or more layers of granular material or stabilized soils, which act as a base. The rigid pavement consists of cement concrete slabs

Portland on a cemented or granular material base. The semi-rigid pavement is composed of a layer of bituminous material on a base of stabilized material with cement.

Rigid pavements are layers that work essentially in traction, unlike flexible pavements. Its design is based on the resistant properties of Portland cement concrete slabs, which are supported by a transition layer, the sub-base (BERNUCCI, 2012).

Fig 2 Rigid Pavement, IBRACON (2008).

The semi-rigid pavement is, therefore, a pavement composed of an asphalt coating with a base or sub-base in material treated with high rigidity cement, excluding any type of concrete (BALBO, 2007).

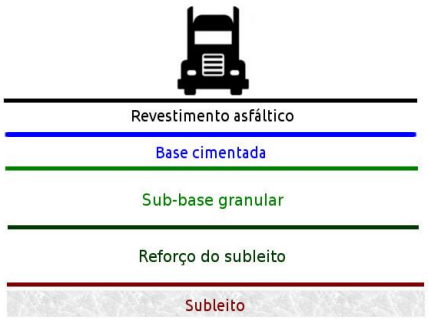

Fig 3: Semi-rigid pavement, IBRACON (2008).

According to the DNIT Pavement Manual (2006), flexible pavement is the one in which all layers undergo significant elastic deformation under the applied load and, therefore, the load is distributed in approximately equivalent portions between the layers.

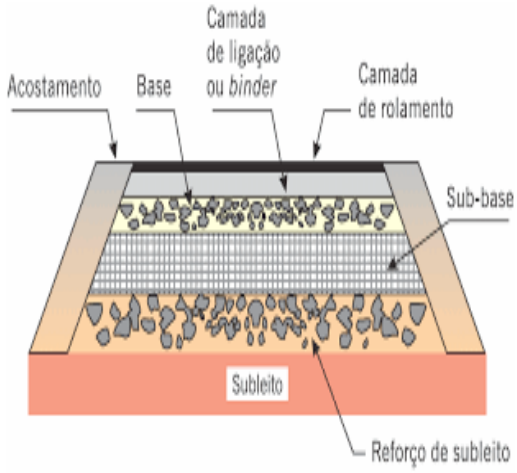

Fig 4 Flexible Pavement, BERNUCCI *et al* (2012).

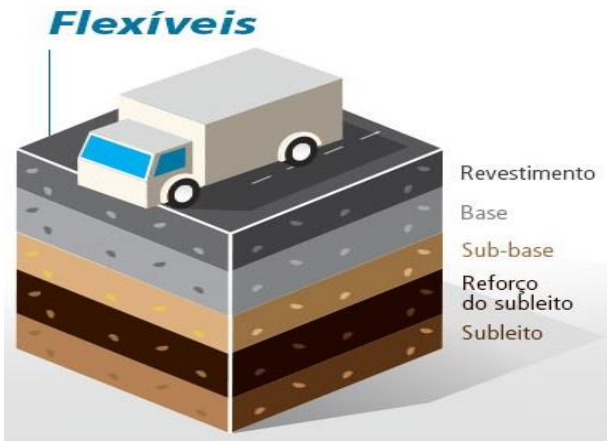

Fig 5: Flexible pavement layers, CAPEL(2017).

1.3. Flexible Pavement

1.3.1. Distribution of flexible pavement tension.

In flexible pavement, the load is distributed in portions proportional to the rigidity of the layers, in which all layers undergo significant elastic deformations, deformations up to a limit do not lead to rupture, and the quality of the soil is relevant, as it is subjected to high tensions and absorbs greater deflections (ARAÚJO, et al, 2016).

According to Pinto (2013), flexible pavement usually requires large thicknesses, due to the use of deformable materials or of dubious quality, and

the application of high loads. Thus, such thicknesses ensure that the tension on the foundation soil is less than its resistance.

1.3.2. Flexible Pavement Layers

First and foremost, as completely as possible, the pavement has the following layers: coating, base, sub-base, reinforcement of the subgrade and subgrade, the latter being the foundation and an integral part of the structure. Depending on the case, the pavement may not have a sub-base or reinforcement layer, but the existence of the coating, even if it is primary, and of the subgrade are minimum conditions for this structure to be called pavement (SILVA, 2008).

As for the flexible pavement, object of this study, its layers are represented below.

The subgrade is called the pavement foundation space, composed of natural and compacted material, for example.

As for the reinforcement of the subgrade, it is a non-mandatory layer, however, if used, it has a constant thickness, built, if necessary, above the regularization, with technological characteristics superior to those of regularization and inferior to those of the layer immediately above, that is, the sub-base.

The sub-base is the complementary layer to the base, when, due to technical and economic circumstances, it is not advisable to build the base directly on the regularization or reinforcement of the sub-grade.

The base should have better quality material than the sub-base material, because it is the most important layer of the pavement structure, as it is located just below the pavement coating.

The pavement coating is the last layer existing in the structure, which directly receives the action of traffic and is intended to improve the running surface in terms of comfort and safety.

2.4 Pavement pathology

Asphalt pathologies that may appear over time can have different origins, such as improper project performance, failure to select materials, inadequate alternatives for conservation and maintenance, among other factors, that may affect the usefulness of the pavement.

Generally, the pathologies presented in the asphalt are caused by the responsibility of human work, which derives from the wrong choice of material to a improper performance of the procedures that must be carried out.

2.4.1 Types of defects that occur on flexible pavements

On flexible pavements, pathologies can be classified as set out in Table 1.

Patologias Estruturais	Corrugações
	Afundamentos
Patologias Funcionais	Exsudação de Asfalto
	Desgaste
	Escorregamento do Revestimento Betuminoso
	Trincas e Fissuras (Fendas)
	Panela

2.4.1.1 Corrugations

According to the DNIT 005/2003 – TER (DNIT, 2003) norm, it is defined as transverse undulations on the pavement surface.

The figure below shows an example of corrugations, also known as Ribs, and it is common to find them on climbs, ramps, curves and intersections (SILVA, 2008, p. 31).

Fig 6 Corrugation example, DNIT (2003)

2.4.1.2. Foundering

It is characterized as a permanent deformation through a depression on the surface, which may be accompanied by lifting.

Therefore, the DNIT (2003) states that foundering is a perennial defect determined by depression in the pavement coating, combined or not with lifting, showing itself as a plastic foundering or consolidation.

Fig 7 Afundamento da trilha de roda, DNIT (2003)

2.4.1.3. Asphalt exudation

According to Balbo (2007), he explains that this type of pathology may be related to the segregation of the asphalt mixture at some moments during its execution, excessive compaction of the mixture, excess binder, use of low viscosity binder in places with high climate average temperatures or the lack of adhesiveness of the asphalt binder. It may also be related to the slipping of the asphalt mixture.

Fig 8 Asphalt exudation, DNIT (2003)

2.4.1.4. Wear

According to Dnit (2003), wear is conceptualized as a result of the progressive pull out of the paved structure's aggregate, identified by the roughness of the bearing cover surface and caused by tangential loads caused by traffic.

It is noteworthy that surface wear can be classified as the association of traffic with bad weather. At the limit we may have a polished surface, which can compromise skidding safety. In the progressive pullout of aggregates, surface wear is at an advanced stage. Wear is characterized by surface roughness. (SILVA, 2008).

Fig 9 Wear exmple, SONEGO (2018)

2.4.1.5 Slip of bituminous coating

For Balbo (2007), it is described as a transverse displacement of the asphalt mixture, usually occurring in lanes requested by commercial vehicles and attributes its origin to inadequate priming of the coating on the lower layer, inadequate compression of the asphalt mixture before the release of the lane for traffic, the inadequate viscosity of the asphalt cement for the conditions of use and the excess of binder in the mixture.

Fig 10 Slip, DNIT (2003)

2.4.1.6 Cracks and fissures (Slot)

In flexible pavements, cracks are a more common form of pathology, due to the flexural traction of these layers repeatedly with the passage of load from vehicles (BESKOU, et al, 2016, p. 476).

There are several types of cracks, however, the most common are alligator or crocodile skin cracks, isolated retraction cracks, block cracks, longitudinal cracks, transverse cracks and edge cracks.

According to DNIT (2003), crack is any break in the structure's coating that leads to greater or lesser degree grooves, presenting itself in various forms, it can present as a fissure or crack according to what is exposed ahead.

Fig 11 Alligator skin crack, Bernucci et al.(2012)

2.4.1.7. Pan

Also called a hole, thus, the DNIT (2003) states that pan is precisely the hole formed in the coating due to various factors (including the lack of cohesion between overlapping layers, generating the peeling of these), which can reach the underlying layers of the pavement, leading to the disaggregation of these layers.

Fig 12 Panela ou buraco, DNIT (2003)

Therefore, in addition to these defects, what can occur would also be design errors, highlighting the traffic conditions and the selection of materials and execution errors.

2.5 Repair techniques

It stands out that (DNIT 2010) in order to ensure a strategic plan that has a better cost-benefit in the application of public resources, since keeping the asphalt in good condition is more viable than intervening several times to recover it, it was created the Pavement Management Manual.

For some of the asphalt pathologies, some repair techniques can be applied.

According to DNIT (2006), the making of patches should consist of the following steps: regularization of degradation (geometric delimitation of the pan); waterproofing (priming) of the affected granular layers; spreading, shaping and compacting the filling

material and surface sealing (when the filling material has high void rates).

The superficial patch is also known as a filler, and its use is quite common, with the objective of repairing degradations in the road.

Fig 13 Superficial patch

Deep patching is already a more corrective technique, in which fractions of underlying granular layers can be removed.

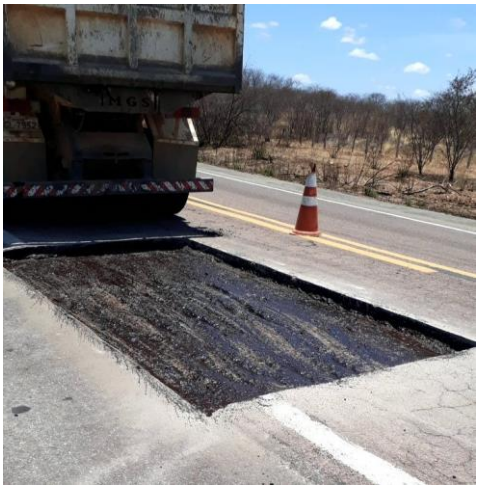

Fig 14 Deep patch

In relation to isolated cracks, the procedure starts with the opening of the crack for cleaning and sealing, then the application of the sealing product is made and finally the application of lime for protection, however the cracks interconnected ones need some control measures and reduction of reflection using geotextiles impregnated with asphalt binder at the interface between the old deteriorated coating and a resurfacing, with this the cracks are delayed.

For the treatment of foundering, two techniques are suggested: recapping and crimping, as seen in the following figures:

Fig 15 Resurfacing

In the event of undulation/corrugation, the recommended techniques to recover pavements with this defect are also the same used in the recovery of foundering: resurfacing and milling.

Fig 16 Milling

III. METHODOLOGY

The methodology for execute this course conclusion paper was developed through a case study.

This research is exploratory and explanatory, as its objective is to show the type of pavement, its complications and which techniques can be used to recover the urban road.

3.1 Place selection

Due to its important location in the south of Manaus, the stretch of Luiz Antony Street was chosen as a study, between the parallel avenues of Leonardo Malcher Avenue (at the end of the avenue, towards the Aparecida neighborhood) and Ramos Ferreira Avenue in the Centro neighborhood.

3.2 Used material

The material used in this technical visit were the following items:

- PPE helmet
- Measuring tape
- Ruler
- Pen

- Note block

3.3 Result Analysis

Three types of pathological manifestations were constated during the visit, namely: cracks and fissures, pans and foundering, factors that occur due to the lack of maintenance and conservation of the road. It is noticed that the urban road had no design or execution error, however, in the observed occurrences may be applied techniques of patching application of sealant, resurfacing and crimping.

A large amount of heavy vehicle traffic was also observed and this facilitates the deformation of the urban road.

For significant improvements, the city of Manaus-AM could draw up a schedule of visits in order to carry out maintenance or conservation for the comfort and safety of the population.

IV. CONCLUSION

The objective of the work was to explore the concepts of pavement and pathological manifestations in order to clarify and identify the possible problems and causes found in public roads.

Therefore, it can be concluded that with the use of proper maintenance we can avoid various types of manifestations having an execution alignment and correct materials related to each type of pathology presented, this can prevent the total wear of the pavement.

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