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Global Gravity Index (IGG) of a Stretch of a Street in the Amazonian Capital

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Abstract

The aesthetic and functional evaluation of an asphalt pavement of the flexible pavement type is important for the development of the road's trafficability. The assessments, in Brazil, are regulated by the government agency of the National Department of Transport Infrastructure (DNIT), the assessments of the physical and structural conditions of highways, streets and the like, have guidelines for guidelines for construction techniques and assessment techniques. This article, used one of the standards of the agency, to assess the physical condition of a street in the capital of Amazonas, located in the city of Manaus and through the evaluation, it was concluded that the case study section has a very bad traffic quality. and possible causes of the appearance present in pathologies of the flexible pavement type asphalt pavement were suggested.

Keywords: Pavement, Streets, Manaus City.

1. INTRODUCTION

Flexible pavements have a viscoelastic characteristic due to the presence of petroleum asphalt cement (PAC) where, usually, refineries process the product from its origin to the manufacture of the product for companies to use. The usual asphalt mixture has fine aggregates in its composition, generally characterized by sand, coarse aggregates, characterized by gravel or pebbles and the petroleum asphalt cement binder, known as CAP, usually some companies use another type of material to fill the mixture, known as filler, where in turn it is cement or gravel powder.

According to Senço (2007, apud. Júnior, 2014), pavement is a structure built on a foundation ground, made up of several layers of finite thickness and is intended to support vertical loads from traffic and distribute

it to the subgrade; to promote safety and comfort when rolling; resist horizontal efforts.

Asphalt pavement goes through different phases during its useful life. Initially, there is consolidation by traffic, in which the wheels of automobiles consolidate the pavement structure due to the contact pressure. There is still the phase of recoverable deflections, when there are elastic deformations that make up the useful life of the asphalt structure. Finally, there is the phenomenon of fatigue, which is characterized by plastic deformations whose deflections are no longer recoverable. (2007, apud. Júnior, 2014)

The quality of the pavements is configured as one of the main obstacles to the economic development of Brazil, as this is a primarily road-based country where, according to the National Confederation of Transport (CNT, 2017), 60% of the loads that circulate internally and 90% of passengers use road transport. The poor condition of the country's highways significantly increases the operational cost of transporting cargo and goods, while damaging vehicles and reducing transport speed, in addition to compromising safety and comfort for users (NETO, 2017).

The knowledge of the functional and structural state of the roads allows intervention in their characteristics aiming at extending their useful life, thus enabling improvements in the Brazilian road network, in a simple way, reducing their costs with reconstructions. Aiming to determine the degree of road deterioration and ensure user comfort regarding the bearing and surface condition. With the help of this inventory and structural assessment, it is possible to diagnose the problems presented in the analyzed coating, carrying out an assessment of the extent of its degradation, determining its maintenance needs and thus avoiding an accelerated deterioration (MARQUESINI, 2012).

Each type of pavement presents, throughout its service life, different manifestations of defects, related not only to the types of materials used, but also to the types of mechanical response in the structure in question. From there, as observed by Balbo (2007), not only the types of materials, but also the structural behavior of the pavement together provide useful information to engineers, so that they understand the technical problems of paving and the most appropriate ways of maintenance (GUEDES, 2016).

From the value of the IGG it is possible to indicate a concept in: great, good, fair, bad or very bad. This method in Brazil is regulated by the DNIT 006/2003 standard, which establishes the criteria for detecting defects. The results arising from the evaluations based on the IGG can be used in reinforcement projects (SANTOS; OLIVEIRA, 2017).

Thus, this article aims to calculate the global severity index of a stretch of a street in the city of Manaus, objectifying the real situation of the location to describe whether it is a satisfactory stretch for traffic or not.

2. METHODOLOGY

The methodology used in the elaboration of the study will take place in two stages, the first part refers to a literature review on topics relevant to the work topic, such as: flexible pavement, global severity index, the terminologies of defects in flexible floors according to NORMA DNIT 005/2003 and the procedure for the objective evaluation of the surface of flexible floors according to NORMA DNIT 006/2003.

The second part of the work alluded to the photographic records of the pathologies found in addition to the number of registered defects, focusing on the most recurrent defects and, finally, a table showing the result of the street IGG, showing which was the obtained concept.

3. BIBLIOGRAPHIC REFERENCE

3.1 Flexible Paviment

The technique of construction of highways, runways, avenues, streets, airport runways and the like, primarily needs a dimensioning to satisfy the need of each section topic, for example an airport runway that receives in its asphalt coating a load totally different from an asphalt coating of a condominium street. Satisfying the interest of each asphalt coating, dosage, testing, compaction and other elements, are factors that, if executed and prepared in a good way, characterize the flexible pavement, given that the differential to rigid pavements is its construction technique and its asphalt mixture components.

Flexible pavement is a type of coating that consists of asphalt coating under a granular base layer or under a granulometrically stabilized soil base layer, and the efforts from traffic are absorbed by the various layers coming from the road. The choice of pavement type is determined by several factors. Flexible floors are the most used due to their lower cost compared to rigid floors and because they are executed more quickly. Despite this, over time, flexible floors need maintenance and restoration processes more than rigid floors (GUEDES, 2016).

3.2 Pathologies in Flexible and Semi Rigid Flooring - DNIT STANDARD 005/2003

For construction techniques, the highest authority for the standardization of road construction, entitled by the National Department of Transport Infrastructure (DNIT), determined, through its guidelines, the NORMA DNIT 005/2003, by which it is the current standard mentioned in its description, the existence of 12 types of pathologies that can be present in pavements and within these defects there are subclassifications as determined below:

3.2.1 Crack type 01

Any discontinuity in the surface of the pavement, leading to smaller or larger openings, presenting different shapes, as described below.

3.2.2 Crack type 02

Capillary-width slit in the cladding, positioned longitudinally, transversely or obliquely to the axis of the track, only noticeable to an unarmed view from a distance of less than 1.50 m.

3.2.3 Crack type 03

Existing crack in the cladding, easily visible to the naked eye, with an opening greater than that of the fissure, and may appear in the form of an isolated crack or an interconnected crack.

3.2.4 Isolated crack

a) Transverse crack

Isolated crack that has a predominantly orthogonal direction to the axis of the road. When it has an extension of up to 100 cm, it is called a short transverse crack. When the extension is greater than 100 cm, it is called a long transverse crack.

b) Longitudinal crack

Isolated crack that has a direction predominantly parallel to the axis of the road. When it has an extension of up to 100 cm, it is called a short longitudinal crack. When the extension is greater than 100 cm, it is called a long longitudinal crack.

c) Retraction crack

Insulated crack not attributed to fatigue phenomena, but to phenomena of thermal shrinkage or the coating material or rigid or semi-rigid base material underlying the cracked coating.

3.2.5 Interconnected crack

a) "Alligator leather" type crack

Set of interlocking cracks without preferential directions, resembling the appearance of alligator leather. These cracks may or may not have marked erosion on the edges.

b) "Block" type crack

A set of interconnected cracks characterized by the configuration of blocks formed by well-defined sides, which may or may not present accentuated erosion at the edges.

3.2.6 Sinking

Permanent deformation characterized by depression of the pavement surface, accompanied or not by lifting, which may present in the form of plastic sinking or consolidation.

3.2.6.1 Plastic sinking

Sinking caused by the plastic creep of one or more layers of the pavement or subgrade, accompanied by lifting. When it occurs in an extension of up to 6 m,

it is called local plastic sinking; when the extension is greater than 6 m and is located along the wheel track it is called the plastic wheel track sink.

3.2.6.2 Consolidation sinking

Consolidation sinking is caused by the differential consolidation of one or more layers of the pavement or subgrade without being accompanied by lift. When it occurs in an extension of up to 6 m, it is called local consolidation sinking; when the length is more than 6m and is located along the wheel track it is called the wheel track consolidation sink.

3.2.7 Ripple or Corrugation

Deformation characterized by transverse undulations or corrugations on the pavement surface.

3.2.8 Slip

Displacement of the coating in relation to the underlying pavement layer, with the appearance of half-moon-shaped cracks.

3.2.9 Oozing

Excess bituminous binder on the pavement surface, caused by the migration of the binder through the coating.

3.2.10 Wear

Effect of progressive pull-out of the pavement aggregate, characterized by surface roughness of the coating and caused by tangential stresses caused by traffic.

3.2.11 Pot or hole

A cavity formed in the coating for various reasons (including lack of adhesion between superposed layers, causing the layers to peel off), which can reach the lower layers of the pavement, causing these layers to break down.

3.2.12 Patch

Pan filled with one or more layers of pavement in the so-called “hole filler” operation.

3.2.12. 1 deep patch

One in which there is replacement of the coating and, eventually, of one or more lower layers of the pavement. It usually has a rectangular shape.

3.2.12.2 Surface patch

Correction, in a localized area, of the coating surface, by applying a bituminous layer.

3.3 Techniques for the Objective Evaluation of the Surface of Standardized Flexible Flooring - STANDARD DNIT 006/2003

In this standard, alluded to the possible methods, which are necessary to carry out a superficial assessment of the pathologies present in the study excerpt.

3.3.1 Switchgear

For surface evaluation, the following equipment must be used:

a) standardized aluminum truss, 1.20m long at the base, equipped with a movable ruler installed at its midpoint and which allows measuring, in millimeters, the arrows of the wheel track;
b) auxiliary equipment and material for location and demarcation on the track of assessment stations; such as: measuring tape with 20m, chalk, paint, brush, forms etc.

3.3.2 Execution

Assessment surfaces must be located as follows:
a) on single lane highways, every 20 m alternated in relation to the axis of the carriageway (40 m in 40 m in each traffic lane);
b) on dual carriageways, every 20m, in the most requested traffic lane of each lane.

3.3.3 Calculations

To obtain the severity index, it is necessary to calculate the relative frequency. The absolute frequency (fa) corresponds to the number of times the occurrence was verified.

The relative frequency (fr) is obtained through the formula:

$$f_r = \frac{f_a \times 100}{n} \quad (1)$$

fr - relative frequency;
fa - absolute frequency;
n - number of inventoried stations.

With the result of the relative frequency, it is possible to calculate the individual severity index of each stretch, using the formula:

$$IGI = f_r \times f_p \quad (2)$$

fr - relative frequency;
fp - weighting factor, obtained according to the DNIT 003/2006 road weighting factor table.

The table below presents the information with details of the coding characteristics in relation to its numerical value represented by the weighting factor.

Type occurrence	**Coding of occurrences according to DNIT 005/2002-TER Standard**	**Weighting Factor**
1	Isolated Cracks and Cracks (FI, TTC, TTL, TLC, TLL and TRR)	0.2
two	FC-2 (J and TB)	0.5
3	FC-3 (JE and TBE) NOTE: For weighting purposes when occurrences of types 1, 2 and 3 are found in the same station, only consider those of type 3 for the calculation of the relative frequency in	0.8

	percentage (fr) and Individual Severity Index (IGI); in the same way, when occurrences of types 1 and 2 are verified in the same station, only consider those of type 2.	
4	ALP, ATP and ALC, ATC	0.9
5	THE FEET	1.0
6	EX	0.5
7	D	0.3
8	R	0.6

Table 1. Weighting factor value.

Finally, to calculate the global severity index, the sum of all individual severity indexes is made. According to the formula:

$$IGG = \sum IGI \quad (3)$$

Through the IGG result, we can analyze the concept of pavement degradation according to table 2:

Concepts	Limits
Excellent	$0 < IGG \geq 20$
Good	$20 < IGG \geq 40$
Regular	$40 < IGG \geq 80$
Bad	$80 < IGG \geq 160$
Terrible	$IGG > 160$

Table 2. Concepts of pavement degradation as a function of the IGG.
Source: DNIT 003/2006 Standard.

4. RESULTS

The object of study is located at Rua São Eusébio, 199, in the Colônia Terra Nova neighborhood, with CEP 69093-553 in the city of Manaus, in the state of Amazonas and in the country of Brazil, has its georeferenced reference 3.013141508659378, -59.999749202351. In the image below it is possible to locate the excerpt and pathology. The street is approximately 600 meters long and 08 meters wide.

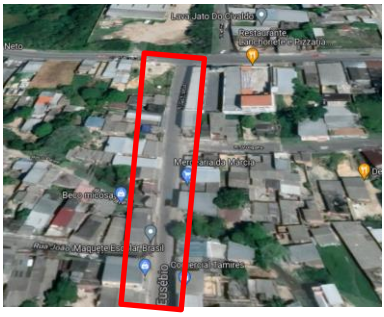


Image 01 – Location. Source – Google Maps

Along its axis, the present street has a number of pathologies, however in image 02 one of the pathologies present attracted great attention due to the complexity of its possible causes of problems.

Image 02 – Location of the pathology. Source - Own

Image 02, it is possible to verify the pathology empirically, in a brief evaluation in loco, the authors can suggest a problematic pathology related to isolated Cracks of the longitudinal type and Sinking By Consolidation, the reason will be given by:

Isolated longitudinal cracks: The empirical evaluation suggested that the cracks present had an opening greater than 05 cm, and because of the similarity that the image that the DNIT standard presents.

Image 03 - Standard DNIT 005/2003

Image 04 – Isolated cracks in loco

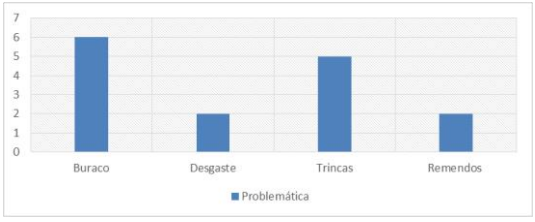
In images 03 and 04, it is possible to verify the similarity of the description that the standard cites (Image 03) with the crack present in the field (Image 04)

Consolidation sinking: In view of the detailed reading of the regulation of the DNIT 006/2003 standard in force, when looking at the type of execution that is possible to recover the stretch, only the consolidation sinking that exemplifies the relationship of a possible recovery to the sub-grade of the paving, this statement is possible because when carefully observing the section, the asphalt coating that was removed, the sub-base layer is already observed, thus suggesting that it will not only be necessary to repair the asphalt layer, but the layer bottom.

Image 05 – Pathology location. Source – Own.

In image 05, we can see that not only the presence of cracks are causing the pathology, but also the presence of a possible erosion at the site, since a slope and the detachment of the asphalt layer to the sub-base layer are notable. Suspicion of the motive will be given by the presence of an underground gallery below the section where the pathology is found.

In the chart below, the presence of other pathologies present along the 600 meter stretch with 8 meters wide was listed.



Graph 1. Number of defects evaluated on the street

In terms of percentage, the most recurrent defect was the hole with 42.00%, followed by cracks with 35.00%, wear with 14.00%, and finally patches with 9.00%.

Through the number of absolute and relative frequencies of defects, it was possible to calculate the Avenue's global severity index, as shown in the following table:

Type occurrence	Defects	Weighting Value	Fan	Fr	IGI	IG G	pavement degradation
1	Crack	0.2	5	100	20		
5	Hole	1.0	6	120	120	176	IGG>160
7	Wear	0.3	two	40	12		BAD
8	Patch	0.6	two	40	24		

Table 3. Global street severity index.

With the tabulated values and the quantitative surveyed *in loco,* it was possible to carry out the standardized mathematical calculations, and the

expected result was an index of poor quality assessment in the section, where the standard dictates that IGG numbers greater.

Another method for evaluating asphalt performance is the International Irregularities Index (IRI), which assesses, through modern equipment, the presence of irregularities in the roadway. empirically and through shooting in vehicles, where the authors inside the vehicle performed passes in the section that presented the pathologies, and it was possible through body sensing that the suspension of the vehicle exerted a greater effort where the pathologies were passed over.

5. FINAL CONSIDERATIONS

Although the DNIT standardization has some direct specifications for a better understanding, it presents a detailed description regarding the description of the types of pathologies, the possible cause of the problem and the teaching methodology through the mathematical equation, it is a relationship that is a collection of field data with the mathematical equation, objectifying the performance of a highway. The bad traffic conditions of the road, it is not necessary to calculate the performance index, due to the bad visible conditions and the bad trafficability of the asphalt coating. The calculation of the global severity index carried out with the collection of data *in loco* , was a formal methodology to present the terrible quality and the great degradation that the stretch presents during its beginning and end, it is suggested that an immediate intervention be carried out. to the site due to the commitment of the underlayer to the asphalt coating, known as the sub-base layer.

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