Identification of the main defects in plain concrete coating

Identificação dos principais defeitos no revestimento de concreto simples

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1 INTRODUCTION

Brazil is a country with great territorial amplitude and a developmental and diversified economy, operating in several areas, such as agribusiness, mining, manufacturing and services that are increasingly in demand in this growing economy of transportation infrastructure that works mainly by highways (VITÓRIO, 2011:43).

According to a CNT survey (2016:23), 58.2% of the roads analyzed have some kind of defect, either in the geometry of the road, the sidewalk or the signage. These flaws or irregularities will increase the risk of accidents and impacts on both passenger comfort and safety. In addition, based on research from the same source, 48.3% of the stretches evaluated received a regular, poor or very poor rating. Featuring great durability and high resistance to stresses, concrete sidewalk, usually Portland cement, has its high initial cost of application, compared to flexible sidewalk, offset by the low need for maintenance throughout its useful life.

A large number some highways in Brazil still require paved road construction, it can be seen that much of the paved highways (213,299 km) received flexible sidewalks, this option made the road network susceptible to environmental conditions such as humidity and temperature changes, as a significant part of the vast territory of the country has a climate what else, the increase in traffic and freight is also being made a factor that deteriorates the quality and durability of the surface every time most require maintenance and regeneration. While the highway rigid sidewalk for durability and minimum maintenance increasingly employed in the country (CNT, 2016:25).

Identification of constructive errors and other problems that occur in rigid sidewalks are made using sidewalk management systems such as the Pavement Condition Indicator (ICP), used by government agencies in Brazil federal and state levels, use of methods and

sidewalk management systems aims to identify major defects and their causes as structural and functional problems affect the safety of users, exposing themselves to compromises the ability to withstand traffic loads and driving deterioration conditions on the road, in addition to reducing maintenance costs, avoiding corrective maintenance because it is expensive and opts for preventive maintenance (SENÇO, 2007.):65).

This research is based on the resolution to identify possible defects in plain concrete coatings, to be able to distinguish which types of pathology can be cured and which cannot, and how to treat them.

2 OBJECTIVE

Systematically analyze the main defects in rigid sidewalks, since their characteristics and other construction methods are of greater resistance to the thrust transmitted by the axle of the vehicles on the coating, however, even so, this advantage does not exempt the appearance of pathological manifestations, which may be related to several factors, such as defects in the construction process; wear; accidents; flaws in the composition material over the years; insufficient support of the subgrade of the road; among others. Therefore, this research aims to analyze specific cases of pathologies in urban roads and airports. In order to solve, in some cases, possible treatments in the restoration of rigid sidewalks.

3 METHODOLOGY

The types of defects identified in this study were based on the evaluation of paved roads located on Avenida Buriti, in the Industrial District I - Manaus/AM. The main defects of rigid sidewalks found are: corner crack (Figure 1a), joint step (Figure 1b), joint sealing defect (Figure 1c), linear cracks (Figure 1d), repairs (Figure 1e), surface wear (Figure 1f), corner break (Figure 1g) and holes (Figure 1h).

Figure 1. Main defects identified.

Source: Authors (2023).

This research includes the introduction of the study in question by means of field investigation "*in loco*", previous observations of pathological phenomena caused in the sidewalk presented, in order to indicate the most common defects and problems.

POSSIBLE TREATMENTS FOR THE DEFECTS IDENTIFIED

Sidewalk rehabilitation consists of operations to maintain sidewalks in a state similar to that of their construction, seeking to extend their useful life, preserve the sidewalk comfort condition indexes and the safety of users. The DNIT manual (2010:78), cites three activities related to sidewalk recovery, they are:

- ✓ Restoration or repair: consists of repairs carried out on small areas of a slab, they must be carried out as soon as the presence of pathologies is noticed;
- ✓ Reinforcement: is when a sidewalk is superimposed on the existing one, for this the old sidewalk must at least have structural conditions to support the new one;
- ✓ Reconstruction: occurs when it is not possible to recover or reinforce the sidewalk slab because it is too structurally compromised, in which case one or more defective slabs are demolished.

According to Silva (2008:89), the sidewalk recovery strategy consists of performing services directed to each pathology, such as:

- Patching, consists of applying epoxy resin to plastic shrinkage cracks, used to cover cracks with an opening greater than 0.6 mm, the resin penetrates the crack spaces sealing the openings.
- Partial repair of the slab, a procedure used for functional pathologies such as small holes, delaminations, erosion and surface wear, as well as protrusions caused by the passage of animals or foreign objects on the concrete of the slabs. Partial repair is applied when the defect reaches up to one third of the thickness of the concrete slab and is between 3.5 cm wide and 15.0 cm long, and the repair material is compatible with the existing concrete. Defects with a depth of less than 0.7 mm do not need to be repaired.
- Protrusions are removed with the use of a concrete micro-milling machine, in case of grooves where the sidewalk has been polished the micro-milling machine should also be used, if the micro-milling does not have an effect, perform partial repair on the plate.
- Full slab repair, used when there are transverse cracks in the slab due to delays in cutting joints, misalignment of transfer bars and problems in leveling the subgrade. This type of repair is applied when the depth of repair is greater than half the thickness of the sidewalk slab, when cracks intersect or when the area required to be repaired is greater than 65% of the slab area, the slab must be completely removed. The total repair process is carried out covering a strip of the roadway, with a minimum length of 2 m, the concrete is removed with caution so as not to hit the surrounding slabs and not to break the edges of the slab, after the execution of the cut, transfer bars are added with half of their length greased, also realign the connecting bars, cover the sub-base with plastic tarpaulin before concreting, a new transverse joint must be added to the top of both sides of the cut, it may be necessary to place reinforcement distributed over the width of the cut. In all cases of rehabilitation affecting the surface of the slab a new texturing with nylon brooms should be done in the same way as when the sidewalk was executed.
- Transfer bar retrofit, performed when there is transverse cracking due to sub-base settlement and misalignment of the transfer bars, this technique improves load transfer, increases the structural capacity of the region in which it is applied and

reduces the unevenness between slabs. The technique consists of sawing grooves or slots in the concrete slabs in the direction perpendicular to the transverse cracks and then inserting the bars, in the direction of the inner and outer wheel tracks of the traffic, in order to re-establish load transfer.

4 RESULTS AND DISCUSSION

Although no volumetric survey was conducted for this study in the year 2023, data obtained from traffic counts performed in previous years can be considered to have a more comprehensive assessment of sidewalk conditions.

Some important aspects can be highlighted in relation to the surveys previously conducted. The observed vehicles that characterized the daily traffic on the analyzed concrete sidewalk, such as trucks or light vehicles, were accounted for in the counts.

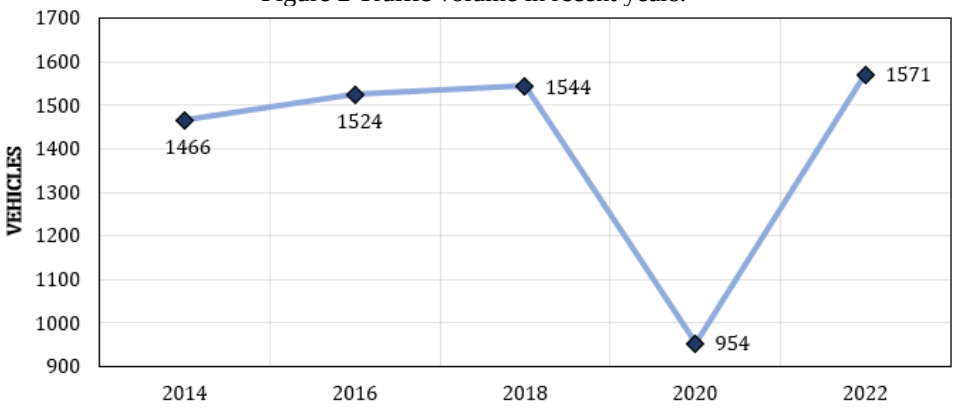
As for the capacity of the vehicles considered, all previous studies used the same standard categories. Buses traveling in the corridor were classified as light, medium or heavy, light when many seats were unoccupied, medium when all seats were occupied and heavy when several passengers were standing.

The times at which the counts were carried out were determined to ensure that the existing traffic was represented over a 24-hour period.

Hourly intervals not covered in the surveys were disregarded due to virtually zero vehicle traffic during these periods.

Figure 2 shows the evolution of traffic over the last years in which the survey was carried out.

Figure 2 Traffic volume in recent years.



Source: Authors (2023).

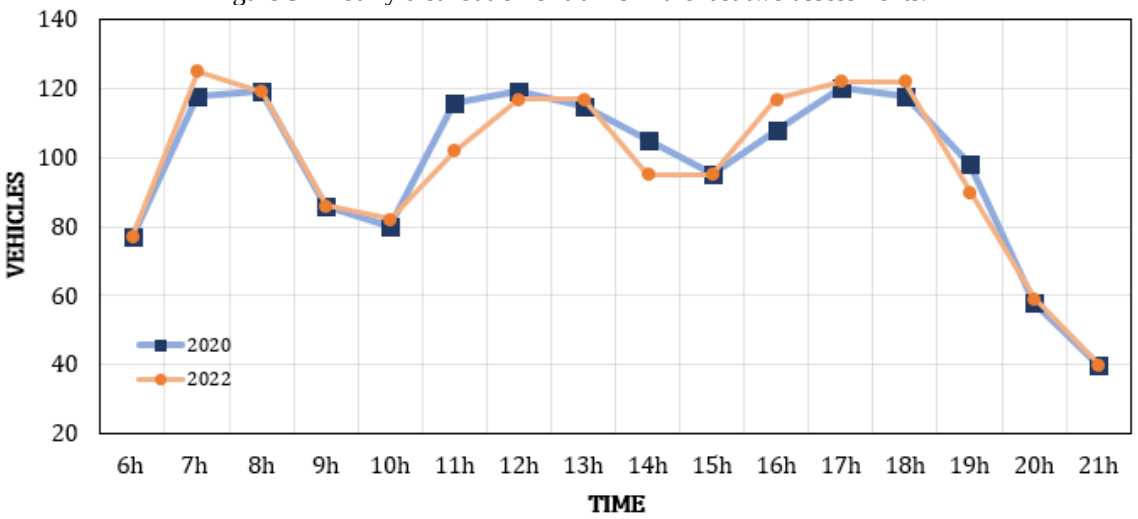
Analyzing the traffic observed over the last years, as shown in Figure 2, it is possible to verify a maximum total of 1571 vehicles in the year 2022. Considering that the concrete sidewalk was designed to withstand a daily demand of 1000 vehicles, it can be seen that the highest traffic exceeds the expected by almost 60%.

On the other hand, in the sidewalk design it was predicted that 80% of the vehicles would travel with maximum load. Thus, according to the design VMD, 800 vehicles would travel daily with a load equivalent to the Heavy condition or higher. In the count carried out in 2022, only approximately 3.5% of the observed traffic was traveling with a large passenger capacity, a value well below the design dimension.

It can also be observed that Figure 2 shows an upward curve, which represents the increase in traffic over the years, consistent with the constant increase in demand for transportation. Even so, traffic growth has been occurring slowly, with an increase of just over 100 vehicles over 8 years, from the first to the last survey carried out.

Figure 3 shows the distribution of traffic throughout the day in the last two evaluations carried out, making it possible to observe the hourly variations in flow. The traffic in the last two years analyzed, as can be seen in Figure 3, presented the same three distinct peaks. The hour intervals that comprised the traffic peaks are from 07:00 to 09:00 hours, from 11:00 to 14:00 hours and from 17:00 to 19:00 hours, representing the times when the concrete sidewalk was most requested by traffic. Also, it is noticed that these traffic peaks coincide with the start and end times of commercial and school activities, which justifies the increase in flow during these periods.

Figure 3 - Hourly distribution of traffic in the last two assessments.



Source: Authors (2023).

5 FINAL CONSIDERATIONS

As can be seen, in several countries Portland cement sidewalk has become preferred for highways since it simultaneously performs the functions of base and coating. However, the lack of more specialized construction knowledge turns out to be a preponderant factor for the emergence of numerous pathological manifestations over the years, which entails a high cost of early maintenance, since many of these interventions are necessary before the useful life of the sidewalk established in the project.

Concrete paving is far superior to asphalt paving, with its very high durability, low maintenance and speed of execution as its main advantages. Among others, it is precisely the independence in relation to the joints, since they work as two separate independent sidewalks, but which deform in the same way.

Repairs are directly related to the pathology manifested, which can be extremely complex when they show cracks of various types and in high impact locations. Because of this, poor traffic projection can lead to incorrect sizing of sidewalk thickness, and consequently, lack of control in execution.

In view of this, the study of problems occurring in concrete structures contributes to the elaboration of guidelines for new projects. It is important to know the mechanisms of formation of these pathological manifestations, to find more appropriate and economical solutions. A detailed study on the economic feasibility of using rigid sidewalks, with a determined plan of quarterly or semi-annual inspections, and the effect that can impact on the lower cost of repairs considering that with a more regular inspection and in shorter spaces of time the intervention in the sidewalk tends to be smaller and cheaper consequently. The frequency of these studies can contribute to the identification of the most common anomalies, opening space to identify with greater care the increase in the life of the sidewalks.

REFERENCES

BALBO, J. T. Pavimentos de concreto. São Paulo: Pini, 2009, p. 45-90.

Confederação Nacional do Transporte – CNT. Pesquisa CNT aponta 58,2% das rodovias com problemas. p. 23-25. Disponível em: <https://cnt.org.br//pesquisa-cnt-aponta-58-das-rodovias-com-problemas>. Acesso em 15 de fevereiro de 2023.

DEPARTAMENTO NACIONAL DE INFRAESTRUTURA DE TRANSPORTES. DNIT. Manual de recuperação de pavimentos rígidos – Publicação IPR – 737. Rio de janeiro, 2010, p. 009-078.

____. DNIT, 062/2004 PRO. Pavimento rígido – Avaliação objetiva – Procedimento. Rio de Janeiro, 2006, p. 45-78.

____. DNIT, Manual de Estudos de Tráfego. Rio de Janeiro, 2005. (IPR. Publi., 723), p. 12-18.

FHWA, M. Y.; WALTHER, J. A. Pavement Maintenance Management for Roads and Streets Using the PAVER System. Construction Engineering Research Laboratory, US Army Corps of Engineers, 2003, p. 34.

NASCIMENTO, D. Recuperação de pavimentos de concreto. 3º Congresso de Iniciação Científica do Centro Universitário do Distrito Federal – UDF: Vol. 1 – Nº 1 / Nov. 2013, p. 65.

PEREIRA, D. M. Introdução aos Sistemas de Transportes e à Engenharia de Tráfego. Notas de Aula, Disciplina: TT 401 – Transportes "A", Universidade Federal do Paraná, 2007, p. 67. Disponível em: <http://www.dtt.ufpr.br/ApostilaSistemasDeTransportes-2008.pdf>. Acesso em 17 de fevereiro de 2023.

SANTOS, P., PEREIRA, P., BRANCO, F. Pavimentos rodoviários. Almedina, Coimbra, 2006, p. 56.

SCHIAPATI, R. S.; COMAR, L. C. A Influência de Rodovias na Área Urbana. 14 p. In. Revista Nacional de Gerenciamento de Cidades, Vol. 02, nº 13, 2014, p. 67.

SENÇO, W. Manual de Técnicas de Pavimentação. 2.ed. São Paulo: Pini. 2007. v.1, p. 65.

SILVA, P. F. A. Manual de Patologia e Manutenção de Pavimentos. 2.ed. São Paulo: Pini, 2008, p. 56-89.

VITÓRIO, C. R. Patologia em pavimento rígido. Curitiba: IDD, 2011, p. 43.