DIAGNOSIS OF PATHOLOGIES IN BRIDGES OF THE ROAD SYSTEM IN BRAZIL

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ABSTRACT

Infrastructure is an indispensable and decisive requirement for the economic development of a country; it is directly linked to the set of structural economic activities and serves as the foundation for the development of other activities. In this context, the bridges have fundamental importance to the social and economical development of the cities, because the roads are to ensure the entry of inputs on farms, as well as the disposal of products and free movement of populations. The aim of this study is to present a survey of the existing bridges in the south region of Brazil, more specifically in the city of Pato Branco, identifying the most recurrent damages, in order to provide bases to administrators, with the intention of ensuring the correct functioning of the transport infrastructure and in the preservation of public property and security for the users. Data collection was conducted through visits, using the method of visual and photographic records. After the analysis was done, we identified several pathological manifestations, both in concrete and wood bridges, such as moisture stains, cracks, corrosion, erosion, clogging of drains; wood decay, lack of verticality of the pillars and foundation repression, among others. Moreover, there was little or no maintenance on the existing bridges. Similar conditions can be observed in most cities in the south region of the country.

Keywords: bridges; concrete structures; wood structures; maintenance

REZUMAT

Infrastructura reprezintă o cerință indispensabilă și decisivă pentru o țară; ea este direct legată de un set de activități economice structurale și constituie baza pentru dezvoltarea altor activități. În acest context, podurile au o importanță fundamentală pentru dezvoltarea economică și socială a orașelor, deoarece căile de comunicație asigură aprovizionarea fermelor, ca și livrarea produselor și mișcarea liberă a populației. Scopul studiului de față este de a prezenta o situație a podurilor existente în zona de sud a Braziliei, și anume în orașul Pato Branco, identificând cele mai frecvente avarieri, pentru a furniza administratorilor baza asigurării funcționării corecte a infrastructurii de transport, întreținerii proprietății publice și menținerii siguranței utilizatorilor. Colectarea datelor a fost realizată prin vizite la fața locului, utilizând metoda înregistrărilor vizuale și fotografice. După analiza acestor înregistrări, au fost identificate numeroase manifestări patologice, atât la podurile din beton, cât și la cele din lemn, precum, între altele, pete de igrasie, fisuri, coroziune, eroziune, înfundarea scurgerilor, putrezirea lemnului, deficiențe în verticalitatea pilelor și deformații la fundații. Mai mult, s-a constatat o mentenanță slabă sau absentă a podurilor existente. Condiții similare pot fi observate în majoritatea orașelor din zona de sud a țării.

Cuvinte cheie: poduri; structuri din beton; structuri din lemn; mentenanță

1. INTRODUCTION

Infrastructure is an indispensable and decisive requirement for the economic development of a country; it is directly linked to the set of structural economic activities and serves as the foundation for the development of other activities. Among the many works of infrastructure, the bridges have fundamental importance to the development of the cities, economically and socially speaking, because the roads are to ensure the entry of inputs on farms, as well as the disposal of products and free movement of populations.

Bridges are structures of high cost of construction, repair and recovery. When an intervention is necessary, it causes big disturbance and an incalculable social cost. Thus, investment in preventive actions, both in terms of better knowledge of pathological manifestations, and also in preventive maintenance techniques during use (Laner, 2001), is justified.

The Brazilian road system is formed by bridges of different ages, designed and sized according to different criteria and supposed to stand the traffic of moving loads ever increasing. At the same time, some works were built with structural process now condemned, and this situation is true for the city of Pato Branco, located in the south of the country.

This set of works, aged and degraded, should be carefully and regularly inspected, in order to assess load capacity, safety and comfort to provide users maintenance and improvements (Brazil, Manual Inspection of Road, 2004).

The Union, States and cities, in their absolute majority, do not adopt systematic procedures for inspections and maintenance of the bridges that are part of their road network. As a result, these works are undergoing a process of deterioration whose evolution over time can lead to structural failure of a significant part of them.

The aim of this paper is to present a study of the structural conditions and pathological manifestations of the bridges in the city of Pato Branco, seeking to ensure the correct functioning of the transportation infrastructure in the preservation of public property and safety for the users. With this purpose, it was originally performed the geographical mapping of the bridges in the city of Pato Branco, which were, in sequence, identified and characterized by type of structure, size, age and material.

The following items of this work succinctly describe the methodology employed, as well as the analysis and discussion of results and final considerations. Further details of the conducted study can be obtained in Milani (2010).

2. METHODS AND MATERIALS

Pato Branco is located in Paraná State, distant 433 km from the State capital, Curitiba, has a total area of 562.30 km2 and 16.22 km2 in urban areas. It has a population of approximately 70,160 inhabitants. The main economic activities are the production of soybeans and corn, and dairy, with agricultural production of R$ 94,836,878.86 (DERAL / SEAB - 2008).

The method used to identify the most frequent damage of the bridges was based on the standard inspection DNIT - Standard 010/2004 - PRO, which aims to interpret and evaluate harmful occurrences found during inspections and can be visual and instrumental. In this case, it was only visual, but based on photographic recordings.

The data were obtained primarily through personal non-participant observation, with a descriptive reporting and photo illustrations. Non-participant data collection manifests for the researcher that the relationship is simply a field one. Participation tends to be deeper because of an informal observation of the most relevant facts and of monitoring of daily practices (Marconi & Lakatos, 2001).

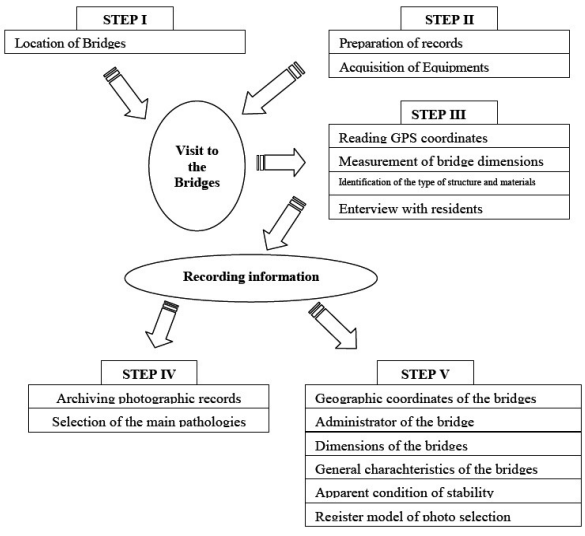

Figure 1. Stages of research

Data collection was developed through visits to the road system bridges in the city of Pato Branco for three months. Thus, the general outline of the research demanded five consecutive steps, as described in Figure 1.

Based on the map of the city road system (http://www.ippupb.org.br/) and with the help of Google Earth (http://earth.google.com/), we identified the possible bridges located on roads.

3. ANALYSIS AND DISCUSSION OF RESULTS

This study sought to identify the bridges in the city of Pato Branco, showing the main aspects of each one, such as: location; superstructure material, length, width of the lane, type of structure, age estimate.

The administration of the bridges (Fig. 2), 66% is responsibility of Pato Branco City. In addition to its bridges, the city is administratively partnering with other towns: 9% with Itapejara D'Oeste, 5% with Vitorino; Mariópolis with 5%, 3% and 2% in Clevelândia with Honório Serpa. Other bridges that are part of this road network are well managed: the DNIT 5% and 2% with the DER-PR.

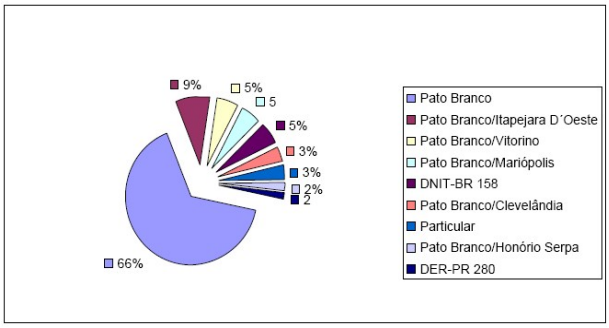

Figure 2. Administration of the bridges

The structural model found in the bridges is composed, on wood bridges, of roundwood or rough-hew beams and in concrete bridges, of beams and slabs (Fig. 3). The precast beams such as "I", and "T" predominate, and there are also concrete beams cast on the site. The slabs are mostly made of reinforced concrete cast on the site and some were executed with pre-cast slab with layer of concrete.

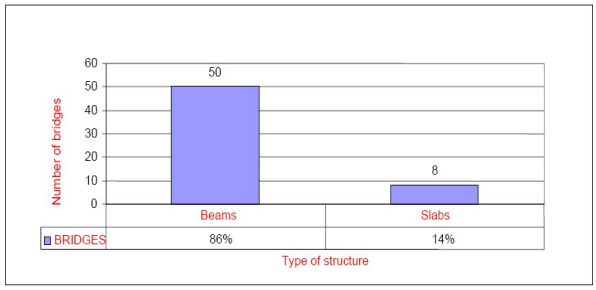

Figure 3. Structural model of the bridges in the city of Pato Branco

The existing bridges in the city are composed of 74% of small bridges under 10 meter long and 90% with extension below 20 meters (Fig. 4). The sum of concrete bridges occurs is composed of an area of 765.70 meters and wooden bridges a range of 197.25 meters, totaling 962.95 meters of bridges in the city. The longest bridges are administered by agencies of the State and Federal government. It should be noted that in the case of small bridges, we noticed the lack of care with design, implementation, use, maintenance and other care which requires a work of such importance as bridges, whose risk is not restricted to occasions when there is any accident or impossibility to move.

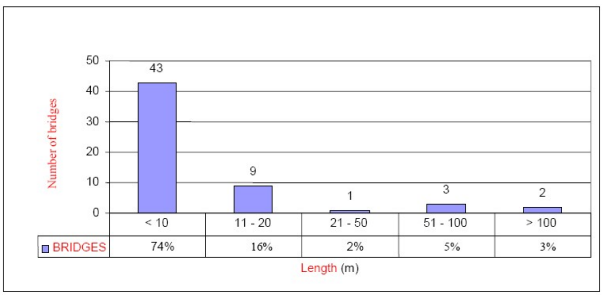

Figure 4. Length of the bridges in the city of Pato Branco

The age of the bridges (Fig. 5) is difficult to obtain concerning a precise data, because of the lack of registers by the responsible agencies. The information in this chart is a result of registration plates fixed on the bridges and inscriptions in fresh concrete, as well as for field research through interviews with residents bordering the bridges.

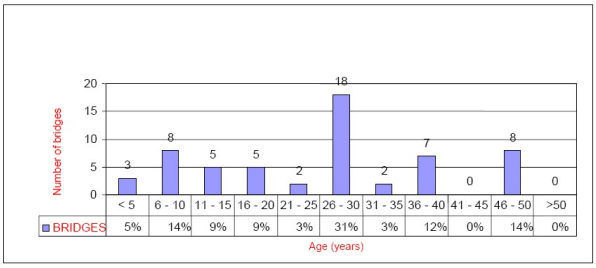

Figure 5. Estimated age of the bridges of the city of Pato Branco

The bridges of the city of Pato Branco were built with easy-to-purchase materials, being 48% in wood and 52% in concrete (Fig. 6). However, it should be noted that the lack of planning and qualified technical staff to handle these materials eventually resulted in a myriad of pathologies.

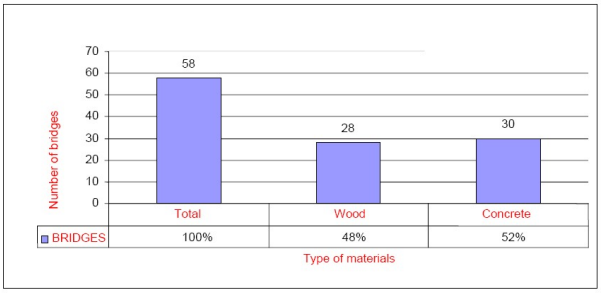

Figure 6. Material of the superstructures of the bridges in the city of Pato Branco

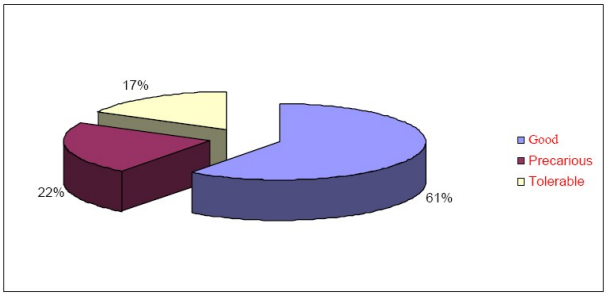

Figure 7. Conditions of apparent stability in accordance with the standard 010/2004 - PRO DNIT

It would be advisable that those responsible for implementation and maintenance of this public property draw up plans for management of bridges in order to a have better physical and financial performance and greater security for its population.

It is apparent that the conditions of stability (Fig. 7) of the bridges in the city of Pato Branco require urgent improvement as 22% of them are in precarious situations, 17% in a really fair state (Standard 010/2004 - PRO DNIT) .

The following are some illustrations of pathologies found in the elements of concrete bridges in the city of Pato Branco:

The bridge of Figure 8 shows, near the drain pipes, stains and peeling from the concrete and apparent reinforcement in advanced stages of corrosion. It is an established fact that one of the most common symptoms and impairment are the stains on the concrete and corrosion of reinforcement.

Figure 8. Peeling of concrete and corrosion of reinforcement

Figure 9. Reinforcement corrosion of the side beam of the bridge

The bridge of Figure 9 shows accelerated corrosion caused by the lack of drip tray on the side and improper coating on the reinforcement. Incorrect use of drip pans and nests of concrete in concrete structures is a failure that may, individually or together, create the necessary conditions to reduce the life cycle of the structures.

Figure 10. Detail of fixed pipes in the slab of the bridge

Figure 11. Bottom view of the slab in the access of rainwater drainage

One can check on the bridge of Figure 10 the detail of fixed pipes in the slab of the bridge. There is lack of planning for attaching external elements such as pipes, causing a starting point of corrosion process of the reinforcement. The rain water galleries were performed directly on the slab of the bridge. In Fig. 11 it is noticed that the corrosive process is intense because of constant moisture.

On the bridge of Fig. 12 there is a disruption of the structural element in the balance of access. Among the pathological problems found in the bridge we noticed the excessive apparent vibration felt during the inspection of the bridge

Figure 12. Disruption of the access balance of the bridge structure

The impact on the structures of the bridges (Fig. 13) in the city of Pato Branco occurs, almost entirely, due to tree trunks that are dragged by water streams and end up colliding with structural elements of bridges, causing damage to the structure.

Figure 13. Tree trunks impacting on the pillar

It can be seen on the bridge of Fig. 14 that it is the containment of the landfill and support beams of a wooden bridge, where erosion has occurred in the foundations causing the disruption of the concrete. The lack of

reinforcement is visible on this support structure.

On the bridge of Fig. 15 it can be seen, apparently, the phenomenon of abrasion caused by the friction of vehicular traffic, causing deterioration on the concrete pavement of the board and exposing the reinforcement.

Figure 14. Disruption of the support and containment concrete of the bridge

Below are some pictures with the main pathologies found in the wood elements of the bridges in the city of Pato Branco.

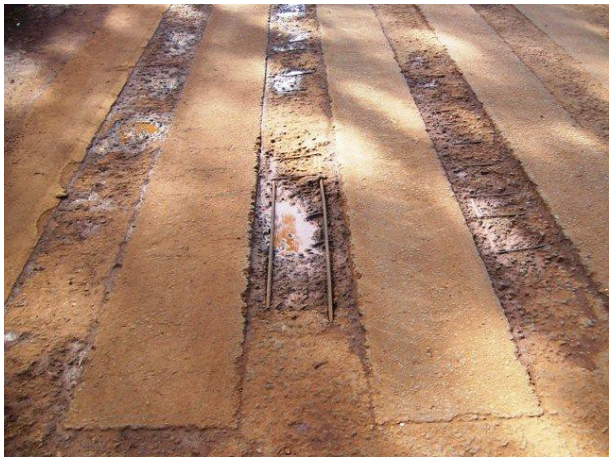

Figure 15. Deterioration of the concrete pavement with reinforcement exposure

On the bridge of Fig. 16 the beam is attacked by microorganisms, bacteria and fungi that cause the wood to rot. In wooden structures of bridges fungi meet favorable conditions for their development because of favorable factors such as humidity, temperature, oxygen, little sunlight.

Figure 16. Wood attack by bacteria and fungi (Bridge P119)

It can be seen on the bridge of Fig. 17 the attack of insects in the logs (support beams of the bridges). The wood suffers attack from several species of insects such as termites and larvae, which use the wood as a shelter and source of feeding

The insects produce galleries which reduce dangerously the resistant sections of the parts in service, facilitating the entry of moisture, necessary for the development of fungi.

Figure 17. Insect attack in logs (beams) of the bridge support

On the bridge of Fig. 18 one can notice the rotting of the wood caused by the attack of biotic agents.

Figure 18. Bridge beam rotting

Part of the rainwater that passes through the cracks of the joints of the board is retained in the regions of contact between the stringers and crossbeams thus providing a faster degradation of the elements of the bridge.

On the bridge of Fig. 19 there is an advanced stage of deterioration with rupture of the beam, indicating an imminent collapse.

It can be seen on the bridge of Fig. 20 the defects caused by several factors, such as attack by fungi and insects; damages due to overloads, connection of the pieces, displacements, cracks, defects in the wood like cracks, knots, cup shakes, sweep , camber, warping, among others.

Figure 19. Wooden beam at an advanced stage of decomposition

The bridge of Fig. 21 has its board endangered. All the wood presents widespread deterioration. Besides the board, this bridge has the support structure with an apparent state of collapse of beams and reinforced concrete columns.

Figure 20. View of the board showing extensive damage

Figure 21. Overview of the board

Figure 22. Cantilevered crossbeam to support beams

The bridge in Fig. 22 had its central pillar built with lean concrete and a large quantity of bush rocks without reinforcement. There is support for the stringers with a tree trunk in balance, without adequate fixation and without continuity of the crossbeam.

On the bridge of Fig. 23 we identified disruption of the wooden beam and damage in the board. It is observed fungal attack on all pieces of wood.

Figure 23. Disruption of the beam and fungi attack

Regarding the general characteristics of the lanes, 54 out of the 58 bridges of the city (93%) do not have any road shoulder, 51 (88%) do not have sidewalks; 29 (50%) do not have wheelguards, 50 (86%) do not have parapets, 55 (95%) of the bridges do not have road signs, the lines on the lanes are difficult to identify, and they are mostly of one line.

Another important finding is that in 14 (24%) bridges the flow section seems insufficient.

4. CONCLUSIONS AND FINAL CONSIDERATIONS

It was found that the structural model found in the bridges of Pato Branco city consists, fundamentally, on wooden bridges, of roundwood and rough-hew beams, and in concrete bridges, of beams and slabs. Most bridges are made up of bridges under 10m long and the majority has an extension under 20 meters. Concerning their ages, the prevalence of bridge structures is over 20 years, and most (18 bridges) between 26 and 30 years. Additionally, we identified 15 bridges with supposed ages between 36 and 50 years.

The main pathologies found in the elements of concrete bridges were: peeling from the concrete; corrosion of the reinforcement, some with greater intensity and some a little less, indicating the lack or failure of reinforcement cover; clogged drains; accumulation of water in the bridge deck caused by faults in the drainage system, which causes the appearance of wetlands intensifying the corrosion of the reinforcement; concrete erosion caused by flowing water, among others. Most parapets present peeling of the concrete with signs of corrosion of the reinforcement.

The main pathologies found in the wood elements of the bridges were: wood damage by insects and fungi attack; bridge beams in advanced stage of decay; mechanical abrasion on the bridge deck (wheelset), defects in the wood pieces, bridges made by improvisation not providing security either for vehicles or for users.

There was little or no maintenance on the existing bridges. At some bridges there is some recovery work, but poorly executed. This lack of maintenance ends up accelerating the emergence of several kinds of problems.

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