Monitoring and performance analysis of two pavement sections of highway BR-448/RS included in the Asphalt Thematic Network Project

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ABSTRACT

The highway modal is responsible for the majority of loads and passenger transportation in Brazil, but the lack of conservation of pavements has caused several losses to the country economy. Only through suitable pavements management the rehabilitation measures taken might ensure a satisfactory level of service. The present research aimed at evaluating the performance of two pavement sections on federal highway BR-448/RS, in southern Brazil. During three years, the evolution of the structural capacity and functional condition were followed in order to propose interim performance trend lines. Deflections, permanent deformations and surface distresses surveys scarcely varied and were quite low due to the thick asphalt layers (19 cm). On the other hand, segregation of the asphalt mixture was observed when the final layer was laid. That segregation affected the pavement texture, reduced tire-road friction and caused the formation of surface water films, reducing the road safety. In general, the proposed trend lines predicted quite accurately the pavement performance throughout the period evaluated, although it is recognized that a longer monitoring period is mandatory in order they become performance models.

Keywords: Flexible pavements; Performance monitoring; Trend lines.

1. INTRODUCTION

In Brazil, although goods and people transportation is predominantly done through highways, this modal infrastructure has historically shown remarkable deficiency. The lack of conservation of the road network has caused several economic damages to the country, such as: loss of production, increase of vehicles operation cost, greater risks of accidents, among others.

The poor quality of highways is a reflection of a history of low investments in the sector, where in 2015 federal investment in transport infrastructure was only 0.19% of GDP [1].

In the last decades, the quality of Brazilian pavements has diminished due to factors, such as the increasing traffic volume, climatic and environmental changes, inadequate pavement maintenance, among others. Besides, the ancient empirical method of asphalt pavement design officially adopted no longer meets the actual traffic demands.

Such scenario has supported a nationwide effort with the purpose of developing a new method for asphalt pavement design, which was launched in 2009 and known as the Asphalt Thematic Network Project. The program includes: a complete characterization of materials used in the pavement sections; following pavement construction and performance monitoring. In Rio Grande do Sul state, researches of the Federal University (UFRGS) have monitored test sections built in two federal highways (BR-290/RS and BR-448/RS).

In this context, this paper reports and analyses the performance of two test sections in the BR-448/RS highway, in order to contribute to the development of the new flexible pavement design method.

2. BACKGROUND

According to AASHTO [2] the performance of a pavement is the ability of this to meet its objectives over time. In order to predict this performance, the Restoration Pavement Manual - IPR-720 [3] states that it is necessary to quantify the reduction of utility or generation of defects throughout the service life of the same.

The present and future evaluation of pavement performance involves techniques to obtain parameters of performance in the field, knowledge of the behavior expected for each type of pavement and use of mathematical models that make it possible to portray the pavement behavior along the pavement over time [4].

The performance of a pavement is closely linked to the deterioration mechanisms of the pavements. In this way, it is important to point out that the main factors that contribute to the beginning, and propagation of deterioration are climatic factors, traffic demands, functional and structural behavior, physical and chemical characteristics of building materials and pavement age [5,6]. Thus, for the development of a rational method of designing flexible pavements, it is essential to establish design criteria based on adequate performance prediction models.

The performance models are established to predict the speed at which the values of the functional and structural parameters of the pavements vary according to the requests of the traffic or the climatic conditions. They are used by Pavement Management Systems as a tool to aid decision making.

The performance prediction models developed in Brazil with the highest international recognition were incorporated into the HDM system with some adaptations [5,7]. In regional terms, the performance models proposed by [8-10] present good results. Finally, the trend lines presented for the highways monitored by UFRGS [11-13], help in the understanding of highway performance in southern Brazil.

3. METHODOLOGY

The highway BR-448/RS, is located near the metropolitan area of Porto Alegre, in the state of Rio Grande do Sul, with a length of 23 km. It was concluded in December 2013 and since then, two sections have been monitored, with section I located between km 15+600 and km 15+900 and section II between km 16+760 and km 17+060. The follow of the construction of the experimental sections and the analysis of the materials used are presented in Bock [11].

The two experimental sections were defined according to the geotechnical design solutions adopted. In section I vertical drains were implanted to consolidate soils of the subgrade. In Section II, the removal of soft soils and the replacement with sandy soil, forming a draining mattress. The highway structure has a 5 cm layer of polymeric asphalt concrete, 14 cm of conventional asphalt concrete, 19 cm of granular base and 21 cm of sub-base dry macadam.

The activities developed to evaluate the monitored sections consisted of monitoring of the evolution of parameters of functional and structural performance. TABLE 1 shows the dates of the monitoring carried out together with the respective traffic estimates (N_{AASHTO}).

TABLE 1 Date of monitoring performed

Date	Monitoring	Traffic
15/12/2013	0 months	0.00E+00
08/03/2012	3 months	8.22E+05
27/09/2014	9 months	2.48E+06
18/04/2015	16 months	4.45E+06
23/01/2016	25 months	7.27E+06
17/12/2016	36 months	1.19E+07

3.1 Field Tests

The structural evaluation of the pavement was performed with the measurement of deflections through the Falling Weight Deflectometer (FWD), following the standard DNER-PRO 273/96 [14]. The choice of equipment was due to the presence of deflections closer to those that would be caused by a real dynamic load.

The comfort conditions were evaluated by measuring the irregularity associated with the road, determining the International Roughness Index (IRI). The evaluation of the longitudinal irregularity is established by standard DNER-PRO 182/94 [15] and the equipment used was the Inertial Laser Profiler.

The permanent deformations were measured according to the DNIT 006/2003-PRO [16] procedure, which determines the use of a standard aluminum framework with a length of 1.20 m at the base and fitted with a movable ruler.

In order to evaluate the tire-pavement adhesion, the macrotexture and the microtexture of the pavement were verified. The test used to determine the roughness of the pavement was the Sand Patch Test, standardized by ASTM E 965-06 [17]. The equipment used to check the microtexture was the British Pendulum [18], which determines the surface slip resistance with the measured friction value expressed in BPN (British Pendulum Number).

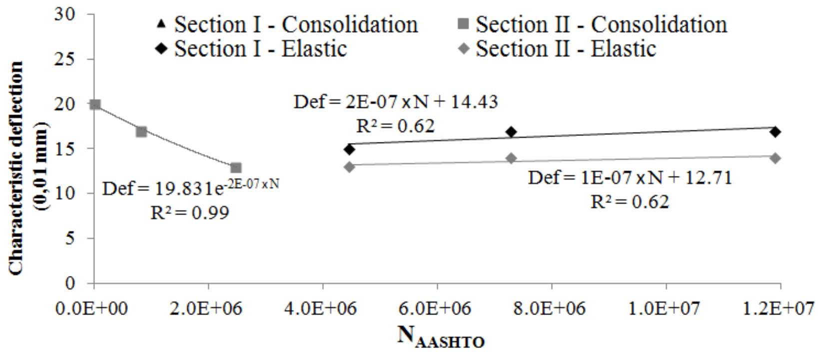
The survey of defects followed the standards of identification and interpretation of the degradations established by standard DNIT 005/2003 – TER [19]. An objective evaluation of the surface of the pavement was carried out, according to standard DNIT 006/2003-PRO [16] establishing the Global Severity Index (GSI).

4. RESULTS

4.1 Deflections (FWD)

The structural evaluation is an important parameter that verifies the evolution of deflections at the top of the pavement due to traffic. FIGURE 1 shows the trend lines of the maximum deflections of each section, corrected according to the temperature.

FIGURE 1 Trend lines of the deflections measured in the two sections

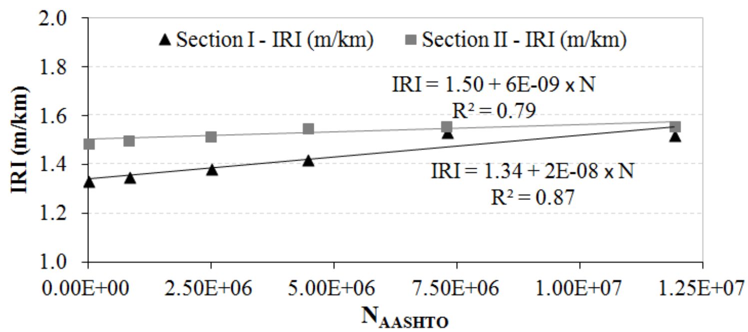


The maximum deflection values obtained were very low, which may be related to the robustness of the pavement structure, where only the coating layer is 19 cm thick. It is possible to observe a very similar evolution of the deflection with the passage of time for the two sections. In the first months of opening to traffic there was a strong reduction of deflections, corresponding to consolidation due to traffic. Only after a traffic of $2.48x10^6$, does section I begin to present deflections greater than section II, entering the elastic phase.

4.2 Longitudinal Irregularity

For the BR-448/RS highway, the International Roughness Index (IRI) was also evaluated, which is presented in FIGURE 2 through trend lines.

FIGURE 2 Trend lines of the IRI in the two sections



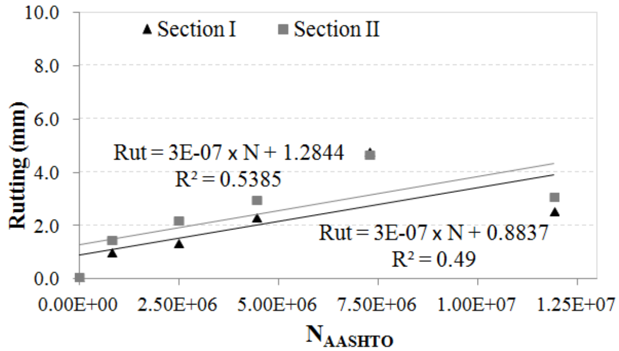
Immediately after the construction of the highway, section I presented a lower IRI than section II, being 1.33 m/km and 1.49 m/km, respectively. However, observing the evolution of the parameter during the first months, we can see an approximation of the values, where section I presented a higher rate of evolution than section II, and this factor may be associated to the different solutions adopted in the subgrade of each section. Currently, the two sections have IRI values of 1.56 m/km (section I) and 1.52 m/km (section II).

According to Bock [11], the Pavement Executive Project specifies that the final layer should have a maximum IRI of 2.5 m/km. In this way, the two sections are classified in an "excellent" condition.

4.3 Wheel Path Depressions

Permanent deformation is an important parameter for the safety of road users. The evolution of the permanent deformation for the two sections can be seen in FIGURE 3.

FIGURE 3 Trend lines of the evolution of the rutting

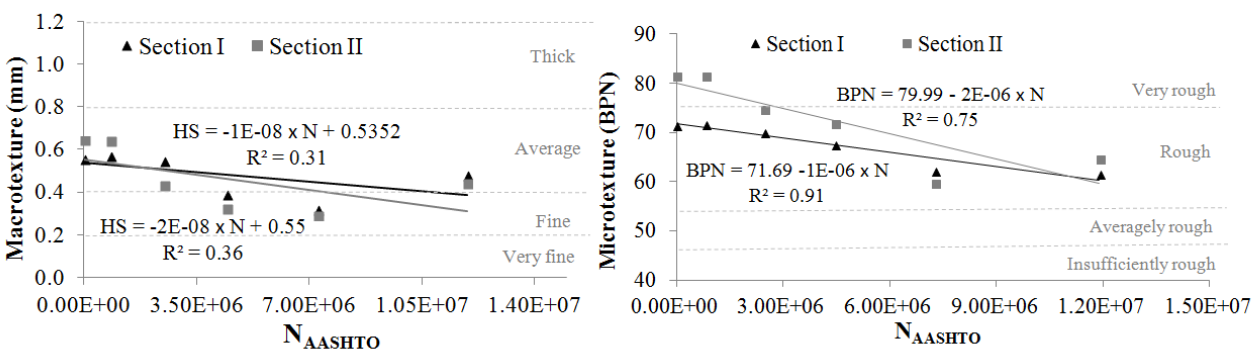


As traffic demand increased, deformations increased gradually, with maximum values of 4.8mm. In the last survey (36th month) a decrease in deformation was observed for the two sections. It is quite probable that the rutting are very open, which makes their measurement difficult and can result in not locating the most critical point.

4.4 Tire-road Friction

The data collected in the wheel path for the evaluation of the macrotexture (Sand Patch Test) and microtexture (mean BPN value) are presented in FIGURE 4 through trend lines.

FIGURE 4 Trend lines for the evolution of macrotexture and microtexture



Considering the macrotexture of the pavement, during the first two years of monitoring there was a marked drop, going from an "average" condition to a "fine" condition of texture. In the last inspection, an increase of the macrotexture of the pavement was observed, returning to the "average"condition.

In relation to the microtexture, initially the mean values in section II were significantly larger than in section I. Section II, which presented a "very rough" surface until a traffic of

2.48×10^6, soon passed to a “rough” surface. Section I presented from the beginning a decreasing rate lower than that of Section II.

In the execution of the sections, it was verified that the quality of execution of the asphalt mixture was not satisfactory, presenting segregation [11]. Another aspect identified during the monitoring is the loss of surface texture, characterizing an aggregate polishing. These two factors caused great variability of the results in the sections, and could affect the safety of the vehicles in day of wet road.

4.5 Surface Distresses

During the three years of monitoring, no critical defects were observed, only wearing surface (affecting roughness) and bleeding. The Global Severity Index (GSI) confirms this low incidence of defects, where section I obtained a GSI of 15.3 and section II a GSI of 12.6, classifying the pavement as “excellent” in the two monitored sections. FIGURE 5 shows the current surface appearance of the two monitored sections after 36 months.

FIGURE 5 Appearance of the coating layer after three years of monitoring

5. CONCLUSIONS

The surveys carried out in three years on the BR-448/RS highway allowed to follow the evolution of pavement degradations, making possible to evaluate its performance.

The measured deflections scarcely varied from the beginning of the traffic loads (between (20×10^{-2}mm and 14×10^{-2}mm) up to this date. In the same way, IRI and permanent deformation values were also low.

Significant segregation of the asphalt mixture was observed when the final layer was laid, which latter affected the pavement texture, reducing tire-road friction. The macrotexture of section II initially “average” (HS = 0.64mm) reached the texture limits “fine” (HS = 0.4mm) after N_{AASHTO} equal to 3×10^6 (only 10 months of traffic). In comparison, in section I that limit was reached latter (after 16 months), after traffic accumulating N_{AASHTO} of $4{,}45 \times 10^6$.

These values show the reduction of tire-road friction, suggesting the formation of surface water films along with a greater accumulation of water in the wheel paths, which can considerably affect the safety of road users.

The data here presented and analyzed have helped in the development of a preliminary version of the new Brazilian method for asphalt pavements design, while the proposed trend lines will yield performance model to be used in pavement management.

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