The usage of pavement drains in roads with asphaltic revetment - The Brazilian experience road BR-277

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RESPONSIBLE FOR THE SUB-SUPERFICIAL DRAINING PROJECT OF THE BR-277 – SECTION CURITIBA - PARANAGUÁ

SUMMARY

This paper was elaborated to demonstrate the necessity of pavement drains when asphaltic revetments with draining properties are used, whose objective is to eliminate problems of hydroplaning and to improve the vehicle's adherence. The usage of this kind of revetment allows infiltration of water volumes which can cause damage to the pavement and reduce its useful life. Being aware of this, there is a necessity of draining the infiltrated water and/or existent water in the asphaltic pavement layers. The usage of pavement drains has been the most common resource used to collect this water and destine them to a safe disembogue.

This paper presents the Brazilian experience in pavement drains, showing its aplication even in new pavements as in old pavements that have suffered restoration. The paper refers to the projected and executed situations in of the most important Brazilian road, in which the is a big number of vehicles, even commercial ones as passenger ones. The paper contains the narration of the adopted procedures during the project, the solutions proposed, the execution way and the modification made during the construction to permit its adaptation to the real conditions found.

The solutions presented in this paper show the success achieved in the aplication of this kind of draining in order to allow the pavement to have a bigger useful life than the prevision in the pavement project.

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INTRODUCTION

This paper presents all procedures developed to achieve adequate solutions to the problems appearing in pavements with asphaltic revetment in one of the most important roads in Brazil, the BR-277/PR, in the section Curitiba - Paranaguá. From the surrender of operations and administration in this route to a private company on (concession contract), more than ever, solutions were searched to stop the deterioration detected in the pavement, that had been already studied for some time by consulting companies hired by the brazilian government's agency, which, before the concession to a private company, was responsible for the roads administration (DNER - Departamento Nacional de Estradas de Rodagem, in Portugese – In English: National Department of Main Roads).

The solution adopted, introduction of pavement drains, was selected after a careful analysis of elements that can influence in the do pavement condition.

The elements used were:

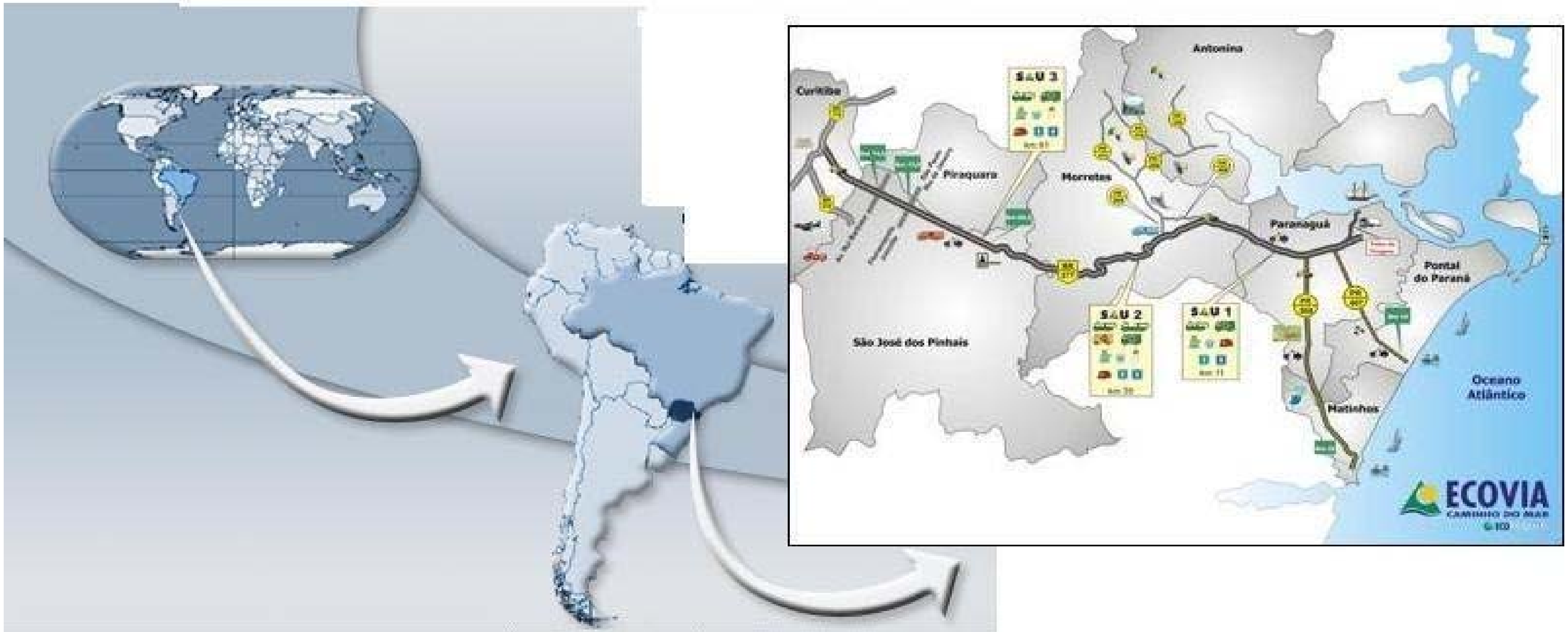
- Traffic Studies
- Topographic Surveys
- Geotechnical Studies
- Pavement and Construction History
- Visual inspections to the road section mentioned

It's worth to mention that, in other Brazilian roads, where were occurring problems from the same nature, similar solutions were adopted and satisfactory results have been achieved in those segments that needed pavement restoration and used this kind of intervention.

SITUATIONAL MAP

The map presented next indicates the localization of the road mentioned in this paper.

The BR-277/PR, road that cuts state of Paraná in the direction East-to-West, links in the section submitted to studies already mentioned, the cities of Curitiba and Paranaguá. In Paranaguá is located the most important port of the country in terms of flowing off harvest, through it flow off around 24,4 million tons/year[1], most of it constituted by soybeans and its derivates. Also through this port are imported 9,0 million tons/year[1] of different goods, and most of the transportation of these products happens with the utilization of trucks that go by the BR-277.


Curitiba
Piraquara
Morretes
Antonina
São José dos Pinhais
Paranaguá
Pontal do Paraná
Matinhos
Oceano Atlântico
SAU 3
SAU 2
SAU 1
ECOVIA
CAMINHO DO MAR

ROAD HISTORY

This section of road BR-277 was implemented with the objective of being an alternative to the railroad transportation that existed between Curitiba and Paranaguá since the end of 19th century. Its implementation occurred in 1946, although its adequate paving only occurred between 1967 e 1968. In terms of altimétric variation, the road develops itself between quota 908 m, in the city of Curitiba, to quota 2m, since its final point is located near the port in Paranaguá, even so, in the region in the crossing of the Serra do Mar it reaches quota 1100 m. The total extension executed was 85,7 km, being able to be divided in 3 segments, considering topographic aspects, to be known: i) Segment between km 85,7 and km 60,0, with an extension of 25,7km, which is denominated plateau (Planalto, in Portuguese), ii) Segment between km 60,0 and km 31,2 with an extension of 28,8km, known as mountain ridge segment (Serra, in Portuguese) e iii) Segment between km 31,2 and km 0,0, with an extension of 31,2km, denominated plain (Planície, in Portuguese). The structure established consisted in a simple track with 2 traffic lanes, each one with 3,6m and paved shoulder in each side of the traffic lanes with a width of 2,5m. Alongside its trace, although it develops itself in different place near the mountainous region, it haven't been built any tunnels, however there was a necessity of implementation of 2 viaducts to surpass talveg that present an very high transversal inclination e whose landfills probably would have big heights. The pavement structure was executed with a layer of bituminous concret of 10cm, foundation/sub-foundation with assorted materials and thickness alongside the section with the utilization of bituminous macadam, soil with crushed stone and soil cement.

With an increase in the traffic volume through the years, the DNER hired a project to duplicate this segment. The Studies and Projects[10] were developed in 1974 and conducted the definition that a new track should be sometimes implemented in the existing road's left side, and sometimes in the right side due to the region's topographic characteristics, especially in those segments, which had been implemented in half hillside creating situations of mixed session in cut and landfill. This option allowed rationalizing the cost of duplication, resulting in a smaller volume of earthwork and reduction in the extension of special art and contention works. Implementation works of the new track and restoration of the old track started in 1976 e were finished in 1981.

During these works, the existing track's pavement structure was restored consisting basically in reinforcing the revetment. On the new track was implemented a pavement[10] whose revetment had 10cm of bituminous concret, foundation/sub-foundation of 22cm e roadbed reinforcement of 42cm. The project's number N considered was $6{,}9 \times 10^7$.

After the implementation of the track duplication and the existing track's restoration, the road displayed a good behavior in its infra and super structure during some years (between 1981 and 1988), however the heavy traffic and nature's agents actions combined with lack of conservation and maintenance started a process of degradation that obliged the DNER to hire a simplified project[11], executed in 1989. From project few solution were implemented, which resulted into deterioration of the road body.

Worried about the section's condition, the DNER hired in 1996 a new project[9], still in expeditious way; however, one more time the solution proposed weren't implemented.

In December 1997 this section had its administration addicted to private initiative in a 24-year concession, what gave origin to the concessionary ECOVIA. This company is controlled by Group Primav Ecorodovias S.A. The group shares'[7] composition is of 65% from Group CR Almeida (Brazil) and 35% from Impregilo IINV (Italy).

One of the first measures taken by the concessionary was to search for a solution to the road's pavement, especially in those sections in the Serra do Mar region, where the pavement was extremely deteriorated.

In the years of 1997 and 1998 studies and projects[3] were hired seeking to evaluate the existing situation and to propose solutions, which permitted the pavement to present characteristics that conducted to road user's comfort and had the usual durability of this nature pavements. The solutions proposed by these papers weren't implemented completely, resulting from that in new damages to the pavement by the time it had been needed by traffic.

In 1999 new studies and projects[8] were hired, this time aiming to a more long lasting solution to this road segment.

In conformity with ECOVIA's solicitation, the Consultant hired to execute these services elaborated an analysis that consisted in a comparative of values of the control parameters from the Programa de

Exploração da Rodovia (PER, Road Exploration Program in the abbreviation in Portuguese) with the ones observed on the road now under studies. The parameters considered from the PER were:

- Maximum value of IGG (Index of Global Gravity) after restoration (< = 40)

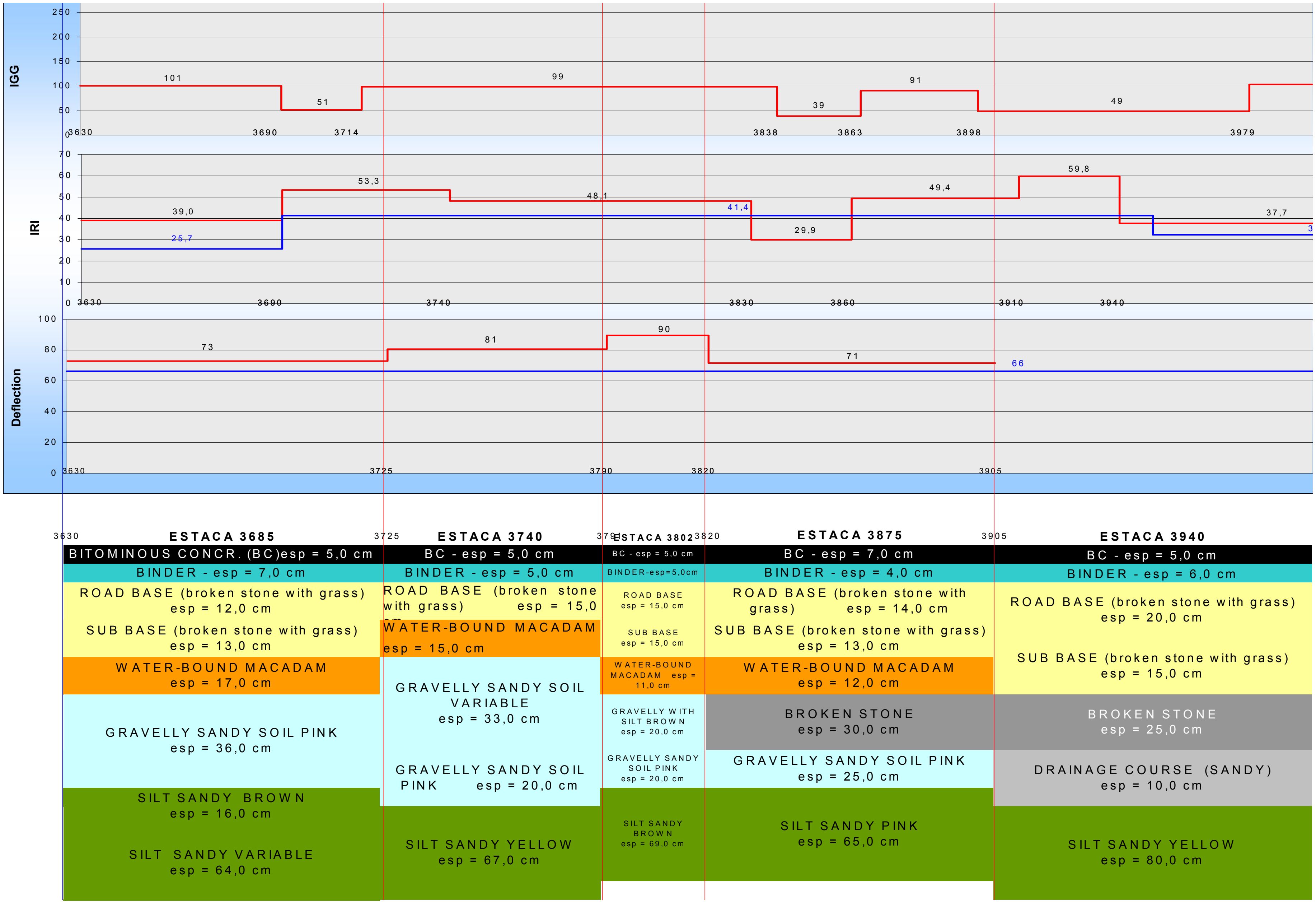
- Maximum values of IRI (International Roughness Index) after the initial recovery and after the restoration (IRI<=4,0m/km and IRI<=2,5m/km);

- Maximum values of the arrow in the wheel track after the initial recovery and after the restoration (f<=20mm and f<=10mm).

To obtain the road's parameters, and later execute the pavement restoration project, at that time, some usual surveys were made to the flexible pavements attending to the "Service Instructions"[5] in vigour, as well as wells were made to make some exploration in a total of 69 (sixty nine) places, with trials being executed with collected materials in 20 (twenty) of these places. These explorations allowed understanding the pavement's characteristics not only about its thickness but also about the composing materials.

With the results obtained during the surveys already mentioned, graphics were elaborated and the information, which helped in the diagnostic and in the solutions of the Pavement Project and the Subterranean Draining Project, was made available

The following drawing is an example of the elaborated material during this stage of the Project[8]



Restoration- graphic of pavement

From the information previously mentioned, it became evident that:

a) There were serious problems of pluvial waters confinement in different segments. Those problems were sensibly analyzed and resolved so satisfactory results could be obtained in the future restoration.

b) It has been observed various modifications were made in the project during the period of track duplication works execution.

c) Some materials presented humidity "in situ" extremely above the optimum compacting humidity. This fact is pretty abnormal, considering the region's weather conditions. All researches made until now tropical regions indicate that the balance humidity of pavement constituent layers is an important rule, a little less important than the optimum humidity. The fact that layers with high water tenor have been observed on the BR-277 indicated that there were places where materials saturation is deriving from problems relatives to the level of the water table or the confinement of pluvial waters.

Analyzing the pavement condition a project was developed to reinforce the pavement, which consisted in particularized situation to each segment, aiming to optimize service costs as well as rationalize its execution.

During the project execution of pavement restoration, it couldn't be forgotten the item draining accordant to what was detected and mentioned previously, also there was special attention given to the subterranean draining project, in which constitutes the main theme of this paper now presented.

VOLUMES AND TRAFFIC COMPOSITION

According to information about the traffic that transits on the road, it has been obtained an average daily volume[6] in the section of 13.690 vehicles, being 10.300 automobiles (75,3%), 340 buses (2,5%) and 3.050 trucks (22,2%).

SUBTERRANEAN DRAINING PROJECT

Existting situation

The studies now narrated and which compose this paper were executed in the most critical segment of this road, by means, between km 60,0 and km 31,2 which correspond exactly to the Serra do Mar crossing.

This Subterranean Draining Project **(Projeto de Drenagem Profunda, in Portuguese)**, elaborated on the scope of the Pavement Restoration Project, had **as** principal intention detecting, diagnosing e solving problems related to water presence, deriving from phreatic water sheet, perchance not yet drained, on pavement layers, including there the subgrade in its final 60cm. For that, exhaustive field inspection were realized by technicians from the Consultant's[8] draining team, when was programmed an investigation campaign composed by the execution of 73,5m of explorations by boring, positioned in various existent cuts alongside BR-277's extension, and established by the field teams allocated to services related to surface and existent pavement structure being that to this definition also were considered information from the field teams. Its works were developed through 6 (six) months, which permitted to understand the behavior of subterranean waters in this road segment.

For the existent pavement layers to be recognized and analyzed and then to apply the reinforcement dimensioning procedures of the pavement, window type exploration wells were executed alongside the road's extension. It's worth mentioning here the register that, by further discussed reasons, these exploration wells, in the moment of their closure, received, to their confined pavement layers relay e because of that saturated, flat drains with the objective of emptying the water excess.

To accomplish the proposed service goal and treat the problem in a judged convenient form by the consultants, the Subterranean Draining Project, according to systems that, eventually, could be foreseen, was divided in 2 parts, to be known:

- Subterranean draining at the cuts' bottom - system rated in terms of pertinent aspects to water draining in the phreatic water sheet, observing the detection e solution of possible harmful actions on the road body, specially on the pavement; and

- Subterranean draining of the pavement - system rated in terms of pertinent aspects to water presence in pavement layers, by other reasons than high water table, objectifying the detection and solution of problems related to excessive levels of humidity of the materials that compose the structure existent.

This waters' action, what is widely known, threatens the capacity of supporting and the pavement's resistance, reducing its useful life.

The proposed solutions, were supported, as mentioned previously, on the following elements:

- Information obtained on field visits made by the author, who was the responsible for the Consultant's Draining Project team;

- Information obtained by the Consultant's resident engineer, based in his daily acquaintance with the section in analysis;

- Information obtained by Concessionary's resident engineer;

- Consultations to implementation, duplication and restoration projects previously made;

- Boring explorations made during December 1999 according to the schedule specifically built for the case, based on field inspections made by the Consultant's Draining team. These investigations, besides searching undesirable water levels, aimed to detect existence of deep drains, characterizing them, especially in terms constituent materials. It's also worth remembering that those explorations were executed during on of them months with highest pluviosity on the region and particularly during this month, December 1999, when different precipitations occurred, and this fact validated the efforts concentrated to accomplish prospections in the referred period. In this way, the search for possible influences of water tables in the road's deterioration could be more precise. The boring explorations related to planed investigations based on the elaborated schedule, were positioned between paved shoulder and the cut's base. 57 (fifty seven) boring exploration holes were effectively executed, being 31 (thirty one) of those on the track Curitiba - Paranaguá and 26 (twenty six) on the track Paranaguá - Curitiba, completing a total of 73,5m that were investigated;

- Information related to deflectométric surveys made with FWD in the whole analyzed extension in a cadency of 50m, and the other pavement surface assessments, on the same cadency of 50m;

- Taking advantage of information contained in window type exploration wells' bulletins; executed regarding the knowledge and characterization do pavement layers in the track/ paved shoulder interface. The 69 executed inspection wells were then analyzed, under draining aspects alongside the BR-277, being 33 (thirty three) in the track Curitiba - Paranaguá and 36 (thirty six) in the track Paranaguá – Curitiba, and

- Information driving from solutions in the Pavement Restoration Project[8] proposed to this section.

Having this diagnostic, analysis were made about encountered situations from where it was concluded the following:

a) In 6 segments, the pavement's water existence is related to, probably, the fact that its revetment is in a high deterioration condition in a way to permit superficial waters infiltration. These waters that ended up reaching the track's pavement layers, which in the interface with paved shoulder's pavement layers do, with a smaller permeability, confine themselves, causing undesirable accumulations. It was expected that these situations would be solved by the layers homogenization or pavement flat drains implementation conveniently spaced, and

b) In 5 other segments, a more detailed and sensible analysis verified that there is no waters' action in the pavement, maybe for the efficient draining existent, or for the more adequate pavement characteristics and/ or for the road's geometry, that permit a proper flowing off.

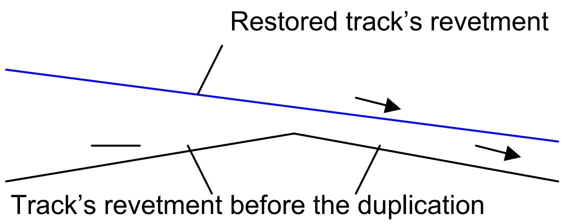
- In conformity with what has already been mentioned, another procedure that has been utilized in the search of a correlation between the high water levels existence (boring realized explorations' objective) and existent damage in the pavement, was the analysis of the results prospecting inherent to exploration wells in the pavement restoration project that aimed to the characterization of material constituents in its structure, as well as its respective test. In this opportunity, was aimed to correlate information from the 2 researches to then obtain conclusions. Results haven't point out any linkage between excessive humidity in layers and imperfections on the pavement's surface, although have detected, in exploration wells, some places where natural humidity is higher than optimum humidity, in other words, excessive humidity presence in pavement layers;

- Searching to consolidate this affirmatives were taken into consideration information from tests of in situ density, natural humidity, characterization, compaction and CBR of samples from the track's exploration wells;

- It has to be considered that the verification of existence/ localization of longitudinal deep drains through boring explorations, constituted in a hard task, in a way that, in a big part of this locations it wasn't possible this checking, ahead of it, was taken as a supposition that the drains indicated in the existent documentations analyzed, existed and worked in a satisfactory way, once it wasn't detected the necessity of implementing longitudinal deep drains based on the diagnostic made;

- The most relevant fact to be mentioned, about the water appearing in the revetment, refers to pertinent observations to the revetment's situation, which because it is found deteriorated in many places, permits precipitations to infiltrate, those flow off, obviously and naturally, through the biggest declivity trace, this makes that, in those segments where the longitudinal declivity is superior to the transversal declivity, precipitated waters infiltrate and flow off under the existent revetment, emerging when this geometric situation changes, this is, when the transversal declivity overcomes the longitudinal one. This situation was detected as the most critical in the segments between stakes 6240 and 7892 (track Curitiba-Paranaguá) and between stakes 1435 and 3093 (track Paranaguá-Curitiba). The mentioned situation, lasts during 3 days at most after precipitations, being that, in those cases is observed the appearing of marks in the revetment referring to a carrying of tiny particles from base and/ or sub-base pavement layers.

- Another factor observed is that, when the road's duplication was being executed, the existent track, which had camber, had its pavement restored with the execution of an additional layer of bituminous concrete and had a modification in its transversal declivity to the external border of the transversal section, as shown in the following sketch:



In this situation, when there is an infiltration, through the revetment's sulcus, which had been deteriorated through the years, causes in determinate opportunities an accumulation of water near the border.

These places determination has hard definition; since there are no trustable records about the adopted solutions used in the pavement at the time of the road's duplication.

The consultants understood that, with the execution of the existent revetment reinforcement and implementation of a conservation/ maintenance system adequate to this occurrence should stop.

- The execution, through the years, of successive layers of resurfacing in the rolling track, without the utilization of reforming technique, caused an appearing exaggerated revetment thickness; with completely different permeability coefficients from those in the existent materials under paved shoulder's revetment. This fact made the consultants take the conclusion that, part of the precipitated water stays restrained due to this permeability coefficient difference;

- The existence of places with water appearing under the revetment occurs specially in landfills, in other words, it doesn't occurs only on sections in cut, what, if occurred, could, at first, that the provenience of those waters was due only to the phreatic water sheet,

- It has been observed, also, that in places where, previously, were made recoveries in the pavement, with the implementation of transversal drains, the water appearing in the revetment disappeared, whatever is through the new revetment, or even because of the adequate draining implementation;

- The Subterranean Draining Project of the Pavement was studied according to the course of pavement restoration solutions, compatibilizing the characteristics of the existent/ projected pavement with the necessity of removing the water-bearing layers, which could end up infiltrating in the pavement after its recovery, and

- Base on the definition pavement solutions, were projected transversal and/ or longitudinal pavement drains. In the project were presented the following elements: track in which it should be implemented, initial and final device stake, geometric characteristics, materials which would constitute it, distance in relation to the axle or border and whatever particular elements that could necessary to the device's constructive process.

Concluding, it can be said that the BR-277 wasn't defective, under the point of view of the subterranean lowering's draining of the phreatic water sheet on those cut region, but it was defective:

- On the structure's composition of its pavement, in which precautions related to layers' permeability homogenization weren't taken;

- Due to the exposure to bad weather during too much time of the extremely cracky pavement surfaces;

- Because of the existence of confinement due to the restoration which only aimed to recover the track's rolling without considering the infrastructure immediately inferior to the rolling surface, and

- Due to the fact that all precautions related to pavement plain draining weren't taken.

Proposed project and implemented

The system proposed[8] aimed to eliminate water presence in do pavement layers, by other reason than elevated water table, objectifying reduce excessive levels of humidity in the materials that compose the existent structure.

It is worth recording that in the Serra's region, limitation referring to information about the segment's geometric characteristics, specially to those inherent to transversal and longitudinal track declivities were an obstacle to the predict the adequate location of the device mentioned in this chapter. Aiming to minimize this difficulty was used data from de Geometric Project elaborated because of the duplication[10] project of the BR-277.Due to it, were searched more conservative as possible solutions to determine the localization and constitution of sub-superficial draining.

To this draining were projected sub-superficial longitudinal and transversal drains. Being that the first ones were foreseen in the following situations:

a) In the external border of sections in tangent when the earthwork section indicated a situation of cut;

b) In the internal border of sections in horizontal curve, and

c) In any case, where there was necessity of collecting and taking to a safe disembogue waters originated from transversal drains.

The transversal drains, which were foreseen with maximum space of 40m between them, aimed to intercept waters that infiltrate in the pavement.

To the disembogue, were foreseen the following situations:

Longitudinal drains

a) When in the external curve border, being the earthwork section in cut, the projected devices were taken a landfill section, where they flowed off in a passage box with armed concrete tampion. Parting from this box, the flow off would occur over a slope in which was foreseen protection with hand-placed stone with cement mortar, and

b) When in the curve internal border, being verified a possibility of flowing off to the existent collecting boxes next to the rigid separator/ existent central separator, these were used to this.
This situation was analyzed in the moment of the devices implementation, and, not having condition to it, the drain was prolonged until a safe disembogue place.

Transversal drains

a) When, a earthwork section in cut, situation that obstructs the transversal flowing off, the water originated from these devices was destined to passage boxes, being further conduced, longitudinally, by parallel drains to the track border, until the adequate disembogue place. In this location was built a passage box with armed concrete tampion. Parting from this box, the flowing off occurs over the slope which was protected with hand-placed stone with cement mortar, and

b) When in landfill transversal section, the disembogue was foreseen to happen directly over the slope protected with hand-placed stone with cement mortar.

As collecting and draining flowing off auxiliaries, were foreseen passage boxes, in concrete, with tampion from the same material, but the armed one.

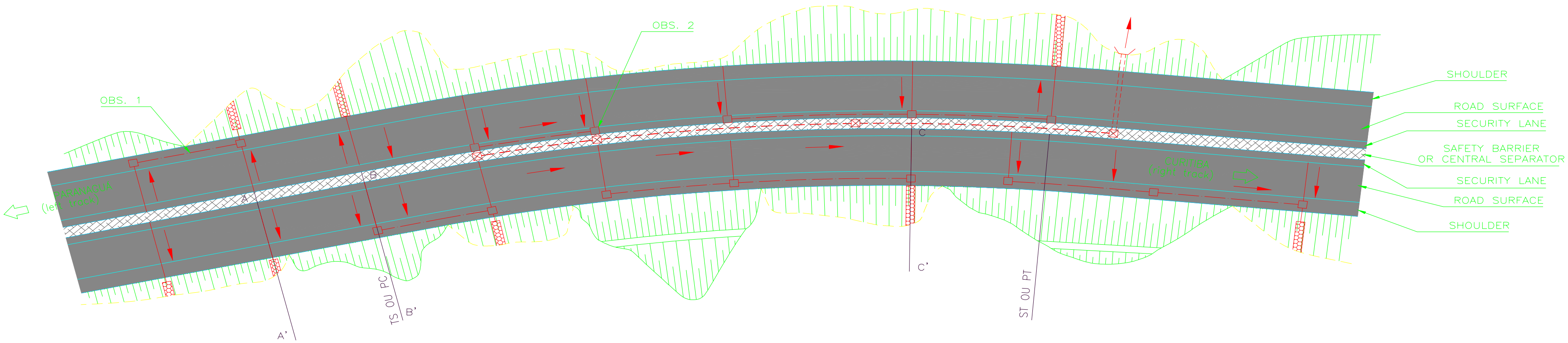
The paper's author studied the option of using the following types of drain[2, 4]:

- Drain constituted by draining material (gravel 3), geotextile and perforated concrete or corrugated PVC tube PVC with a diameter of 0,20m, and

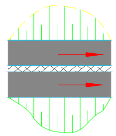
- Drain constituted of geodren and perforated corrugated PVC tube with diameter of 0,20m. To this type, was foreseen the usage of 2 (two) drain options. One manufactured by the company Motormac and the other manufactured by the company Maccaferri.

The basic details of implementation and construction of the projected[8] devices are presented in the drawings DSS-01 and 02 displayed a below.

PLANT WITH SUBSUPERFICIAL DRAIN SOLUTIONS



CAPTION:



OFF-SET FILL

DISEMBOGUE DIRECTION

DISEMBOGUE DIRECTION

OFF-SET CUT

OBS. 1: IN CASE IT'S POSSIBLE, DISEMBOQUE CAN BE MADE IN THE PASSAGE POINT FROM CUT TO FILL WITH A LONGITUDINAL DEFLECTION. THIS CRITERIA CAN BE ADOPTEDT IN ALL PASSAGE.

OBS. 2: IN CASE IT'S NOT POSSIBLE THE DISEMBOGUE IN THET EXISTING GULLET, THEO LONGITUDINAL DRAIN SHLOUD BE PROLONGED UNTIL THE NEXT GULLET (PROJECTED OR EXISTENT) IN WHICH THE DISEMBOGUE IS POSSIBLE.

OBS. 3: THE CONSTRUCTIVE DETAILS IS PRESENTED IN THE DRAWING DSS-02.

OBS. 4: THE TRACK'S TRANSVERSAL OF ROAD SURFACE AND SHOULDER DECLIVITY OBEYED TO THE EXISTING CRITERIA IN THE BR-277 DUPLICATION PROJECT ELABORATED BY CONSULTING COMPANY PROENGE.

PROJECT:

GULLET

TRANSVERSAL DRAIN

LONGITUDINAL DRAIN

SLOPE WITH STONE CEMENT MOSTAR

EXISTENT:

GULLET

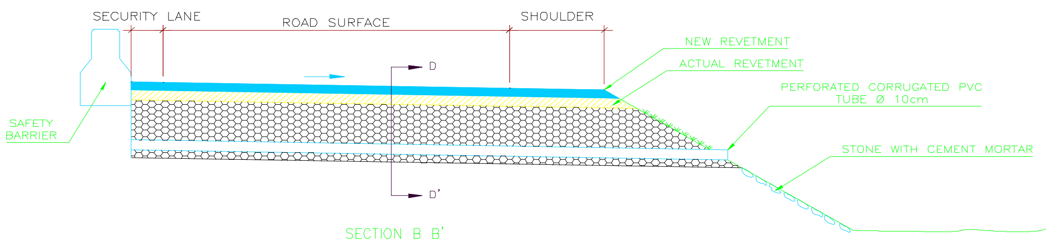
LONGITUDINAL CULVERT COLETOR

TRANSVERSAL CULVERT

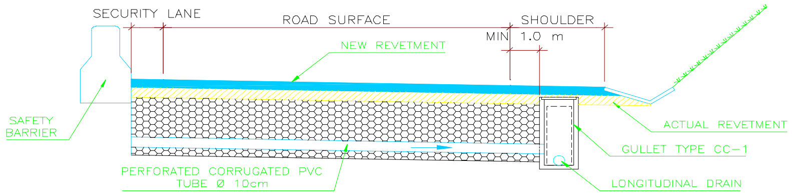
DSS 01

TYPE SECTIONS WITH SUBSUPERFICIAL DRAIN SOLUTIONS

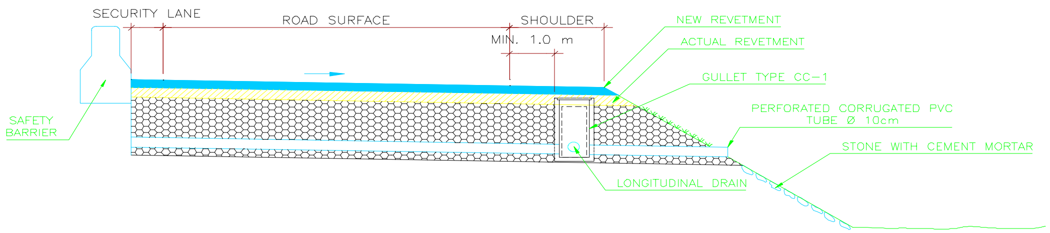
SECTION A A'



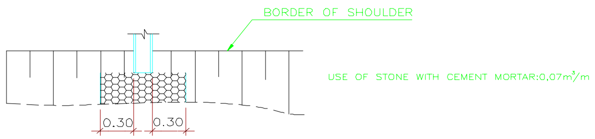
SECTION B B'



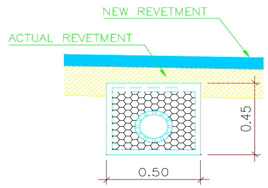
SECTION C C'



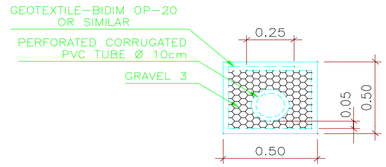
DETAIL OF THE SLOPE
STONE WITH CEMENT MORTAR



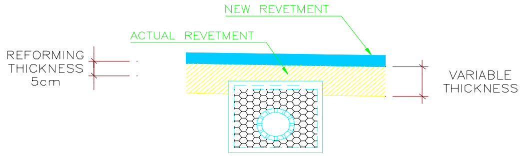
SECTION D D'



DETAIL OF TRANSVERSAL/ LONGITUDINAL DRAIN



POSITION OF DRAIN SUBSUPERFACE



USE OF MATERIALS FOR
1 m DRAIN

SERVICE	QUANT.
EXCAVATION (m³)	0.225
GRAVEL 3 (m³)	0.225
GEOTEXTILE (m²)	2.15
PERFORATED CORRUG. PVC TUBE	1

NOTES:

1 – DIMENSIONS IN METERS.

2 – IF THE DRAIN IS EXECUTED IN A PERIOD BEFORE THE ACTUA PAVEMENT RESTORATION, THE FOLLOWING ITEMS SHOULD BE OBSERVED:

a) THE DRAIN SHOULD HAVE ITS TOP PLACED, IN MINIMUM, 5cm AWAY FROM THE INTERIOR REFORMING FACE.

b) SHOULD BE INFORMED TO THE EXECUTOR REFORMING THE EXISTENCE OF DRAINS.

c) IN THE PLACES WHERE THERE IS NO REFORMING, THE DRAIN SHOULD BE POSITIONED 8cm UNDER THE ACTUAL REVETMENT.

3 – THE CITED PROCEDURES SHOULD BE ADOPTED TO TRANVERSAL DRAINS AS WELL AS TO LONGITUDINAL DRAINS.

Besides the constructive elements mentioned, it were elaborated service notes of drains and passage boxes. On drains' service notes were evident the following elements:

- Track in which the device is located;
- Initial stake;
- Final stake;
- Device extension;
- Platform side, and
- Disembogue place.

To the passage boxes, were also elaborated de service in which were evident the following elements:

- Track in which the device is located;
- Stake; and
- Platform side.

After the project conclusion, the Concessionary, through the construction company that assisted them, started the implementation of the Subterranean Draining Project proposed and following it, the pavement restoration/ recuperation.

In relation to the pavement drains execution, the Concessionary optioned to used drains made with gravel 3, geotextile and perforated tube with a 0,20m diameter. This decision was taken due to the implementation cost of this type of drain is inferior to the other type made with geodreno and perforated tube, allied with immediate availability of equipment, by the hired construction company, to execute the first type of draining device.

The paper author, after the conclusion of the drains implementation and the pavement restoration, has been following, through visits to the segment and contacts with the Concessionary engineering team, the performance and the behavior as well as the ones from implemented draining as the ones from the restored pavement. With the information collected, it has been concluded that up to now the results presented are still inside the project expectations. It's worth to mention that, having in mind these results; the Concessionary is amplifying the implementation of this solution to pavement draining problems to other road segments under its responsibility.

The pictures presented next illustrate the pavement situation during the period before the project, the actual situation and the functioning of the referred devices.

View of a BR-277/PR segment with water emerging on the revetment (January 1999)

Detail of a transversal drain implemented with disembogue direct to the gutter

Detail from the local, placed in a segment that suffered intervention with the implementation of pavement drain and pavement restoration (November 2003)

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