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CONCRETE BLOCK PAVEMENTS AS A SOLUTION TO A RAIL CROSSING SUBJECTED TO LOADS OF HEAVY TRAFFIC, IN AN URBAN AREA

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Note: The following is the notation used in this paper: (.) for decimals and ( ) for thousands. Currencies are expressed as: AR$ Argentinean Pesos and US$ for Dollars of the United States of America. Approximate exchange rate (2009-08) = 3.8 AR$ / 1.0 US$.

Summary

Most of the railway crossings in Argentina have their access surfaces generally in bad shape, with the consequent negative impact for the movement of all kinds of vehicles passing the crossings. It generates important traffic congestions, with an increase in the gas emission to the environment, by product of the combustion in the vehicles, and the consequent loss of time in the displacement of people and goods. All this increases when these rail crossings are located in urban areas with a considerable traffic density, mostly due to the permanent and expensive repair and maintenance works of the railroad crossings.

This paper describes in detail the use of concrete blocks in a surface railroad crossing, located in the town of Olive, in the Province of Córdoba, in Argentina. The railway tracks bear daily cargo and passenger trains and divide the city in two densely populated sectors, so the circulation over this crossing is important. Additionally, it has an intense transit of trucks with loads of more than 30 t, which carry much of the production of grains of the entire province, towards the port of Rosario.

Considering the need to give a definitive solution to this problem, with a fast constructive method, possible to develop by sections and with an easy maintenance, the municipality decided to design and build this rail crossing with a concrete block pavement.

This paper describes the stages of project and the construction of the pavement. It also evaluates the behavior of the project after three (3) years intense use.

1. LOCATION OF THE WORK

It is the surface railway crossing in the city of Oliva, 3er *Departamento Arriba*, Province of Córdoba, Argentina, in Rivadavia Street and National Route No. 9 South (see Figure 1).

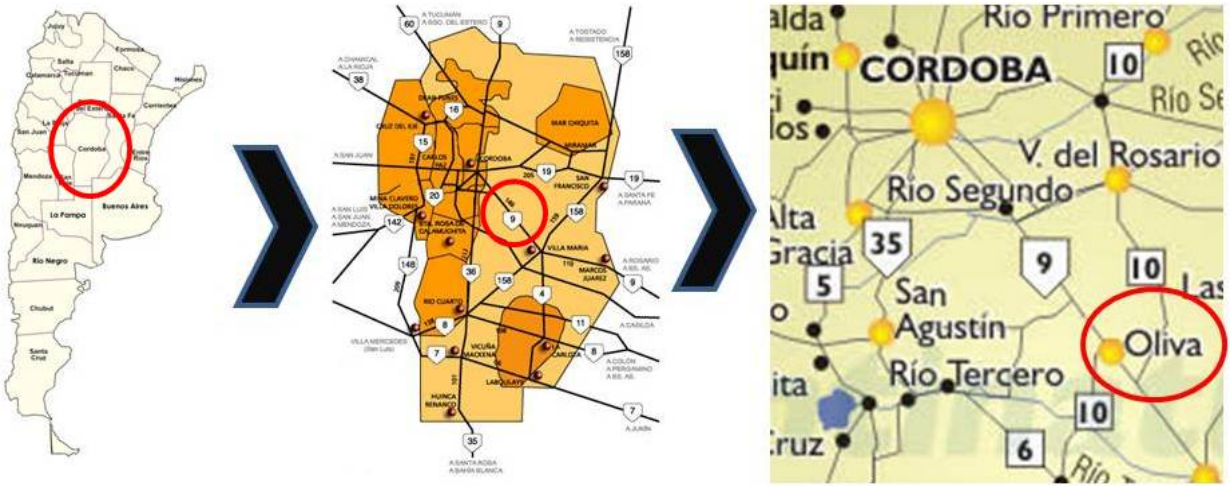


Figure 1. Maps of Argentina, the Province of Córdoba and the location of Oliva.

2. DESCRIPTION OF THE LOCATION OF THE CROSSING

It is a level railway crossing, with high density of transit and heavy loads, because part of it area trucks with coupled trailers, loaded to the top with cereals transported from the Province of Cordoba to the port of the city of Rosario, in the Province of Santa Fe.

The railways belong to the concessionary company the Mitre Railroad, *Nuevo Central Argentino* (NCA). They carry daily freight trains by the main track plus two (2) passenger trains per week. The area to pave has 566 m^2 and four (4) rail tracks, the main one and three (3) secondary tracks.

Initially, there was an asphalt pavement in the crossing, very spoiled and with permanent repair interventions by the Municipality, without an optimal finish job of the structure (see Figures 2 and 3).



Figures 2 and 3. Initial state of the crossing in the main road area. Asphalt concrete.

3. STUDY FROM THE SOIL

The soil studies were made previously to the structural analysis. They found three (3) well defined layers, as shown in Figure 4.

Layer 1, the most superficial, 300 mm thick. It had a "leosoide" lime, whose maximum Proctor density (1.87 t/m^3) was acceptable and indicates that the material is adequate for its position in the structure.

Layer 2, intermediate, 250 mm thick. The material was similar to the one in Layer 1, but with a vey low maximum Proctor density (1.55 t/m^3) and indicates incompetence of the tested material. The onsite density averaged 1.24 t/m^3, 80% of its maximum density, which is below the recommended limit of 95%.

Layer 3, the deepest one. Another "leosoide" lime was found, with a maximum Próctor density of 1.53 t/m^3 and an onsite average density of 1.55 t/m^3, considered to be acceptable for their position in the structure.

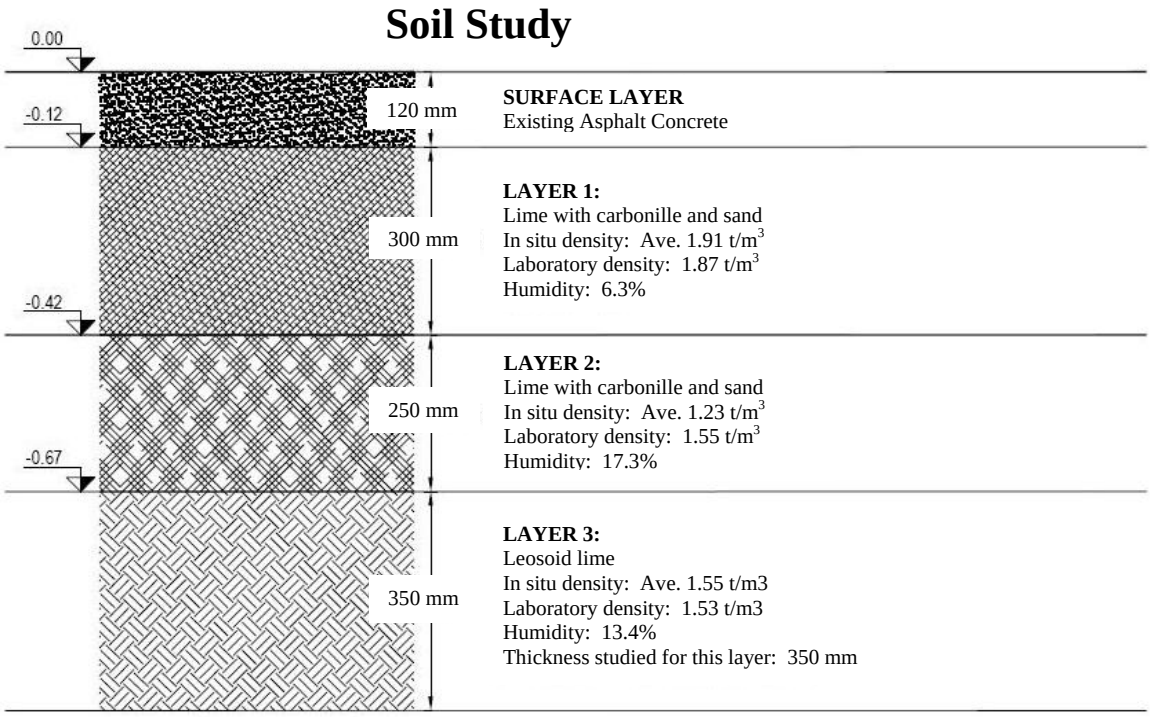


Figure 4. Detail of the previous soil study. Differentiated layers.

4. DEFINITION OF THE STRUCTURE

It is important to stress out that the intention was intended to reformulate only the surface layer of an existing flexible pavement, in service for many years, without any settlement of the base layers. So it was decided to use the same structure, looking forward to homogenize their densities for a most reliable behavior of the structure.

This procedure was carried out in a box 0.86 m deep from the finished pavement surface. Once the existing asphalt concrete was removed, the base material was removed to a depth of 0.75 m, keeping it on site, in separate stocking piles, according to the nature (layer).

After the mechanical compaction of the subgrade (compactor - tamping), the box was filled up with an mixture of equal part of the soils in Layers 1 and 2, plus 3% (by weight) of "live" lime, to complete 0,55 m, of stabilized material.

The maximum obtained Proctor density for this "mixed" material 1.7 t/m^3, with an optimum moisture content of 15%.

In situ densities in situ were acceptable, because they exceeded 95% of the maximum density.

The remaining 200 mm were filled with crushed type 0-20 (0 to 20 mm gradation) granular material, whose maximum in situ Proctor density was 2.3 t/m^3, with values from 98% and 103% of its maximum density. Figure 5 outlines the finally built structure.

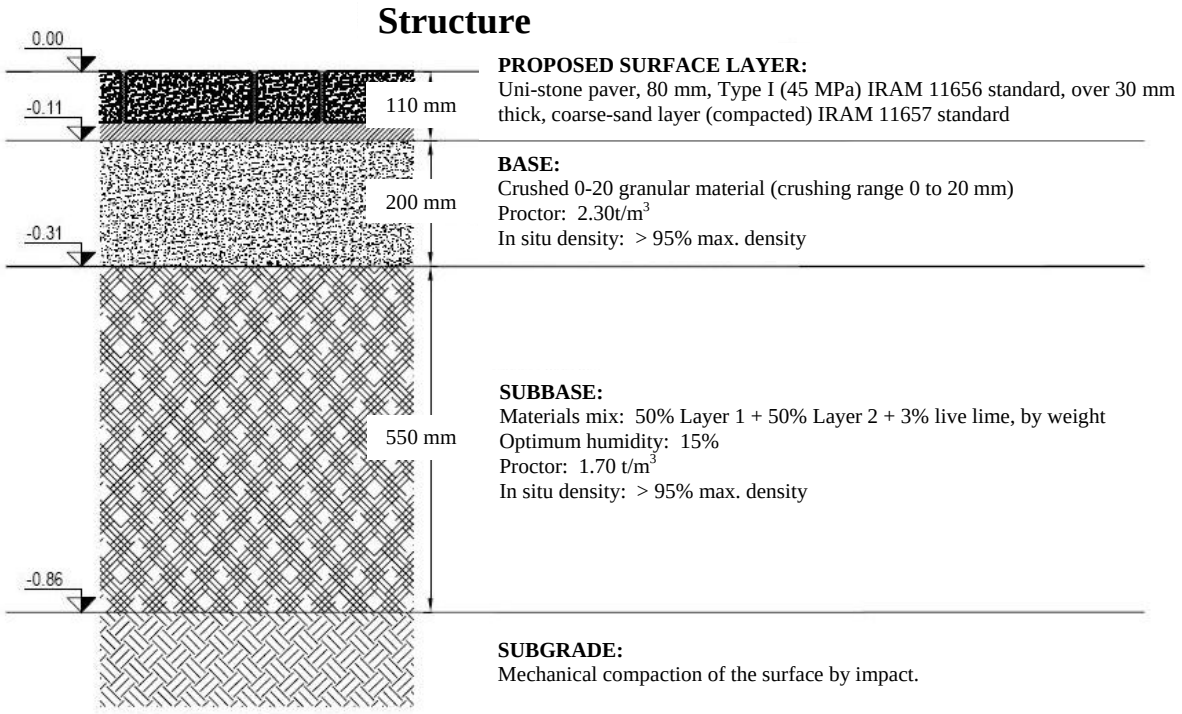


Figure 5. Detail of the adopted structure.

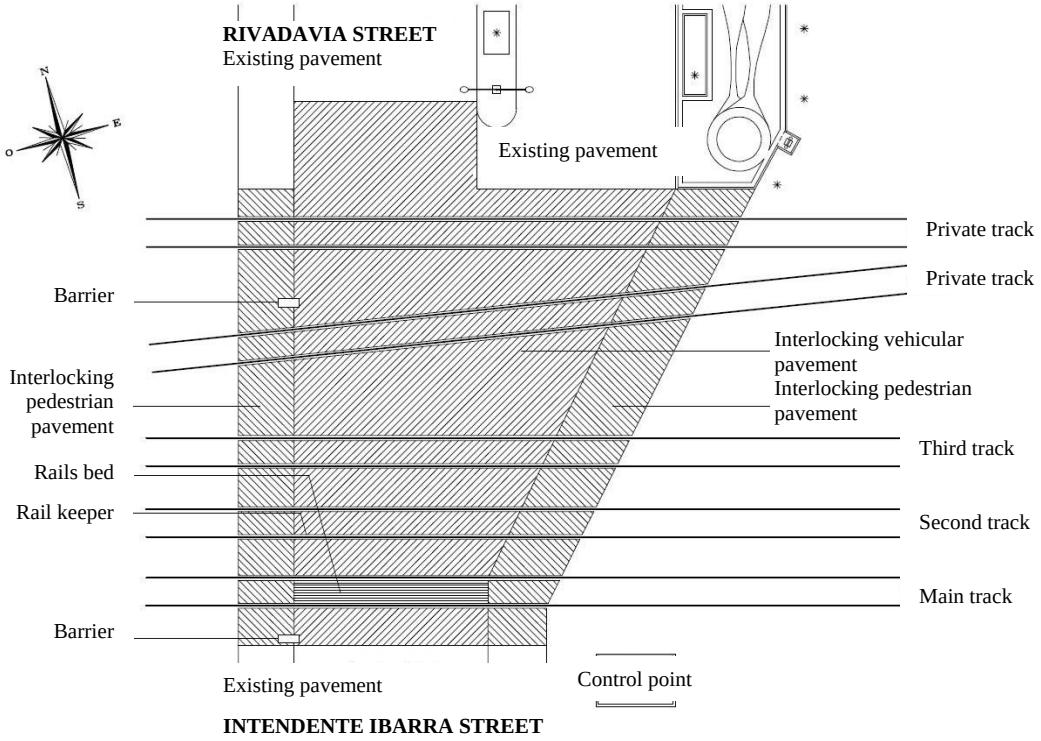


Figure 6. Drawing of the general area of the work.

5. CONSTRUCTIVE DETAILS. PAVERS - SLEEPERS INTERACTION

Due to the poor state of secondary rail tracks, especially in their sleepers, they were completely replaced by the NCA with new wooden sleepers made of "*quebracho colorado*". In addition, a new battery of rails was installed on both sides of the main track, as rail keepers, in order to protect the track from the loads of the crossing traffic, and serving as confining structure for the pavers laid parallel to them.



Figures 7and 8. Replacement of sleepers in secondary and primary tracks plus rail keepers.

The confinement perpendicular to the direction to the tracks was built in situ, with H13 (13 MPa) concrete, 120 mm wide and 300 mm tall, with two 10 mm reinforcing bars and 6 mm stirrups every 300 mm. Those curbs were isolated from the rails with flexible joints filled with acrylic putty.



Figure 9. Union of the concrete curbs and the tracks.

A geotextile was placed against the protective rails to avoid the escape of the bedding sand, covering the sleepers. Once the sleepers were fixed with square-headed wooden screws, part of the heads was cut in order to avoid the puncturing of the pavers. Then the remaining of the heads was covered with mortar.



Figure 10. Laying of the geotextiles and protection from the heads of the screws.

6. CONCRETE PAVERS

A gray "Uni-stone", 80 mm thick paver was chosen, with an average strength of 45 MPa (Type I), as required b y the IRAM Standard 11656 Concrete Pavers for pavements, manufactured in the city of Córdoba by a company Member of the Argentinean Concrete Block Association (AABH).

7. LAYING OF THE PAVERS

The pavers were laid according to IRAM Standard 11657 Requirements for the paving block laying and recommendations on the basic structure, in topics like the type and thickness of the bedding and joint sand, the cutting of pavers against the confining curbs and the compaction of the surface. The selected laying pattern was 90° herringbone pattern.




Figures 11 and 12. Laying of the pavers in the area of the main road.

8. JOB TIME AND COSTS. FINISHED WORK

The total time of the construction was 45 d, from May 15 to June 30, 2005.

The cost per square meter (May 2005), including the pavers manufactured 100 km far from the work, the preparation of the base, the confinements for the lateral forces, labor for block laying, the geotextil and the bedding and sealing sands and the 0-20 granular material, was of AR$ 85/m^2 (US$ 30/m^2).




Figures 13 and 14. Finished pavement already in use for pedestrian and vehicular transit.

8.1 Maintenance and initial batching activities

As part of the guarantee for the construction of the project, the Contractor strictly followed the Evolution of the structural behavior of the pavement during first year in service (see Figures 15 to 17).



Figure 15. Start of the batching.



Figure 16. State of the sand.



Figure 17. Detail of a sleeper.

These repairs were minor and executed in one day, without interruption of the vehicular traffic. Subsequently, the responsibility for the structure was transferred to the municipality. This interrupted the maintenance works as the sweeping of the sealing sand (see Figures 18 to 20).







Figures 18, 19 and 20. Bacheo operations the year of commissioning.

During that period, some important settlements were generated, mainly close to the rails and the sleepers. There was a clear "reading" on the block paved surface, of the location of the sleepers (see Figures 21 to 23), produced by the difference of rigidities among the base of the structure and the sleepers, along them. There were also some pieces broken by flexure in the base to sleeper transition (see Figure 24). No damaged were observed due to punching of the screws, maybe due to the fact that they were cut and covered with mortar, as indicated above.







Figures 21, 22 and 23. Details of the "markup" "of the sleepers".

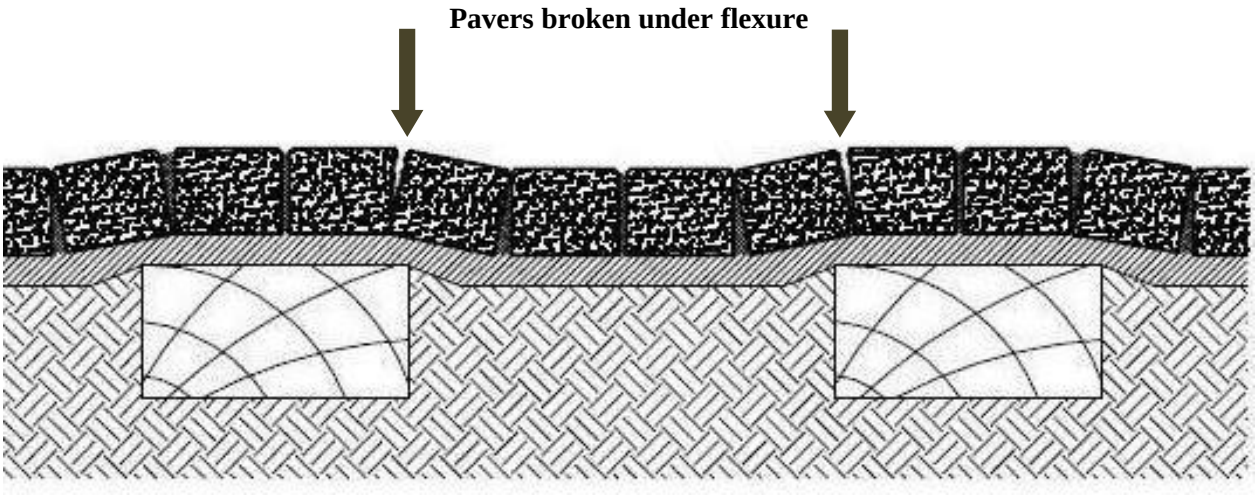


Figure 24. Detail of the deformation in the sleepers' area.

It is important to stress that the vibrations produced by the passing of the train had not had a detrimental effect neither on the structure nor on the surface layer, as it was initially thought, especially in regard to the loss of bedding sand. This was accomplished with the geotextile, and the sealing the several specific points.

9. CURRENT STATUS

Today there are some partial deformations in some sectors with vehicular traffic, where paves interact with the sleepers and the rails, but not in the pedestrian crossings. In the area between lines, where the movement of the sleepers does not alter the pavers, the pavement maintains the original surface construction.



25 And 26 figures. Detail of the current state of the pavement nearby the main road.

The paver surface layer is a little abraded by the tires bringing natural sand existing all along the city due to many non-paved streets. This same problem can be seen in the concrete pavement of the street accessing the block pavement.

10. CONCLUSIONS

The most important conclusion that emerges from this experience is that the passing of the train do not influences by itself, in the behavior of the block pavement, neither in regards to the interlock of the blocks nor in the eventual loss of the bedding sand.

The point to solve is the "reading" of the sleepers, due to the vertical displacement of the adjacent pavers, originated in the rigidity gap among the pavers and the base.

For this is purpose it is proposed to build a layer of poor concrete over the sleepers and to lay the pavers over it with a sand bedding layer in between, with a thickness of, at least, 2 cm.

The Olive City Municipality, was in accordance with the work, since the use of pavers, simplified substantially the maintenance required by the asphalt used until that time, improving in a notorious way the cost/benefit relationship. It made that this solution be adopted for the other level crossing in town, to be begun in short time.

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