Construction process of base recycling with foamed asphalt and microcarpet reinforced with fiberglass, from km 110+000 to km 155+000 body B of the Gómez Palacio - Corralitos Highway

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Abstract- **An inspection of the Gomez Palacio - Corralitos highway revealed a series of sections with deflection, cracking, and potholes, the most structurally influential of which were rehabilitated by deep pothole patching using a base stabilization technique with foamed asphalt in conjunction with a glass fiber reinforced microfurred road surface with a pair of surface treatments. The recovery of the materials that form part of the existing pavement structure and their subsequent mixing with the foamed asphalt makes it possible to obtain a base with significantly improved characteristics. In turn, the application of both surface treatments results in the improvement of the surface characteristics of the wearing course and, therefore, in the extension of the pavement's service life. The main objective is to show clearly and orderly the construction process of both the foamed base and the micro-folder.**

Keywords- **Asphalt pavements, foamed asphalt, micro-agglomerate, seal irrigation**

I. INTRODUCTION

The current environmental urgency, a product of human action, demands the maximum use and management of resources, and the planning, development, and use of sustainable, economical, and efficient techniques. Currently, according to the National Road Network, the current road infrastructure allows the transportation of 80% of the national cargo; generating diverse activities (social, cultural, commercial, and economic) which constitute a fundamental factor in the country's development. These transportation routes require maintenance (periodic and routine) and rehabilitation actions that allow for efficient service management while adapting to current traffic needs.

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A very efficient and sustainable method for preserving existing road infrastructure is recycling. Among the most Such actions have generated a wide range of experiences and, consequently, the development of new techniques and technological innovations [6]. outstanding advantages offered by the implementation of pavement recycling are the saving of natural and economic resources, the reduction of pollution and the fact that engineering properties like virgin mixtures are obtained [2], [5].

Pavement recycling is not a new technique. However, there are records that in 1970, in the face of the oil crisis, the need to recycle asphalt pavements arose due to the high cost of oil. Therefore, by implementing the use of RAP, it is possible to reuse materials that are part of the existing pavement structure, which allows savings in both natural and economic resources in relation to maintenance and rehabilitation criteria [1].

Consequently, a wide range of possibilities opens, which are developed depending on the application or final design of the recovered material. These are classified according to their recycling temperature (cold or hot), and the recycling process can be performed in-plant or on-site [1], [4].

Cold recycling is among the most cost-effective techniques for reducing the carbon footprint of roads, thanks to the stabilization of the materials that constitute the hydraulic base with asphalt without requiring high temperatures to reprocess the materials [1].

The technique of recovering granular bases by means of foamed asphalt is considered a new trend in Mexico. The asphalt foaming system was patented in 1927 by August Jacobi in Germany. To find a purpose for asphalt in its foamed state, in 1957, Ladis Csyani achieved the first application on pavement bases thanks to research conducted in the United States, specifically, at Iowa State University. Subsequently, in 1997, the company WIRTGEN created the first laboratory and on-site recovery equipment [1], [3], [6].

Among the success stories particularly presented in Mexico are the works carried out on the Durango - Torreón and Gómez Palacio - Corralitos highways.

The importance of disseminating technologies that are part of the technological innovation for road maintenance in Mexico lies in the identification of procedures that allow not only the improvement of the characteristics of the layers that make up the pavement structure, but also the positive impact on environmental criteria.

II. OBJECTIVE

To show with order and clarity the constructive procedure corresponding to the application of foamed asphalt technology for the stabilization of granular bases, as well as the pair of surface treatments that constitute the glass fiber reinforced microcarpet for the maintenance of road infrastructure.

III. MATERIALS AND METHODS

The injection of a small amount of cold water (1 to 2% with respect to the weight of asphalt) and compressed air at a pressure of 5 bar (500 Kpa) on hot asphalt (160 to 180°C), a process carried out in an expansion chamber, makes it possible to obtain the foamed state of asphalt [1], [6], [9]. Once the foamed asphalt is added to a RAP (Reclaimed Asphalt Pavement), it is dispersed to the fine particles to subsequently bind the proportion of coarse aggregates by a kind of "spot welding" [8].

The mixture of RAP, foamed bitumen and, if necessary, virgin aggregate forms a flexible pavement base.

The design of bases stabilized with foamed bitumen is constituted as follows:

- Characterization of materials (asphalt, stone, and RAP)
- Granulometry design
- Asphalt foaming parameters
- Material mix design
  - Level 1: Determination of the "active filler" requirement
  - Level 2: Determination of optimum foamed bitumen content
  - Level 3: Determination of mechanical properties
  - Level 4: Determination of resilience modulus

Level 4 is only considered for roads that will serve high-speed traffic.

A. Characterization of materials

Asphalt material. Classified by its PG (Performance Grade). The performance grade is the range of temperatures in which the asphalt material, whether conventional or modified, enters service efficiently [7].

The PG Grade can be determined based on Mexican standard N-CMT-4-05-004/18. However, the Secretaría de Comunicaciones y Transportes facilitates the obtaining of the PG grade thanks to a free access User's Manual.

Stone material and RAP. The sampling of the materials, carried out in accordance with the provisions of standard M-MMP-4-04-001/02, allows the subsequent determination of the plasticity (M-MMP-1-07/07) and granulometry (M-MMP-4-04-002/02) of the materials. It is essential to perfectly homogenize the materials, by following the respective Standard M-MMP-1-03/03, before performing the granulometric test.

B. Determination of the granulometry design

The adjustment of the granulometric parameters (variation of material proportions or addition of virgin material), allows to meet the granulometric parameters required by the design of the material mix [1], [6].

Since a percentage of water is required for foaming the asphalt and to ensure proper compaction of the base, Standard M-MMP-1-09/06 is applied to determine the maximum dry volumetric weight and the optimum water content of the materials.

C. Determination of asphalt foaming parameters

This determination is carried out to find the ideal asphalt temperature and the optimum amount of water needed to produce the best results in terms of expansion ratio and half-life.

D. Material mix design

The design of the material mix comprises 4 levels of determination, focused on determining the optimum number of materials and on obtaining the best mechanical and structural behavior of the foamed base.

- Level 1: Determination of "active filler" requirements.
  A maximum of 1% by mass of active filler (hydrated lime or Portland cement) improves asphalt dispersion and reduces susceptibility to moisture.
  The objective of this level is to determine, based on the plastic index (PI) value, whether the addition of active filler to the material mixture is necessary [1].
  The application of ITS (Indirect Tensile Strength) tests not only allows to determine the indicated active filler but also to obtain the TSR (Tensile Strength Ratio) value.
- Level 2: Determination of the optimum foamed bitumen content.
  The optimum foamed bitumen content required is determined by applying ITS tests, adjusting the values and taking as a starting point the content used in level 1, in intervals of ±0.2% until 4 different concentration percentages are obtained.

- Level 3: Determination of mechanical properties. The basis of the application of triaxial tests is that by applying stresses in three mutually perpendicular directions, it is carried out with the purpose of determining the cohesion and angle of internal friction of the materials stabilized with foamed bitumen based on the Mohr-Coulomb theory. In other words, the application of triaxial tests allows determining the mechanical properties of the working formula [1], [8].
- Level 4: Determination of resilient modulus. The cyclic triaxial test in dynamic condition allows determining the resilient modulus (RM) or structural capacity of the material mixture to incorporate the results into a pavement structural design [1], [8].

E. Fiberglass-reinforced seal irrigation

This is a stress-absorbing membrane applied on the surface of an asphalt layer. This consists of an irrigation of asphalt material (polymer-modified asphalt emulsion), glass fibers and a layer of crushed stone aggregate [6].

G. Cold micro-agglomerate with glass fibers and bonded irrigation

Cold microagglomerate is considered a thin bearing layer (it does not fulfill structural functions), produced cold and constituted by a fine crushed aggregate of dense granulometry, controlled breaking asphalt emulsion (usually modified with polymers), glass fibers, filler, water and, if required, additives [6].

IV. PROJECT APPLICATION

Figure 1. RAP acquisition (frontal view)

Figure 2. Extraction of material from the material bank

Figure 3. Truck emptying foamed base. The stabilized base is transferred to the site for paving with a paver

Figure 4 Foamed base paving with a paver

Figure 5. Compaction of the foamed base

Figure 6. Application of seal irrigation

Figure 7. Application of the seal irrigation

Figure 8. Application of microagglomerate (Before)

Figure 9. Application of the microagglomerate (During)

Figure 10. Micro-agglomerate application (After)

The construction procedure begins with the milling and collection of the materials that are part of the existing pavement structure by means of a profiling machine and a 3-ton truck. Synchronization between personnel and machine operators allowed an efficient work pace to be maintained while a rotation of trucks was carried out as they reached their maximum capacity.

Sampling of the material bank was carried out in accordance with the specifications of Standard N-CTR-CAR-1-01-008/00. The use of a pair of crushing plants (primary and secondary) and a screening plant made it possible to obtain an aggregate that met the project specifications.

The use of a hydraulic hammer allowed the extraction of stone aggregate, which required crushing and subsequent screening. A backhoe, a front loader and an excavator played the role of transferring and depositing the material in the respective hoppers.

The transfer of the foamed base from the plant to the job site was carried out by using a dump truck to feed the paver's hopper and then perform the precise paving and, in turn, a pre-compaction of the base.

Subsequently, a primary compaction was carried out using a 2-drum vibratory compactor followed by a secondary compaction using a smooth drum compactor.

Finally, a series of pneumatic compactors made it possible to carry out the last phase of compaction of the stabilized base.

The application process of the cold micro-agglomerate with glass fibers and bonded irrigation was carried out according to Standard N-CTR-CAR-1-04-008/13. Safety measures are considered in this process.

V. CONCLUSIONS

The cold recycling process, particularly the stabilization of granular bases with asphalt in its foamed state, is a highly efficient, economical, and sustainable technique that allows the creation of a material with excellent engineering properties from the recovery of materials that are part of the existing pavement structure, thus generating an ideal solution for the rehabilitation of road sections.

The process of sealing and micro-agglomerating with glass fibers as reinforcement results in the improvement and/or restitution of the surface properties of the bearing layer. Consequently, a prolongation of the service life of the pavement structure is achieved, thus offering an economical, ecological, and effective solution to non-structural problems, as well as greater safety and comfort for the road user.

The importance of rehabilitating roads that are reaching the end of their useful life is that they cannot adapt to current traffic conditions, with higher traffic volumes and loads. The main challenge for the next and current generations of engineers seeking the most efficient service and management of infrastructure has become to come up with solutions that are not only economical and efficient, but also have a positive impact on environmental criteria. Likewise, despite being a technique considered a new trend in the country, the process of construction of stabilized bases using foamed asphalt can be added within an update of the Mexican regulations corresponding to road maintenance techniques.

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