STUDY OF NATURAL MATERIALS USED IN THE IMPROVEMENT OF RURAL ROADS IN THE SOUTH-WESTERN ZONE OF COLOMBIA

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Acceptance Date: April 11, 2022; Published Date : June 12, 2022

Abstract
The objective of this article was to describe the two most important types of crude oil in Colombia, which underwent studies of physical characterization (flash point, fire point, relative density, viscosity), rheological tests, and spectroscopic analysis using FTIR. Several mixtures were prepared using the crude oils to evaluate their behavior and potential use on secondary roads in southwestern Colombia. These natural materials have been used in the improvement of rural roads in the southwestern zone of Colombia. Information corresponding to the characterization, design, behavior, and construction with heavy crude oil and natural asphalts was compiled. Among the sources used, relevant data were found in the library of the University of Cauca, investigative articles related to heavy crude oil and natural asphalt mixtures developed, and information obtained through interviews with individuals and entities that have worked with these materials, among others. Among the main contributions of this research, it was possible to determine that considering the physicochemical characteristics of the materials used, it is recommended to use the compression immersion method for natural asphalt mixtures, as it evaluates the effect of water on the mixture, which is a basic parameter for the durability of road improvements made with these materials.

Key words: *Asphalt Mixture, Natural Materials, Rural Roads, Spectroscopic Analysis.*

1. INTRODUCTION

Starting from the premise that road infrastructure appears as the pillar of the development of a region, which is intimately linked to its economic growth and this in turn is based on its ability to communicate, exchange, transport its inhabitants and products efficiently, we can consider that without the existence or correct maintenance of these, No region will be able to have sustainable development.

Most of the secondary and tertiary roads are in an advanced state of deterioration, mainly caused by the old conservation policies and the use of traditional methodologies that are not very effective, such as the periodic maintenance of the tread course with firming material, which implies high investments with low internal rates of return and the consumption of a large percentage of the budget of the entities in charge of maintenance both at the national level In the end, unsatisfactory results have been obtained in the medium and short term, which are reflected in high transport times, high vehicle operating costs and inconvenience for users.

Many of the most remote areas of the country have road networks in poor condition, which has led to their social backwardness and deterioration of living standards, in addition many of them are characterized by having deposits of natural asphalt resources that have not been used adequately and even in some cases have not even been used in the maintenance of these roads.

For this reason, it is necessary to broaden and deepen the research results obtained so far on these products, in order to use them effectively and practically in road improvement, based on the particular evaluations of the existing products in each region.
For a correct application of the asphalt binders existing in these regions, it is necessary to start from a broad and technical knowledge, which guarantees an optimal behavior and according to the demands of the environment, hence the need to carry out an evaluation that identifies the physical, chemical and rheological properties of the asphalt products and their use as a binder. for application in the improvement of secondary and tertiary roads.

2. GENERAL OBJECTIVE

Describe the natural materials used in the improvement of rural roads in the south-western area of Colombia.

3. METHODOLOGY

3.1 Collection of Information

The existing information regarding characterization, design, behavior and construction with heavy crude oils and natural asphalts was investigated, for which the following sources were consulted:

- ✓ Library of the University of Cauca.
- ✓ Research articles related to heavy crudes and natural asphalt mixtures developed.
- ✓ Articles on the Internet.
- ✓ Information obtained through interviews with people and entities that have worked with these materials.
- ✓ Visit to the sites and information provided by inhabitants of the regions under study where the sources of these materials are located.

4. RESULTS

4.1 Collection of Information

4.1.1 Asphalt

Definition

Asphalts are dark-colored clumping materials made up of complex chains of non-volatile, high-molecular-weight hydrocarbons.
It is separated from the other fractions of crude oil by means of vacuum distillation or solvent extraction, at the bottom of the vacuum tower the final residues of this distillation are obtained, which is known as vacuum bottoms. If the characteristics of the initial crude oil are suitable, then the vacuum bottoms are used directly as asphalt for paving, otherwise they must be subjected to different processes such as solvent treatment, air blowing or the addition of heavy diesel.
Asphalt is a natural component of most petroleums, in which it exists in solution. Crude oil is distilled to separate its various fractions and recover asphalt. Similar naturally occurring processes have given rise to natural asphalt deposits, in some of which the material is virtually free of foreign matter, while in others it is mixed with varying amounts of minerals, water and other substances. Porous rocks saturated with asphalt found in some natural deposits are known as asphalt rocks.
Asphalt is a material of particular interest to the engineer because it is a strong, highly adhesive, highly waterproof and durable binder. It is a plastic substance that gives controllable flexibility to aggregate mixtures, with which they are usually combined. In addition, it is highly resistant to most acids, alkalis and salts. Although it is a solid or semi-solid substance at ordinary atmospheric temperatures, it can be easily liquefied by the application of heat, by the action of solvents of variable volatilization, or by emulsification.

Classification

Asphalts can have two origins, petroleum derivatives and natural asphalts, of which it can be said that:

Petroleum-based asphalts (refineries).

The most widely used asphalts in the world today are petroleum derivatives, which are obtained through an industrial distillation process of crude oil, representing more than 90% of the total production of asphalts. Most crude oils contain some asphalt and sometimes almost all of it. However, there are some crude oils, which do not contain asphalt. Based on the proportion of asphalt that petroleum has, they are classified as:

- ✓ Asphalt-based crude oils.
- ✓ Paraffinic-based crude oils.
- ✓ Mixed-base crude oils (contains paraffin and asphalt)

Asphalt from certain crude oils rich in paraffin is not suitable for road purposes, as it precipitates at low temperatures, forming a second discontinuous phase, which results in undesirable properties such as loss of ductility, with asphalt crudes this does not happen due to their composition.

The crude oil extracted from the wells is subjected to a distillation process in which the light fractions such as naphtha and kerosene are separated from the asphalt base by vaporization, fractionation and condensation, consequently, the asphalt is obtained as a residual product of the previous process.

Asphalt is also a bituminous material because it contains bitumen, which is a hydrocarbon soluble in carbon disulfide (CS2). The tar obtained from the destructive distillation of a fatty coal, also contains bitumen, therefore it is also a bituminous material, but it should not be confused with asphalt, as their properties differ considerably. Tar is low in bitumen, while asphalt is composed almost entirely of bitumen, among other compounds.

Modern petroleum asphalt has the same durability characteristics as natural asphalt, but has the important additional advantage of being refined to a uniform condition, free of organic matter and foreign minerals.

4.1.2 Characterization of bituminous materials

4.1.2.1 Physical characterization

The tests used for the purpose of physically knowing the heavy crudes studied are:

- ✓ **Specific gravity:** This is the ratio of the weight of a given volume of material to the weight of equal volume of water, both materials being at specified temperatures. Thus, a specific gravity of 1.05 means that the material weighs 1.05 times what water weighs at the set temperature. The specific gravity of asphalt bitumen is normally determined by the pycnometer method described in INV-E 707, NLT 122, ASTM D-70. and AASHTO T-43
- ✓ **Penetration:** It is an old measure of the hardness or consistency of asphalt and has been used to classify asphalt cements in different degrees of penetration, it is measured as the distance in tenths of a millimeter that the needle penetrates the asphalt cement during a time of 5 seconds and is described in the INV E 706 standards, ASTM D5, AASHT0 T49 and NLT 124
- ✓ **Water content:** the method is based on the reflux distillation of a sample of the asphalt material, together with a volatile solvent that is not miscible with water, which when evaporated facilitates the entrainment of the water present, separating from it when condensed as described in INV E-704, ASTM D95, AASHTO T55 and NLT 123 standards.
- ✓ **Viscosity:** its purpose is to determine the state of fluidity of the asphalt in the temperature range used during its application, two types of viscosity are determined: absolute or dynamic viscosity measures the resistance of asphalt cement to a shear stress, it is measured at high service temperatures (normally 60ºC) and kinematic viscosity (INV E-715) which is the relationship between the dynamic or absolute viscosity and the density of a liquid; it is a Measurement of resistance to flow under the action of gravity. It is determined at mixing temperatures, and is described in INV E-714, AASHTO T72, ASTMD 88
- ✓ **Flash point or spark:** The flash point corresponds to the temperature at which the asphalt can be heated safely, without danger of ignition in the presence of a flame. It is measured by the Cleveland Cup, and is described in INV Methods E-709, AASHTO T48, ASTM D-92

- **Flame point:** The flame point corresponds to the temperature at which the application of the test flame using the Cleveland cup causes the oils of the bituminous product to ignite for at least 5 s, and is described in INV E-709, AASHTO T48, ASTM D-92.
- **Distillation:** This method illustrated in Figure 3.7 provides information about the volatile components of liquid asphalts and provides a means of separating asphalt cement from these components. The test consists of distilling a 200 cm3 sample in a 500 cm3 flask at a given rate, measuring the distillation volumes obtained at specified temperatures. The residue that remains, after it has reached a temperature of 360°C (680°F), can be characterized using appropriate methods. This is described in INV E-723, AASHTO T78, ASTM D402, and NLT 134

4.1.2.2 Chemical characterization

Chemical composition of asphalt

Asphalt is considered a complex colloidal system of hydrocarbons, in which it is difficult to make a clear distinction between the continuous and dispersed phases. The first experiments to describe its structure were developed by Nellensteyn in 1924, whose model was later improved by Pfeiffer and Saal in 1940, based on the limited analytical procedures available at the time. The model adopted to configure the structure of the asphalt is called the micellar model, which provides a reasonable explanation of this, in which there are two phases; a discontinuous (aromatic) formed by asphaltenes and a continuous one that surrounds and solubilises them, called maltenes. The resins contained in maltenes are intermediaries in asphalt, fulfilling the mission of homogenizing and making compatible the otherwise insoluble asphaltes. Maltenes and asphaltenes exist as floating islands in the third component of asphalt, oils as can be seen in Figure 1

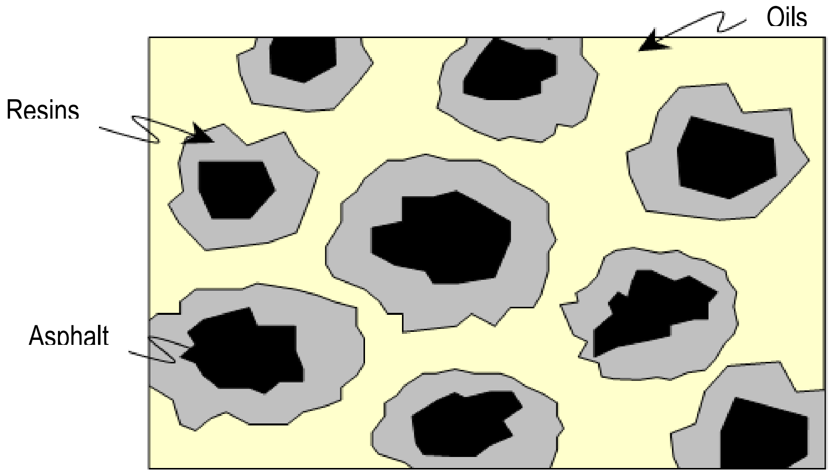

Figure 1. Pfeiffer and Saal's colloidal scheme

Fourier Transform Infrared Spectroscopy (FTIR)

Fourier Transform Infrared Spectrometry (FTIR) is an analytical technique used to study the chemical composition of organic and inorganic samples. It is based on the interaction of infrared radiation with the molecules of the sample, which absorb energy at characteristic frequencies associated with vibrational and rotational movements of chemical bonds. During FTIR analysis, the generated interferogram is decomposed into frequency components by Fourier transform, resulting in an infrared spectrum that shows absorbances as a function of wavelength. Each functional group present in the sample produces characteristic absorption bands in the FTIR spectrum, allowing for the identification of chemical bonds and functional groups present. FTIR spectroscopy has a wide range of applications in various areas, including chemistry, materials science, biology, and environmental sciences, among others (Griffiths & de Haseth, 2007; Silverstein, Webster & Kiemle, 2007; Socrates, 2004).

4.1.3 Asphalt mixtures

Definition

It is an intimate combination of stone aggregates and bituminous binder, in such a way that each aggregate particle is covered with a binder film such that, when the mixture is compacted, a resistant structure with good cohesion is formed.

Classification

Asphalt mixtures can be classified according to various criteria as illustrated in table 1, but for the purpose of this research we are interested in the criterion of manufacture and commissioning.

- ✓ **Hot mix asphalt**

  A mixture in which the components are preheated to the mixing temperature, and the installation requires maintaining a temperature higher than the ambient temperature. The asphalt binder can be regular or modified asphalt cement and can be given to traffic immediately after compaction.

- ✓ **Cold Mix Asphalt**

  Normally, mixing and installation are carried out at room temperature. The asphalt binder used is a normal, modified asphalt emulsion, a liquid asphalt or a heavy crude oil. To give it to traffic requires waiting for it to reach resistance, while the water or fluidizers in the binder evaporate.

CLASSIFICATION	
CRITERION	MIX TYPE
Manufacturing & Commissioning	Hot (On Floor)
	Cold : On the ground floor
	On the road
% of voids in the mix	Closed or dense : % Voids < 6
	Semi-open : % Empty 6 – 15
	Open : % Empty > 15
	Draining : % Voids > 20
Particle size distribution	Uniform
	Continuous
	Dashed
Maximum Aggregate Size	Thickness : Maximum size > 8 mm
	Thin : Maximum size < 8 mm
Employee Aggregate	Chew
	Mortar
	Macadam
	Concrete
Structuring the aggregate	With mineral skeleton
	Non-Mineral Skeleton

Table 1. Classification of asphalt mixtures

Source: ARENAS, Hugo. Pavement Theory Conference

Dosing methods.

The dosing methods for asphalt mixtures consist of determining the optimal percentage of bituminous material, which provides the minimum stability necessary to withstand the stresses to which they will be subjected, adequate waterproofing to prevent water access to the mixture and avoid deterioration, adequate deformation so that the bearing does not lose quality.

The mixture design methods used to evaluate behavior can be classified into:

- ✓ Empirical methods
- ✓ Mechanical Methods

Empirical methods: When laboratory equipment is not available, formulas can be used to calculate the approximate binder content, which are based on the calculation of the specific surface area of the aggregates

Mechanical methods: These are based on the determination of the strength or deformation of the mixture.

4.1.4 Aggregate-binder adhesion

Definition of adhesion

It is the ability of an asphalt binder to stick to the surface of an aggregate and prevent relatively high slippage between the particles, which deforms the asphalt layers or prevents the displacement of the rock fragments that make up the mineral skeleton of bituminous mixtures.

Variables influencing adherence

Adherence depends on several factors, including those listed in Table 2.

BINDER	**AGGREGATE**	**ASPHALT MIX**
Surface tension	Gradation	Drainage
Contact Angle	Mineralogy	Asphalt content
Consistency	Surface Texture	Percentage of voids
Origin of asphalt	Porosity and absorption	Temperature
Refining process	Particle Shape	Chemical Composition of Materials
Asphalt Durability	Surface Cleaning	
Thermal susceptibility	Wear resistance	
	Particle Durability	
	Humidity	

Table 2. Variables influencing adherence

The adhesion that an asphalt binder can develop in the long term with the aggregates is examined in the laboratory with empirical tests, which try to discover the particles previously enveloped by the binder, due to the effect of water, temperature or some chemical dilution.

4.1.4.1 Adherence assessment methods

Adhesion is defined as the affinity between the aggregates and the binder. Adhesion tests establish the procedure by which the affinity of these tests is checked.

4.1.4.1.1 Brazilian Method I or English Method

500 grams of the fraction between 3/4" and 1/2" are analyzed, these previously washed and dried aggregates are mixed with the binder. It is verified by the detachment of the film that covers the aggregate, when the aggregate-binder mixture is subjected to 40ºC and the action of distilled water, for 72 hours, being considered a satisfactory result when more than 80% of the particles are covered with asphalt.

4.1.4.1.2 Brazilian method II or Riedel-Weber

This standard describes the procedure to be followed to determine the adhesion of asphalt binders to natural or crushing sand (fraction contained between sieve number 30 and number 70), when the aggregate-binder mixture is subjected to the action of sodium carbonate solutions of increasing concentrations. This method can be applied to all bituminous binders: penetration asphalts, liquid asphalts, tars and asphalt emulsions as expressed in the INV E-774 standard. Once the adhesion test has been carried out by the Riedel-Weber method, the adhesion index is obtained, which is a value that represents the adhesion between the aggregate and the binder.

4.2. Results

4.2.1. Sampling of Heavy Crude Oils in Colombia

The information was collected and samples of the most relevant heavy crude oils in the Republic of Colombia were taken, Cedrales crude and Rubiales crude located in the Putumayo and Meta departments respectively. These, when evaluated, could be used as asphalt binder in the maintenance of the secondary and tertiary road network in the southwestern zone of Colombia, considering variables such as costs, availability, and location of these materials as presented in Table 3

CRUDE OIL CEDRALES		CRUDE OIL RUBIALES	
Crude Name	Cedrales	Crude Name	Rubiales
Country	Colombia	Country	Colombia
Department	Putumayo	Department	Goal
Operating Company	ECOPETROL	Operating Company	ECOPETROL

Table 3. Crude Location

4.2.2. Location of heavy crude oil characterized in Colombia

Figure 5.1 shows the location map of heavy crude oil in the Republic of Colombia evaluated in the research.

Figure 2. Location of heavy crude oil in Colombia

4.2.3. Physical characterisation

It consisted of carrying out tests on the original crude oil and the distillation residue in order to know the physical characteristics and thus control their quality and determine their possible behavior when they are part of an asphalt mixture.

Below are the results obtained for Cedrales crude oil

RESULTS OBTAINED WITH THE ORIGINAL CRUDE OIL		
PRACTICE	**RESULTS**	
Spark Point	Average	105 °C
Point of Flame	Average	157 °C
Relative density	Average	0.985 gr/cm3

Viscosity. Saybolt -Furol 110 °C 120 °C 130 °C	 Average Average Average	 146.5 SSF 96 SSF 57.5 SSF
Distillation At 182 °C Temperature At 217 °C Temperature At 250 °C Temperature At 305 °C Temperature At 349 °C Temperature % Total Distillate % Residue	 Average Average Average Average Average Average Average	 1.61 % Distillate 0.61 % Distillate 0.88% Distillate 5.55 % Distillate 6.25 % Distillate 14.9 % 85.1 %
Water Content %	Average	2.1 %

Table 4. Characterization of the results of tests obtained with the original Cedrales crude oil.

RESULTS OBTAINED WITH THE DISTILLATION RESIDUE		
PRACTICE	**RESULTS**	
Viscosity. Capillary 60 oC- 300 mm Hg.	Average	130 Poises
Softening point	Average	56.4 °C
Penetration Temperature 15oC, 100 g, 5 sec.	Average	60 °C
Penetration Temperature 25oC, 100 g.5 sec	Average	94 °C

Table 5. Physical characterization-results of tests obtained in the distillation residue of Cedrales crude oil.

Below are the results obtained for Rubiales crude oil

RESULTS OBTAINED WITH THE ORIGINAL RUBIALES CRUDE OIL		
PRACTICE	**RESULTS**	
Spark Point	Average	127 °C
Point of Flame	Average	160 °C
Relative density	Average	0.978 gr/cm3
Viscosity. Saybolt -Furol 60oC 70 °C 80 °C 90 °C	 Average Average Average Average	 201.5 SSF 114.5 SSF 63 SSF 39.5 SSF
Distillation At 182 °C Temperature At 217 °C Temperature At 250 °C Temperature At 305 °C Temperature At 349 °C Temperature % Total Distillate	 Average Average Average Average Average Average	 0.3% Distillate 0.2% Distillate 0.1% Distillate 0.3% Distillate 8% Distillate 8.8 %

% Residue	Average	91.2 %
Water Content %	Average	1.1 %

Table 6. Characterization of the results of tests obtained with the original Rubiales crude oil.

4.2.4- Characterization by infrared spectroscopy
In the present research, two types of crude oil were studied, to which physical characterization studies were carried out (spark point, flame point, relative density, viscosity), rheological tests and spectroscopic analysis by FTIR. Several blends were prepared using the crude oils to evaluate their behavior and potential use in secondary roads in southwestern Colombia
The original crude samples and distillation residues were analyzed using Fourier Transform Infrared Spectroscopy (FTIR) utilizing the GEMINI FTIR ATI MATTSON spectrophotometer (400-4000 $^{cm-1}$).
The original crude oils have specific physical and chemical characteristics, which change when the crude is subjected to distillation.
Cedrales Crude

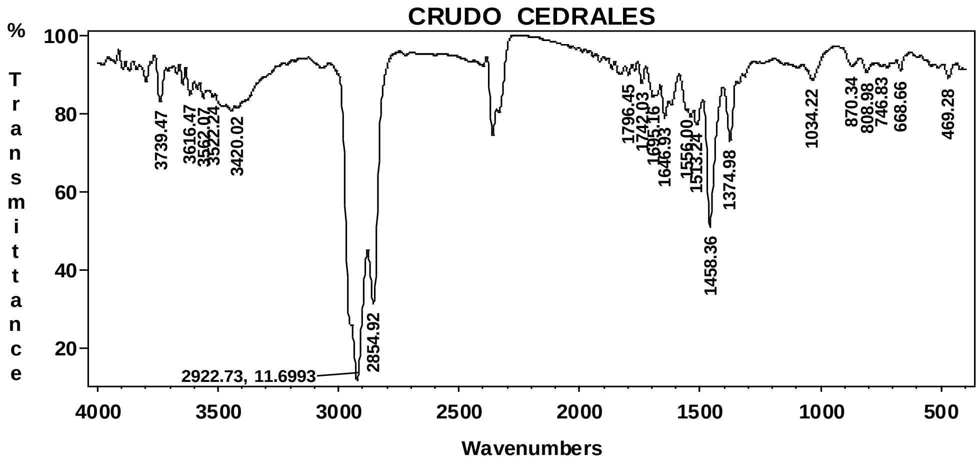

Figure 3. Spectrum of the original Cedrales Crude sample

In the infrared spectrum presented in figure 3, the most characteristic bands at 2922, 2854, 1958, and 1374 $^{cm-1}$ corresponding to the C-H tensions, stretching of the C-H bonds mainly, this type of signals is common for linear chains as well as methyl groups C-CH3.

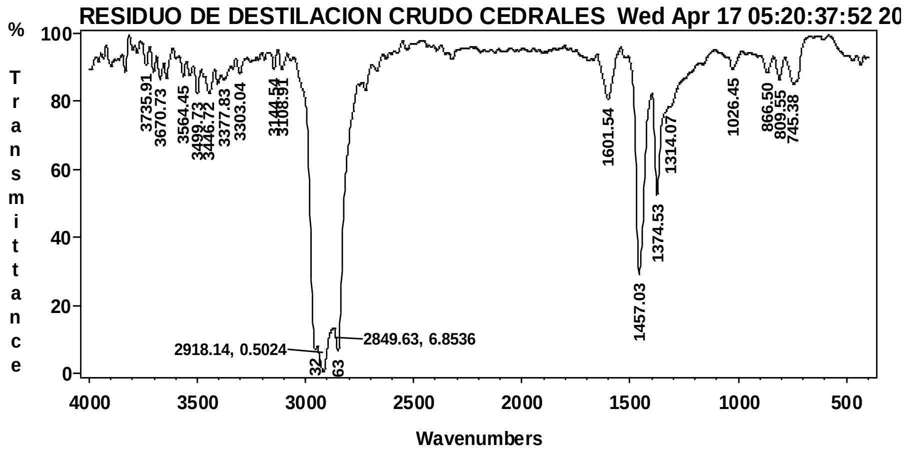

Figure 4. Spectrum of the residue after distillation of Cedrales Crude

The faint signals in the region from 1800 $^{cm-1}$ to 1510 $^{cm-1}$ can be attributed to the presence of aromatic hydrocarbons and correspond to the stretching of the aromatic rings C=C. The deformation signals of the C-H bonds are observed in the region between 870 $^{cm-1}$ and 668 $^{cm-1}$, which makes it impossible to differentiate them from the vibration signals of the methylene groups belonging to aliphatic hydrocarbons. (See figure 4). The signals between 3739 $^{cm-1}$ and 3420 $^{cm-1}$ can be probably attributed to N-H, O-H stretching corresponding to compounds containing oxygen, nitrogen, and sulfur, many of them aromatic.

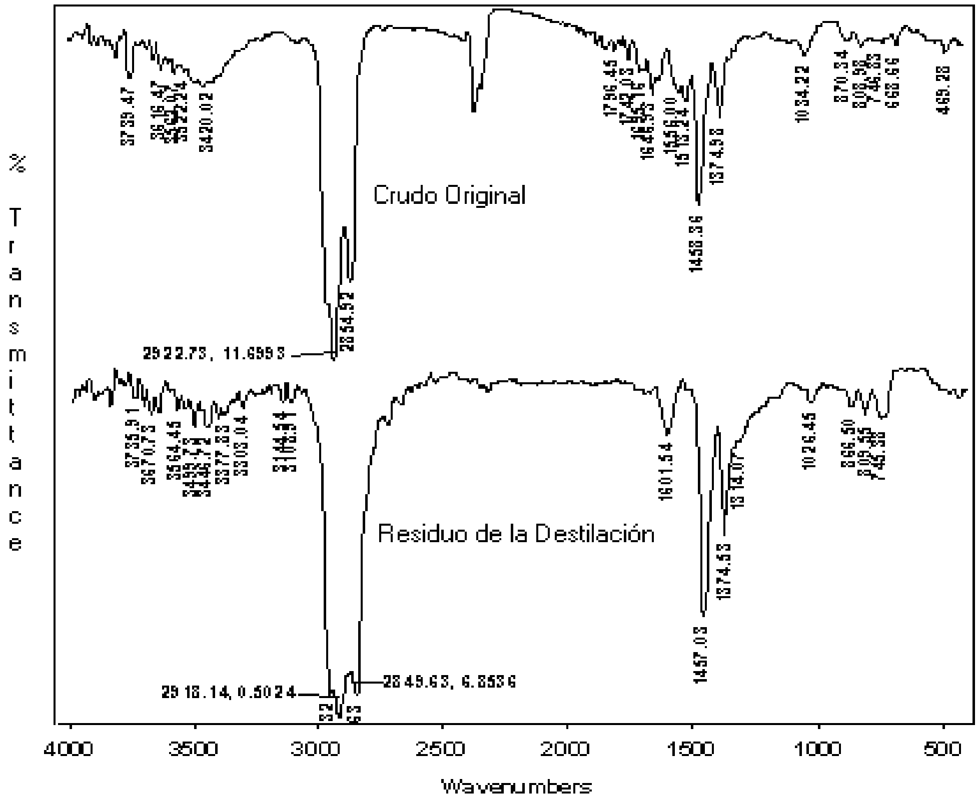

Figure 5. Comparison between the original crude and the distillation residue of Cedrales.

In the spectrum of figure 5, where the spectra of the original crude and the distilled crude Cedrales are presented, it can be observed how the signals in the region between 1800 $^{cm-1}$ and 1500 $^{cm-1}$ disappear and the intensity in the bands in the region 3750 -3100 $^{cm-1}$ decreases. This can be explained due to the loss of low molecular weight hydrocarbons (mainly aliphatic and aromatic), likewise, the loss of oxidized and nitrogenous compounds can be suggested.

Rubiales Crude

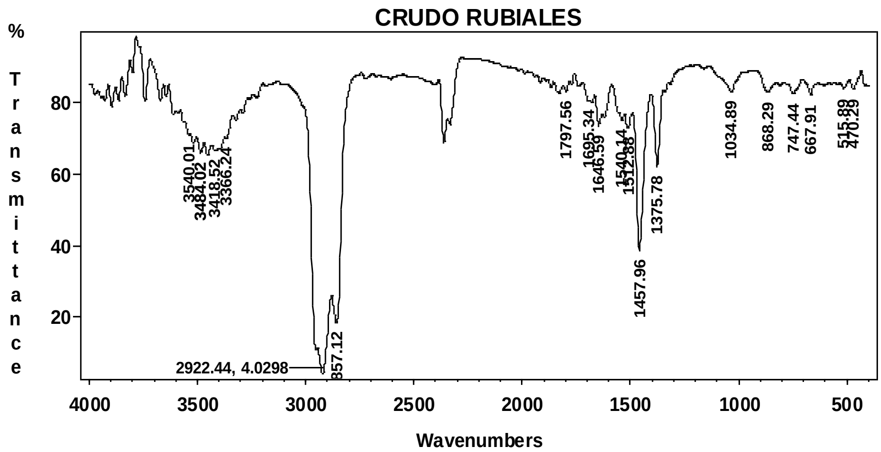

Figure 6. Spectrum of the original Rubiales Crude sample

In the region around 3500 $^{cm-1}$, typical elongations of polar NH and OH groups are obtained, mainly water. The most predominant band is found in the region of 2922 $^{cm-1}$, which indicates the presence of saturated hydrocarbons (All bonds are single). In the region located between 1300 - 1500 cm-1, the CH elongations are observed, which confirm the existence of saturated hydrocarbons. (See figure 6)

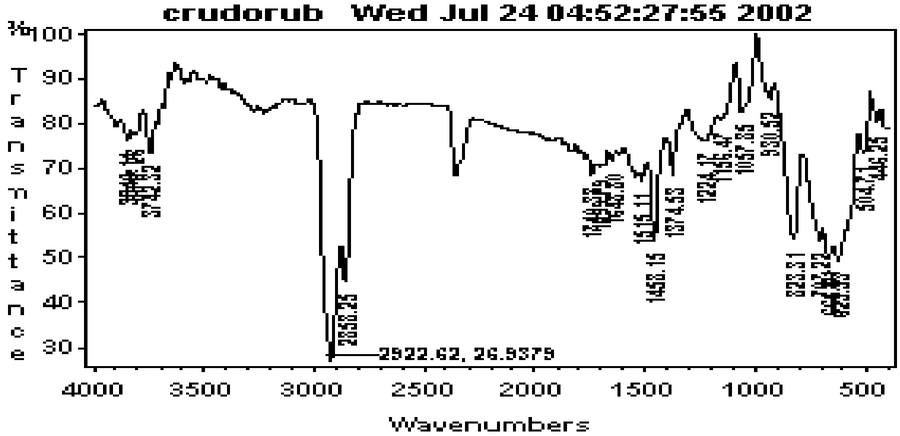

Figure 7 Spectrum of the residue after distillation of Rubiales Crude

In the spectrum of figure 7, in addition to the characteristic hydrocarbon signals observed, the region around 3450 cm-1 can be appreciated, which indicates the presence of N-H and OH vibrations mainly corresponding to compounds containing oxygen, nitrogen, and sulfur, many of them aromatic, which are found in smaller proportions compared to the fractions of aromatic hydrocarbons.

Figure 8 compares the spectra made to the original crude and the distillation residue, in which the disappearance of the bands located in the region of 3500 cm-1 is observed, which is probably due to their origin, translating into the loss of considerable amounts of water. The band located above 500 cm-1 is characteristic of asphaltenes, probably because after the distillation process they are found in greater concentration. The action of heat on the hydrocarbons present in the original crude facilitates their conversion into asphaltenes, this transformation is very important because these compounds indicate an increase in the intensity of the corresponding bands, which can be translated into an increase in the resistant skeleton of the asphalt produced by the oxidation phenomenon implicit in the distillation process, which causes the oils to turn into resins and these into asphaltenes.

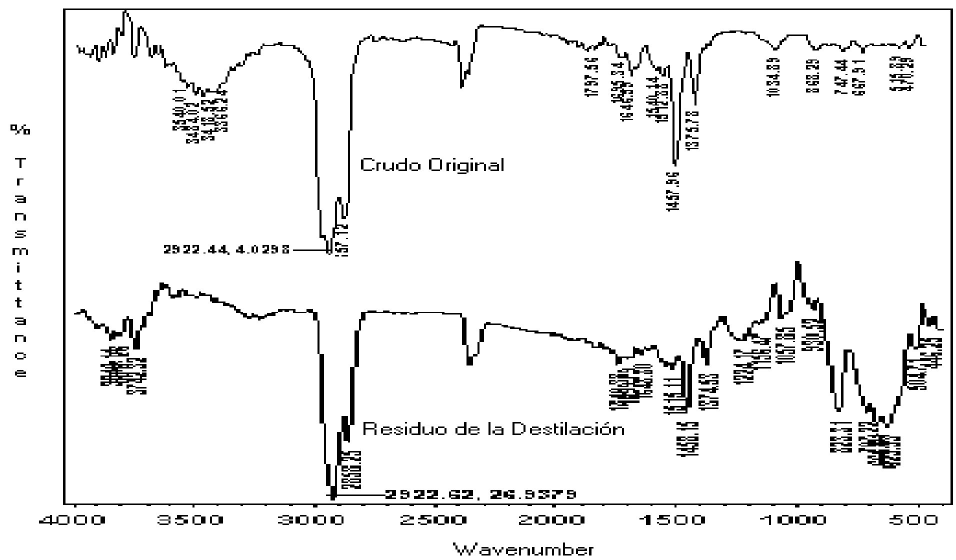

Figure 8. Comparison between the original crude and the distillation residue of Rubiales.

4.2.5. Rheological characterization. This characterization was carried out through the analysis of rheological curves, which were determined from viscosity vs. temperature values. Below are the rheological curves for each of the crudes evaluated, which correspond to the original crudes and to them after losing 25% of their solvents.

to. Raw rheological curve Cedrales

Figure

b.

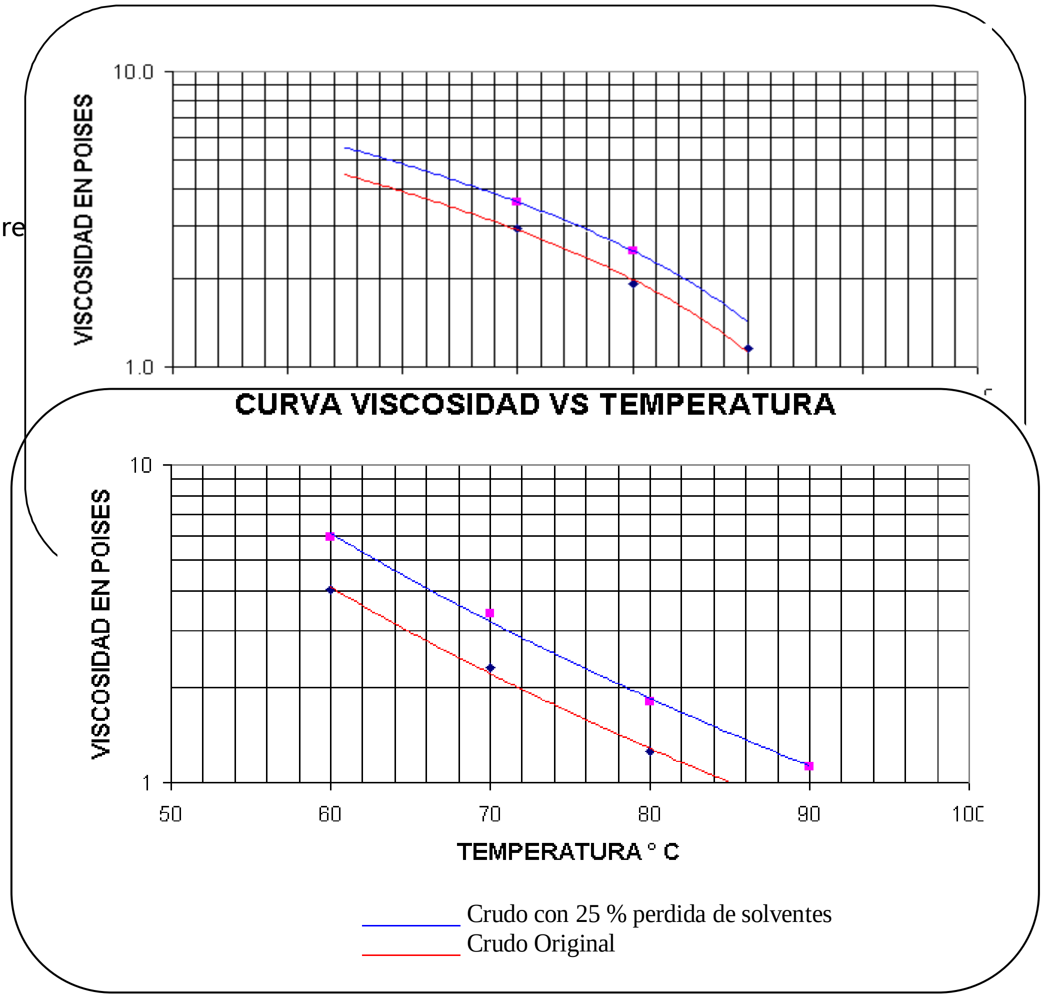

Figure 10. Rubiales Crude Rheological Curve

Rubiales crude oil is the one with the highest thermal susceptibility due to the fact that it has the highest SVT value (Viscosity Susceptibility to Temperature)

4.2.6. DESIGN AND PRODUCTION OF ASPHALT MIXTURES.

4.2.6.1. Evaluation of adhesion aggregate binder. Below are the results of the adhesion evaluation of the different heavy crudes under study and the mineral aggregate of the Puracé source (See Table 7)

ADHESION EVALUATION OF AGGREGATE BINDER PART				
Raw	**Practice**	**Adhesiveness Index**	**% Coating**	**Affinity**
CEDRALES	Weber Riedel Method	10		Optimal
	Brazilian Method I		95 %	Satisfactory
RUBIALES	Weber Riedel Method	6		Good
	Brazilian Method I		90 %	Satisfactory

Table 7. Adhesion Evaluation Aggregate Binder

The results obtained in the evaluation of the fine-binder aggregate adhesion (asphalt mastic) using the Riedel Weber method are between good and optimal for the fine fraction of the aggregate due to the fact that the adhesion index values of the method were between 6 and 10, which guarantees that the affinity between this part of the aggregate and the asphalt binders (crude) allow optimal asphalt mixtures from this point of view. For the adhesion of the coarse fraction of the aggregate, which was determined with the Brazilian method I, a satisfactory coarse-binder aggregate adhesion was obtained, due to the fact that its coating percentage varied between 90% and 95%.

4.2.6.2. Blend design with Cedrales crude oil.

a. The curing process for each of the briquettes was carried out by subjecting each mixture in the oven to a controlled temperature of 128 $^{\circ C}$ in such a way that the solvents are lost up to the required percentage of loss, controlling this by means of constant weighing before proceeding to the specified compaction. The temperatures used during the design of the mixture, obtained from the thermal susceptibility curve (Viscosity vs. Temperature), are presented in Table 8:

Temperature	Rank Earned
Mixing Temperature	121 °C-127 °C
Compaction Temperature	120 °C-114 °C
Curing Temperature	128 °C

Table 8 Working temperatures of Cedrales crude oil

Parameters	Value Earned	Specified Range For liquid asphalts
Maximum Density	144.4 lbs.3	----
Maximum stability	4030 lb	Minimum 500
% empty with air	4.4 %	3 - 5 %
% Voids in Mineral Aggregates	14.7 %	Minimum 13%
Flow	18.2 1/100"	Minimum 8-Maximum 16

Table 9. Raw Marshall Cedrales Assay Results.

4.2.6.3. Rubiales crude oil mix design

a. The temperatures used during the mixture design process, obtained from its thermal susceptibility curve (Viscosity vs. Temperature), are presented in Table 10.

Temperature	Rank Earned
Mixing Temperature	73 °C-77 °C
Compaction Temperature	74 °C-70 °C
Curing Temperature	83 °C

Table 10. Working temperatures of Rubiales crude oil

Parameters	Value Earned	Specified Range For liquid asphalts
Maximum Density	147.2 lbs.3	-----
Maximum stability	3150 lb	Minimum 500
% empty with air	3.33 %	3 - 5 %
% Voids in Mineral Aggregates	13.2 %	Minimum 13%
Flow	15 1/100"	Minimum 8-Maximum 16

Table 11. Results of the Marshall crude Rubiales assay.

4.2.6.4. Design of asphalt mixtures with the Immersion-Compression method

4.2.6.4.1. Mixing: for the execution of this method, six specimens were prepared for each percentage of asphalt, the optimal percentage obtained in the Marshall method and two other values were taken as a reference, with a percentage variation of 0.5% in its content, one above and one below it.

Crude oil name	% Crude Oil	Briquette resistance without immersion Kg/cm2	Briquette resistance in immersion Kg/cm2	Conserved Resistance Index %
Cedrales	7.0	28.4	21.9	77.3
	7.5	**24.9**	**20.2**	**81.0**
	8.0	23.6	9.4	39.8
Rubiales	6.0	10.6	3.9	36.8
	6.5	**8.5**	**4.9**	**57.8**
	7.0	8.0	4.6	57.1

Table 12. Results Obtained from the Immersion-Compression Test for Cedrales and Rubiales crude oils.

5. CONCLUSIONS

Thanks to the documentary analysis proposed in this document, it was possible to know physical and chemical details of the compounds used in the restoration of the road network of the Rural Roads in the South-Western Zone of Colombia, as well as the following final considerations:

It is recommended that, in order to achieve greater durability of asphalt mixtures with bituminous products placed on the road, the action of water should be controlled through the construction of a protective layer such as sand-asphalt, slurry, double surface treatment, etc., due to the high susceptibility of these materials and which was evidenced in the results of conserved resistance of the Immersion-Compression method.

To facilitate the mixing of natural asphalt, water must be added or removed according to the degree of humidity until the pre-wrapped humidity is reached. To do this, if the natural moisture of the natural asphalt is above, the mixture must be dried before spreading with the help of the motor grader; if, on the other hand, the natural humidity is below the optimal compaction humidity; Water must be added to the mixture until the optimum humidity is reached, after reaching this humidity proceed to spread with a motor grader and compact with the help of a vibrocompactor until the appropriate densification is reached.

Cedrales crude oil is the one with the highest viscosity with respect to the other crudes studied in this research, its API grade is 12.15 so it can be considered as a heavy crude (heavy crudes API grade < 15), this crude contains 85% asphalt cement, 15% solvents of different volatility and 2.1% water. 157 ºC which corresponds to the temperature of the flame point, and caution must be taken on site as the application temperature is above the spark point which is 105 ºC

The asphalt residue of Cedrales crude oil obtained from distillation can be classified as an AC 80/100 according to the INVIAS specifications that must be met by asphalt cements in Colombia, according to its viscosity, flash point characteristics and total distillate at 360ºC, this crude oil can be classified as a natural liquid asphalt with properties similar to those of a slow-curing industrial liquid asphalt. From the distillation test, it is observed that the percentage of asphalt cement contained in this heavy crude oil is higher than that generally contained in commercial liquid asphalts, which are on

average 75% asphalt cement, this being an indication that this material will have an acceptable behavior as a binder in an asphalt mixture.
Cedrales crude requires a higher temperature to obtain a given viscosity, while Rubiales crude to obtain the same viscosity requires a shorter temperature range. For the same temperature, the one with the lowest viscosity and therefore the highest manageability is the Rubiales crude oil and the one with the highest viscosity is the Cedrales crude, taking into account the inverse relationship between viscosity and manageability.

Fast Fourier transform infrared spectroscopy can be used to detect changes during the different processes to which an asphalt mixture made with natural bituminous products is subjected, by determining the different concentrations of the characteristic functional groups and thus predicting more accurately their behavior in service. This assay can be used as a complement to other traditional assays
The strength results of the briquettes obtained in the Immersion Compression test for Cedrales crude oil presented higher values of approximately double those obtained with respect to the other crude oils.

For natural asphalt mixtures, it is recommended to use the compression immersion method because it evaluates the effect of water on the mixture, which is a basic parameter for the durability of road improvements made with these materials

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