# INFLUENCE OF WATER IN ASPHALT BINDERS AND ITS IMPACT ON STRIPPING OF ASPHALT MIXTURES

*Ana Sofía Figueroa*[1], *Fredy Alberto Reyes*[2]
[1]*Salle University, engineering faculty, Bogota, Colombia*
[2]*Javeriana University, engineering department, Bogota,Colombia*

## ABSTRACT

*Stripping is one of the main modes of failure for flexible pavements. This phenomenon occurs when debonding at the interface between aggregate and asphalt binder happens due to the presence of water. Despite extensive research in this area, the causes for stripping of asphalt mixtures have not been fully identified and explained. Research has focused on evaluating the mineralogy of the aggregate and its susceptibility to moisture and on evaluating the adhesive strength of aggregate-binder systems in the presence of water. However, efforts on investigating the effects of water in the asphalt binder have been minimal.*
*This paper studies the influence of water in asphalt binders and its impact on stripping of asphalt mixtures. Typical asphalt binders and aggregates used for construction of flexible pavements in Colombia will be used for this study. Asphalt mixtures are prepared according to local standard procedures. The test program includes physical-chemical analysis for the binders, aggregates, and water, moisture susceptibility tests of the mixtures prepared with asphalt binders that have been extensively exposed to water and asphalt mixture dynamic tests to observe performance under cyclic loading. Furthermore, the Bitumen Bond Strength (BBS) test will be used to evaluate the importance of this phenomenon on the bond strength at the binder-aggregate interface.*

**Keywords:** Stripping, Bitumen Bond Strength, Moisture Damage, Asphalt Binder

## INTRODUCTION

The Stripping phenomenon is one of the most frequent damage in roads. This damage usually occurs when traffic is opened and the material reacts with loads and water. The state of knowledge in this area indicates that despite the high number of investigations about this phenomenon and the causes that generate it, this has not been completely resolved. Generally, the consulted studies about *stripping* evaluate the influence of the type and mineralogy of the aggregate and in smaller scale studies have been developed to evaluate the influence of water in the asphalt binder. This research will evaluate the influence of the asphalt in the stripping phenomenon, due to the effect of water in the binder. The experimental plan includes *asphalt 80-100*. The asphalt has an immersion process for 21 months. During this time the asphalt will be monitored in order to analyze the changes that occur in this as a result of permanent water contact. The experimental design includes the physical and chemical characterization of asphalt in dry and wet condition. Another aspect that this researcher will be to analyze the influence of this asphalt in mixtures and how it affects the moisture damage in mixtures

## BACKGROUND

The Stripping has been one of the topics more studied en the last years but the most relevant studies were made in the 60's. Stripping is a damage that generates the braking of the adhesive bond between the aggregate surface and the asphalt. *Stripping is generally contributed to moisture infiltration into the asphalt, causing a weakening of the bituminous binder that holds the aggregates together, known as the asphalt mastic, and a weakening of the aggregate-mastic bond* [1]. The worst problems in pavement life are the combined effects of loads and moisture, so it is very important to control this parameters in order to have expected performance of structure. These effects have been studied since decade 30'S. Nicholson, V., 1932,[2] was one on first researcher that studied the adhesion problems. In his document "*Adhesion tension in asphalt pavements, its significance and methods applicable in its determination* "he discussed the importance of kind of rocks, asphalt in presence o water for adhesion problem in mixtures. In 1958 [3] The American Society for Testing Materials did the "*Symposium on Effect of Water on Bituminous Paving Mixtures. Ed. 240*". The most important topics were the studies about effects of water in pavements and relationship with damage caused by moisture in the pavement. James. M. Rice [3] presented his research about adhesion in mixtures. , aggregates composition, texture, absorption, chemical reactivity and surface energy of three points of view: chemical reaction, interfacial and mechanical theories. This research showed Stripping damages in roads of Ohio, Michigan, Nebraska, Ontario and others. The typical damages were describe that "…unsatisfactory behavior of asphaltic concrete surfaces under traffic as a result of exposure to moisture after construction" and "aggregates were not satisfactorily dried before weighing in pugmill". Another important concept discussed in this decade was the rocks properties and the mixtures adhesion effects. "The properties of aggregates which are considered to affect the adhesion of bituminous materials in the presence of water are surface, texture, surface coating, particle size and surface area, porosity and adsorption, chemical reactivity, and surface energy."[4]. This last concept was strongly reconsidered in the first decade of 2000´s. In 1988 The National Center of asphalt technology –NCAT Auburn University published an interesting report called "*STRIPPING IN HMA MIXTURES: STATE-OF-THE-ART AND CRITICAL REVIEW OF TEST METHODS*" [5]. The purposes in this research were to study the stripping mechanisms failure in order to eliminate or minimize this effects, development test procedures to reliably measure the stripping damage before the fact and to evaluate the function, need and cost the antistripping additives. The researcher was organized in four tasks since 1988 until after 1991. The reviewing realized in this research presented Stripping causes that several researchers have defined such as J.C.Peterson [ 6 ] who defined it as the "*Deterioration or loss of the adhesive bond between the asphalt and the aggregate from the action of water*", T.W Kennedy et al [7 ] who defined it as the "The physical separation of the asphalt cement from the aggregate produced by the loss of adhesion primarily due to the action of water or water vapor". The most important in this definition was introducing the effect of the water vapor in the stripping phenomenon. Kiggundo et al[8], defined the stripping as the *"The progressive functional deterioration of a pavement mixture by loss of the adhesive bond between the asphalt cement and the aggregate surface and/or loss of the cohesive resistance within the asphalt cement principally from the action of water*." He analyzes the Stripping of two points of view: cohesion and adhesion. Until now the different researchers have been focused in the adhesion problems but in less or any proportion the cohesion had been studied. In 1999 Department of Transportation of Wisconsin published the researcher "E*valuation and Correlation of Lab and Field Tensile Strength Ratio (TSR) Procedures and Values in Assessing the Stripping Potential of Asphalt Mixes*" [9]. The objectives of this work were determine if the procedures at this moment predicted the moisture damage of mixes in field, determine if the Wisconsin pavements have moisture damage problems based on laboratory and field TSR, to determine the consequences on the performance pavement based in cores extracted in some sections of this and reviewing the test existing to determine moisture damage and propose others. The results indicated that the TSR test is very sensitive to procedure and details of testing. The threshold value of TSR was studied in this research due to varying of this value between 0,60 to 0,85 in function of materials quality in the mixtures. In Wisconsin the threshold value of TSR is 0,70. Some on the main findings in this research were the lack of a relationship between PDI value (identify the pavement performance) and TSR value (identify pavement moisture damage susceptibility). The TSR testing doesn´t the moisture damage of the mixes in the field. TSR testing is very sensitivity in its process and difficult to establishing a relationship between damage in field and TSR results in lab. In 2006 Bhasin [10] development a researching in order to identify and validity the analytical methods to determinate the moisture damage in asphalt mixtures based in the free energy concept. He introduce a concept to quantify the combined effects of aggregates and binder thru micro microcalorimetry. His work focused on the degradation of the bitumen-aggregate adhesion in presence of water. He based his research in the concept development by Good-van Oss-Chaudhury (GVOC) which is expressed as:

$$\gamma = \gamma^{LW} + \gamma^{+-} = 2\sqrt{\gamma^{+}\gamma^{-}}$$ equation 1

Where:

$\gamma$: material free energy (ergs/cm$^2$ ó mJ/m$^2$)

$\gamma^{LW}$: dispersive or no polar componente (Lifshitz-van der Waals (LW))

$\gamma^{+-}$: acide base component

$\gamma^{+}$: Lewis acide component Lewis

$\gamma^{-}$: Lewis basic component

Adhesion between two materials is expressed as:

$$W = 2\sqrt{\gamma_A^{LW}\gamma_B^{LW}} + 2\sqrt{\gamma_A^{+}\gamma_B^{-}} + 2\sqrt{\gamma_A^{-}\gamma_B^{+}}$$ equation 2

In 2007 Caro et al [11], presented in their research the characterization and modeling on moisture susceptibility of asphalt mixtures. They done a discuss about the methodologies existing to quantify moisture damage, analyzed the mathematical work existing about modeling and future areas of research. This work emphasized the modeling in the MDR, *Moisture Damage Ratio* (Kiggundu and Roberts1988,Birgisson et al. 2005).

$$MDR = \frac{f(P_1^w, P_2^w, P_3^w \ldots\ldots; P_n^w)}{f(P_1^d, P_2^d, P_3^d \ldots\ldots; P_n^d)} \qquad \text{equation 3}$$

Where:

$f(P_1^w, P_2^w, P_3^w \ldots\ldots; P_n^w)$ wet properties of material in laboratory

$f(P_1^d, P_2^d, P_3^d \ldots\ldots; P_n^d)$ dry properties of material in laboratory

In 2010 R.Moraes, R.Velásquez & H.Bahia [12] , development a research to study adhesion and cohesion problems in different asphalts. The most important contribution of this research is the strength cohesion and adhesion analysis with different binders (original and modifiers) and different aggregates. This research will development some of these test in order to analyze the strength cohesion and adhesion with submerged asphalts.

### 1.1. Mechanisms of Moisture Damage

The literature indicates that there are different mechanisms through stripping occurs. Table 1 shows some of this mechanism.

**Table 1 Aspects that contribute that Moisture Damage in asphaltic mixtures[1]**

| | |
|---|---|
| **MIXTURE DESIGN** | - Asphalt and aggregates chemistry<br>- Aspahlt amount<br>- Voids<br>- Additives |
| **PRODUCTION** | - Percentage of covering and quality of material pass sive 200<br>- Mix temparature<br>- Aggregates Moisture<br>- Aggregates with Clay |
| **CONSTRUCTION** | - Execess of compacting in field<br>- Hight permeability<br>- Segregation<br>- Changes in the mixture in field respect mixture design |
| **TEMPERATURE** | - Wet areas<br>- Freezing and defrost cycles<br>- Separation of water vapor |
| **ANOTHER ASPECTS** | - Surface draniage<br>- Rehabilitation strategies (marginal materials use) |

[1] Ref. Moisture Sensitivity of Asphalt Pavements A NATIONAL SEMINAR, Transportation Research Board, 2003, San Diego, California, p7.

| - Heavy loads (vehicles) |
|---|

These mechanisms may act together or separately and they can cause adhesion failures in the asphaltic mixtures. The figure 1 shows the *Stripping Mechanisms* that have been studied since 30´s until now.

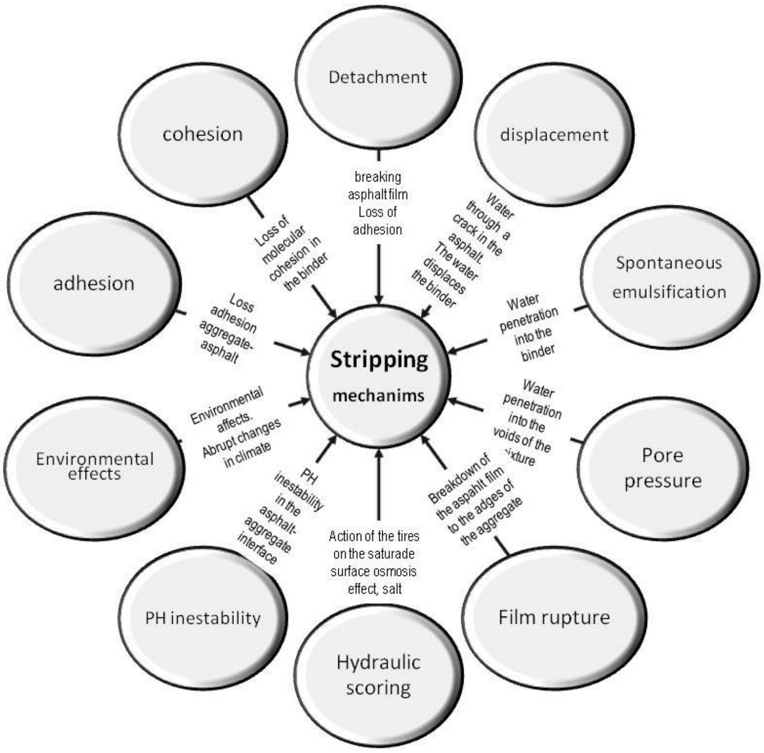



**Figure 1 Stripping Mechanisms**

### 1.2. Identifying the problems of Moisture sensitivity

The engineers have a challenge in order to identify what is the Moisture Damage cause. Some times this problem is related with Moisture and his impact in the pavement other is related with poor construction practices. The associated problems with moisture damage show rutting, pumping and water bleeding, cracking and alligator cracking. This damages also have another causes and should be well analyzed in order to indentify the Stripping phenomenon. Figure 2 shows the stripping damage in pavements.

**Figure 2. Stripping Phenomenon Evidence in Flexible Pavements**

The figure 3 shows a flow chart that helps to recognize the problems in field in order to identify Stripping problems. These problems were discussed in a National Seminar, Transportation Research Board in San Diego, California, 2003.

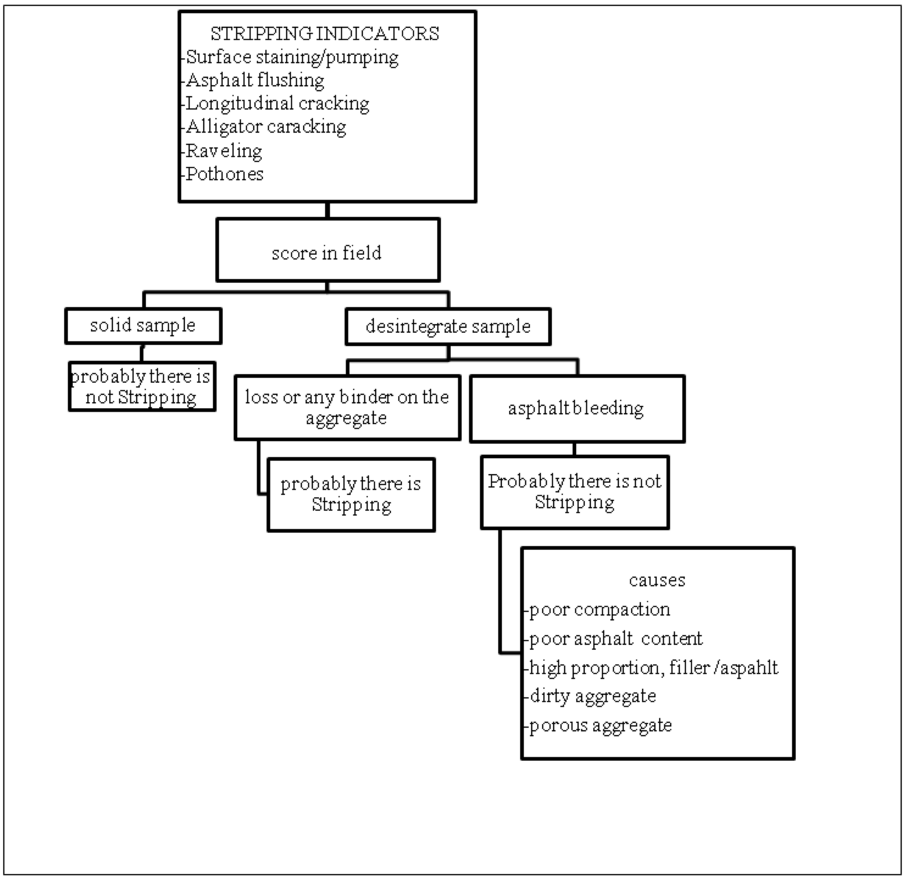



**Figura 3. Flow chart to identify Stripping in field**[2].

## 2. EXPERIMENTAL DESIGN

This project studies the influence of water on asphalt binders and its impact on stripping of asphalt mixtures. The specific objectives are:

- Review background of stripping in asphalt mixtures
- Study physical and chemical properties of asphalt binder CA 80-100 in original condition and after water immersion.
- Evaluate effect of different water immersion times for the asphalt (0, 3, 6, 9, 12,16,18, and 21 months) on the adhesion and cohesion of asphalt/aggregate systems.
- Evaluate stripping phenomenon in mixes prepared with asphalt which was conditioned in water at: 0, 3, 6, 9, 12, 16, 18 and 21 months.
- The water for asphalt submersion is room temperature.

In this paper are shown and analyzed the results for the first three months about submerged asphalts.

[2] Ref. Moisture Sensitivity of Asphalt Pavements A NATIONAL SEMINAR, Transportation Research Board, 2003, San Diego, California, p12.

## 3. TEST MATRIX

Immersion in water of asphalt thin films (height=2mm) during 21 months. Mechanical and chemical tests will be performed before and after conditioning.

**Figure 4. Asphalt binders submerged in water**

In this research are being analyzed the chemical changes in the submerged asphalt as well as the temperature influence.

**Figura 5. Aggregate-asphalt submerged**

## 4. METHOD AND MATERIALS

This research considers a test plan which is presented in the figure 6.

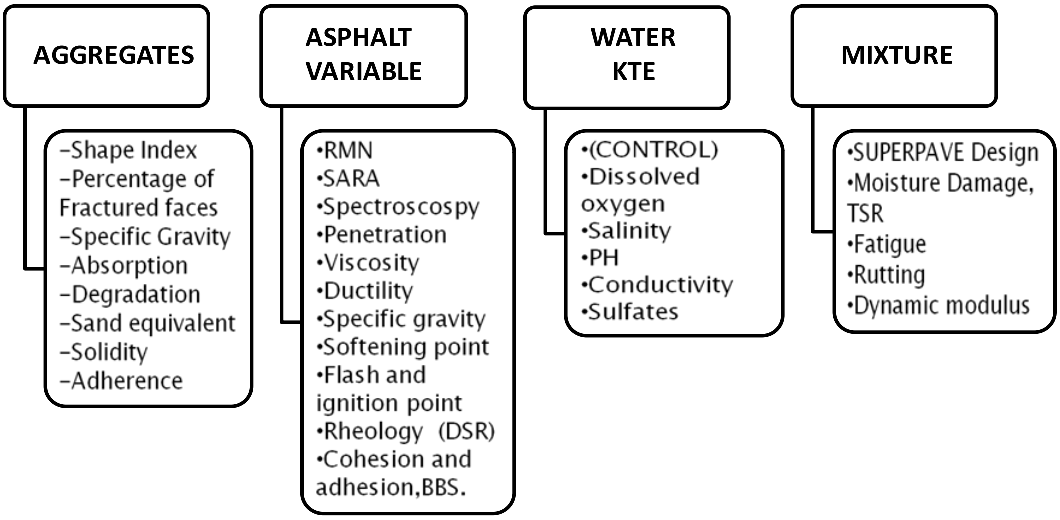



**Figura 6. Test plan**

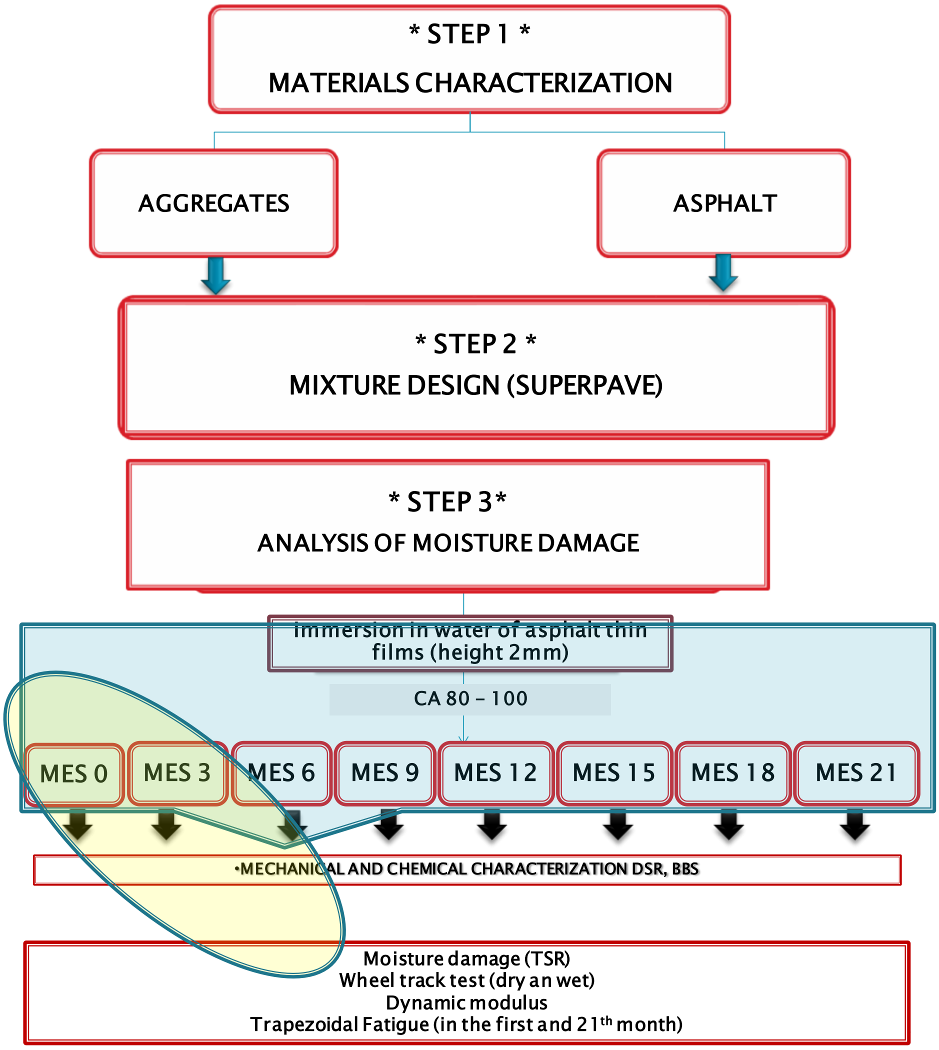



**Figura 7. Work plan**

In this research first phase are showed some results for asphalt submerged for three months.

## 5. PARTIAL RESULTS

**Aggregates**. The aggregates are extracted of *Coello River* in Tolima - Colombia. These aggregates belong to Superior Gualanday group and have siliceous rocks. The river has active alluvium, sand and materials that are crushed in primary, secondary and tertiary crusher. The aggregates characteristics are presented in the tables 2 and 3.

**Asphalt**. The asphalt belong to *Ecopetrol Refinery* in Barrancabermeja-Colombia. The asphalt characteristics are shown in the table 4. In order to have repeatability in the test the statically analysis was realized with six (6) samples for the original asphalt and four samples for the submerged asphalt.

## Table 2. Aggregates characteristics

| CHARACTERISTICS | Un | Especification | International Reference | Minimum limit | Maximum limit | Coarse aggregate | Fine aggregate | Total samples | Average | Estándar Deviation | Coefficient of Variation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lost on abrasion "Los Ángeles" <size 37.5 mm | % | INV E-218 | ASTM C 131 – 01<br>AASHTO T 96 – 02<br>UNE EN 1097 – 2: 1998 | | 35% | 28,59% | N/A | 3 | 28,59% | 0,62% | 0,02 |
| Lost on abrasion "Microdeval" | % | INV E-238 | AASHTO T327 – 05<br>ASTM D6928 – 03<br>UNE EN 1097 – 1 | mezcla MDC-1 20% (rodadura) | 20% (rodadura) | 10,38% | N/A | 3 | 10,38% | 0,26% | 0,03 |
| Gravel Solidity | % | INV E-220 | DNER-ME 096 – 98<br>BS 812 Part 110 – 1990 | | 18% | 1,00% | - | 5 | - | - | - |
| Fine aggregateSolidity | | | | | | - | 4,10% | 4 | - | - | - |
| Azul de Metileno value | % | INV E-235 | AASHTO TP 57-01 (2004) | - | 10% | N/A | 4,83% | 3 | 0,48% | 0,14% | 0,30 |
| Elongation Index (IL) | % | INV E-230 | UNE EN 933-3 1997<br>NLT 354- 91 | - | 30% | 6,92% | N/A | 3 | 6,92% | 0,99% | 0,14 |
| Flatening Index(IA) | % | | | | | 21,09% | N/A | 3 | 21,09% | 0,69% | 0,03 |
| Elongation and Flatening Index (IAL) | % | | | | | 2,54% | N/A | 3 | 2,54% | 0,46% | 0,18 |
| Fractured aggregates | % | INV E-227 | ASTM D 5821 – 01 | 75% | - | 87,68% | N/A | 3 | 87,68% | 0,02% | 0,00 |
| Flat particles | % | INV E-240 | ASTM D 4791 – 99 | - | 10% | 0,00% | - | 3 | - | - | - |
| Flat and elongated particles | % | | | | | 0,25% | - | 3 | 0,10% | 0,13% | 1,33 |
| Sand equivalent | % | INV E-133 | ASTM D 2419 – 95<br>AASHTO T 176 – 02 | 50% | | - | 58,00% | 3 | 49,00% | 9,64% | 0,20 |
| Especific Gravity (Bulk) | | INV E-223 | ASTM C 127 – 88<br>(Reaprobada en el 2001)<br>AASHTO T 85 – 91 (2004) | Depends of the design | | 2,60 | 2,38 | 3 | 2,60% | 0,02% | 0,01 |
| Specific Gravity Bulk sss | | | | | | 2,63 | 2,42 | 3 | 2,63% | 0,02% | 0,01 |
| Especific Gravity Bulk apparent | | | | | | 2,69 | 2,69 | 3 | 2,69% | 0,04% | 0,01 |
| Absorption | % | | | | | 1,25% | 1,97% | 3 | 1,25% | 0,31% | 0,25 |

## Table 3. Aggregates Petrography

**GRAVEL COMPOSITION**

| MINERAL FRAGMENTS | % | VOLCANIC IGNEOUS ROCK FRAGMENTS | % | PLUTONIC IGNEOUS ROCK FRAGMENTS | % | SEDIMENTARY ROCK FRAGMENTS | % |
|---|---|---|---|---|---|---|---|
| QUARTZ | 3,9 | DIABASE | 2,0 | DIORITE | 13,8 | SANDSTONES | 15,1 |
| | | ANDESITE | 7,2 | CUARZODIORITA | 4,6 | SILSTONE | 25,0 |
| | | BASALT | 9,8 | GRANITE | 11,8 | CHERT | 0,7 |
| | | RHYOLITE | 5,9 | | | | |

**SAND COMPOSITION** **size** **ϕ >2mm** hasta limo grueso de 74μ a 88μ

| MINERAL FRAGMENTS | % | VOLCANIC IGNEOUS ROCK FRAGMENTS | % | PLUTONIC IGNEOUS ROCK FRAGMENTS | % | OTROS | % |
|---|---|---|---|---|---|---|---|
| QUARTZ | 28,4 | BASALT | 2,8 | GRANITE | 2,3 | CLAY FRACTION | 2,1 |
| PAGIOCLASE | 16,9 | ANDESITE | 18,4 | CUARZODIORITA | 0,2 | | |
| AMPHIBOLE | 7,7 | RHYOLITE | 0,5 | | | | |
| BIOTITE | 5,7 | DIABASE | 0,9 | | | | |
| FELDESPAR | 11,3 | PHYLLITES | 2,8 | | | | |

**MINERAL DUST COMPOSITION (Difracción de rayos X)**

| QUARTZ | CALCITE | PAGIOCLASE | AMPHIBOLE | CLAY 1*a | CLAY *b | AMORPHOUS |
|---|---|---|---|---|---|---|
| SI | SI | SI | SI | SI | SI | SI |

*a:Illita/Moscovita

*b:Kaolinita/Dickite/Chlorite

**Table 4. Original Asphalt characteristics vs. Submerged asphalt characteristics**

| Test | Un | International Standards | ORIGINAL ASPHALT | | | | SUBMERGED ASPHALT 1month | | | | SUBMERGED ASPHALT 3months | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | N° samples | Avera | Desv Est | Coef Var | N° samples | Avera | Desv Est | Coef Var | N° samples | Avera | Desv Est | Coef Var |
| Penetration 25°C | 0.1 mm | ASTM D 5 – 97<br>AASHTO T 49 – 03<br>NLT 124 / 84 | 18 | 83,22 | 1,11 | 1,34% | 18 | 60,06 | 1,55 | 2,58% | 18 | 58,72 | 1,08 | 1,85% |
| Softening point | º C | ASTM D 36 – 95 (2000)<br>AASHTO T 53 – 96 (2004)<br>NLT 125 – 84 | 6 | 50,55 | 0,51 | 1,01% | 6 | 49,7 | 0,55 | 1,10% | 6 | 48,3 | 0,58 | 1,19% |
| Penetration Index | - | UNE EN 12591 – 1999<br>NLT 181/88 | - | 0,26 | - | - | - | -0,85 | - | - | - | -1,29 | - | - |
| Ductility | cm | ASTM D 113<br>AASHTO T 51<br>NLT 126 | 3 | 145 | 6 | 4,46% | 3 | 105 | 9 | 8,25% | 3 | 111 | 8 | 6,78% |
| Flame Point | º C | AASHTO T 48 – 04 | 3 | 319,4 | 2,8 | 0,87% | 3 | 319,4 | 2,8 | 0,87% | 3 | 590,0 | 14,1 | 2,40% |
| Ignition Point | º C | ASTM D 92 – 02b | 3 | 358,3 | 2,8 | 0,78% | 3 | 358,3 | 2,8 | 0,78% | 3 | 680,0 | 14,1 | 2,08% |
| Specific Graavity | - | ASTM D 70 – 03<br>AASHTO T 228 – 04<br>NLT 122 | 3 | 1,007 | 0,002 | 0,22% | 3 | 0,998 | 0,003 | 0,30% | 3 | 1,039 | 0,042 | 4,05% |
| Brookfield Viscosity<br>135 ºC | Pa * s | AASHTO T 316 – 04 | -<br>33 | -<br>0,43 | -<br>- | -<br>- | -<br>33 | -<br>0,46 | -<br>- | -<br>- | -<br>33 | -<br>0,54 | -<br>- | -<br>- |
| Mass lost | % | ASTM D 2872 – 97<br>AASHTO T 240 – 03 | - | N/A | - | | - | - | - | - | - | - | - | - |
| Ic -Colloidal Inestability Index | | | 2 | 0,3944 | 0,00233 | | 2 | | | | 2 | 0,43207 | 0,02388 | |

**Table 5. PG to high temperatures and fatigue cracking temperature.**

| Cemento asfáltico | 80-100 Barranca Original | 80-100 Barranca S1 | 80-100 Barranca S3 |
|---|---|---|---|
| | | | |
| **VISCOSIDAD BROOKFIELD** | **Máx 3 Pa.s** | | |
| Viscosidad a 135°C, Pa.s | 0,43 | 0,46 | 0,54 |
| Clasificación SUPERPAVE(tabla) | | | |
| **DSR, 10 rad/s** | **Mínimo 1 kPa** | | |
| G*/Sen δ, temperatura °C | 58 | 58 | 58 |
| **RESIDUO RTFO** | | | |
| **DSR, 10 rad/s** | **Mínimo 2,2 kPa** | | |
| G*/Sen δ, temperatura °C | 58 | 58 | 60 |
| | | | |
| **Grado alto SUPERPAVE** | 58 | 58 | 60 |
| **RESIDUO PAV** | | | |
| **DSR, 10 rad/s** | **Máximo 5000 kPa** | | |
| G*xSen δ, temperatura °C | 19 | 19 | 19 |
| Clasificación SUPERPAVE(tabla) | | | |

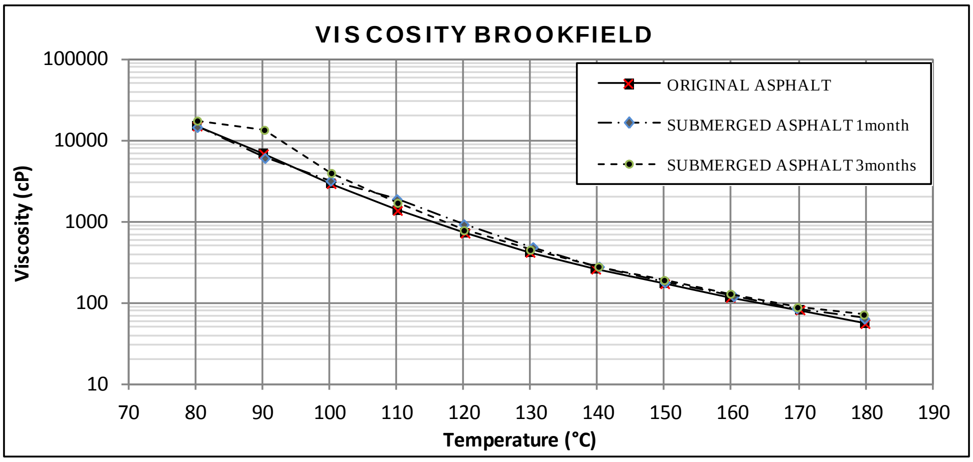
The PG grade of the asphalt did not change for the original asphalt and submerged asphalt but the mechanical properties changed in the submerged asphalt. The original softening point asphalt decreased 4% about submerged asphalt. This value indicates that the submerged asphalt is harder than the original asphalt in this order were analyzed the chemical changes in the asphalt fractions during immersion time. The SARA analysis showed a modification in the asphalt´s aromatics. This fraction usually is between 40 and 65% in the asphalt and one of his components is Oxygen, apparently this value is increasing in the submerged asphalt which can indicate an oxidation process in this asphalt. Typically the asphalt oxidation is related with high temperature but not with water.

The complex modulus for the submerged asphalt decreased. This modulus indicates the relationship between applied stress and the resulting strain under dynamic loads. The variation of the modulus was over 33.55%.

The viscous component, G * / sin δ of the submerged asphalt decrease 36.8%. The variation of the component that governs the fatigue damage, G * x sin δ , was 12.8%. This result is shown in the Table 5.

Another important change that had the submerged asphalt was the viscosity. Viscosity

**Table 6. Viscosities for original asphalt submerged for one month and submerged for three months.**




The changes observed in the viscosity were significant for low temperatures. Anyway over 140° C the viscosity for the submerged asphalt 3 months has a little increasing in this order the viscosity may present major changes at the end of the immersion period, ie 21 months. Considering that the coefficient of viscosity is the ratio of shear stress to shear rate and the viscosity is not an absolute value because depends of the shear rate, shear stress and the temperature a little change in this can have influence en the mixtures mechanical behaviour.

**Table 7. Basic characteristics for original and submerged asphalts.**

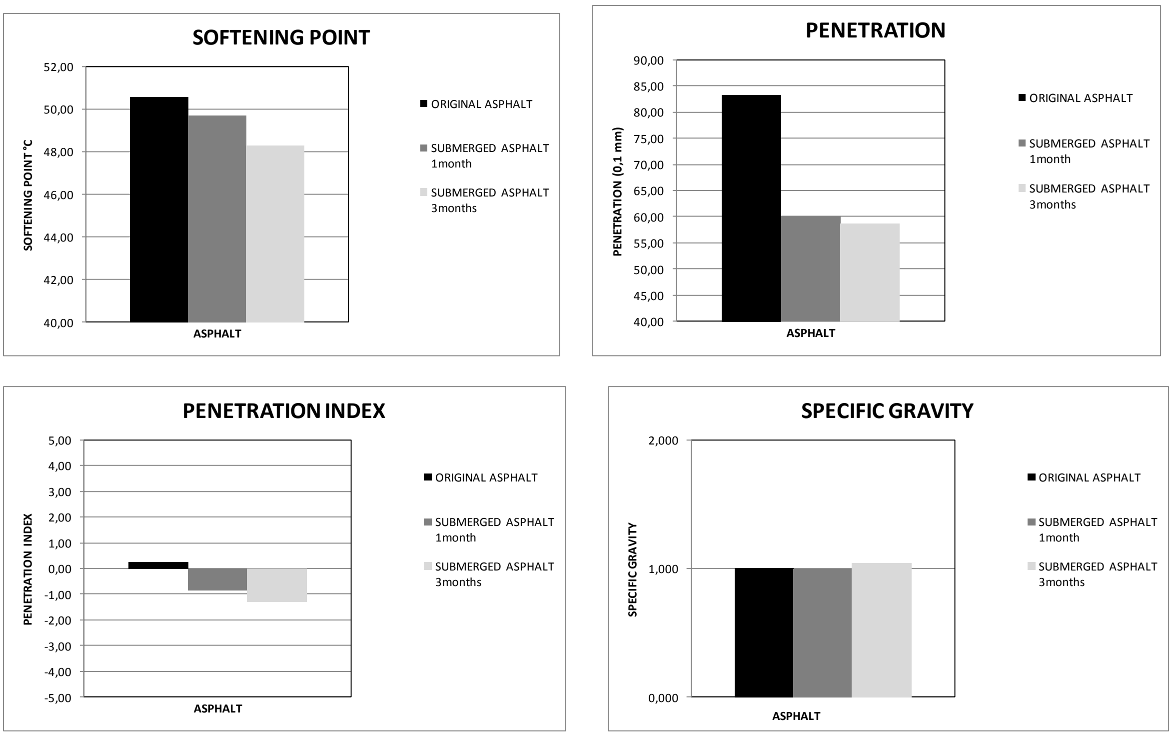
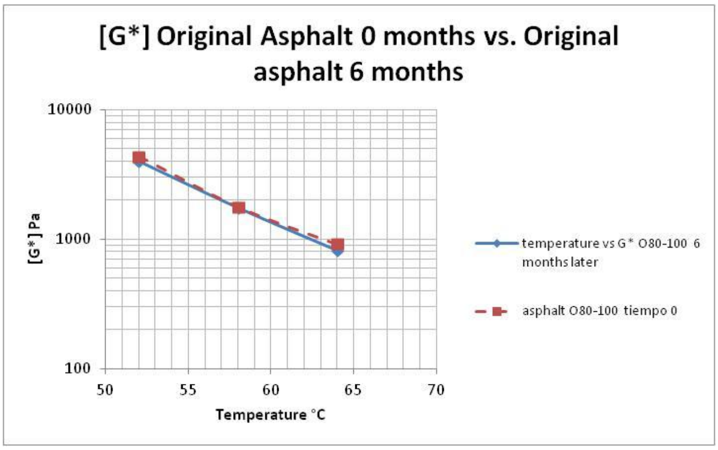


**Table 11. Temperature Sweep**




The asphalt modulus showed a little decreasing for six months. Apparently the submersion time is changing this modulus and doing it lower than original asphalt modulus. This change can reduce the stiffness in the mixture.

## CONCLUSIONS AND RECOMMENDATIONS

• In this experimental phase of characterization and monitoring of the asphalt binder it has been found that there are differences between the three types of binder. The physical mechanical properties most affected have been penetration, softening point and viscosity.

• Despite the PG asphalt submerged for three month is equal to the original asphalt, changes have been evidenced in the mechanical and rheological properties of the material. The complex modulus has reduced this value and it has increased elastic component. It change indicates that the material it is more susceptible to fatigue cracking than the original asphalt.

•Many researchers have been focused on stripping focusing in the adhesion problem but in this researcher the mean purpose is the cohesion problem. These first results show that the water has a high impact in the asphalt and it is necessary study and analyze for a long time the changes that asphalt experiments in presence of water and its viscoelastic properties transformation.

•It is necessary to determine the free surface energy of asphalt dipped to study the incidence of water in it and determine the strength that it has in contact with the aggregate.

• The asphalt penetration rate dipped significantly changed compared to the original asphalt. The original asphalt was a PI = 0.26, ie in the range of -1 to +1 to ensure it is stable and its classification is SOL-GEL, , while the asphalt had an IP submerged =- 0.85, very close to -1. With these values the thermal susceptibility is high and it tends to behave like a Newtonian flow with little elastic deformation.

• More of these results will be presented orally.

## REFERENCES

[1] Modeling of combined physical-Mechanical Moisture Indiced Damage in aspahltic Mixes. Niki Kringos. Ed. Delft, The Netherlands, 2007.pp 1.

[2] Adhesion tension in asphalt pavements, its significance and methods applicable in its determination, Nicholson, V., 1932.

[3] Field observations of the behavior of bituminous pavements as influenced by moisture. Symposium on Effect of Water on Bituminous Paving Mixtures. Ed.240, p-p 3-16. Ward K.Parr. 1958, American Society for Testing Materials.

[4] Relationship of aggregate characteristics to the effect of water on bituminous pavement mixtures. Symposium on Effect of Water on Bituminous Paving Mixtures. Ed.240, James. M. Rice.p-p 17-34. 1958, American Society for Testing Materials.

[5] Stripping in HMA mixtures: state-of-the-art and critical review of test methods. B.M. Kigundu & F. L. Roberts. National center of Asphalt Technology, NCAT Report 88-02, Auburn University,Alabama, 1988.

[6 ] Chemistry of asphalt-aggregate interaction: relationship with pavement moisture-damage prediction test, Transportation Research Record No. 843, Petersen, J C, Plancher, H Ensley, E K, Venable, R L, Miyake, G. Pag 95-104, 1982.

[7] Investigation on Moisture Damage to Asphalt Concrete and the Effect on Field, Performance- a case Study. Tomas Kennedy, Robbert B. Mc.Gennis, Freddy L. Roberts. Transportation Research Board. 1982.

[8] Stripping in HMA mixtures: state-of-the-art and critical review of test methods, NCAT Report 88-02, National Asphalt for Asphalt Techonology, Auburn University, Alabama,1988. Kiggundu, B. M. and Roberts F.L .

[9] Evaluation and correlation of lab and field Tensile Strenght Ratio (TSR) procedures and values in assessing the stripping potential of aspahlt mixes. H.Bahia & S.Ahmad. WisDOT Highway Researh Study SPR#0092-45-91. 1999.

[7(10)] Development of methods to quantify bitumen-aggregate adhesion and loss of adhesion due to water. Amit Bhasin, Texas A&M University. May 2006

[11]Moisturesusceptibilityofasphaltmixtures,Part2:characterisationandmodelling.

S.Caro*,E.Masad,A.BhasinandD.N.Little.

ZachryDepartmentofCivilEngineeringandTexasTransportationInstitute,,TexasA&MUniversity,Texas,TX77843,USA

[12] Measuring effect of moisture on asphalt-aggregate bond with the bitumen bond strength test, R.Moraes, R.Velásquez & H. Bahia. University of Wisconsin-Madison. 2010. [ REPORT]Moisture damage in asphalt concrete, Russell G. Hicks, American Association of State Highway and Transportation Officials, National Research Council (U.S.). Transportation Research Board