



**ROAD MAINTENANCE**

**Registration of *Star Asphalt S.p.A.* to REACH Regulation**

**N. 1907/2006 G.U.E. L396 of 30 December 2006**

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May 2018**

**STAROIL® BIO**

**REACH REGISTRATION NUMBER**

**01-2119471662-36-0036**

**STAROIL® VG30, STAROIL® VG50**

**Mixtures of products registered to the REACH Regulation**

**REACH REGISTRATION NUMBER**

**01-2119471662-36-0036**

*“You change and the world changes,  
you live and the world lives,  
you dance and the world dances,  
you are the world...”*  
Filomena Falvo

To my daughter...

"The road to pursuing change is impervious, fraught, long, wide and bumpy, like the path of life. For a strange game of destiny the Star Asphalt has always dealt with roads and now, through the Filomena Falvo Foundation, its mission merges with the human spirit to create a single purpose. Roads finally become paths, paths become objectives".

This work is the result of the collaboration between Star Asphalt S.p.A., a leading company in the production of special additives for bitumen and bituminous conglomerates, and the "Falvo Filomena" Foundation. Together, we are developing totally eco-friendly and green industrial systems. All Star Asphalt products have the certifications required by the Reach legislation and have been created with a particular focus on respect for the environment. In collaboration with the "Falvo Filomena" Foundation, we aim to continue the constant work of experimentation and innovation to achieve goals that are consistent with truth and clarity, peculiar virtues of my daughter Filomena, to whom this writing is dedicated.

President Prof. Rosario Giovanni Falvo

# Summary

<b>Road maintenance</b> .....	
Traditional cold mix asphalt .....	
Traditional cold mix asphalt produced with recycled bituminous membrane .....	
Cold mix asphalt with cationic bituminous emulsion.....	
Cold mix asphalt with anionic bituminous emulsion .....	
Cationic bituminous emulsion for cold mix asphalt .....	
Cold mix asphalt patch type .....	
Cold asphalt mix type patch packed in SuperPatch form.....	
Binder for the production of cold mix asphalt with 100% of RAP.....	
Performance cold mix asphalt with rubber powder .....	
Bituminous sealant for maintenance operations of joints and cracks.....	
Monocomponent reactive asphalt mix .....	
<b>Experimental activity report</b> .....	
Traditional cold mix asphalt.....	
StarOil® BIO .....	
StarOil® VG30 .....	
StarOil® VG50 .....	
Traditional cold mix asphalt produced with recycled bituminous membrane .....	
Cold mix asphalt with cationic bituminous emulsion.....	
Cold mix asphalt with anionic bituminous emulsion .....	
Cationic bituminous emulsion for cold mix asphalt .....	
Cold mix asphalt patch type .....	
Cold asphalt mix type patch packed in SuperPatch form.....	
Binder for the production of cold mix asphalt with 100% of RAP.....	
Performance cold mix asphalt with rubber powder .....	
<b>Conclusions</b> .....	
<b>Final considerations</b> .....	

# ROAD MAINTENANCE

Road maintenance is defined as "that complex of operations and activities whose purpose is to preserve the functional and structural characteristics of the flooring over the useful life of the road infrastructure", aimed at ensuring:

- Practicability of the arteries;
- User comfort;
- Traffic safety.



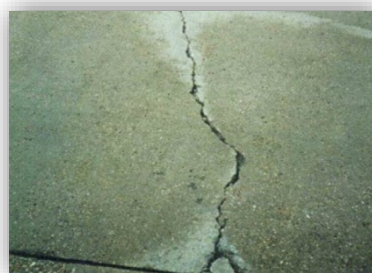
The purpose of the maintenance of the road paving requires that, in every phase of exercise and in time, its functionality must remain unchanged.



Over the years, the problems on the roads have more than doubled, the potholes continue to increase in volume and width, and the number of damaged roads is growing, closed to traffic and with restrictions on circulation and speed. This phenomenon is particularly evident in the secondary roads (provincial and municipal), which represent approximately  $\frac{1}{4}$  of the national road

network, due to problems often derived from:

- Lack of financial resources of managing bodies (municipalities, provinces);
- Difficulties in planning interventions on a multi-year basis;
- Lack of coordination for the sequence and location of the work sites on the network (various assumptions, various responsible departments).



Maintenance interventions must therefore consist in the recovery of functionality, both in terms of structural strength, and of the regularity and safety of the viable plan. This must be proposed with the aim of operating maintaining the road safety levels always above the minimum values, committing the economic resources in the best way: more durability, lower cost, lower environmental impact.



In this regard the Star Asphalt S.p.A. has always been involved in the continuous search for eco-sustainable materials and in the reuse of materials that are too often underestimated, with the aim of giving it new life and new uses, such as the road sector. These choices are increasingly winning because, if properly treated, they are able to guarantee performances at par or even higher than the materials normally used.

In the Star Asphalt laboratories new techniques have been formulated and optimized for the production of cold mixes; different types of high performance asphalt mix have been developed, both in terms of workability and compacting in a wide range of temperatures, and of the useful life of the road pavement:

- I. Traditional cold mix asphalt;
- II. Traditional cold mix asphalt produced with recycled bituminous membrane;
- III. Cold mix asphalt with cationic bituminous emulsion;
- IV. Cold mix asphalt with anionic bituminous emulsion;
- V. Cationic bituminous emulsion for cold mix asphalt;
- VI. Cold mix asphalt patch type;
- VII. Cold mix asphalt patch type packed in SUPERPATCH form;
- VIII. Binder for the production of cold mix asphalt with 100% of RAP;
- IX. Performance cold mix asphalt with rubber powder;
- X. Bituminous sealant for maintenance operations of joints and cracks;
- XI. Reactive cold mix asphalt.

**Repair of:**

- ROADS;
- HIGHWAYS;
- YARDS;
- AIRPORTS;
- INDUSTRIES;
- SERVICES INFRASTRUCTURE (water, electricity, gas).

**Advantages:**

- EASY AND FAST TO BE USED IN SITE;
- SHORT MATURATION TIMES;
- ALLOW A QUICK START-UP OF THE REPAIRED STRUCTURES AND A TIMELY REOPENING OF THE VIABILITY.

## I. TRADITIONAL COLD MIX ASPHALT

### Advantages:

- High degree of workability at room temperature;
- Cold plastic asphalt mix;
- Quick maturation time.

## II. TRADITIONAL COLD MIX ASPHALT PRODUCED WITH RECYCLED BITUMINOUS MEMBRANE

### Advantages:

- High degree of workability at room temperature;
- Cold plastic asphalt mix;
- Quick maturation times.



Cold bituminous conglomerate is a plastic material that can be processed at room temperature deriving from a mixture of aggregates, bitumen and flux; what distinguishes it is the exclusive workability for long periods of packaging, provided it is correctly stored in exclusively sealed bags. The traditional cold conglomerate is generally an advantageous solution for the restoration of holes on the road pavement, since maintenance can be carried out in any weather condition.

However, it is not suitable for repair in areas with high pedestrian/cycle traffic, in areas with heavy vehicle traffic or high traffic volume and, for the repair of extremely large holes, has low cohesion values, ie tends to shell with vehicular traffic.

### **FLUX OILS**

They are special additives produced from oils of both vegetable and synthetic origin. They are used for the production of bituminous mixtures that can be processed at room temperature and used for road maintenance. The asphalt mix produced using these additives is conserved over time perfectly plastic and hardens quickly as soon as it is put into operation; plant products have the particular characteristic of being odorless.



### **Method of use and dosage:**

They are added directly to the asphalt plant mixer during the production phase of the asphalt mix. For a correct operating procedure, it is advisable to introduce the aggregate mixture into the mixer, immediately after the flux and then the bitumen. The dosage rates are variable and depend on: climatic conditions, granulometry of the inert material and the



type of bitumen used. Normally the dosage varies from 15.00% to 35.00% on the weight of the bitumen.

### III. COLD MIX ASPHALT WITH CATIONIC BITUMINOUS EMULSION

**Advantages:**

- Production of the asphalt mix at room temperature;
- Easy and quick to set up;
- Short maturation times;
- Repair holes in roads and motorways without interrupting traffic;
- Preparation of the asphalt mix with acid inerts.



### IV. COLD MIX ASPHALT WITH ANIONIC BITUMINOUS EMULSION

**Advantages:**

- Production of the asphalt mix at room temperature;
- Easy and quick to set up;
- Short maturation times;
- Repair holes in roads and motorways without interrupting traffic;
- Preparation of the asphalt mix with alkaline inerts.

Using a bituminous emulsion as a binder for the production of plastic mixtures that can be processed at room temperature is an advantageous and effective choice of a cold mix asphalt directly in the plant and without using any temperature. It is therefore possible to obtain performance characteristics similar to a traditional cold mix by mixing, completely different from the latter, a mixture of carefully selected aggregates, chemically and granulometrically, and with a low content of fines with a specific bitumen emulsion. This allows, however, a drastic elimination of harmful

emissions into the atmosphere, an indication of extreme sensitivity to environmental issues, and a substantial reduction in production costs.

## V. CATIONIC BITUMINOUS EMULSION FOR COLD MIX ASPHALT

Cationic bituminous emulsion for the production of cold plastic asphalt mix, to be used for road patches.

The realization of this type of conglomerates requires the use of medium-speed bituminous emulsions, appropriately prepared.



### **Formulation type:**

#### **Inerts**

Basalt 3/6	61.5-62.5%
Basalt Sand 0/4	25.5-26.5%

#### **Binder**

Cationic Bituminous Emulsion	11.0-13.0%
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## VI. COLD MIX ASPHALT PATCH TYPE

### **Advantages:**

- Performanceally superior to the classic cold conglomerate;
- Easy and quick to put in place;
- Maturation by compaction;
- Repair of holes in roads and motorways without interruption of traffic;
- Extremely workable mix;
- Non-greasy or dirty.



The idea of using and exploiting the characteristics of a composite material, such as the bituminous recycled membrane, in production related to the road sector arises from its versatility, ease of application, clear cost reduction and durability. Re-using the bituminous recycled membrane for the packaging of cold asphalt mix allows to obtain performing and permanent road surfaces. Furthermore, disposal costs for membrane producers are avoided, virgin raw materials are saved for asphalt producers and, in a more general perspective, there is a reduction in emissions into the atmosphere and consumption of non-renewable resources ( bitumen). Differently from a traditional cold mix it is not greasy or dirty means of transport and tools used during the production and spreading of the conglomerate, compact by compression, and has a high degree of cohesion, it does not tend to shell.

**Formulation type 1:**

**Inerts**

Grit 3/6 mm	58%
Sand/RAP 0/4 mm	25%

**Binder**

Recycled bituminous membrane with additive	8-10% over total weight
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**Binder composition**

Recycled bituminous membrane	77%
Additive	23%

<b>Filler</b>	6-8% over total weight
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**Formulation type 2:**

**Inerts**

Grit 3/6 mm	58%
Sand/RAP 0/4 mm	25%

**Binder**

Recycled bituminous membrane	6-7% over total weight
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**FluxOil**

StarOil® VG30	2.0-2.2% over total weight
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<b>Filler</b>	6-8% over total weight
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## VII. COLD ASPHALT MIX TYPE PATCH PACKED IN SUPERPATCH FORM

### Advantages:

- Higher performance than classic mix with patch;
- Easier preparation;
- Easy and quick to put in place;
- Maturation by compaction;
- Repair of potholes in roads and highways without interruption of traffic;
- Extremely workable asphalt mix;
- Low environmental impact;
- Non-greasy or dirty.



The use of the SuperPatch binder cake makes it possible to produce high performance cold bituminous mixtures for permanent road maintenance. Its particular composition, 100% eco-sustainable, developed after a careful and intense research, ensures the obtaining of a bituminous asphalt mix with exclusive performance characteristics. The opaque appearance characterizing this type of asphalt mix allows not to grease or dirty means of transport and tools used during the spread, indicating a saving in the time needed to clean all the required material, resources and money. The stable

inert bond/binder conferred by SuperPatch is the prerequisite for the durability of the repaired deteriorated road surface; in fact it presents a high degree of cohesion, that is, does not tend to shell with the passage of vehicles. The uniqueness of this binder stick is its versatility of use: just as a normal cold mix is particularly suitable for the repair of holes on the road surface, but, unlike them, its particular composition does not require all those operations preliminary preparations necessary for paving such as cleaning the damaged surface, removing any water inside the application surface, using a bituminous primer and final compaction with mechanical means since it is simply compacted by vehicular passage, with unique performance sliding even at high summer temperatures.

## **SUPERPATCH PERFORMANCE BINDER**

The percentages of employment are variable according to the working conditions. Normally they range from 6.0% to 8.0% of the total weight of the dough. STARPATCH is added to the granulometric curve during the mixing phase at T=100-120°C. Finally, the asphalt mix patch type requires from 5.0% to 7.0% additional filler, to be introduced subsequently to the mixing of the binder in the plant mixer.

## **VIII. BINDER FOR THE PRODUCTION OF COLD MIX ASPHALT WITH 100% OF RAP**

### **Advantages:**

- Recycling of floors at the end of life;
- Ease of preparation;
- Reduced energy consumption and low environmental impact;
- Easy and quick to put in place;
- Quick maturation times;
- Excellent performance in work.



Ricicla is a bituminous binder for the reuse of road milling at room temperature. Its particular composition allows the following functions to be carried out against the old bitumen present in the milled material: wetting, regenerating, antioxidant and plasticizer. It is used for the "cold" production of plastic asphalt mix using 100% of milled material (RAP).

## **IX. PERFORMNCE COLD MIX ASPHALT WITH RUBBER POWDER**



#### **Advantages:**

- Higher performance than classic cold mix asphalt;
- Easy and quick to put in place;
- Short maturation time;
- Repair of potholes in roads and highways without interruption of traffic;
- MBetter ability to repsond to stress;
- High resistance to estreme climates.

The asphalt mixes modified with recycled tire rubber powder are used as a valid alternative for excellent durability and high resistance to severe road loading conditions. In addition to being a concrete application for the reuse of used tires, it allows to obtain substantial improvements in asphalt mix. The modification with rubber powder makes it possible to obtain improved characteristics compared to the use of bitumen only by virtue of a lower thermal susceptibility, a greater resistance to sliding, a lower aging, a lower tendency to crack in cold climates, and of excellent impermeability to water and adhesion with aggregates.



#### **ADDITIVE FOR MODIFICATION WITH RUBBER POWDER**

The technology proposed by Star Asphalt S.p.A, pre-treats the rubber powder with a liquid additive called **CROSSLINKER CR**, which reduces the phenomenon of sedimentation of the modified bitumen with rubber powder.

## **X. BITUMINOUS SEALANT FOR MAINTENANCE OPERATIONS OF JOINTS AND CRACKS**

**Ripair of:**

- Roads;
- Highways;
- Yards;
- Airports;
- Industries.



**Advantages:**

- Easy and quick to put in place;
- Allows a rapid commissioning of the repaired structures and a timely re-opening of the road network.

The product is ideal for sealing cracks that appear on road surfaces. Thanks to its mechanical characteristics, it is also used to make transition seals between two adjacent elements. Sealing longitudinal and transversal cracks in a road pavement is a preventive intervention designed to slow down the crack formation process, but above all, to block the penetration of rainwater inside the superstructure which would cause the gradual degradation of the pavement.

**SEALANT FOR JOINTS AND CRACKS 2K**

BLACKSEAL 2K is a two-component liquid sealant applicable at room temperature; after installation, it hardens very quickly forming a solid mass with a high elastic modulus and a high surface hardness. The product is ideal for sealing joints and cracks that appear on road surfaces.

**SEALANT FOR JOINTS AND CRACKS 1K**

BLACKSEAL 1K is a single-component liquid sealant applicable at room temperature; after installation, it hardens to form a solid mass with a high elastic modulus and a high surface hardness. The product is ideal for sealing joints and cracks that appear on road surfaces. Available soon.



**XI. MONOCOMPONENT REACTIVE ASPHALT MIX**



**Advantages:**

- Easy and quick to put in place;
- Hardens with water and humidity;
- Allows a timely re-opening of the road system.

Thanks to a particular chemical process, it hardens when in contact with water, which therefore acts as a catalyst rather than as a disruptive element, as for all other traditional asphalt mix. It guarantees permanent and permanent applications on asphalt and / or concrete floors. It is ideal for the restoration of

damaged areas of any size and thickness, leveling of manholes and others, and guarantees a lasting result by reducing the costs of ordinary maintenance. Applied appropriately, it ensures definitive interventions with the consequent reduction of labor costs in the management of road maintenance. Available soon.

## Experimental activity report

The following, summarizes the experimental activities carried out at the Star Asphalt laboratories, to characterize the materials produced according to the various techniques previously described. The study envisaged the realization of the following steps:

- Granulometric composition of the mixture;
  - Optimized binder content and additives;
  - Characterization of mixtures according to existing regulations and protocols.
- 
- I. Traditional cold mix asphalt;
  - II. Traditional cold mix asphalt produced with recycled bituminous membrane;
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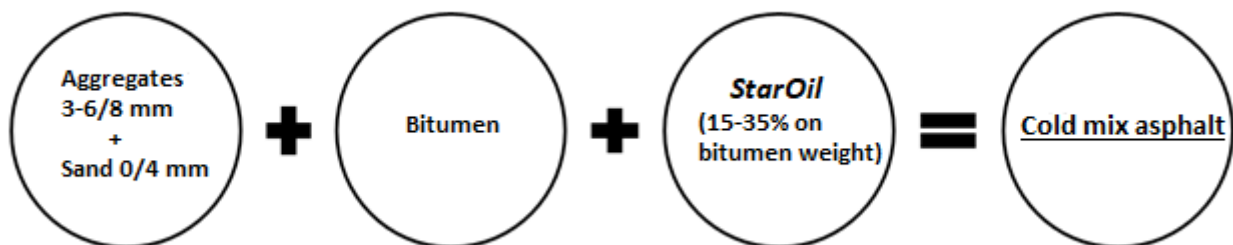
## I. TRADITIONAL COLD MIX ASPHALT

### Introduction

Over time, especially during periods of greater environmental stress, the asphalt deteriorates. Extraordinary maintenance is therefore required to restore road safety.

Cold conglomerate is generally the most advantageous solution, as it can be carried out in any weather condition, with temperatures between 30 and -18°C.

A cold mix is workable at room temperature and is used to perform, usually, the repair of potholes. In addition to a mixture of selected grains and bituminous binder, it is necessary to use additives that guarantee easy workability.



The additives called StarOil® are specially formulated for the production of cold plastic mix asphalt, performing the dual function of fluxing and plasticizing. They are not of oil origin but derive from renewable sources of plant origin.



The production of these fluxes is carried out by Star Asphalt starting from the regeneration of exhausted oils.



The dosage of them is studied in virtue of the ambient temperature expected for the use of the asphalt mix; this allows the workability to be kept constant, preventing the product from being difficult to be compactable in winter or not very consistent and sticky with high summer temperatures.

#### **Main advantages deriving from the use of StarOil®**

- Energy saving;
- Easy and versatile installation;
- Respect for the environment, with drastic reduction of emissions into the atmosphere;
- Reduction of the risk of degradation of products due to overheating.

#### **Choice of suitable flux oils**

The choice of the flux and its relative dosage is dictated by factors such as:

- Storage temperature of the additive;
- Minimum or average seasonal temperatures in the area of use;
- Production temperature and related control;
- Time and method of storage;
- Intensity of traffic expected in the area of use;
- Characteristics of the materials used.

The StarOil® class of plant origin has a low vapor pressure, indicating a persistence of the product inside the bituminous binder. These will certainly produce a cold mix asphalt that is perfectly workable even at low temperatures, but with times of maturation of the conglomerate in slightly longer holes. Probably, they will produce a more stable mix to prolonged storage facilities (in cumulus/bags) and will certainly be less affected by production temperatures that are difficult to control.



The Star Asphalt choice, in line with the worldwide technological development, aims its constant research into plant products, ensuring better performance characteristics of the main competitors. The addition to the vegetable oil of particular additional additives, allows to obtain a lowering of the freezing point of the additive. The so obtained vegetable flux has many advantages such as the achievement of a quality cold mix, the possibility of storage at low temperatures and the strict respect for the environment.

From a performance point of view, the cold mix has characteristics close to those of a hot mix, with workability lower than or equal to 2000 N and with optimum between 700 and 1100 N.

### **Star Asphalt vegetable flux oils:**

- Natural products, respectful of the environment for a clean and eco-sustainable development;
- Suitable for cold plastic asphalt mix and for long storage periods;
- At low dosage values, recommended for temperate climates or for low hardness binders;
- At high dosage values, used for rigid climates or bitumen with low penetration values;
- Variable freezing temperatures, with the aid of additional additives, with performance characteristics similar to a synthetic product.



### **Reference spindle**

Given the lack of a regulation that regulates cold asphalt mix, we have taken as reference the granulometric spindle developed in our laboratories, which provides for the use of 3/6 mm grit and 0/4 mm sand, in ratio 7:3. The integration of sand is obviously important to reduce the phenomena of casting the binder and to give greater stability to the mix.

### **Dosage of the binder**

The minimum percentage of bituminous binder required to obtain the complete coverage of the aggregates, which is 3.8% of the total weight of the mixture, has been identified.

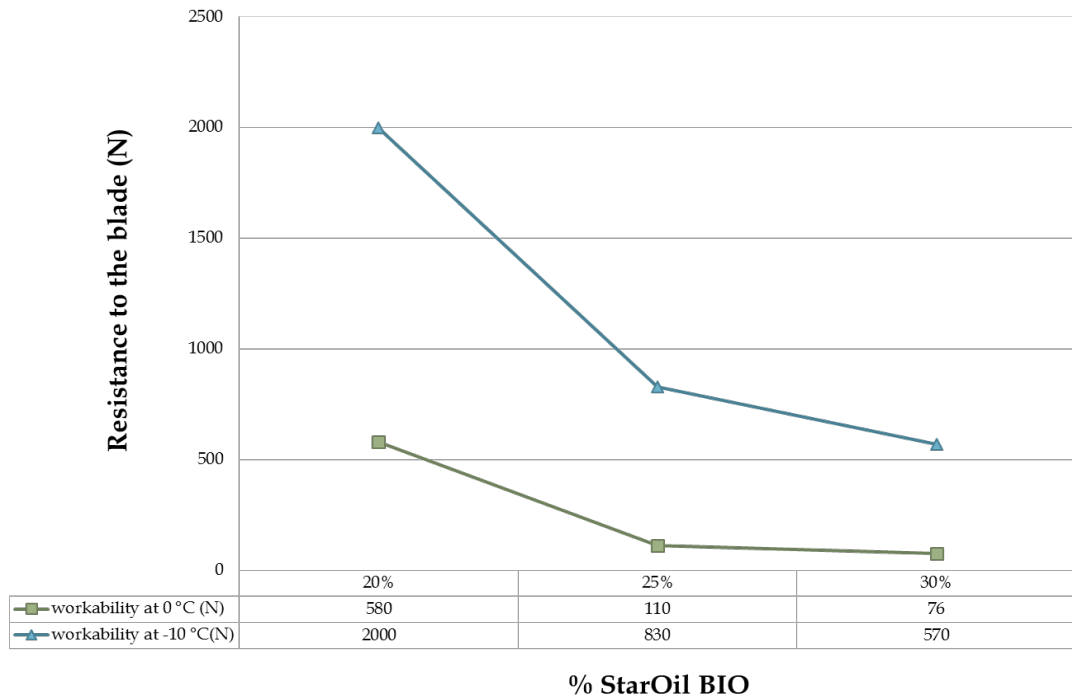
## **StarOil® BIO (REACH REGISTRATION NUMBER: 01-2119471662-36-0036)**

- **Blade test**

This test provides the measurement of the resistance of the cold material (-10°C) to the penetration of the blade of a shovel, a parameter of importance for the realization of an asphalt mix so that it is appreciated by the final user. The test consists in measuring the cutting resistance of a blade applied to the Marshall press at a speed of 50 mm/min for a time of 30 seconds on a sample of asphalt mix conditioned at -10°C and compacted with 2 strokes of a Marshall hammer using a special mold. The resistance, according to the aforementioned legislation, should be less than 2000 N to ensure good workability of the material. The resistance values normally accepted in Italy are however of the order of 700-1100 N. Moreover, considering the hypothesis of a use even in the middle seasons, with minimum temperatures above 0°C, the test is also carried out at 0°C.

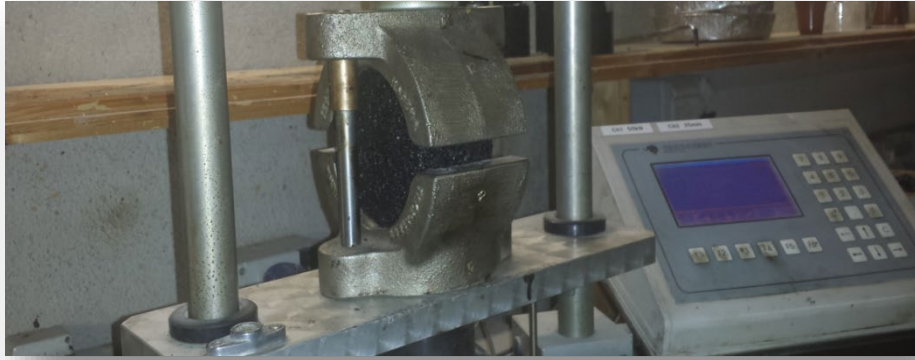


## *Blade test*



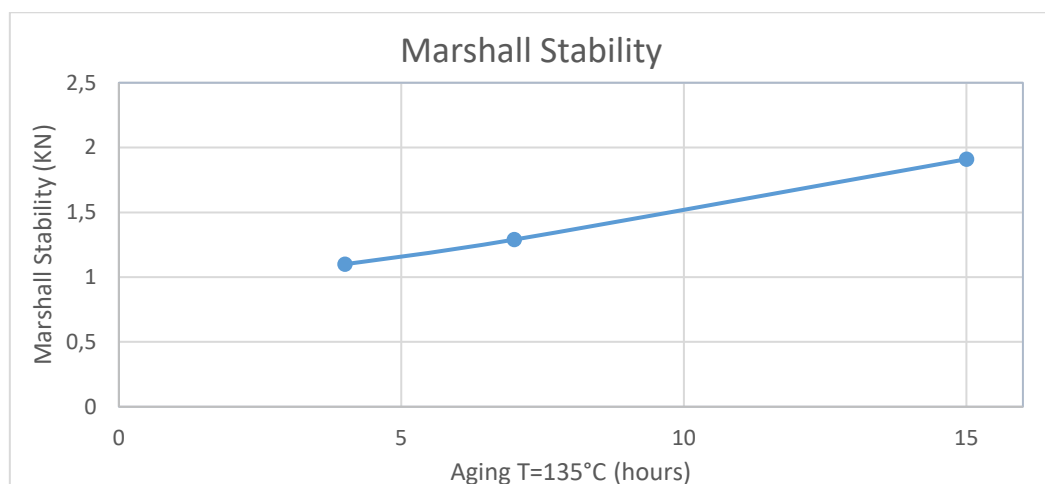
- Marshall stability of the asphalt mix after aging - UNI EN 12697-34**

This is an old test reported in the SHRP procedures; although it is now in disuse, it provides important information on the resistance of a cold mix. The test involves the aging in a stove at 135°C for 15 hours, of a specimen made to the Marshall compactor, applying 75 strokes per face, then allowed to cool and break with a load cell at room temperature. The aging in stove at 135°C for 15 hours, according to the results of the SHRP project, simulates some months of maturation of the asphalt mix in a pit under traffic, quantifiable in about 6 months of light traffic or 2 months of heavy traffic. In this regard, intermediate tests were carried out, to simulate shorter periods. In particular, tests were carried out on freshly compacted specimens and specimens aged at 4h and 7h. The goal is to be able to evaluate the behavior of the material for shorter application periods.



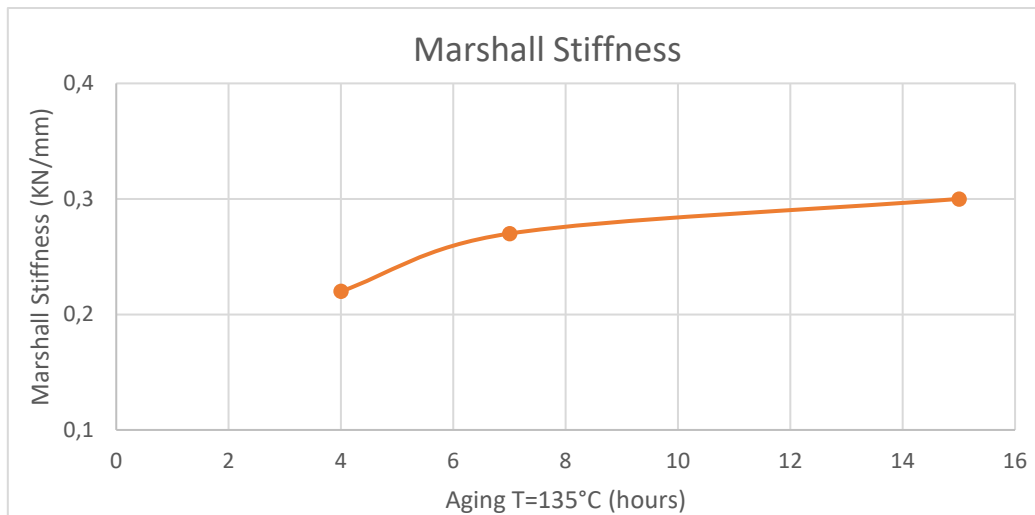
- **Marshall stability of the asphalt mix after aging**

Marshall parameters of specimens made with a percentage of flux on the weight of the binder equal to 25%, with a bitumen amount equal to 4%.



- **Marshall stiffness of the asphalt mix after aging.**

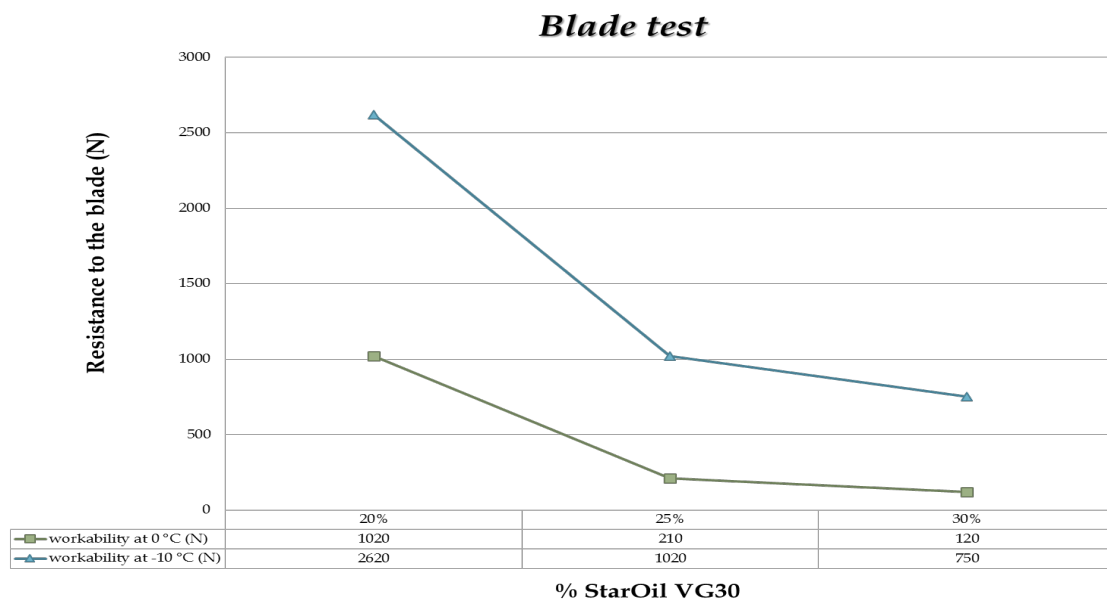
Marshall parameters of specimens made with a percentage of flux on the weight of the binder equal to 25%, with a bitumen amount equal to 4%.



## StarOil®VG30: Mixtures of products registered to the REACH Regulation

- **Blade test**

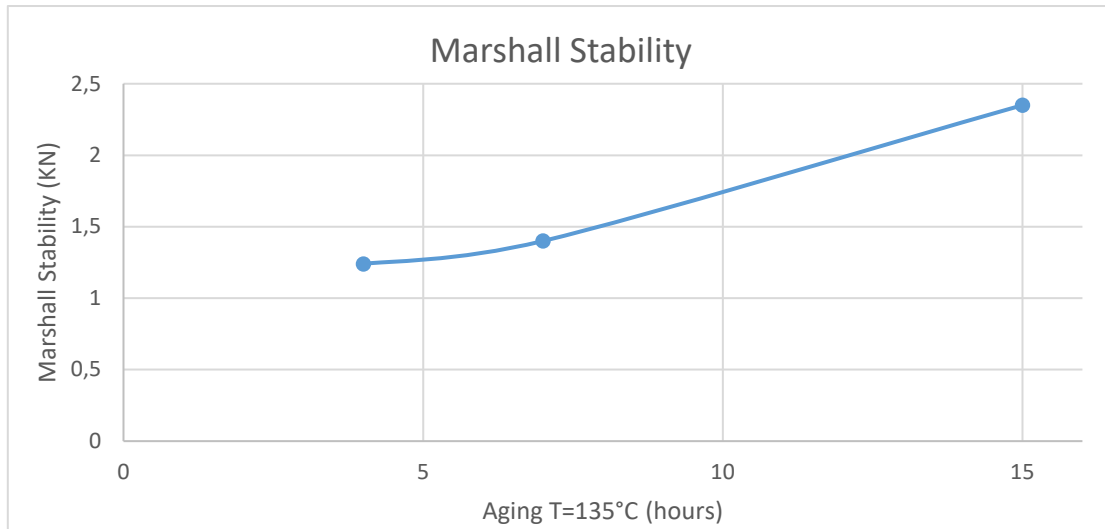
Graph of the shear stress according to the dosage percentage of the additive on the weight of the binder.



- **Marshall stability of the asphalt mix after aging**

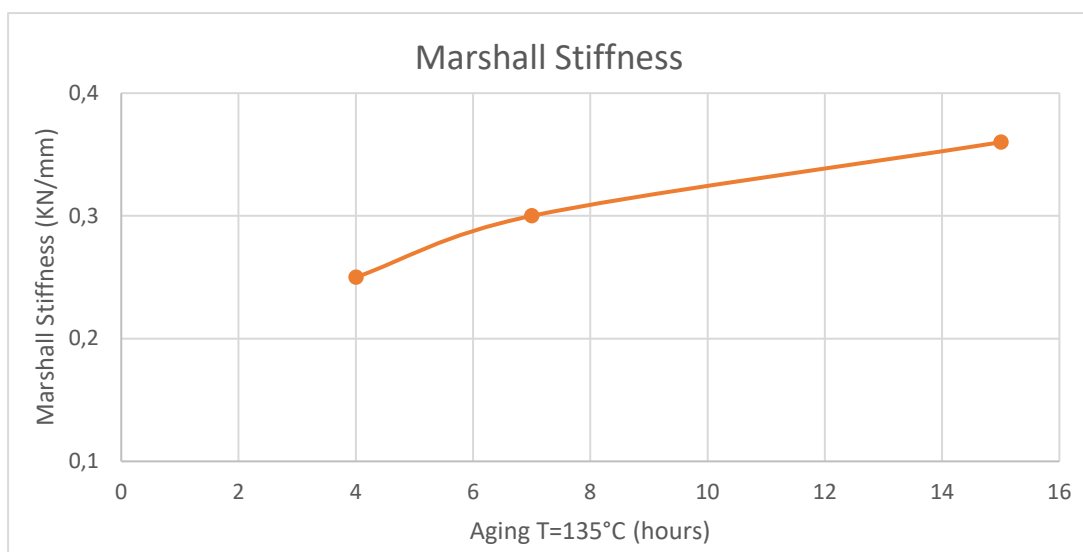
Marshall parameters of specimens made with a percentage of flux on the weight of the binder equal to 25%, with a bitumen amount equal to 4%.





- **Marshall stiffness of the mix after aging**

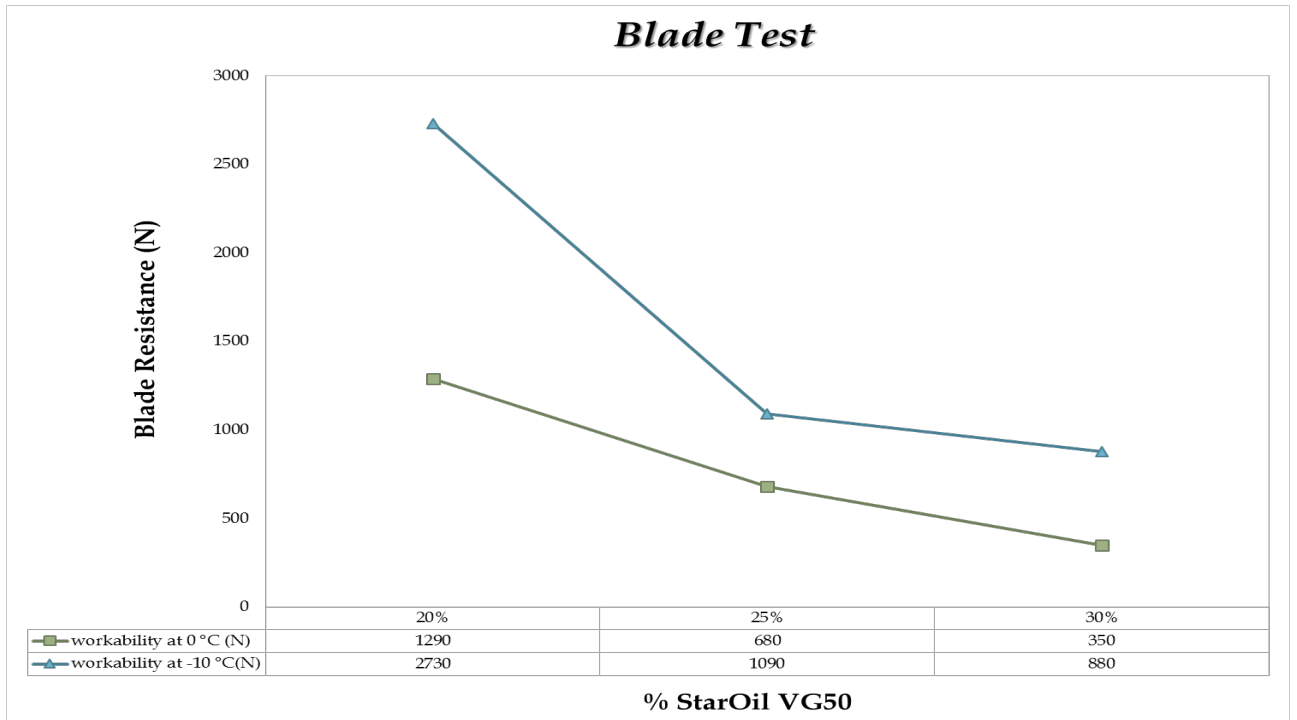
Marshall parameters of specimens made with a percentage of flux on the weight of the binder equal to 25%, with a bitumen amount equal to 4%.



## **StarOil® VG50: Mixtures of products registered to the REACH Regulation**

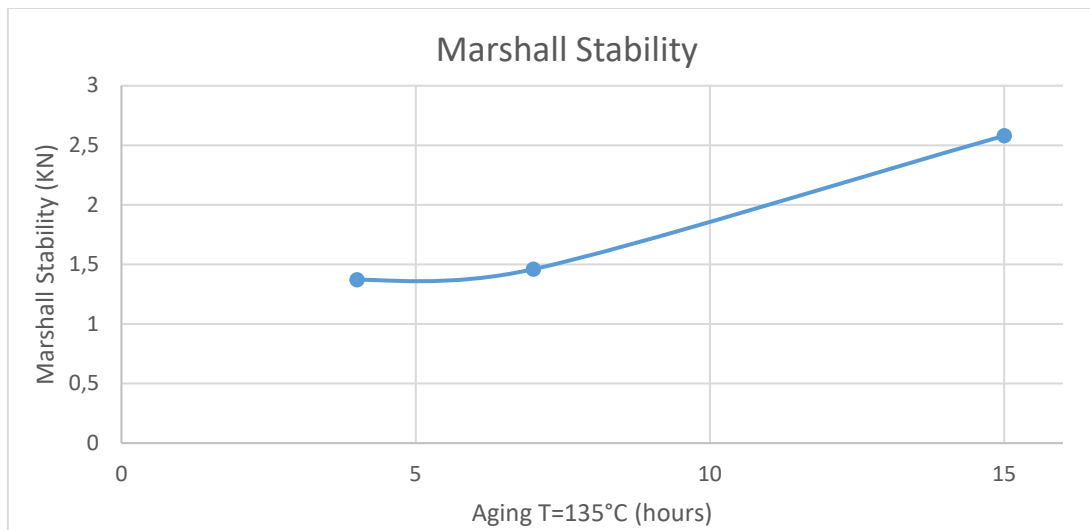
- **Blade test**

Graph of the shear stress according to the dosage percentage of the additive on the weight of the binder.



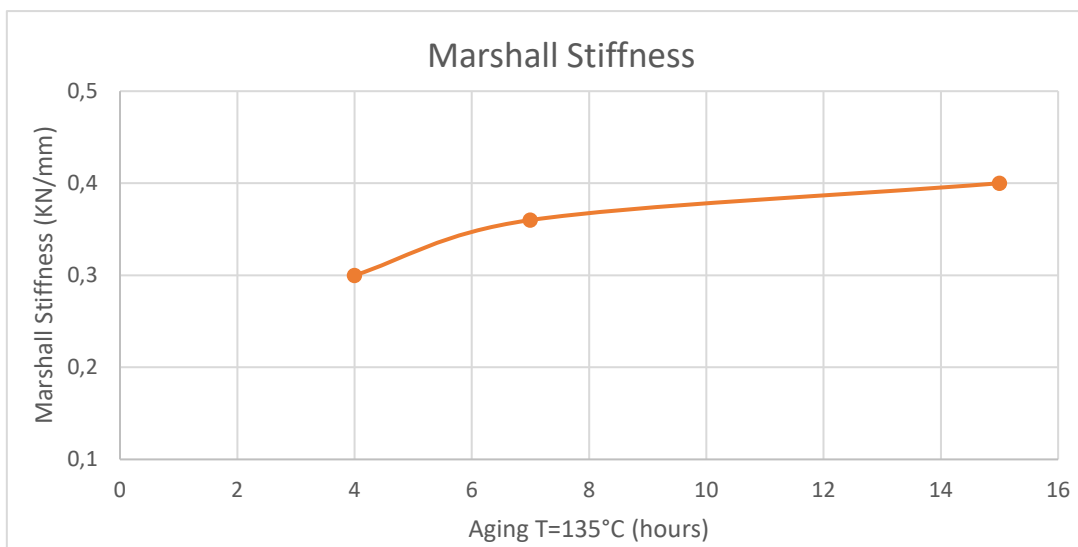
- **Marshall stability of the asphalt mix after aging**

Marshall parameters of specimens made with a percentage of flux on the weight of the binder equal to 25%, with a bitumen amount equal to 4%.



- **Marshall stiffness of the mix after aging**

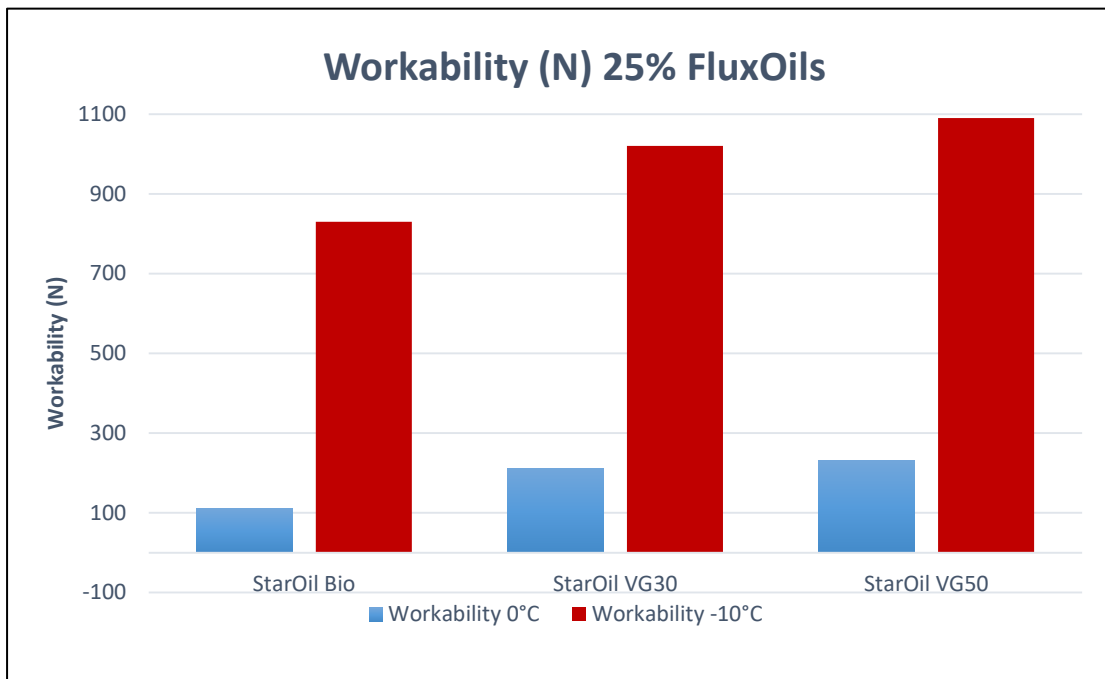
Marshall parameters of specimens made with a percentage of flux on the weight of the binder equal to 25%, with a bitumen amount equal to 4%.



- **Summary table of the asphalt mix workability**

	<u>25% ON BINDER WEIGHT</u>	
	0°C	-10°C
<b><u>StarOil® BIO</u></b>	110	830
<b><u>StarOil® VG30</u></b>	210	1020
<b><u>StarOil® VG50</u></b>	680	1090

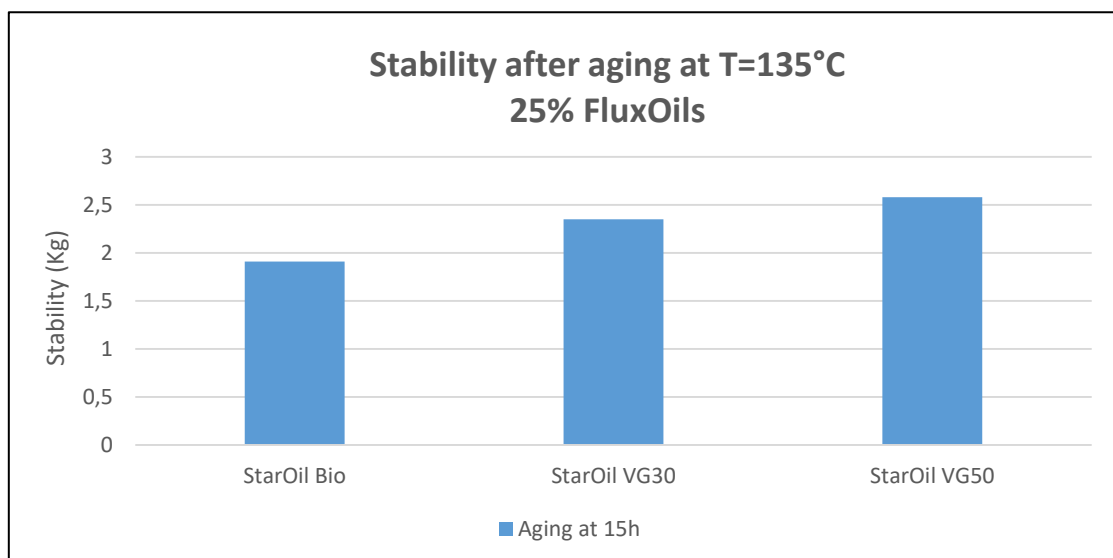
- Summary chart of asphalt mix workability



- Summary table Marshall stability after aging (KN)

	<u>25% ON BINDER WEIGHT</u>			
	0h	4h	7h	15h
<u>StarOil® Bio</u>	-	1,10	1,29	1,91
<u>StarOil® VG30</u>	-	1,24	1,40	2,35
<u>StarOil® VG50</u>	-	1,37	1,46	2,58

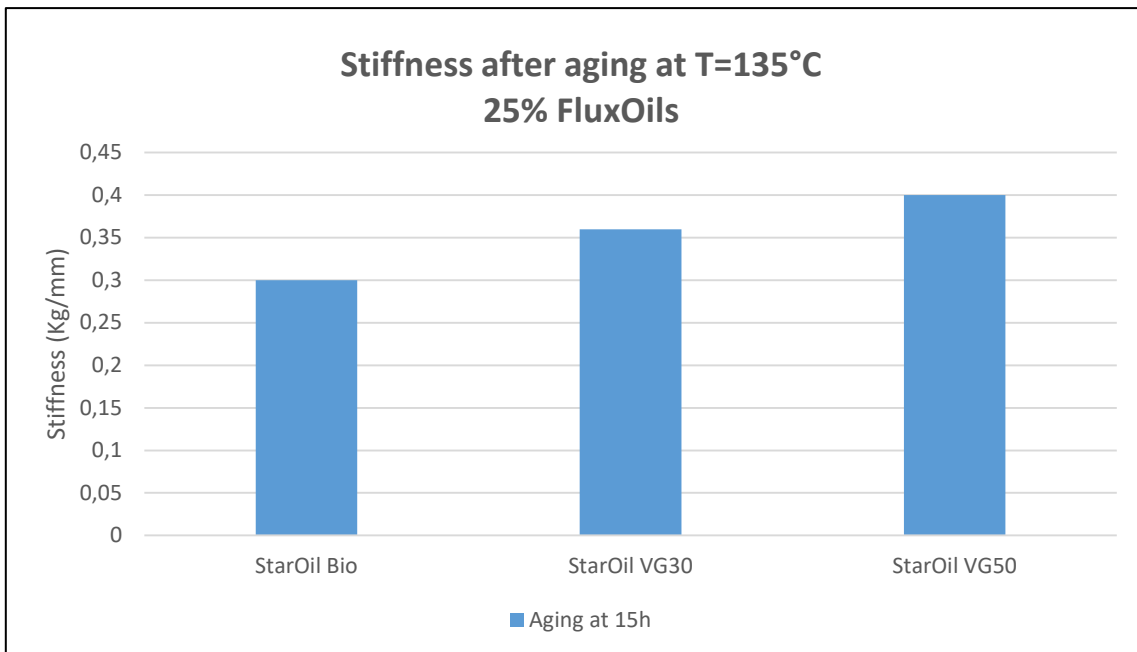
- Summary chart Marshall stability after aging (KN)



- **Marshall stiffness summary table after aging (KN/mm)**

	<u>25% ON BINDER WEIGHT</u>			
	0h	4h	7h	15h
<u>StarOil®Bio</u>	-	0.22	0.27	0.32
<u>StarOil®VG30</u>	-	0.25	0.30	0.36
<u>StarOil®VG50</u>	-	0.27	0.33	0.40

- **Marshall stiffness summary chart after aging (KN/mm)**



## II. TRADITIONAL COLD MIX ASPHALT PRODUCED WITH RECYCLED BITUMINOUS MEMBRANE

### Reference spindle

Given the lack of a regulation that regulates cold mix asphalt, we have taken as reference the granulometric spindle developed in our laboratories, which provides for the use of 3/6 mm grit and 0/4 mm sand, in ratio 7:3. The integration of sand is obviously important to reduce the phenomena of casting the binder and to give greater stability to the mix.

### Dosage of the binder

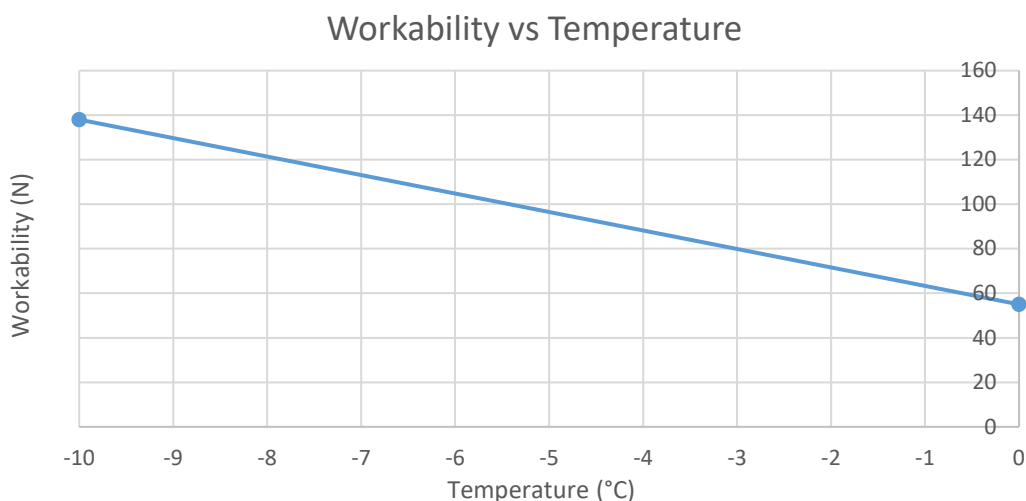
The minimum percentage of bituminous binder required to obtain complete coverage of the aggregates, which stands at 4% of the total weight of the mixture, has been identified.

### Flux dosage

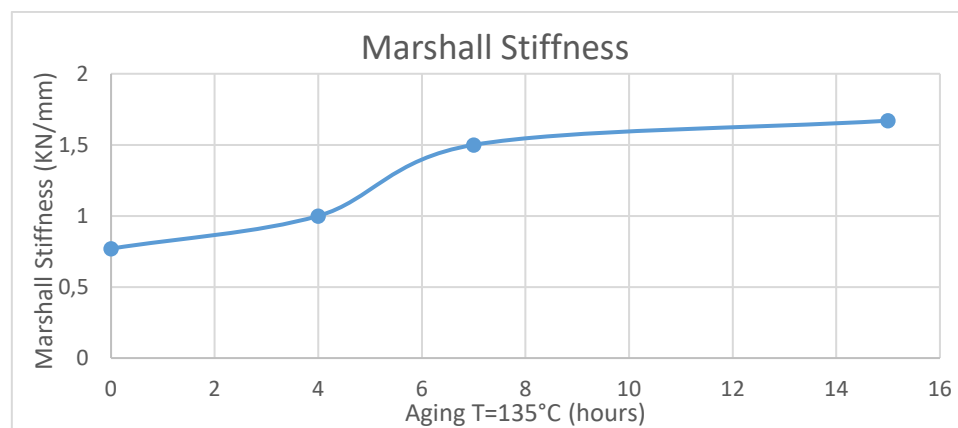
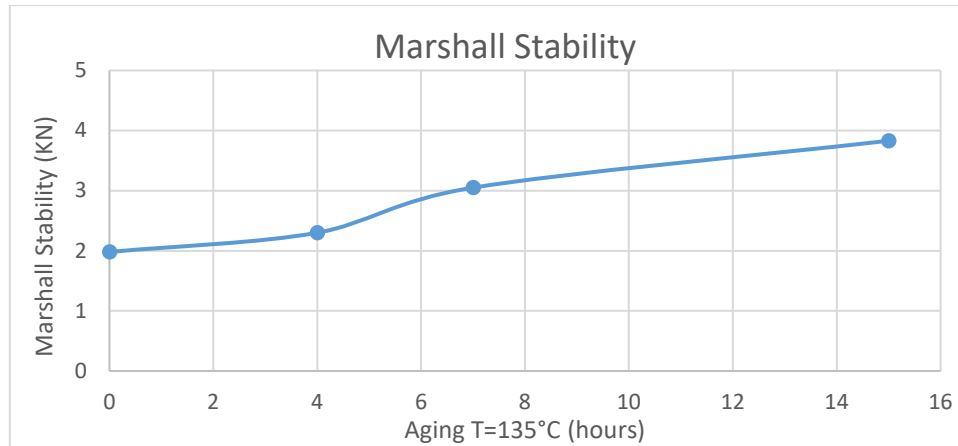
The percentage of flux necessary to obtain the right compromise between workability and performance has been identified, which stands at between 0.7% and 0.8% of the total weight of the mixture.

- **Blade test**

Graph of the shear stress as a function of the 18% dosage percentage of StarOil® VG50 on the weight of the binder.



- **Marshall stability of the asphalt mix after aging**



Depending on the type of product chosen and the percentage of dosage, the Star Asphalt fluxing line allows obtaining a cold asphalt mix that is environmentally friendly, with optimal mechanical characteristics suitable for every type of climate and environmental conditions.

Our flux range guarantees:

- An ecological and natural product that does not derive from fossil sources.
- A cold bituminous conglomerate with good mechanical characteristics.
- An easily workable and odorless conglomerate.
- A value for money ratio.
- A storability even at low temperatures (<math>< -20^{\circ}\text{C}</math>) by adding additional additives, if necessary.
- A line of products compliant with the law and not harmful to human health.



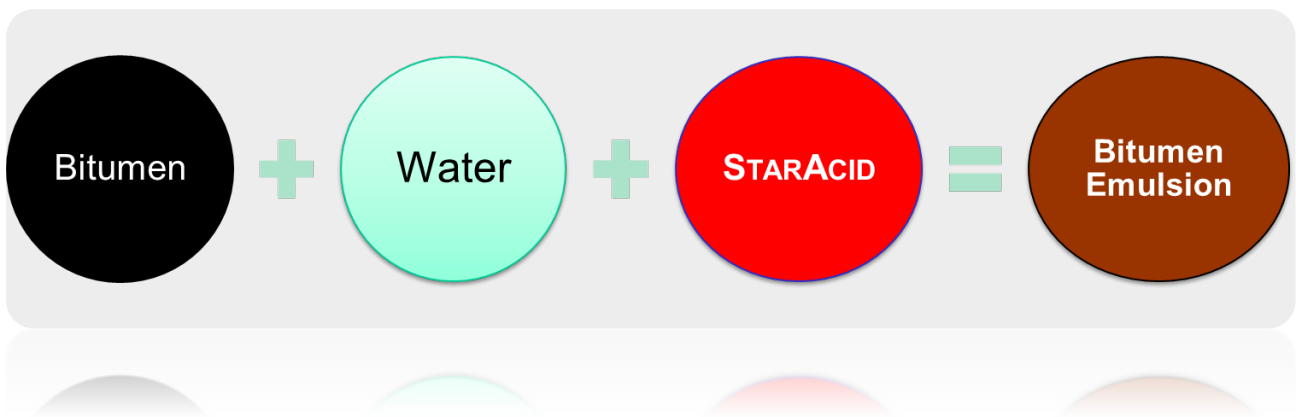


### III. COLD MIX ASPHALT WITH CATIONIC BITUMINOUS EMULSION

Using a bituminous emulsion as a binder for the production of plastic mixtures that can be processed at room temperature is an advantageous and effective choice of a cold mix asphalt directly in the plant and without using any temperature. It is therefore possible to obtain performance characteristics similar to a traditional cold mix by mixing, completely different from the latter, a mixture of carefully selected aggregates, chemically and granulometrically, and with a low content of fines with a specific bitumen emulsion. This allows, however, a drastic elimination of harmful emissions into the atmosphere, an indication of extreme sensitivity to environmental issues.



From a scientific point of view, an emulsion is a thermodynamically unstable heterogeneous system consisting of at least two phases dispersed in the form of droplets in one another; the stability of such a system, which in itself is minimal, needs to be increased by means of suitable surfactants, having the property of lowering the surface tension at the interface between the phases, favoring the dispersion of the bitumen in water. As a consequence, the bituminous emulsions, in addition to the two main phases, must contain suitable agents that favor the maintenance of equilibrium.



The additives called StarAcid and StarBas, depending on the type of bituminous emulsion that you want to produce, whether cationic or anionic respectively, are specially used in complex formulations studied in the Star Asphalt laboratories for the production of perfectly plastic and cold workable mixes.

**Main advantages deriving from the use of a bituminous emulsion for the production of a cold mix asphalt:**

- Remarkable energy savings;
- Easy and versatile installation;
- Respect for the environment, with total elimination of emissions into the atmosphere;
- Reduction of the risk of degradation of products due to overheating;
- Significant reduction in production costs.



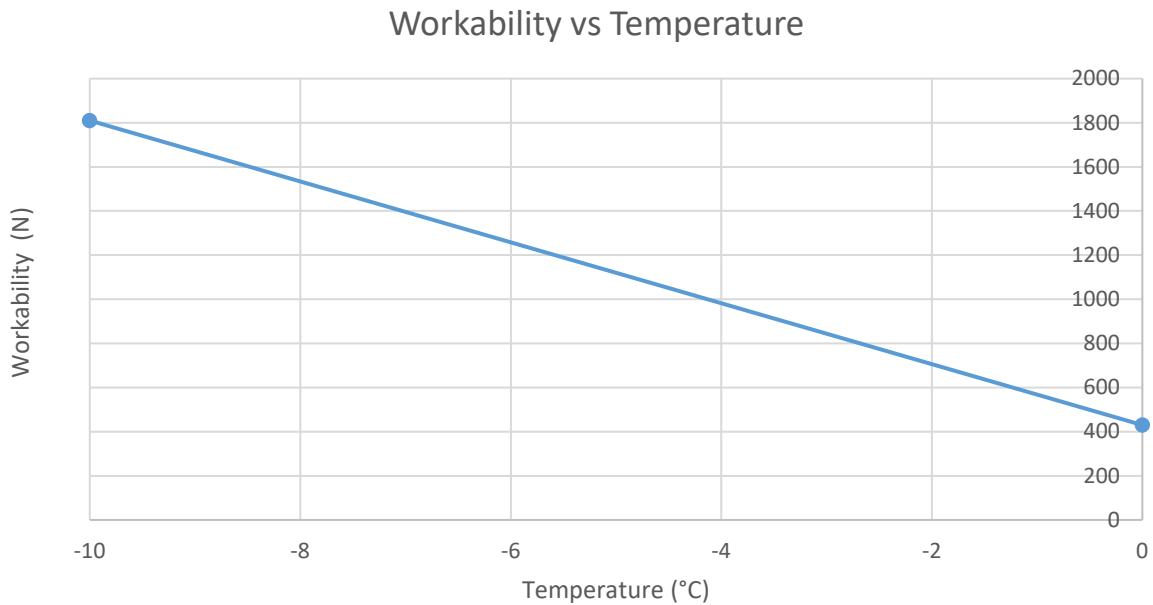
### Reference spindle

Given the lack of a regulation that regulates the cold mix asphalt, we have taken as reference the granulometric spindle developed in our laboratories, which provides for the use of baseplate 3/6 mm and basalt sand 0/4 mm, in 7:3 ratio. The integration of sand is obviously important to reduce the phenomena of casting the binder and to give greater stability to the conglomerate.

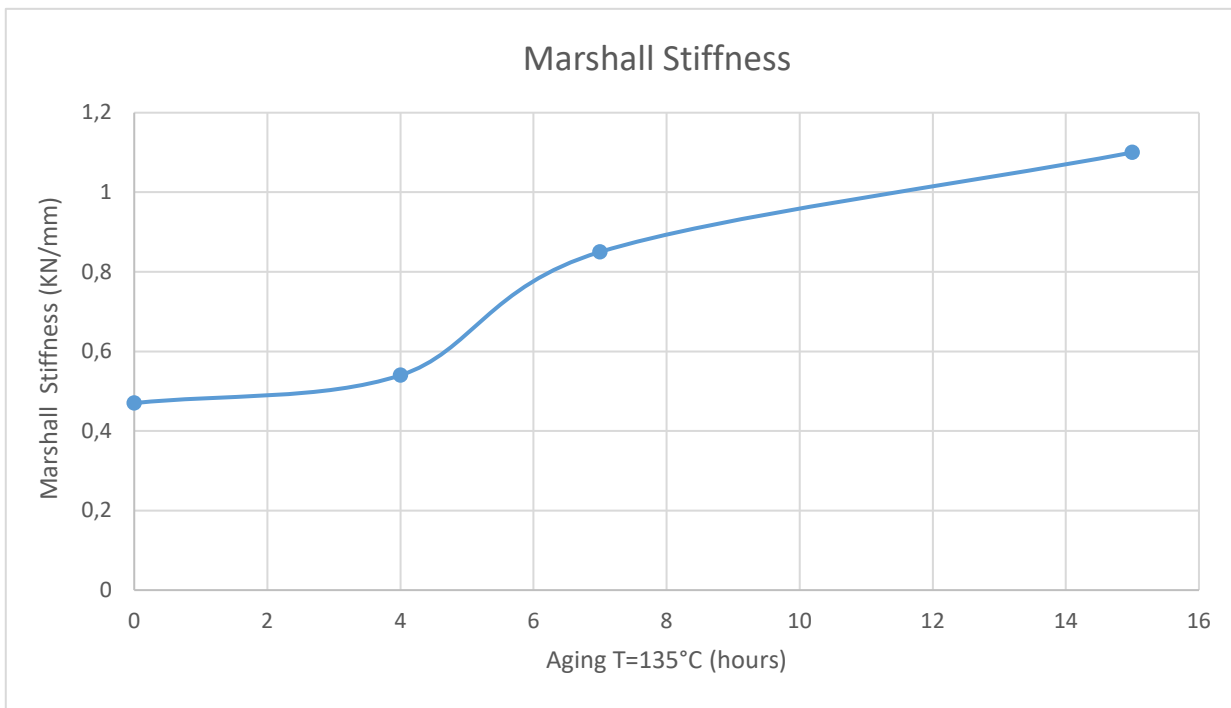
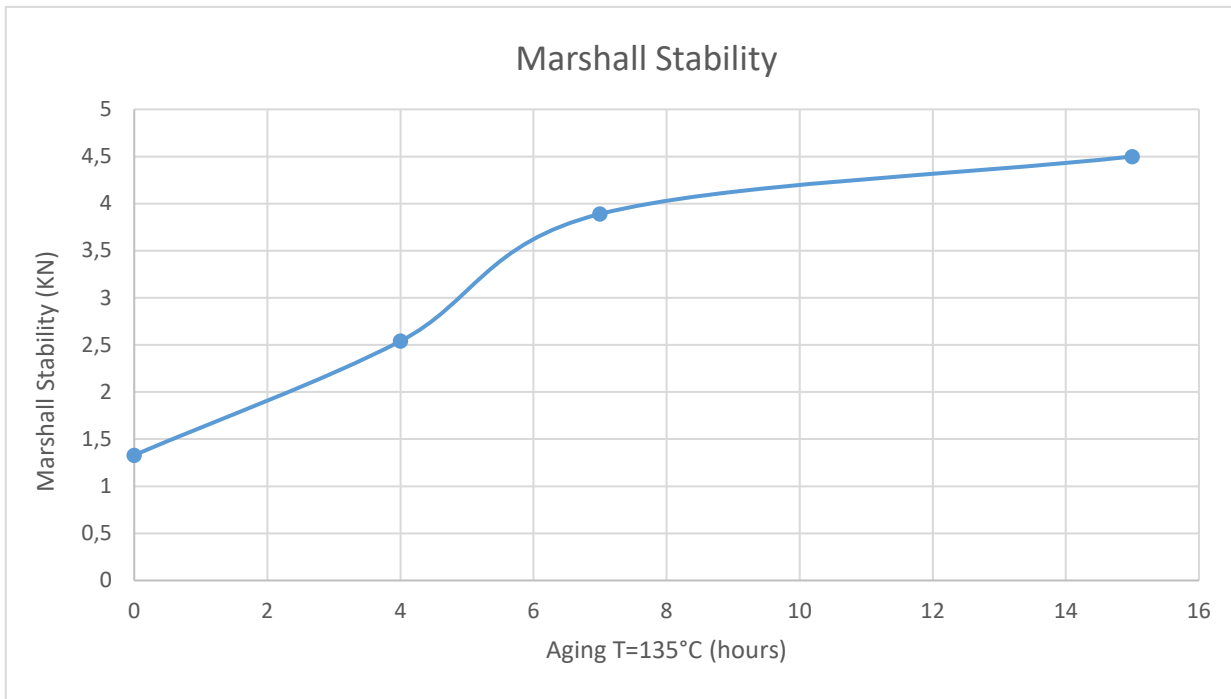
### Dosage of the binder

The minimum percentage of cationic bituminous emulsion necessary to obtain the complete covering of the aggregates, which stands at 11-13% of the total weight of the mixture, has been identified.

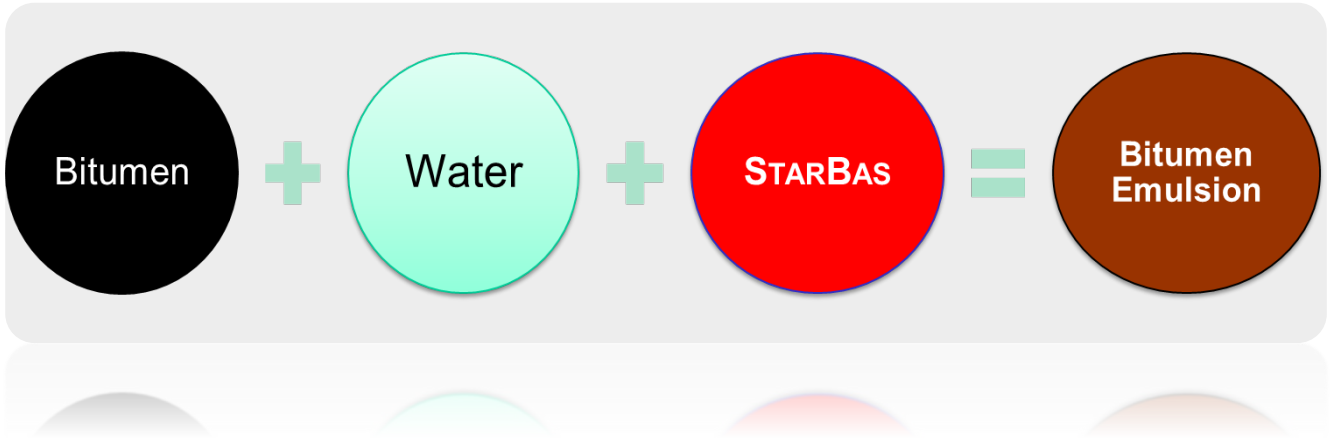
### Cold workability: blade resistance test (MTO-LS289)



- **Marshall stability of the asphalt mix after aging – UNI EN 12697-34**



#### IV. COLD MIX ASPHALT WITH ANIONIC BITUMINOUS EMULSION



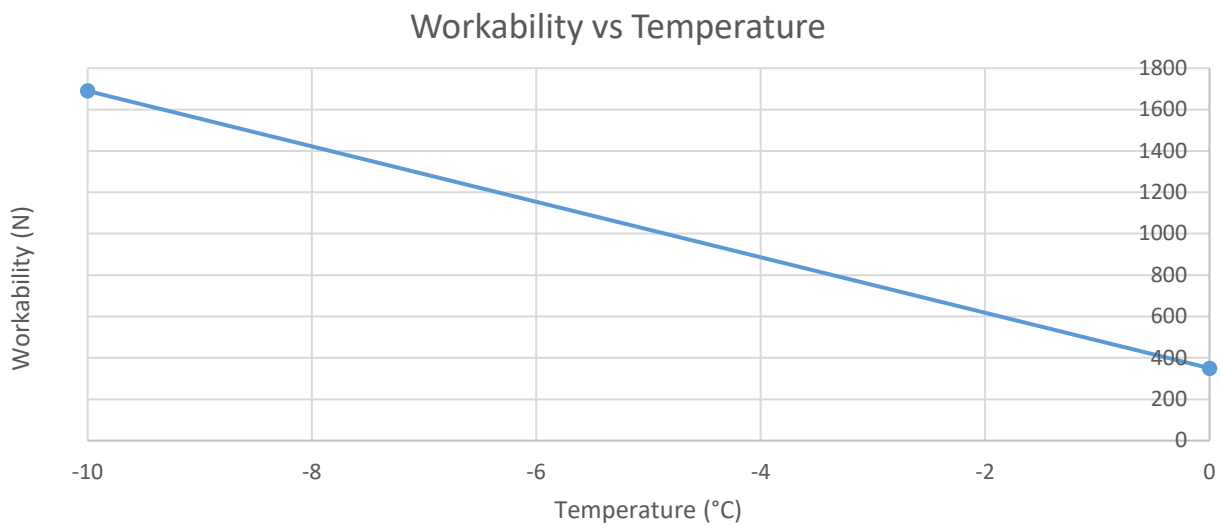
##### Reference spindle

As a reference, the granulometric spindle developed at our laboratories provides for the use of calcareous granular 3/6 mm and calcareous sand 0/4 mm, in a ratio of 7:3.

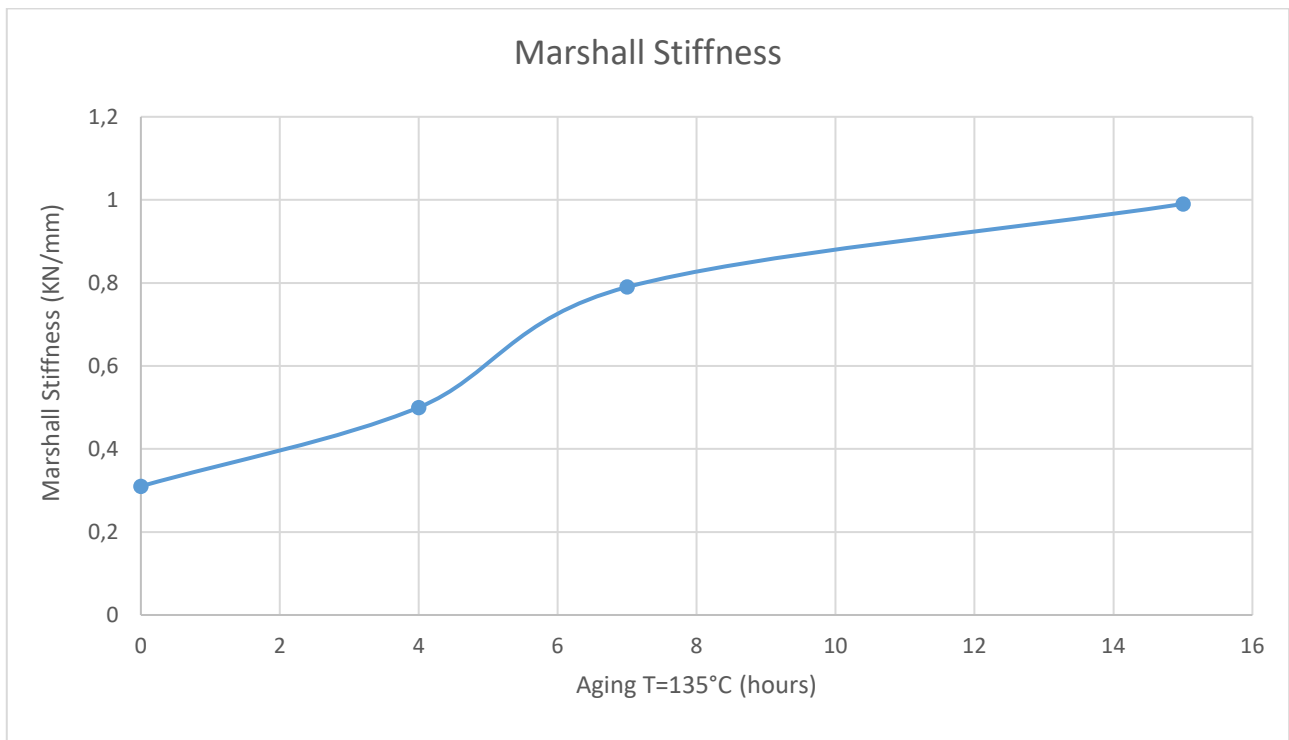
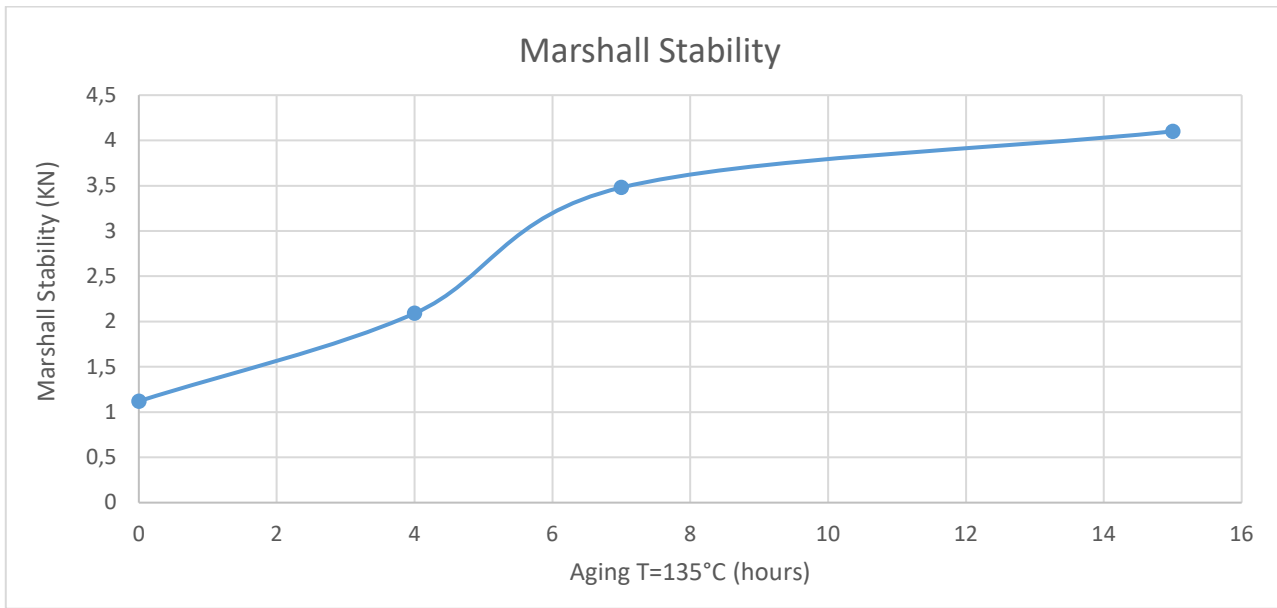
##### Dosage of the binder

The minimum percentage of anionic bituminous emulsion necessary to obtain the complete coverage of the aggregates, which is equal to 12.5-13.5% of the total weight of the mixture, has been identified.

##### Cold workability: blade resistance test (MTO-LS289)



## Marshall stability of the asphalt mix after aging – UNI EN 12697-34



## V. CATIONIC BITUMINOUS EMULSION FOR COLD MIX ASPHALT

### **Cement test - UNI EN-12848**

The purpose of the test is the determination of stability of bituminous emulsions when mixed with cement. Applies to over-stabilized cationic bituminous emulsions and to over-stabilized anionic bitumen emulsions with slow sedimentation. The test is considered to have been passed if the dry residue passing through the sieve is less than or equal to 2 grams.

CEMENT TEST → Not passed

### **Rupture index, mineral filler method - UNI EN 13075-1**

The rupture index is a dimensionless number corresponding to the amount of filler, in grams, necessary to "break" 100 grams of emulsion. By breaking an emulsion we mean the water/bitumen separation process.

FILLER MINERAL RUPTURE INDEX → BV=150-170

## VI. COLD MIX ASPHALT PATCH TYPE

Every year large quantities of waste materials are produced, that is, deriving from scraps and remains of construction materials or materials deriving from demolition, construction and excavation, with both economic costs of disposal and environmental pollution.

The motivations that push towards this direction are multiple:

- Reduction of the use of virgin raw materials;
- Reduction of the territories to be disposed of in landfills;
- Limitation of soil and atmospheric pollution, deriving from transport and incineration of waste;
- Conservation of energy;
- Economic advantages;
- Technical advantages.

Therefore, it is urgent to find effective technical solutions to recycle these materials to reuse them in the process, a condition that is even prescribed in the European Directive 2008/98/EC which requires that the level of recycling of construction waste goes up in all countries members at least 70% by 2020; therefore, the search for an alternative solution to the problem becomes even more necessary.

Among the most common materials deriving from the demolition of buildings is the bituminous sheath. The bitumen-polymer membranes (commonly called bituminous sheaths), are widely used in the field of building as waterproofing, with the essential function of making sure that there are

no infiltrations of water inside a structure; in fact, they are usually applied where the risk is considered greater: common examples are the roofs, constantly exposed to rains and snow, and foundations, in order to counteract the rising of water by capillarity. To date, they represent the type of product most used in the construction sector for their versatility, ease of application and durability. The bitumen-polymer membranes are made by coupling a mixture of distilled bitumen and polymers with a non-woven reinforcement.

From this assumption, the idea of using and exploiting the characteristics of this composite material in the production connected to the roads sector was born. In this context, the interest is growing and the Star Asphalt, always anchored to eco-sustainability, has been forward-looking, developing a system that allows the reuse of membranes in the production of asphalt mix for long-lasting road repairs.

The benefits are numerous for the benefit of both production sectors: avoided disposal costs for membrane producers, savings of virgin raw materials for asphalt producers and, more generally, reduction of emissions into the atmosphere and consumption of resources not renewable.

This type of cold mix asphalt has been called Patch Mix Asphalt.

In our laboratories two techniques have been developed for the preparation of advanced mix:

- The first provides an initial pre-treatment of the sheath, followed by the use of the same in a similar way to a classic bituminous binder;
- The second provides for the direct dosage of the sheath on hot aggregates about 160°C, and then doses at temperatures below 100°C, the flux necessary to ensure the workability of the mixture.



### Reference spindle

Given the lack of a regulation that regulates cold mix asphalt, we have taken as reference the granulometric spindle developed in our laboratories, which provides for the use of 3/6 mm grit and 0/4 mm milled sand, in ratio 7.7:2.3.



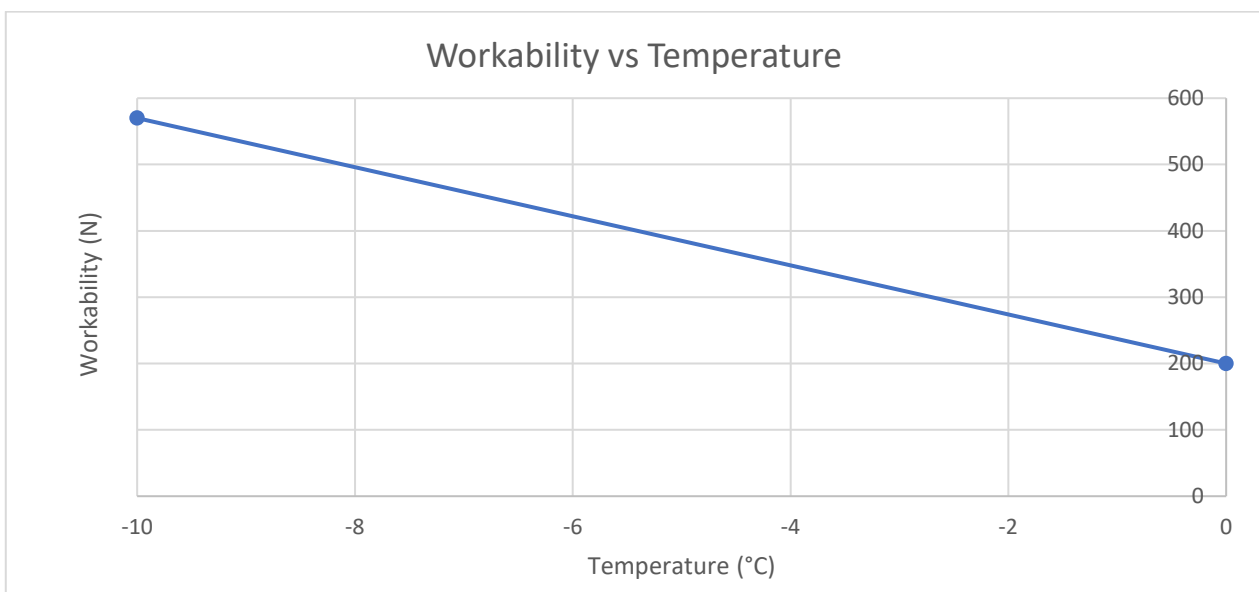
### Dosage of the binder

The minimum percentage of bituminous binder required to obtain complete aggregate coverage has been identified, which is 7-8% of the total weight of the mixture, with a filler intake of 1.5-2.0%.

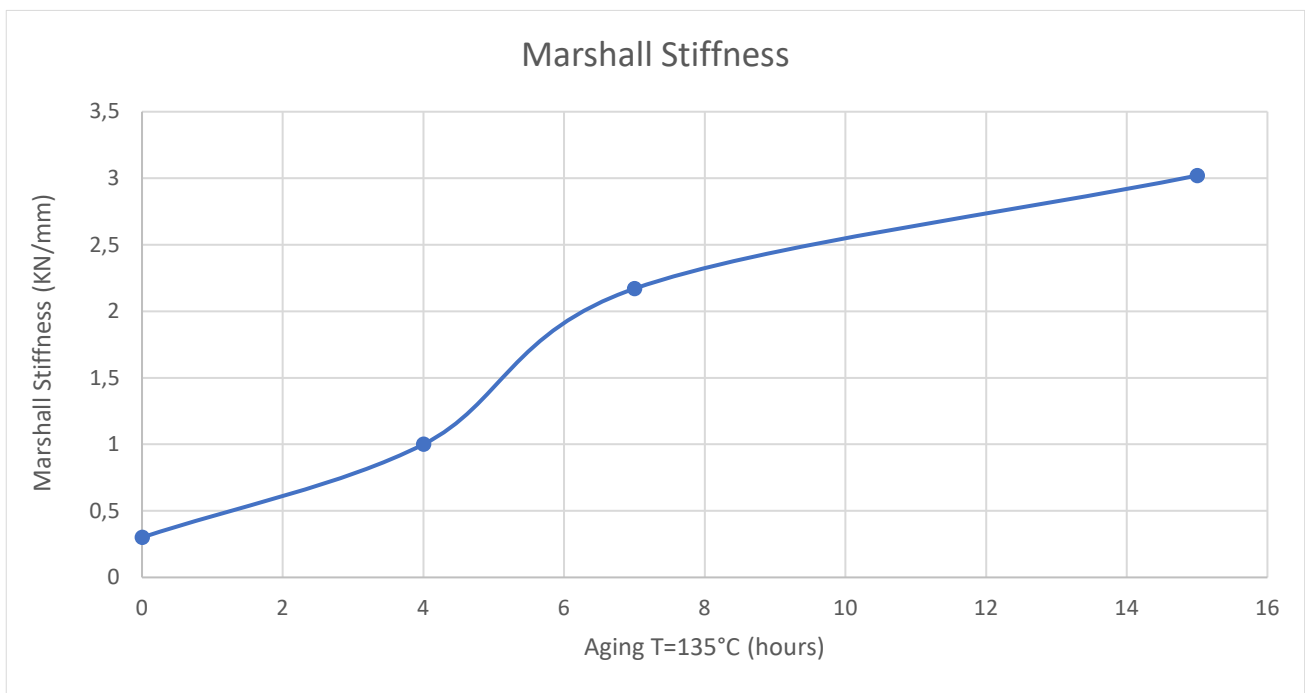
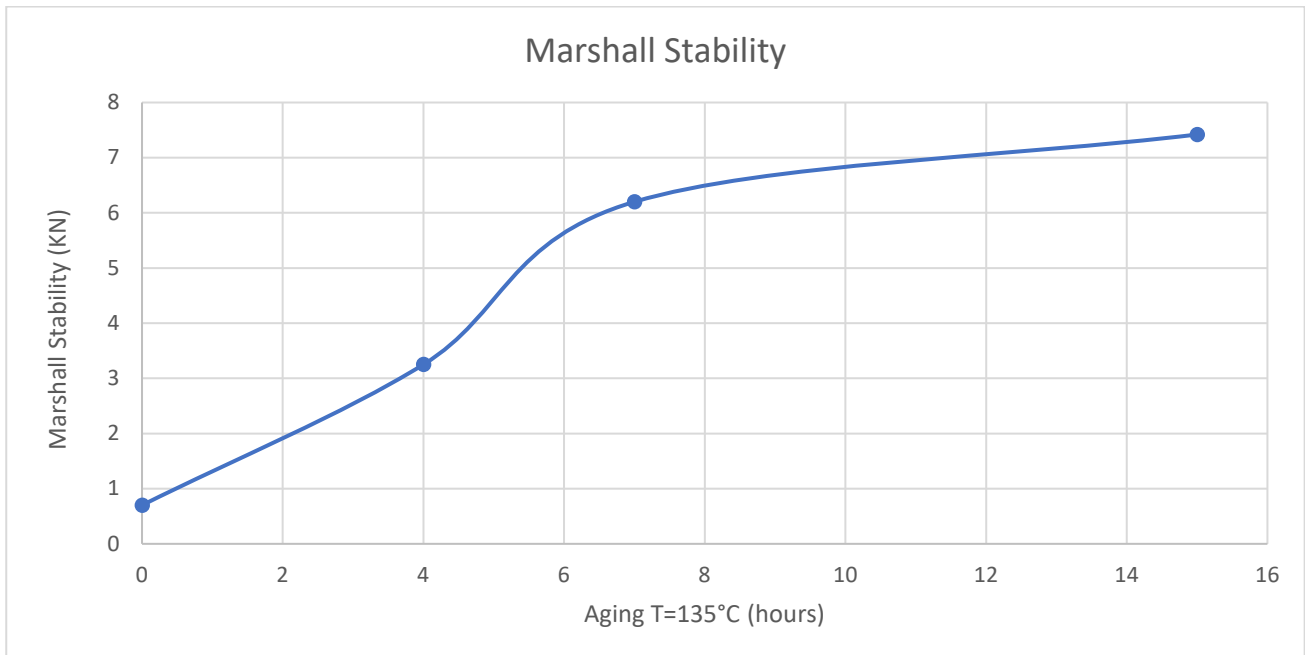
### Flux dosage

The percentage of flux necessary to obtain the right compromise between workability and performance has been identified, which stands at between 1.5 and 2.0% of the total weight of the mixture.

### Cold workability: blade resistance test (MTO-LS289)



### Marshall stability of the asphalt mix after aging – UNI EN 12697-34



## VII. COLD MIX ASPHALT PATCH TYPE PACKED IN SUPERPATCH FORM

SuperPatch is a binder packaged in rolls form to produce high performance cold bituminous mixtures for permanent road maintenance. Its particular composition, 100% eco-sustainable, developed after a careful and intense research work, conducted in the StarAsphalt laboratories and incessant road tests, guarantees the achievement of the asphalt mix with exclusive performance characteristics.

SuperPatch was born from a thorough study based on the need to obtain the first binder packaged with an innovative production process, exclusive for its realization, and with raw materials exclusively based on recycling. The firm point of our research work is in fact environmental sustainability: the mix produced by using SuperPatch do not give off toxic fumes.



An exclusive feature of the asphalt mix obtained using this stick is the opaque aspect, almost dry, at the end of the production process, indicating a perfectly stable bond inert / binder, this is a prerequisite for the durability of the repaired deteriorated road surface, with a consequent energy saving, resources and money. Moreover, the opacity characterizing this type of asphalt allows not to grease or dirty means of transport

and tools used during the laying, this indicates a further saving in the time needed to clean all the necessary material required.

The stable inert bond/binder conferred by this stick and the perfect adhesion of each particle of asphalt with itself, avoids the grating of the road pavement to the passage of vehicles of any kind, unlike traditional cold mixes which, very easily, break up requiring further maintenance.

Unique characterizing SuperPatch is, again, its versatility of use: just as a normal cold conglomerate is particularly suitable for the repair of holes on the road surface, but, unlike them, its particular composition does not require all the preliminary operations necessary for the spread such as the cleaning of the damaged surface, the removal of any water inside the application surface, the use of a bituminous primer and the final compaction with mechanical means since it is compacted simply by vehicular passage, with unique sliding performance even at high summer temperatures. Differently from the simple installation of a cold conglomerate, SuperPatch can also be applied using pavers for the construction of short road sections as well as a traditional hot bituminous conglomerate.



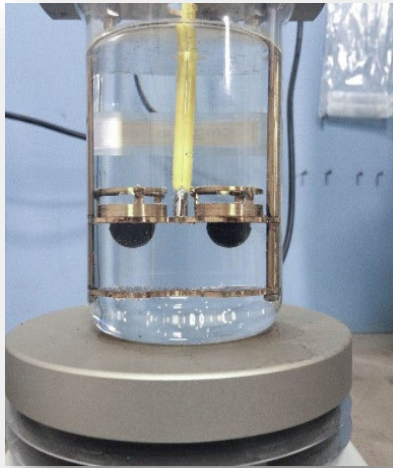
The innovative StarAsphalt technology guarantees the strict respect for the environment associated with a road surface performance and durability parallel to a hot asphalt mix albeit anchored to the practicality and speed of use of a cold mix.



## CHARACTERISTICS OF BINDER

### **Degree of penetration of the binder - UNI EN 1426**

The penetration test is a standard test performed on bituminous binders to evaluate their physical and performance characteristics. This test involves measuring, on a bitumen sample maintained at 25°C, the degree of penetration in dmm with a special diameter needle defined under a load of 100 grams for a time of 5 seconds.



Degree of penetration of StarPatch: 250 dmm

### **Softening point (Ring&Ball) - UNI EN 1427**

In this test, the softening point of a substance is measured by observing the temperature at which a standardized sized steel marble passes through a ring filled with the sample, all immersed in a thermostatic water bath.



Softening point of SuperPatch: 47°C

## CHARACTERISTICS OF ASPHALT

### Reference grain size

The particle size has been developed in our laboratories and involves the use of 3/6 mm aggregate and 0/5 mm RAP sand in a ratio of 7:3. The integration of sand is obviously important to reduce the phenomena of the binder and to give greater stability to the asphalt mix. For the realization of this type of asphalt it is necessary the integration of filler, in the measure of 5-7% after mixing with the binder.

### GRANULOMETRIC CURVE

	mm	% passing
SIEVE	8	100,00
SIEVE	4	49,40
SIEVE	2	25,00
SIEVE	0,5	7,10
SIEVE	0,25	3,00
SIEVE	0,063	0,85

### SuperPatch dosage

The minimum and maximum percentage of binder required to obtain a complete coverage of the aggregates, which is 6% and 8%, respectively, of the total weight of the mixture has been identified.

#### Formulation tipe

Aggregates 4-8/3-6 mm	RAP 0-5 mm	SUPERPATCH	FILLER
65.8%	28.2%	6.0%	5.0%

Aggregates 4-8/3-6 mm	RAP 0-5 mm	SUPERPATCH	FILLER
64.4%	27.6%	8.0%	7.0%

**T<sub>production</sub>=100-120°C**

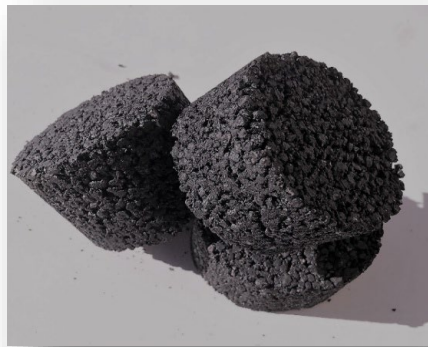
### Method of use

SuperPatch it is packaged in the form of 15 Kg rolls packed with heat-shrink films. It is easy and quick to apply: it is added to the aggregates at T=100-120°C and mixes for a time necessary for the complete covering of the same; when the mixture is finished, filler is added to make the mixture opaque and grainy.

It can be stored for 12 months in original sealed packaging and away from heat or bad weather.

### Degree of leaking of the binder – SHRP H349

The measurement is carried out by recording the loss of binder from a sample of asphalt mix at 60°C for 24 hours. The maximum accepted value corresponds to 4% of the bituminous mixture contained in the mix sample.



Content of SuperPatch	6%
Start weight of sample (g)	1000
Final weight of sample (g)	994
<b>% lost binder</b>	<b>0.6</b>

### Cohesion test – SHRP H-349

This method simulates the abrasion of the tires on the mix applied in the hole by measuring the cohesion of the material. The test consists of preparing the mix tile compacting it at 4°C with 5 strokes per Marshall hammer face, then rolling it for 20 laps inside a 25.4 mm sieve. The percentage of stored material must be above 60% to guarantee correct persistence in the hole.



Start weight of sample (g)	1000
Final weight of sample (g)	820
<b>% lost sample</b>	<b>18</b>
<b>% mantained sample</b>	<b>82</b>



### Cold workability: blade resistance test (MTO-LS289)

This test provides the measurement of the resistance of the cold material (-10°C) to the penetration of the blade of a shovel, it is a parameter very important for an asphalt mix realization, so that it is appreciated by the final user. The test consists in measuring the shear strength of a blade, applied to the Marshall press at a speed of 50 mm/min for a time of 30 seconds, on a sample of asphalt mix conditioned at -10°C and compacted with 2 strokes of a Marshall hammer by a special mold. The resistance, according to the aforementioned legislation, should be less than 2000 N to ensure good workability of the material. The resistance values normally accepted in Italy, however, are of the order of 700-1100 N. More over considering the hypothesis, of a use also in the middle seasons, with minimum temperatures above 0°C, the test is also performed at 0°C.



Temperature  
Shear Strenght

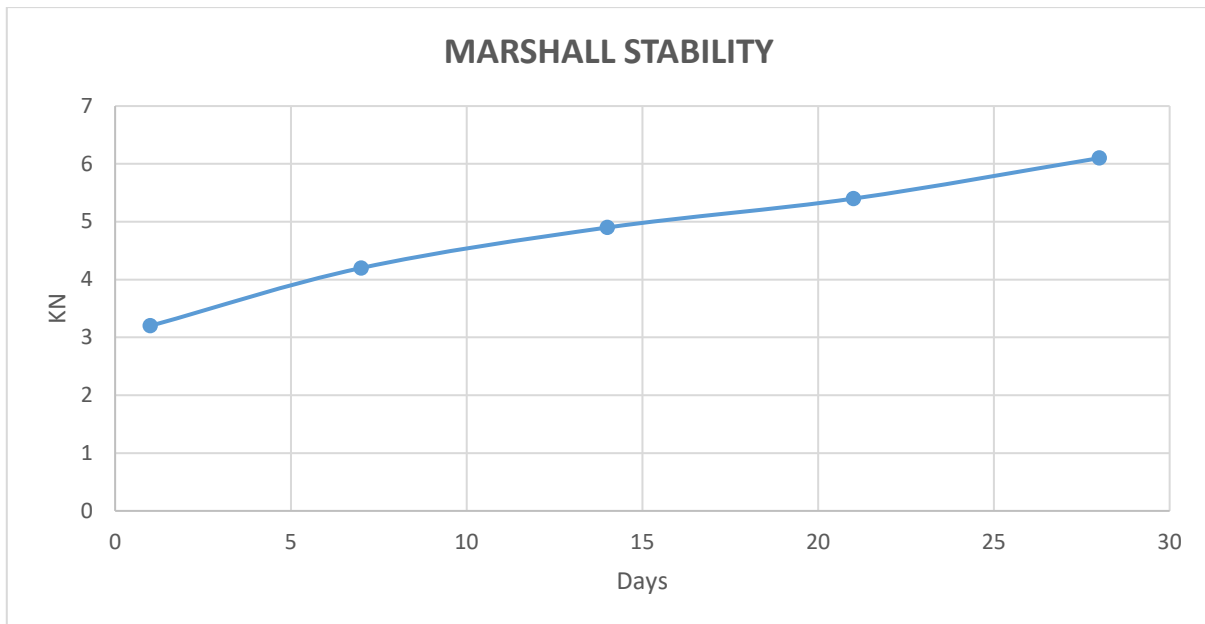
#### BLADE TEST

-10°C  
700 N

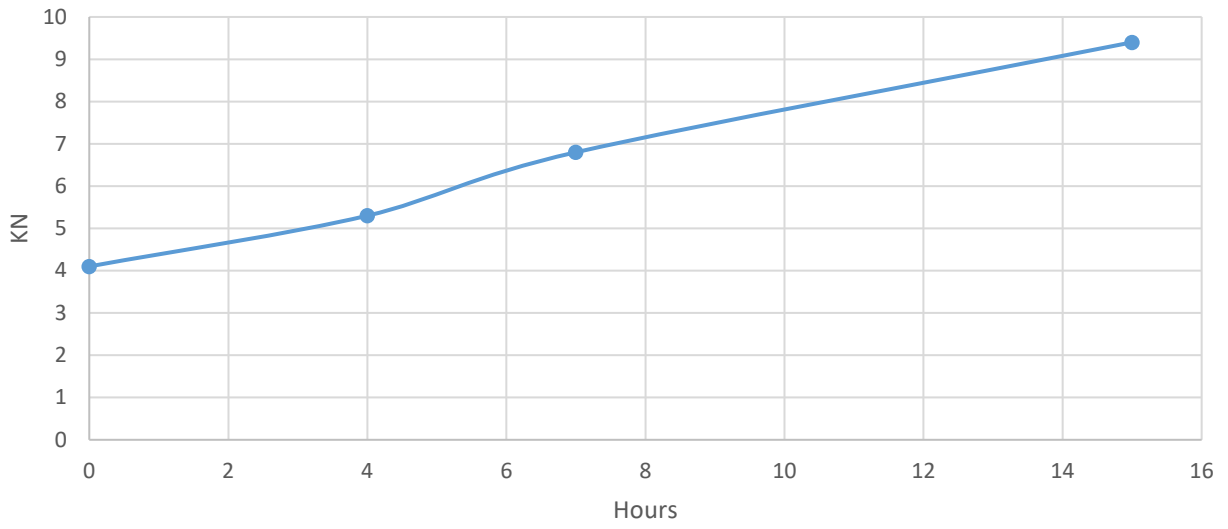
0°C  
300 N

### Marshall stability of the asphalt mix after aging – UNI EN 12697-34

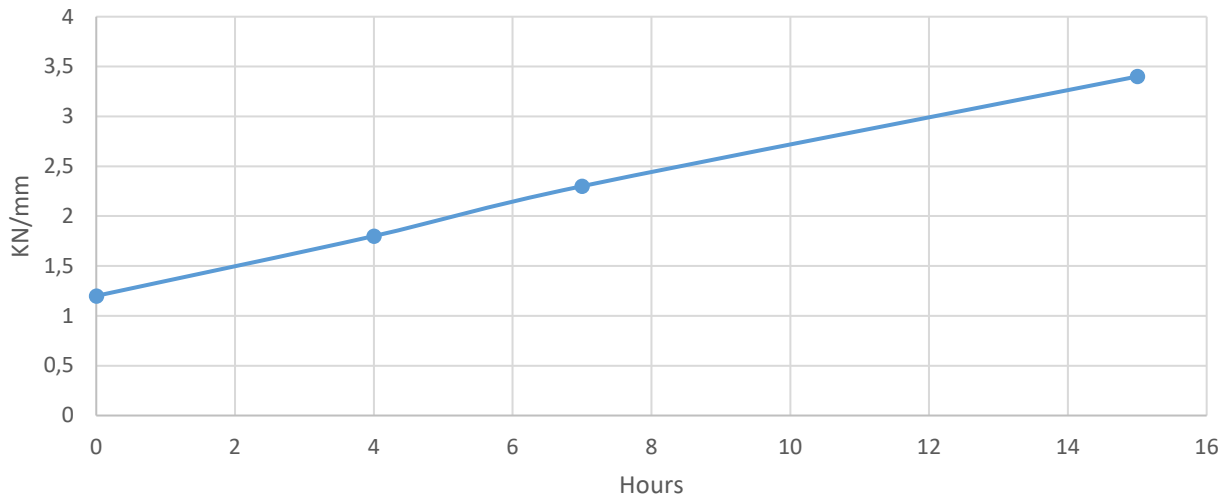
The test provides valuable information on the compressive strength of the mix as the maturation time varies. The test was performed at a temperature of 25°C with specimens compacted with 75 strokes per face. It was evaluated the aging at 135°C for 15 hours (in oven), of a specimen obtained from Marshall compactor with 75 strokes per face, leaving it to cool and causing it to break with a room temperature load cell. The aging in oven at 135°C for 15 hours, according to the results of the SHRP project, it simulates some months of curing asphalt mix in a hope under traffic, quantifiable in about 6 months of light traffic or 2 months of heavy traffic. To simulate shorter periods, intermediate tests were carried out. In particular, tests were carried out on freshly compacted specimens and specimens cured for 4h and 7h, with the aim to evaluate the material for shorter application periods behavior.



### MARSHALL STABILITY AFTER AGING

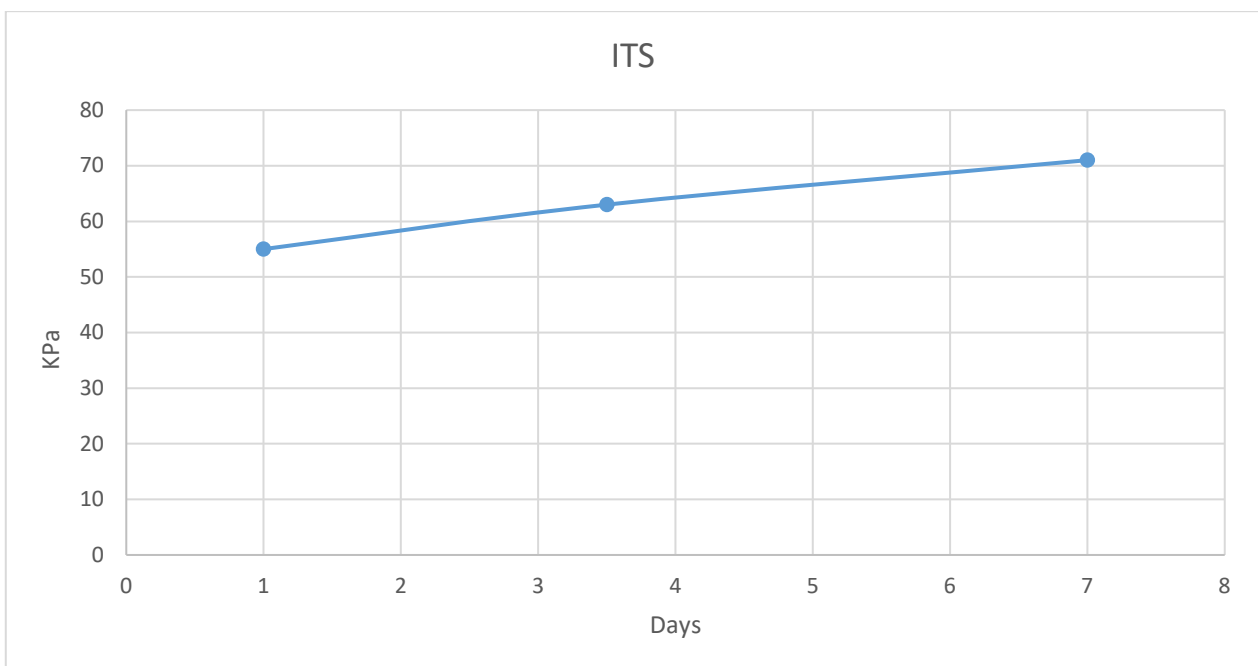


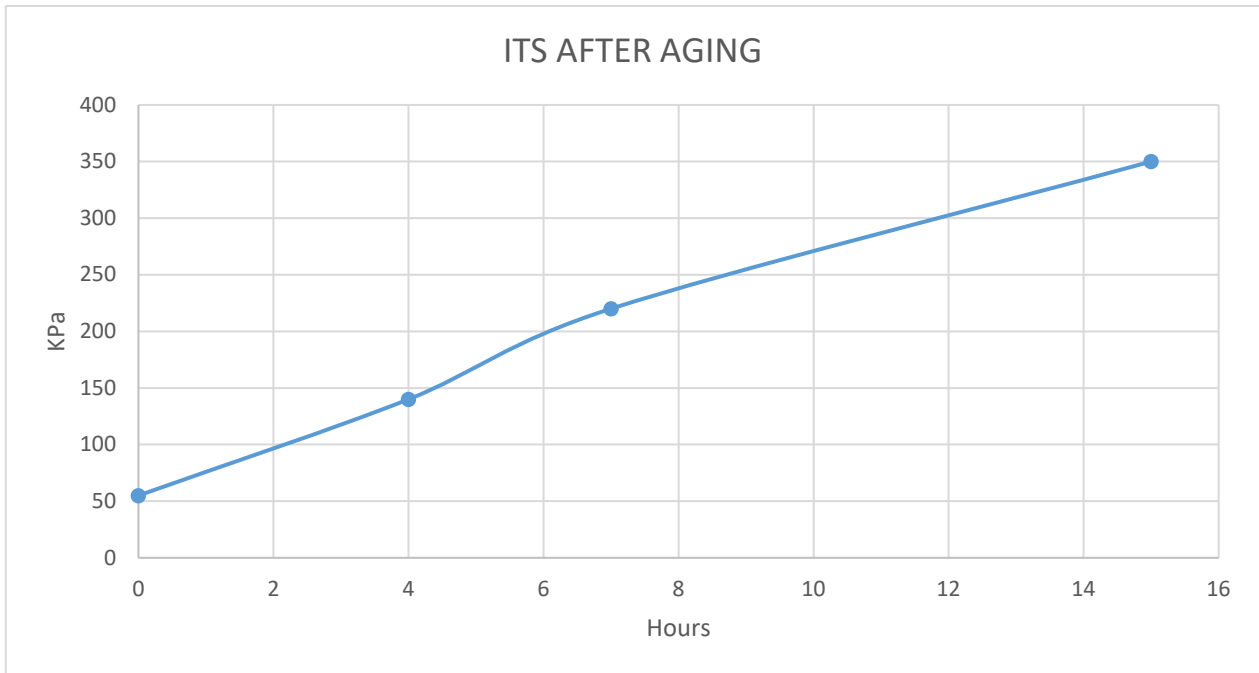
### MARSHALL STIFFNESS AFTER AGING



### Indirect tensile index - UNI EN 12697-23

The purpose of this test is to conventionally measure the resistance to indirect tensile stress ( $R_t$ ) and the breakage unit deformations, in order to evaluate the mechanical resistance of the asphalt mix. The behavior of the mix was evaluated after 7 day of maturation at  $T=25^{\circ}\text{C}$  and after aging at  $T=135^{\circ}\text{C}$  at 0h, 4h, 7h and 15h.





#### **Verification of the resistance to sliding friction - UNI EN 13036-4**

The values of the test, expressed in BPN, confirm the excellent resistance to friction of the asphalt mix made by SuperPatch. In fact, the result obtained is superior to that required by the road specifications for surface course.



**FRICION RESISTANCE**  
79 BPN

### Freeze-thaw and salts resistance

The test was performed with reference to indirect tensile strength. A comparison was made between specimens not subjected to stress cycles and specimens exposed to freezing and thawing cycles at -30°C in chemically aggressive environments based on CaCl<sub>2</sub> and NaCl. The samples of asphalt mix do not show any kind of fragility due to the low temperatures and in the presence of aggressive chemical agents.



### CURING

	Specimen not subjected to stress	10 cycles of freezing/thawing at 30°C for 9 hours Thaw in solution of 3% CaCl <sub>2</sub> at 20°C for 3h	10 cycles of freezing/thawing at 30°C for 9 hours Thaw in solution of 3% NaCl at 20°C for 3h	30 cycles of freezing/thawing at 30°C for 9 hours Thaw in solution of 3% CaCl <sub>2</sub> at 20°C for 3h	30 cycles of freezing/thawing at 30°C for 9 hours Thaw in solution of 3% NaCl at 20°C for 3h
<b>Indirect Tensile Strength (KPa)</b>	60	70	70	70	70
<b>Indirect Tensile Coefficient (KPa)</b>	6490	6380	6710	6460	6740

## VIII. BINDER FOR THE PRODUCTION OF COLD MIX ASPHALT WITH 100% OF RAP

Ricicla is a bituminous binder for the reuse of road milling at room temperature. It allows the production of a plastic mix asphalt that can be processed at room temperature, using only and only milled material. It guarantees the realization a mix for ordinary maintenance interventions in an easy and versatile way: just a simple bricklayer mixer for minimum productions or a kneading bucket, up to an asphalt or mixed cement plant, all rigorously cold.



### PRODUCTION

The binder is added (manually or by means of a metering pump) and is mixed for a time necessary to completely cover the entire milling mass: mixing times vary from 2 to 3 minutes, mixing in a cement mixer; up to 40-50 seconds, in asphalt plant.

The milled material must be screened. The optimal fractions for a performing mixture are the following:

- 0/10 mm fraction for restoration of holes or trenches of medium thickness;
- 0/20 mm fraction for restoration of holes or trenches of high thickness.

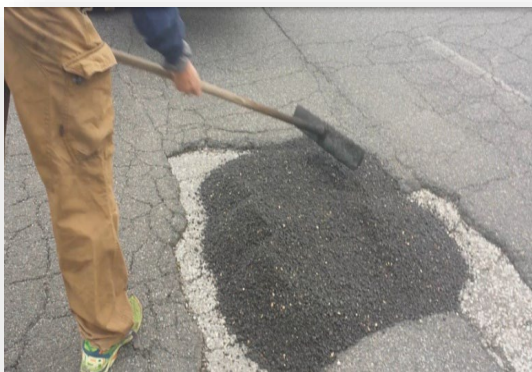
The recommended amount of recyclable varies according to the milled; doses suitable for the complete covering of the milled material can vary between 1.7% and 2.0%.



## APPLICATION

The product conglomerate can be spread by hand in the same way as traditional cold plastic mix asphalt or alternatively with pavers for larger surfaces, and compacted appropriately according to the thickness and the surface involved with a plate or roller compactor, within 24 hours from its dosage.

With this technique it is therefore possible to restore holes of all types: from small size to large deterioration; it is also possible to create new floorings and arrange ormings and webs.



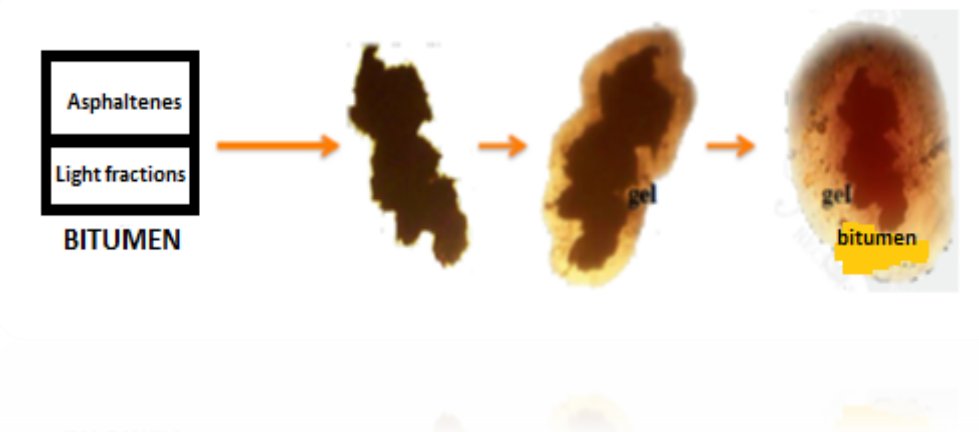
## MECHANICAL CHARACTERISTICS

	Stability (KN)	Scrolling (mm)	Stiffness (KN/mm)
After 12 hours room temperature (T= 25°C)	632	3.25	194
After 20 hours of aging at 40°C	1017	3.56	280

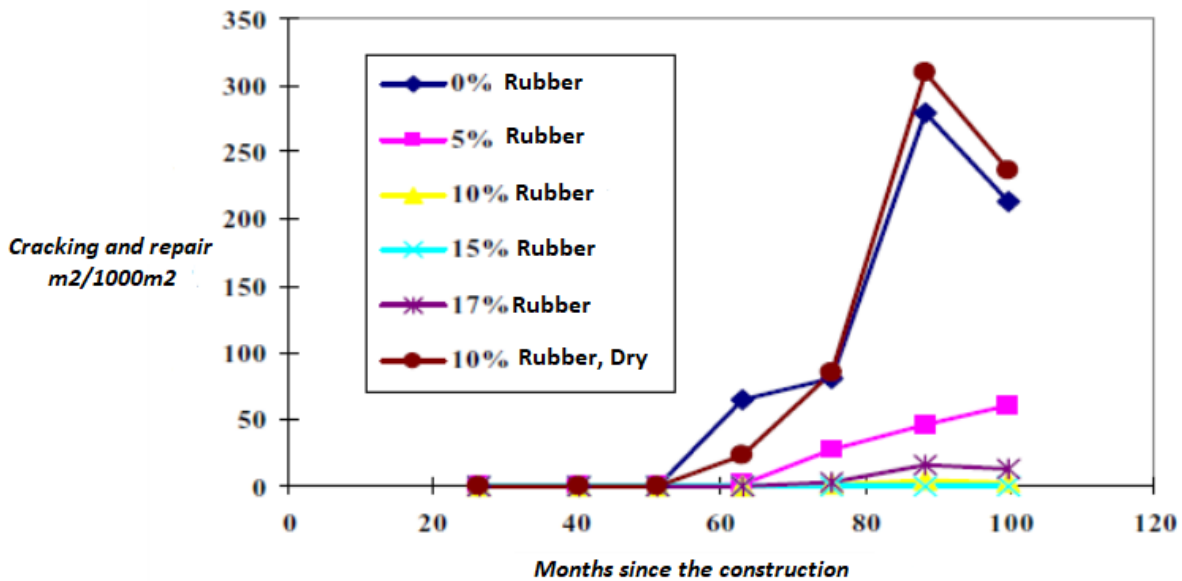


## IX. PERFORMANCE COLD MIX ASPHALT WITH RUBBER POWDER

In recent decades, the construction of roads with environmentally sustainable technologies has become increasingly dominant due to the constant accumulation of waste materials, such as milled material and used tires. With modern technologies, it is possible to reuse these materials while ensuring high performance. An example is the technology of Asphalt Rubber, born in the United States in the 60s and today more and more frequently used in many European countries. The bitumen modified with recycled tire rubber powder (wet process), known as Asphalt Rubber, is used as a valid alternative for the packaging of bituminous mixtures of excellent durability and resistant to severe loading conditions. The use of the Asphalt Rubber, besides being a concrete application for the reuse of used tires, allows to obtain substantial improvements of the asphalt mix. The modification with rubber powder makes it possible to obtain a binder with improved rheological characteristics compared to the original bitumen due to the higher density, the higher softening point, the lower thermal susceptibility, the greater resistance to sliding, the less aging, the lower tendency to cracking in cold climates, and excellent waterproofing and adhesion with aggregates. Furthermore, the use of the Asphalt Rubber allowed to record significant attenuations of the rolling noise of vehicle traffic, with a reduction of up to 9 dB of the noise level in urban areas of circulation. The complex process of interaction between bitumen and rubber can be summarized as follows:



The conjugated effect of the high temperature and the presence of aromatic oils, as well as of resins, in the bitumen, allows the swelling of the rubber particles, which also come to duplicate their volume generating a bitumen-rubber gel: the additive binder, from lumpy becomes homogeneous and fluid.



Bitumen modified with powder can be subject to segregation problems; in this regard the use of special additives comes into play, with the aim of improving the physico-chemical characteristics of the mixture, as well as making it homogeneous and facilitating the exchange of volatile components between bitumen and powder. According to the studies conducted at the "La Sapienza" University of Rome's civil and industrial engineering department, the additive developed in the Star Asphalt laboratories called Cross-Linker CR, allows to improve the binding and adhesive properties in the modified bitumen with dust. Its presence in the asphalt guarantees, in fact, a better bond between bitumen and aggregates, a greater resistance to deformation and a better flexibility of use.

The technology proposed by Star Asphalt, in the context of cold mix asphalt, involves the use of bitumen modified with a rubber powder, and the reuse of 30-40% of milled asphalt material, in order to realize an eco-friendly asphalt mix sustainable and higher performance.

The mixture, studied in our laboratories, foresees the use of selected aggregates of 3/6 mm or 4/8 mm grains, and 0/5 mm milled sand, (alternatively it is also possible to use other appropriately selected milling sizes), using a bitumen modified with rubber powder (appropriately pretreated with the additive called Cross-Linker CR), and environmentally friendly vegetable oils, which make the mixture workable, if properly stored, for long periods.

The production technique is very similar to that of producing a classic cold mix asphalt, with the only variant represented by the preparation of the bituminous binder. The modification must be carried out on a bitumen with a penetration degree of 70/100 or more (depending on the type of modification), at a temperature of at least 180°C, under agitation, for a minimum time of 30 minutes, even if typical values are included between 60 and 90 minutes.

### Reference spindle

Given the lack of a regulation that regulates the cold conglomerates, we have taken as reference the granulometric spindle developed in our laboratories, which provides for the use of 3/6 mm grit and 0/5 mm milled sand, in 7:3 ratio. The integration of sand is obviously important to reduce the phenomena of casting the binder and to give greater stability to the mix.

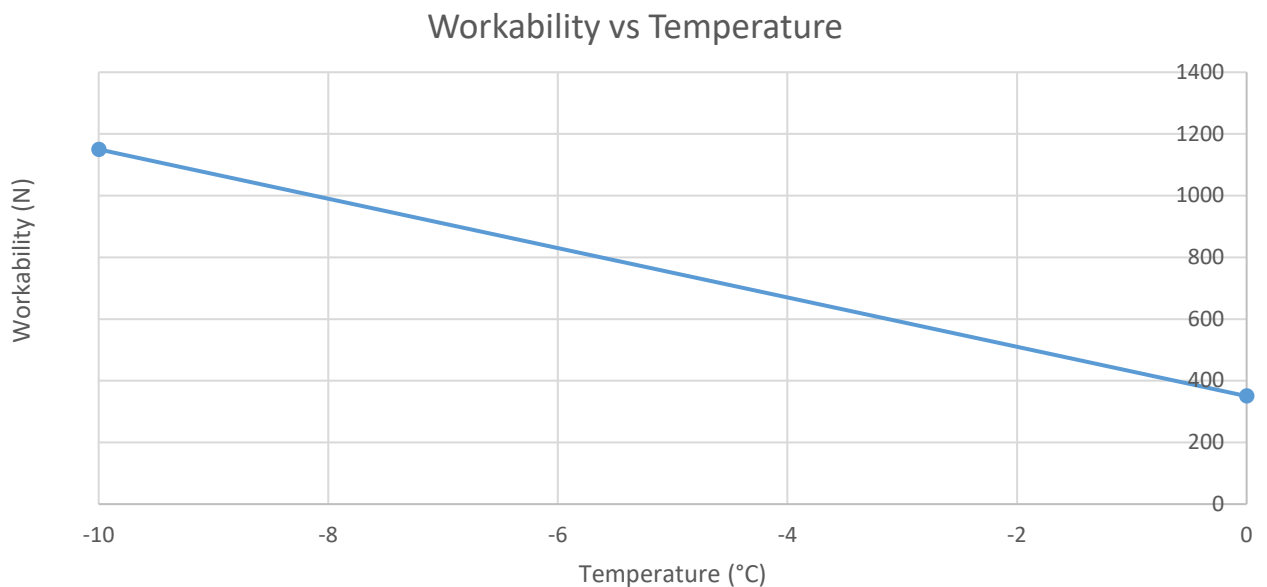
### Dosing of the binder

The minimum percentage of bituminous binder required to obtain the complete coverage of the aggregates, which is 3.8% of the total weight of the mixture, has been identified. The binder was modified with 5% of rubber powder added with 5% of CROSS LINKER CR.

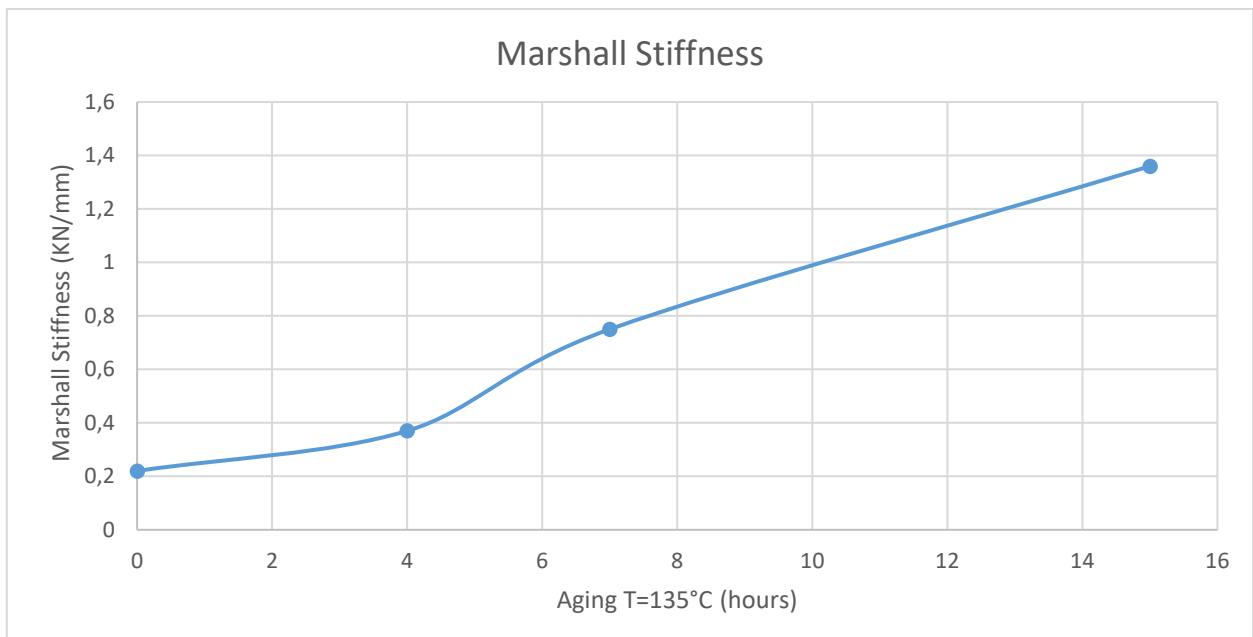
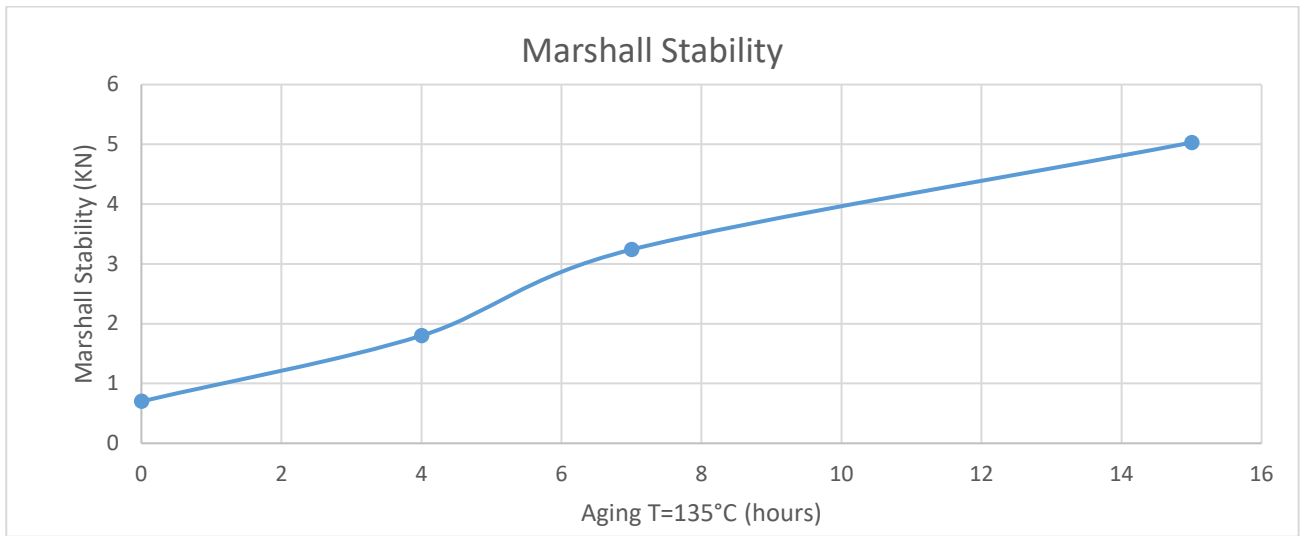
Degree of penetration of the binder - UNI EN 1426    67 dmm

Softening point (ball-ring) - UNI EN 1427    48°C

### Cold workability: blade resistance test (MTO-LS289)



### Marshall stability of the asphalt mix after aging – UNI EN 12697-34



## CONCLUSIONS

With this manual we want to focus on the material and methodology made available by Star Asphalt S.p.A. for long-lasting, economical and efficient road maintenance. Correctly correct the defects detected through preventive ordinary maintenance, involves a considerable economic saving while maintaining excellent levels of performance standards to which reference is made to quantify the level of safety and comfort. One of the most technically obvious, applicable solutions is to limit waste in the various corrective actions. Using proper preventive maintenance, done in a workmanlike manner, following the special tender specifications and properly designed case by case, is the first step to optimize these interventions. Given the low level of service found in a large portion of the main territorial network, the second step is to design a rehabilitation appropriate to the needs of each individual road section in order to raise safety levels through appropriate interventions and working with methodologies proposals in these pages. It is therefore necessary to proceed with a planning of the interventions based on the priorities identified, after having qualified and quantified the existing critical issues.

In conclusion, it is emphasized how to always work "in a workmanlike manner", in all sectors and at all levels, from the designer to the site technician, from the project manager to the operating staff, and the main coordinator to obtain a result with excellent safety and comfort features, promoting long-term economy.

## **FINAL CONSIDERATIONS**

The purpose of this "textbook" is to suggest the appropriate improvements in order to guarantee a high quality level of our roads, eliminating improvisation, coordinated with these indispensable for the managerial responsibility of the operators involved in the construction of road paving.

The StarAsphalt S.p.A. is constantly looking for innovative solutions and undisputed advantages on several fronts for the community, proposing advanced performance additives studied in its laboratories and realized in its production sites, in compliance with Regulation (EC) no. 1907/2006 concerning the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) and the establishment of the European Chemicals Agency, resulting from the use of diversified products that are less and less harmful to humans and for the environment.

Considering the amount of the treated aspects and the continuous development of products and technological innovations, the following writing will be in continuous evolution.

