CONFERENCE PAPER 8

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Lasting asphalt mixtures "Rehabilitation of roads and roadways with low traffic in cold and/or rainy weather and long distances"

#ICA4point0

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Lasting asphalt mixtures "Rehabilitation of roads and roadways with low traffic in cold and/or rainy weather and long distances".

1. INTRODUCTION

When looking at investments in road infrastructure in Spain, it is convenient to highlight the following three central aspects:

- The use of bituminous mixtures occupies a large part of the volume of materials to be used both in the new construction and in the rehabilitation works, and they take around 30% of the investment of the pavement structure, being one of the largest expenses of the Ministry.
- Maintenance processes contemplate, in a large number of cases, proceeding to milling or recycling the existing upper layer of bituminous mix.
- The production processes of hot bituminous mixes demand high energy consumption and consequently the generation of greenhouse gases, among which the tons of $C0^2$ emitted in said process are used as the most representative indicator.

The current technologies of hot agglomerates and cold mixes with emulsion have many limitations in terms of execution distances, application climatology and work times that sometimes make it impossible to carry out certain works, in addition to the limitation or problems of efficiency, as manufacturing facilities need large amounts of agglomerate to be efficient.

What is hot mix bituminous? Hot bituminous mix is defined as *"the combination of a hydrocarbon binder, aggregates…. Its manufacturing process involves heating the binder and the aggregates and its installation must be carried out at a temperature much higher than ambient"*

As we can see, the definition already marks one of the fundamental limitations of the bituminous mix, which is the need to be used before the binder hardens and loses its ability to stick the aggregate and compact .

The limitations have been overcome, stressing the system to overcome its limits, exceeding its technical and regulatory limits of use, exceeding manufacturing temperatures to lengthen distances and times and manufacturing specific days, which causes a greater environmental impact, deterioration of bitumens and an extra cost.

There are cold techniques, but the latter also have many limitations, both performance and not being able to be used in humid or cold climates.

In this way, there is a use barrier in the asphalt mix that until today has been difficult to break.

In addition to this, in current times it is necessary to move towards the incorporation in the construction of bituminous mixtures in the amounts demanded, considering the design of the same with high rates of recycled or milled bituminous mixture available in the maintenance strategy, adding techniques with ecological additives that allow the production temperature of bituminous mixtures to be reduced, the compaction temperatures and thus reduce the global energy consumption measured in Mega Joules, as well as CO_2 emissions measured in tons of CO_2 equivalent.

Also, in order to generate a bituminous mixture that is more resistant to permanent plastic deformations, fatigue and aging, it is considered opportune to add dust from end-of-life tires (NFVU), counting on the technologies of pre-digested tire dust, the which greatly facilitate the direct modification of the bituminous mixture.

The following communication informs of the execution of works where these conditions are met:

- Site of the work very distant from the manufacturing plants.
- Prevailing winter weather.
- Low volume of action.

In this communication, an ecological construction system has been proposed that also aims to break current barriers using the following technological innovations:

- *Technology used:* ***LASTING ASPHALT****, name that we intend to establish as a new system in the market.*
- *Manufacturing process:* ***WARM WITH ECOLOGICAL ADDITIVE***
- *Recycling technology:* ***RAP ADDITION*** *,*
- *Durability and mechanical resistance: NFVU POWDER by means of a* ***predigested rubber additive and additives***

With these innovations these current barriers will be overcome:

- *Storage capacity of the bituminous mixture.*
- *Extended and cold compacted in subsequent days, even in extreme cold environmental conditions.*

The communication reveals a completely pioneering and innovative technology in Spain that not only provides an answer to roads and driveways where the use of conventional asphalt mixes is impossible, but is also a totally ecological technology, since it integrates:

- USE OF RAP
- WARM MANUFACTURING
- USE OF TIRE POWDER
- USE OF ECOLOGICAL ADDITIVE

To evaluate this technology, we have had the support of administrations and clients who have allowed its execution, more specifically the most excellent Avila Provincial Council .

In the communication the action carried out in the province of Avila and others will be presented, together with some tests carried out in which the individual capacity of some of the techniques and the joint capacity of all of them will be seen.

2. SUSTAINABILITY AND CIRCULAR ECONOMY

One of the axes of our communication is sustainability and the use of resources.

The circular economy is a paradigm that seeks to modify the way in which it is produced and consumed. Faced with the linear economy of extraction, production, consumption and waste, the circular economy encourages a constant flow, a virtuous solution, in which waste can be used as resources to re-enter the productive system. In this way, waste is reduced and fewer natural goods are extracted from the planet.

Can the production of asphalt mixes be considered as a closed cycle production with the characteristics of a Circular Economy? The present proposal considers that this is possible by adding to the production process the milling or recycling of deteriorated bituminous mixtures and removals from the pavement, by equipment suitable for this purpose.

Photograph 1: Asphalt plant for the production of hot bituminous mix

3. THE MILLED MATERIAL, "RECLAIMED ASPHALT PAVEMENT" (RAP)

According to EAPA, the current average RAP reuse rate in Spain is 4.7%, which means that it is in last place among reference countries, and does not reach the minimum of 5% proposed in the PEMAR 2016-2022 "

This milled material is made up of stone aggregate and aged bitumen. Being to date withdrawn to an authorized manager as construction and demolition waste without any use.

The recycling of existing pavements and pavements comprises a series of construction techniques aimed at maximizing the use of materials aged by their use in the structural rehabilitation of highway pavements and pavements.

If we look at the environmental requirements and regulations, the PEMAR 2016-2022 establishes the reuse of at least 70% of construction and demolition waste before the year 2020.

On the other hand, the Spain Circular 2030 strategy establishes a 30% reduction in the consumption of materials in relation to GDP, taking 2010 as the reference year .

Circular order 40/2017 establishes a regulatory review of the use of milling in works, adapting to new techniques and experiences in the sector. In this way, three milling reuse systems are established:

- On-site recycling with emulsion of bituminous layers.
- Recycled in situ with cement for firm layers.
- Hot and semi-hot recycling of bituminous layers.

Recycling of bituminous mixtures in a hot plant is understood to be the reuse of bituminous mixtures removed from aged layers by treatment in a hot manufacturing plant. In this treatment, other new aggregates and binder are added to the old mixes and, sometimes, a binder rejuvenating agent. The use of recycled materials can be done on the same firm from which they come or in another location, and the bituminous mixtures made with these materials must comply with the same requirements required for conventional hot bituminous mixtures.

Recycling of bituminous layers in a plant is defined as the technique for manufacturing bituminous mixtures consisting of the use of RAP with the contribution of asphalt bitumen, aggregates, mineral dust, and possibly additives, with which a bituminous mixture is obtained (hot and semi-hot) of those specified in article 542 of the General Technical Specifications for Road and Bridge Works (PG-3).

Article 22 "Hot plant recycling of bituminous layers" of the future General Technical Specifications for Road and Bridge Maintenance Works (PG-4).

The following sequence should be considered

a) The mixtures obtained by recycling must meet the same requirements as the equivalent conventional mixtures .

b) The characteristics of the final binder of the mix must be in the range or close to that of the binders that would be applicable in equivalent mixes with new aggregates .

c) For effective mixing and reconstitution of the mixture, the RAP must reach a sufficiently high temperature to allow the old binder to liquefy and mix with the new one .

d) When heating the RAP by heat transfer from superheated aggregates, their temperature should not be so high as to cause additional aging of the binder due to thermal shock .

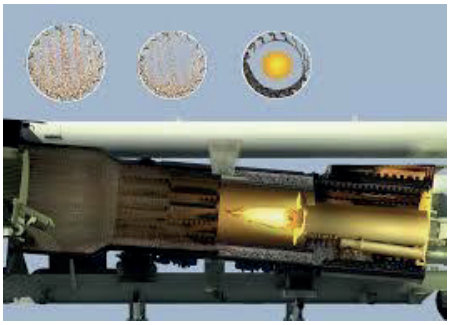
Pursuant to Circular Order 40/2017, a recycled bituminous mix will contain:

TABLA 22.1- CLASIFICACIÓN DE LAS MEZCLAS BITUMINOSAS RECICLADAS

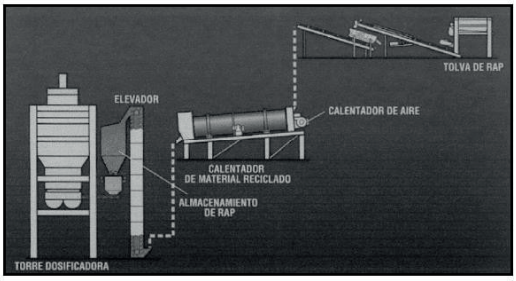
TIPO	CONTENIDO DE RAP (% sobre la masa total de la mezcla)	
	Límite inferior	Límite superior
1	>15	≤ 30
2	>30	≤ 60
3	>60	≤ 80

Table 1: specification of types of bituminous mixtures depending on the content of RAP

To execute this type of bituminous mixtures, it will be necessary to have the adaptation for the incorporation of RAP in the asphalt plant.



Photograph 2: Place of incorporation of the RAP, so that it is not altered by exposure to the burner flame



Photograph 3: General scheme of the incorporation of RAP in manufacturing plants

We have to keep in mind that incorporating RAP does not lead to a new type of bituminous mixtures: it is simply the most efficient and environmentally correct way to produce bituminous mixtures.

Photograph 4: Deteriorated section and recovery of the milled bituminous mix

If we look at the best practices, the milled material must be classified by size, as can be seen in photograph 5, to then be incorporated into the plant, through a device called a recycling ring, where it is incorporated in the middle of the process. mixing bitumen with dry aggregates and filler .

Photograph 5: granulometric classification of the RAP and incorporation into the mix.

In the work carried out in any of our works, the RAP samples used in each case were analyzed according to the following test protocol:

- Determination of the real granulometry
- Determination of bitumen content
- Determination of quality of extracted bitumen

Photo 6: classified RAP deposits

The extraction of the bituminous binder was observed in order to be able to calculate the rate of virgin binder which was added in the dosage based on the granulometry of the RAP, its inclusion rate, properties of the RAP binder, and rate of virgin aggregates.

Photograph 7: Determination of binder content of the RAP.

The granulometry of the RAP had to be such that, according to the percentage in which it participates, it guaranteed the granulometry specified for the type of bituminous mixture chosen according to PG3 and in full accordance with circular order 40/2017, especially with regard to to tolerances.

What is sought as the first concept provided, is that faced with the scarcity of virgin materials, such as aggregates, asphalts and filler , it is necessary to observe the sustainability of the production process and address the environmental pressure in the face of the scarcity of natural resources.

4. USE OF ECOLOGICAL ADDITIVE FOR THE PREPARATION OF WARM MIXES AND COLD LAYING.

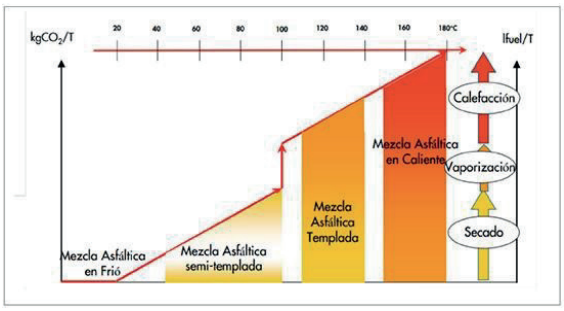
On the other hand , it is proposed to elaborate the bituminous mixtures with a decrease in manufacturing and installation temperatures.

The manufacturing process of bituminous mixtures requires the heating of its components for two reasons:

- Ensure that the asphalt bitumen has a viscosity such that it can be wrapped with the aggregates and the manageability of the manufactured bituminous mixture.
- Eliminate water from the aggregates used for the mix.

This heating process implies a high energy consumption and an emission of greenhouse

gases that are clearly harmful to the environment. The fuel consumption to produce a ton of MBC is around 7 kilos. Each kilo of average fuel emits approximately 3 to 3.5 kg of CO_2.



Graph 1: Fuel consumption and gas emissions depending on the heating temperature of the aggregates

semi-hot mixes are manufactured and placed on site between 100 and 140ºC and are based on the use of asphalt bitumen which, by incorporating some type of additive of different natures (reducing the viscosity or improving the "wettability" of the aggregate) , by foaming the bitumen or by means of some modification in the manufacturing process, make it possible to improve the manageability of the bituminous mix at these temperatures, thus facilitating its manufacture and installation in conditions similar to those of a conventional hot bituminous mix.

It is intended to use an additive that allows maintaining cold workability conditions. The storable bituminous mixtures can be marketed in bulk or in bags, both for pothole activities and for the construction of complete wearing courses.

5. USE OF END-OF-LIFE TIRE DUST IN BITUMINOUS MIXTURES

According to the manual for the use of tire dust published by CEDEX of the Ministry of Public Works of Spain, as well as the SIGNUS guide, there are three ways of incorporating NFVU dust into asphalt or asphalt mixes:

- wet way .
- dry way:
- .Predigested rubber , misnamed semi-wet method. This form has revolutionized the market of bituminous mixtures with rubber, since it is incorporated as an aggregate in the asphalt plant, as in the dry way, but with the contribution that the rubber dust granules have been PREDIGERED, with additives and thermal processes in asphalt. This allows the digestion process to have already been activated, and only mixing in the plant mixer guarantees the modification of the bituminous mix as well as the binder incorporated into it.

Predigested NFVU powder passes ASTM 20 mesh (0.841 mm)

The technological advantages of using NFVU powder are:

- Greater resistance to ruts;
- Greater resistance to fatigue;
- Greater resistance to aging;
- Reduction in the thickness of the reinforcement layers of pavements or new pavements by having a greater structural contribution per centimeter of bituminous mixture;
- Less energy consumption in the production process;
- Lower C0² emissions

As has been pointed out, other of the technological advantages is the incorporation of NFVU powder, with technology patented by CIRTEC, under the RARX® trademark.

Photograph 9: Bags of RARX incorporated into the bituminous mix

RARX® is an elastomeric additive composed of recycled rubber from end-of-life tires, which is processed and treated under patented technology, obtaining a dry digested rubber that directly achieves the benefits of a modified asphalt mix. Its behavior after being incorporated into the bituminous mix can be interpreted as an elastomeric additive to the asphalt mix, modifying increasing its resistance to fatigue, increasing its useful life and its resistance to cracking. RARX® can be added to any type of hot mix. In the manufacture of mixes, the RARX® is added directly to the mixer or the drying drum of the plant together with the aggregates and before incorporating the bitumen, using the existing silos or mineral powder dispensers or additives in the plant. The additive expressly complies with the requirements of MITMA NT 02/2020.

The bulk density of the material is approximately 600 Kg/m³, although slight variations in this value may occur as a result of movements caused during transport and handling. The material is completely stable on storage, for long periods of time that can exceed a year, without deterioration, although they must be avoided to avoid caking that, although they do not deteriorate the material, are more complex to handle .

The RARX® is CE marked by the European Union.

Estado físico:	Sólido, polvo gris oscuro
Olor y apariencia:	Grano fino, gránulos grisáceos
Humedad:	<0.3‰
Densidad aparente:	0.6 [± 0.03] gr/cm3
Peso Específico:	1.031 gr/cm3 [± 0.03]
Punto de Inflamación [°C]:	> 300 (grados centígrados)
Solubilidad:	Insoluble en agua
Estabilidad química:	Incompatible como oxidante fuerte

Table 2: RARX® technical data

Photograph 10: Incorporation of the RARX in the manufacturing center

6. SUSTAINABLE ADDITIVES USED IN THE WORKS

The key to the proposed technologies has been the joint use of two sustainable additives that have allowed us to execute the previously exposed asphalt systems.

The additive produced in Valencia, BIOROAD WARM MIX, presents several characteristics that represent a true revolution, especially because it is a particularly much more sustainable additive than its competitors on the market.

It is a liquid product from various streams of by-products and chemical additives with a large contribution of by-products from waste. Its composition is complex and it has been adapted to the origin of residual vegetable oils, alpechín, by adding chemical components and graphenic compounds .

COMPONENTS
vegetable water
Amphiphilic amphoteric surfactants
Amides of fatty acids from petroleum and vegetable residual oils and tetraethylenepentamine
graphene

Table 3: COMPONENTS of BIOROAD WARM MIX

The compounds present in the additive allow us to observe the presence of Alpechín, a by- product of the olive industry, organic, available in Spain, transforming a residue that is a real environmental problem in Spain, into a new product for the production of bituminous mixtures at lower temperature and storable.

Photograph 11: Large water tank ponds in Jaén.

It is a last generation asphalt additive, based on amphiphilic surfactant based on ecological residual vegetable fatty acid ester enriched with graphene that provides a longer duration of the asphalt agglomerate while improving the manufacturing, spreading and compaction processes. It is an ecological additive for semi-hot asphalt mixes (manufactured between 100 ºC to 140 ºC.

), enriched with graphene that provides relevant improvements in the production process of bituminous mixes.

Its behavior after being incorporated into the bituminous mix can be interpreted as an additive to promote adhesiveness and/or an additive to manufacture and spread semi-hot .

Its contribution of graphene increases the conductivity of heat and electricity easily. This additive used in many industries confers many useful properties to substances with which it is mixed and is probably the promoter of its effectiveness in its function within a semi-hot mix. Graphene has a network-like structure that is responsible for the mechanical characteristics of the material that derive from the strong covalent interaction between carbon atoms, improving workability.

This additive at high doses has a rejuvenating effect and can be combined with high rates of RAP/RAS (up to 80%).

Increases the water resistance measured with the indirect tensile test and the Cantabrian test. It incorporates amphoteric surfactants guaranteeing the neutral character of the composite base and its stability.

It also facilitates the compaction process due to the greater workability of the mix.

The additive can be incorporated into the bitumen tank with slight agitation or recirculation, or dosed to the binder scale, or directly into the mixer after adding and mixing the bitumen with the aggregates.

The final dosage will depend on the required performance and will be determined or verified by prior laboratory tests, using the formulation and materials available in each case.

Photograph 12: Incorporation of the dose of BIOROAD WARM MIX, in the bitumen in the laboratory

The doses of the additive can vary depending on two essential factors:

- The type of bitumen;
- And the desired manufacturing and compaction temperature.

In order to provide a guide based on the works carried out in different countries of the region, indicative values can be seen in Table 4.

% additive / % bitumen	Temp . of elaboration	Temp . compaction	PERDURABILITY (**)
0.7	135+/-5	100 +/-5	NO
1.0	130+/-5 (*)	90 +/-5	NO
1.5	120+/-5 (*)	80 +/-5	NO
2.0	115+/-5 (*)	70 +/-5	NO
10.0/15.0	115+/-5 (*)	COLD EXTENDED	5 TO 10 DAYS
30.0/50.0	115+/-5 (*)	COLD EXTENDED	UP TO 5 YEARS

Table 4: Temperatures vs Doses of BIOROAD WARM MIX communication mix

(*) In the case of using modified bitumen or modification with tire dust, either through RARX®, temperatures should not go below 135 +/-5, since the viscosity of the joint binder can give problems of mix sensitivity.

(**) DURABILITY, ability to be stored in bulk for cold spreading.

In photograph 13 you can see the incorporation of the additive in the cistern of the asphalt plants used. It is mixed with the bitumen by means of the recirculation pump of the plant's own tank.

Photograph 13. BIOROAD WARM MIX additive in plant

The additive has European environmental certification as well as quality and marketing.

Regarding the safety in its handling: it does not contain VOCs , nor volatile substances. It is formulated with recycled natural compounds that are exempt from any hazard classification. On the other hand, by working at a lower temperature, a reduction in fumes and emissions is generated during the manufacturing, spreading and compaction process of the agglomerate, even at temperatures close to 120°C, the disappearance of fumes, vapors and odors from the binders. It is a product without odors, thermo-resistant and stable at storage temperatures. The latter causes a reduction in gas emissions derived from fuel savings (up to 50% fuel reduction). Health, comfort and safe handling of the operators due to the decrease in working temperatures and the use of a non-hazardous vegetable additive.

The CO_2 emissions for the manufacture of the BIOROAD are minimal, since we use almost all recycled ingredients.

Regarding its economic sustainability compared to the conventional mix, the semi-hot mix with BIOROAD can be between €1 and €2 cheaper per ton manufactured. On the other hand, manufacturing at a lower temperature causes less wear on the parts of the plant, which means savings in spare parts and working hours in corrective maintenance.

In the communication, we also show the ability to manufacture semi-hot mixtures in cold ambient temperatures and special for works with difficult access-transfer and/or long distances from the asphalt plant to the paving.

7. WORKS CARRIED OUT AND DEVELOPED IN COMMUNICATION

For the evaluation of this communication, various actions have been taken into account where tests have been carried out on the mixtures that have allowed a technical analysis of their viability.

Works have been carried out in Germany, Italy and Spain, as the most relevant cases of the application of detailed technology.

ASPHALT OF THE ACCESS TO THE VILLAGE OF HOYO DE LA GUIJA (AVILA)

The province of Avila has a network of low -traffic local and provincial highways that run through mountainous areas with extreme winter climates. This circumstance complicates maintenance work in winter due not only to the weather but also to transport times from the asphalt plant. On the other hand , the volume of interventions sometimes makes asphalting using hot technology impractical.

In this sense, the Avila Provincial Council uses cold techniques during the summer season for the work of cleaning and patching the pavements. But these techniques do not allow their use in winter.

Photograph 14: Cold patch truck Avila Provincial Council

The Provincial Council of Avila gave us the experience of testing durable agglomerates as an emergency rehabilitation system.

Manufacture: January 27, 2023

Plant: Quarries Square

Ambient temperature: -3 °C SNOWING

Photograph 15: Cuadrado Quarry, January 27, 2023.

On January 27, 2023, the manufacture of an asphalt agglomerate is carried out under the conditions of the presentation, at a semi-hot manufacturing temperature with the contribution of 15% of BIOROAD ADDITIVE, collecting said asphalt for its spreading and compaction in days later. 150 tons of agglomerate are manufactured and collected.

Photograph 16: Stockpiling at Cantera Cuadrado days prior to spreading

Extended and compacted:
February 6, 2023 (10 days of collection)

Ambient temperature: 3ºC

Asphalt temperature: 12 ºC

Location: Access to Hoyo de La Guija (Peguerinos)

Contractor company Elsamex-Ecoasfalt

The spreading and compacting of the mix cannot be carried out until 10 days after its manufacture, and this also causes the asphalt mix to be exposed to extreme weather during those days, reaching lows of -5 °C and even snowing . for several days.

But despite these difficulties, the agglomerate is extended and compacted on February 6 without presenting difficulties in terms of its workability and compactability .

Photograph 17: Ambient and agglomerate temperature

Photograph 18: Sequence of the spreading and compacting works

8. WORKS IN OTHER COUNTRIES:

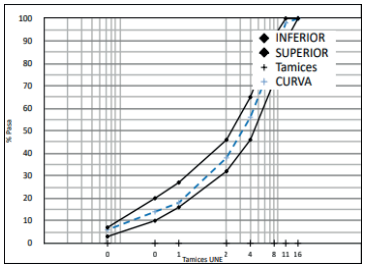
For the evaluation of the technique, works carried out in Germany, Belgium and Italy have also been taken into account.

TECHNICAL CONDITIONS OF DESIGNED ASPHALT MIXTURES

The asphalt mixes designed in all cases have corresponded to types of dense mixes in rolling, being the most common mix the one corresponding to use AC 11SURF50/70D, hot bituminous mix for construction and maintenance of roads, airfields and other paved areas.

Table 5 and Graph 2: Bituminous mixture with RAP in 50%, uses of RARX

TAMICES UNE	CURVA %	Huso AC 11 D	
		Mínimo	Máximo
16	100	100	100
11.2	98	90	100
8	83	72	92
4	56	46	65
2	38	32	46
0.5	18	16	27
0.25	14	10	20
0.063	6.0	3	7



and additive BIOROAD WARM MIX

WORKING TEMPERATURES

Continuous mixing with RAP and RARX plus use of BIOROAD additive

Temperature	ºC
Elaboration	130 semi-hot , Action of BIOROAD WARM MIX
Semi-hot production mix storable in the specific case for 2 weeks	
Bituminous mix temperature when compacting	100/80
outside temperature	-5 / 3

Table 6: Bituminous mix and outdoor temperatures

The processing temperatures of the bituminous mixture both on site and in the laboratory

MAXIMUM DENSITY, BULK DENSITY AND VOIDS: Applied standards: UNE-EN 12697-5, UNE-EN 12697-6 and UNE-EN 12697-8

Use of a rotary compactor , in order to make the design of the proportions by weight, and compliance with the recommended volumetric ratios.

Photo 19: Gyratory compactor to determine volumetric design

Table 7 shows the values obtained for the optimal design.

PROPIEDAD	VALOR	UNIDADES
Densidad máxima	2471	Kg/m³
Densidad aparente S.S.D.	2340	Kg/m³
Huecos en mezcla	5.3	%
Huecos en áridos	16.3	%
Huecos rellenos	67.6	%

Table 7: Volumetric values

SENSITIVITY TO WATER: Applied standards: UNE-EN 12697-12 (15 ºC .)

PROPIEDAD	VALOR	UNIDADES
Resistencia aire, ITS_d	3059	kPa
Resistencia agua, ITS_w	2740	kPa
Resistencia conservada, ITSR	90.0	%

Photograph 20 and table 8: Sensitivity to water

ROLLING TEST: Applied standards: UNE-EN 12697-22

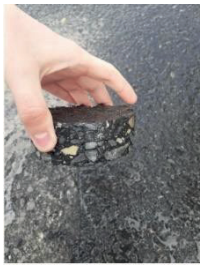
PROPIEDAD	VALOR	UNIDADES
Densidad	2318	Kg/m³
RD	3.31	mm
PRD	8.28	%
WTS (aire)	0.093	

Table 9. WTS and PRD values achieved

THE EXPERIENCE WITH THE MANUFACTURING UNIT AND PLACEMENT ON SITE

The results of the laboratory experiments are valid both for the design mixture, and for the results achieved on site after the extraction of cores in the final quality control.

Photo 21: Quality control by extraction of cores in the finished layer



The manufacturing plants are of the discontinuous type in all cases. They have been able to adapt the pumping of the BIOROAD WARM MIX to the bitumen in the design doses in each case.

In all three cases, a BIOROAD rate of between 10 and 15% of additive on the weight of bitumen has been incorporated.

The RAP percentage in the three cases was 50%. The rest of the aggregates have been virgin aggregates.

The manufacturing temperature has been 130 °C. Semi-hot mix .

NFUV dust has been incorporated into the dosage with the hopper shown in photograph 10, at a value of 0.7% by total weight of the bituminous mix, so that the final mix is a modified asphalt mix.

In all three cases, the mixture was extended on roads that had in common:

- Being far from bituminous mix manufacturing centers, which makes it difficult to arrive with hot bituminous mixes;
- Low ambient temperatures;
- Low production volumes.

A paver has been used without the heating plate. The temperature of the mixture was between 10 and 15 °C.

And the air temperature fluctuated in the works between -4 and 10 °C.

9. CONCLUSIONS

The present communication has tried to show a new sustainable technology that does not intend to displace conventional hot or semi-hot asphalt , but that allows breaking down barriers that help to work in various temporary, distance or climatic circumstances that until now generated a difficulty. We have called this new technology LASTING ASPHALT.

This has been done under a premise of ecological respect and a sustainable approach, well above proposals that add some of the technologies used here.

It has been demonstrated and executed:

- A SEMI-HOT BITUMINOUS MIXTURE, is made with an ecological additive, based on vegetable water, managing to reduce the manufacturing temperature to 130°C.
- The incorporation of graphene and the use of dispersion nanotechnology has allowed another factor of great importance to be added to the doses used (10% by weight of bitumen): STORABLE MIXTURES TO BE PLACED IN COLD.
- 50% RAP has been added to the design, a condition that reduces the consumption of virgin aggregates and binder.
- MODIFIED BITUMINOUS MIXTURES have been elaborated, using RARX, pre-digested rubber powder. This technology competes in performance with bituminous mixtures with high performance virgin polymers.

The results obtained and reported in this communication are very encouraging.

It remains to provide in future communications the precise assessment of the reduction in energy consumption in the production and placement process, in relation to a hot bituminous mix.

FIELDS OF APPLICATION OF LASTING ASPHALT:

Durable asphalts should in no case displace hot asphalts in conventional situations, but new technology can provide an answer:

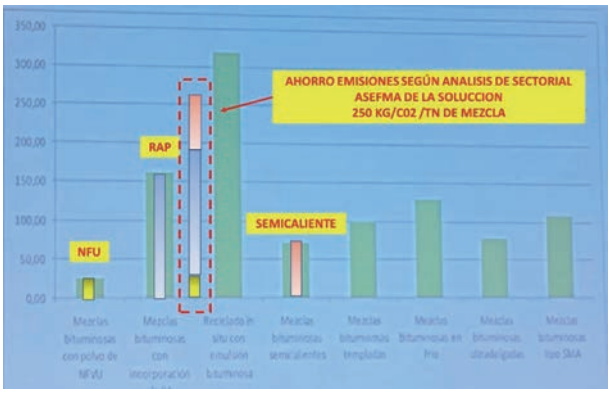
- Situations that require interventions in extreme cold climatic situations.
- Small one-off actions that make starting a plant inefficient.
- Trenching , drainage , emergency lanes, or any high-cost punctual intervention in conventional systems.
- Works at long distances from the production center.

SUSTAINABILITY:

Climate change is a reality that no one doubts. In this sense, the construction sector should not be oblivious to the need to work for more sustainable, ecological techniques that allow a real reduction of the carbon footprint.

If we take into account the analysis of potential reductions in emissions from the asphalt sector, a reduction of more than 250 kg/CO2 could be achieved for each ton of mixture manufactured, through the solution studied. Since it unites the use of several sustainable techniques such as the

use of NFU, the use of RAP and the use of semi-hot asphalts .



Photograph 21: Emission reduction data ASEFMA DAY 2022 and estimated savings of the new LASTING asphalts.

Without taking into account the partial substitution of the binder by an ecological additive, but taking into account the addition of NFVU in the working formula, the replacement of 50% of the virgin aggregates by RAP and the reduction in manufacturing temperature, we can calculate that occurred in the AVILA project, in which 150 tons of asphalt mix were manufactured, a carbon footprint reduction of 27,500 kg of CO_2 was achieved.

If we calculate proportionally for a 5 cm rehabilitation on 1 km of 6 m wide track, we could reduce the carbon footprint by approximately 180,000 kg of CO_2 for each km of rehabilitation.

The project has shown not only that it is possible to generate semi-hot mixtures, that it is possible to use high RAP rates and that it is possible to use tire dust when modifying the performance of a mixture, but that it is a simple and economically viable system.

As engineers we should take this into account.

10. THANKS

We want to thank all the collaborating entities in this communication, not only for their support, but also for the interest shown in new technologies. More specifically:

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- ELSAMEX
- ecoasphalt
- SQUARE QUARRIES
- CEMOSA
- LA PLATA TECHNOLOGICAL UNIVERSITY
- CIRTEC
- UNIQUE GREEN
- CITY COUNCIL OF PEGUERINOS

It is very difficult to advance with the new technologies and for this our gratitude is even greater, since without a willingness to analyze new experiences, even exposing yourself to the challenge of failure, no progress can be made.

11. BIBLIOGRAPHY

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