Winterpave System

Anti-Icing Additive for Asphalt Pavements

Technical Booklet

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1. Preview

The cold spell of December 2010 brought heavy snowfalls, which paralyzed our highways and airports for several days. The affects of the snow fall was further exacerbated by falling temperatures, which resulted in slippery roads and pavements for several weeks thereafter. The need for a remedy for this disruption resulted in the realization of a unique product know as **WINTERPAV/ECO-S, which** is a scientifically proven method for disrupting the formation of ice crystals at temperatures as low as -8°C, which when added into asphalt surfaces, will significantly reduce the disruption caused by snow and ice.

2. Introduction

Currently, when snowfalls are forecast, the most common preventative intervention is the spreading of large quantities of sodium chloride (salt) on our roads and pavements, which is a relatively inexpensive solution for the problem, as the salt melts the snow which remains liquid and at some degrees below zero. Salt is a basic commodity and approximately 260 million tons is produced worldwide every year. China is the leading producer, followed by Unites States, India, Germany and many other countries.

Most of the salt produced worldwide is used by chemical industries (approximately 100 million tons) for the production of sodium hydrate and chlorine through electrolysis, and sodium carbonate. Part is also used for human consumption, as each person needs approximately one kilogram of salt per year, which corresponds to a demand of approximately 7 million tons per year. Another part is required for livestock feeding, meat and cheese industry, feeding industry, pelt tanning and other applications. In fact salt has been used for food and pelt conservation for over ten thousand years.

More than 25% of the salt produced worldwide, is used to eliminate ice from our roads.

The salt used for ice fusion, must have specific characteristics. It shouldn't have a high grade of purity, unlike industrial and alimentary salts, which must be completely pure and it should be in the form of crystals measuring less than one millimeter, Only then, can it melt quickly in liquid water or snow.

An alternative solution to sodium chloride is calcium chloride, which forms as inevitable by-product in the production of sodium carbonate, starting from sodium chloride.

Salt spreading on our roads saves a lot of human lives, and also has an economic relevance, as it allows the movement of people and goods in transportation, but it also has a negative effect on the environment, as salt doesn't completely disappear, it is dragged by the liquid water in which it is melted into surrounding fields, ditches and rivers, with harmful effects **on agriculture, as many plants cannot tolerate the contact with excessively saline water.**

With reference to these considerations, Iterchimica realized an ecological product called **WINTERPAVE/ECO-S.**

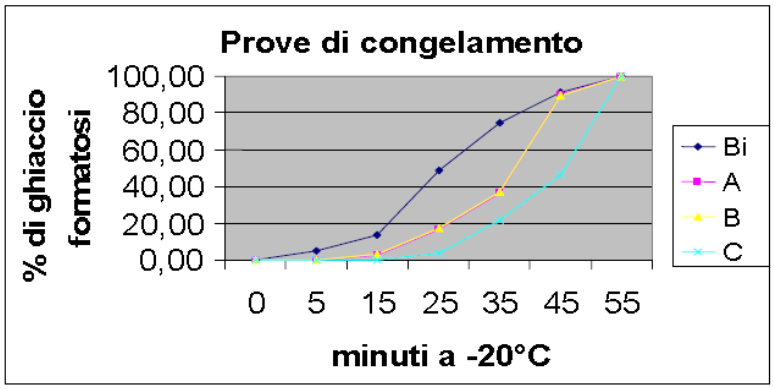
3. Winterpave/ECO-S

The first attempts to find an alternative solution to those mentioned in point 2, were carried out in Switzerland in early '90s, when chloride based antifreeze was incorporated in the bituminous mix, unfortunately resulting inconvenient in making the road surface slippery during the first spring rains. More Recently, analogous compounds blended with controlled substances reappeared on the market, with improved reliability compared to the Swiss predecessors, although still maintaining sodium chloride based additives..

WINTERPAVE/ECO-S is an anti-freeze of the latest generation:

- It mixes with the bituminous mix for the wearing layer as a *filler*, from 3% to 5% of the aggregate weight.
- It is completely and homogeneously mixed with in the bitumen film which covers the aggregate in order to act in the optimum way, especially in high adherence wearing layers characterized by increased specific surface of the aggregates (type SMA – Stone Mastic Asphalt -).
- Does not compromise the mechanical characteristics of the bituminous mix in which it is used, unlike products previously realized by other companies where the resistances worsened.
- **Does not contain chlorides** that could attack metallic road structures and concrete reinforcements.
- **Does not release corrosive or environmentally harmful substances.**
- It steadily and continuously remains effective over time, as the active elements of the product gradually migrate towards the outside of the bitumen film, always providing new particles effective for the auto-defrosting action.
- it provides the salt spreading vehicles with a longer margin of time to intervene during heavy snowfalls or frozen rains , as **it lowers the freezing temperature of the water in contact with the road surface by disrupting the formation of ice crystals, ensuring the ice is not well anchored to the asphalt surface.**

Recent data can be seen in the graph hereunder which shows a laboratory test in which tiles of bitumen and anti-freeze mixtures at 5% in weight, covered with 0,5*cm* of H2O, have been brought to a temperature of –20°C. The delay in water freezing ***(cryoscopic lowering)*** can be seen overhanging the auto defrosting bituminous mixes, and in a more pronounced way, in the sample containing **WINTERPAVE-ECO/S.**



Graph 1 Bi = bitumen itself; A and B = Competitors' anti-freeze and bitumen mixtures at 5%;
C = anti-freeze and bitumen mixtures WINTERPAVE-ECO at 5%, calculated on aggregates weight

3.1 How WINTERPAVE/ECO-S works

The product was created through having a deepened knowledge of some of the aspects related to chemistry-physics and *thermodynamics*. Having understood the snow system, or to better say, *its metamorphism*, allowed us to find a better solution for influencing its physical state.

3.1.1 Variation of snow metamorphism in presence of WINTERPAVE/ECO-S

Snow is composed of ice crystals. All Though it is said that no ice crystal is identical to the another , all of them have a recognizable hexagonal symmetry . The snow crystals' structure varies with the concentration of steam and temperature, while the dimensions of the crystals depend on the availability of steam and the efficiency of the collisions between the different nucleus inside the clouds, or on the turbulent motions during the ascent phase. As soon as snow accumulates on the ground, a *metamorphism* process starts (*see Figures 1 and 2*) and it continues until fusion is completed in a group of transformations caused by heat variations and chemical reactions produced by the presence of **WINTEPAVE/ECO-S** inside the mass of the bituminous mix for wearing layer.

Fig. 1 Fresh snow

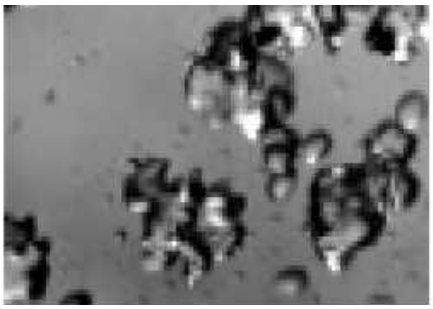


Fig. 2 Fusion grains. Fusion in presence of WINTERPAVE/ECO-S

WINTERPAVE/ECO-S facilitates the fusion metamorphism. Thus, when fusion water becomes abundant, the bonds among the crystals are quickly destroyed and the blanket of snow has a weak cohesion. Besides, if temperature returns below 0°C, **the presence of our additive doesn't allow fusion water to freeze** cementing the snow crystals among themselves (cohesion for re-frost) preventing, thus, the formation of frozen snow crusts (*see Figure 3*).

Fig. 3 Cohesion for re-frost IN ABSENCE of WINTERPAVE/ECO-S

3.1.2 Cryoscopic lowering and formation of eutectic solution in presence of WINTERPAVE/ECO-S

The lowering of the freezing temperature (better called s*olidification temperature*) of a liquid in a solid state through addition of a chemical substance melted inside the liquid is called cryoscopic lowering *(see fig. 4*). *Cryoscopy* can be commonly traduced as *ice vision*. It belongs to the so-called colligative properties of the solutions together with other well known properties such as *ebullioscopic elevation* and osmotic pressure.

The organic and inorganic components making up the compound **WINTERPAVE/ECO-S** have the property to lower the freezing point of the water. Being in contact with water, their salt molecules split up in ions, which bind electrostatically to the water molecules. If temperature drops below zero, water starts to form the first ice crystals, but the presence of ions interfere with the growth of the single crystals and this is the same as saying that liquid freezing point lowers by some degrees. Besides, the reaction of **WINTERPAVE/ECO-S** tends to form a three-phasic system composed of:

I. ice (that's to say water at solid state);

II. salts (lacking in chlorides) at solid state;

III. aqueous solution saturated with salts (*lacking of chlorides*) forming the compound **WINTERPAVE/ECO-S**.

Describing exactly and without unforgivable thoughtlessness what happens at this point is probably an undertaking which exceed the purpose of this article. We can simply say that we fall in a circumstance known in chemistry-physics *as eutectic*. In an eutectic mixture composed, in this case, of solids (salt and ice) and liquids (water saturated with salt) the overall solidification temperature is less than the one that each component separately would have. More specifically, there's a ratio between the weight of the different components (*called eutectic ratio)* in which this temperature is minimal and it is therefore called *eutectic temperature*. **WINTERPAV/ECO-S** has been formulated according to the considerations mentioned above.

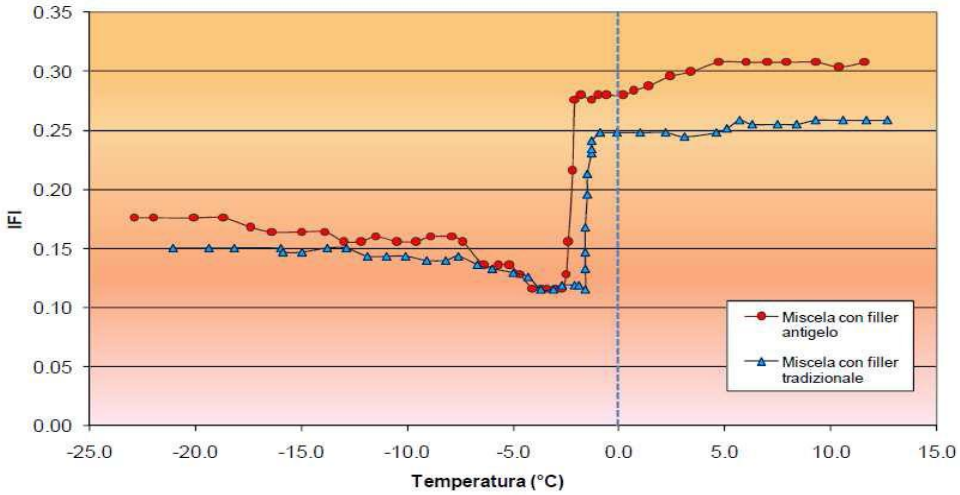
4. Safer road conditions with WINTERPAVE/ECO-S

In the latest years, the approach to planning, control and management of road infrastructures is undergoing a deep transformation with the introduction of a concept of *performances requirements* that an infrastructure, both new or already running, should meet. One of the main performances requirements that a road infrastructure should offer is **circulated safety** and in this context the control of the characteristics of *pneumatic-paving* interaction, in particular as regards phenomenon of adherence, assumes a primary valence. The *adherence force* represents the interaction between pneumatic and paving in slippery conditions, and it is essentially generated from two phenomenon: *adhesion and pneumatic hysteresis.*

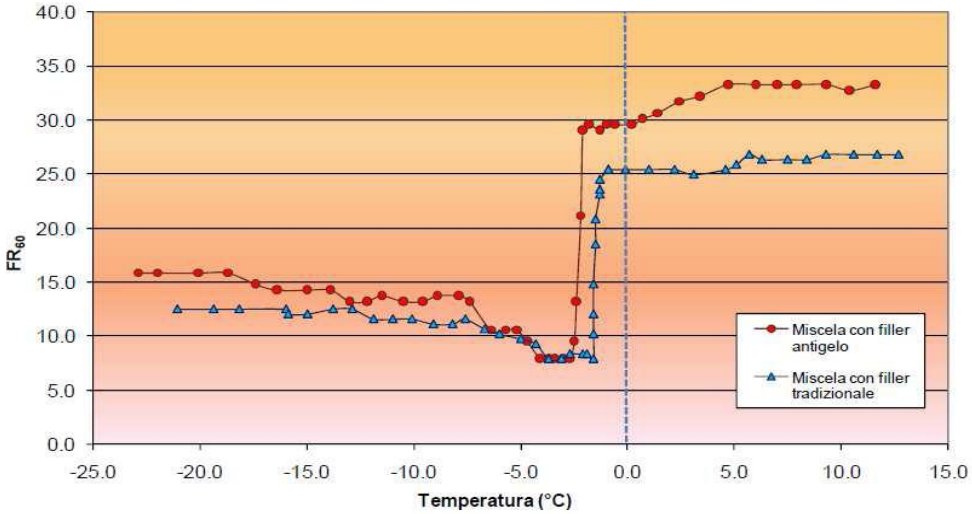
The *adherence force* is influenced, besides paving characteristics, by a quantity of factors among which are to be pointed out: tyres inflation pressure, tread's drawing, water film's thickness, load and speed of the vehicles.

As regards paving characteristics, without going into the analysis of the phenomenon, we specify that **the physical characteristics of the superstructure which influence adhesion are: *the aggregates micro-weaving and the superficial macro-weaving.***

The former influences the entity of the adhesion forces through adhesion phenomenon, while macro-weaving acts on hysteresis phenomenon *(loss of energy caused by pneumatic deformation during contact with paving*). Thus, in synthesis, the superstructure characteristics which affect more, both adhesion and aquaplaning are: *micro and macro roughness*, and **the ultimate aim of WINTERPAV/ECO-S is to assure high values of macro-roughness, and consequently adhesion, in adverse weather conditions, during the whole wintry period.** (*see Graphs 2 and 3 on the following page*).



Graph 2 Trend of the adhesion parameter values IFI-International Friction Index Values determined at the laboratory of the University of Pisa Red: mixture with anti-freeze filler. Blue: mixture with traditional filler



Graph 3 Trend of the adhesion parameter values measured at the slipping speed of the test pneumatic (FR60). Values determined at the laboratory of the University of Pisa Red: mixture with anti-freeze filler. Blue: mixture with traditional filler.

The different experimental studies carried out by some universities on the use of proactive filler **WINTERPAVE/ECO-S** shows that:

1. The resistance values of grazing friction *PTV* measured in laboratory on cores extracted from paving treated with our product, in standard test conditions, showed a resistance to skidding (*PTV = 61÷63*), superior to the limits generally prescribed in *Technical Specification norms* that refer to this parameter for the control of the adherence conditions.
2. Identical performances obtained with grazing friction tests in standard conditions show that the presence of proactive filler with anti-freeze function doesn't cause alteration in the functional performances of the bituminous mixes in weather conditions different from winter ones.
3. The PTV value determined both on samples thickened in laboratory and on cores extracted from paving treated with our product, after formation of superficial ice from water film with nominal thickness of 1*mm*, allow to appreciate the better performances of the mixtures additivated with proactive filler having specific defrosting function in comparison with the adhesion values' recovery of the frozen samples kept at room temperature.
4. The results of the comparison tests point out that the bituminous mix samples containing **WINTERPAVE/ECO-S**, unlike what happens with mixtures lacking winterpave filler, reach with notable advance adhesion values close to those detected when frost effect can be considered completely exhausted.
5. The characterization of the macro-weaving conditions of the test surfaces, carried out through survey of the superficial profiles with laser devices for the evaluation of the MPD parameter (*Mean Profile Depth*), allowed to determine the *IFI parameter* (*International Friction Index*) and to evaluate the macro-weaving values of the cores subjected to investigation.
6. Also the values of *IFI* index show that bituminous mix's cores containing **WINTERPAVE/ECO-S** present adhesion values close to those detected when frost effect can be considered completely exhausted, earlier than what happens in case of mixture lacking winterpave filler;
7. The presence of anti-freeze filler Winterpave, allows to obtain ice fusion with notable advance and at lower temperatures: this factor brings more positive consequences considering the operating aspects of road safety and maintenance.

Consequently to the research activities developed at Universities, experimentations of Winterpave technology have been carried out in order to evaluate their functional characteristics. It is possible to sum up the results of these scientific activities as written in the charts on the following page :

Characteristic [u.m.]	Norm reference	Traditional mixture type	Mixture additivated with technology Winterpav®
Pendulum Test Value (PTV) @ -7℃	EN 13036-4	22	29
Pendulum Test Value (PTV) @ -3℃	EN 13036-4	23	47
Pendulum Test Value (PTV) @ -0℃	EN 13036-4	58	73
Pendulum Test Value (PTV) @ +5℃	EN 13036-4	74	76
International Friction Index (IFI) @ -3.6℃	ASTM E1960 - 07	0.1191	0.2760
International Friction Index (IFI) @ -1.6℃	ASTM E1960 - 07	0.1156	0.2760
Reduction of ice formation temperatures [℃]	-	6.4	
Bitumen penetration [dmm]	AASHTO T 49	63	61
Softening point [℃]	AASHTO T 53	52	55
Fraass breaking (at low temperatures) [℃]	EN 12593	-10.9	-10.3

Such experimental evidence represent the state-of-the-art of Winterpav technology development at the date of issue of this document. This experimental activity is however in phase of development and tecnological integration.

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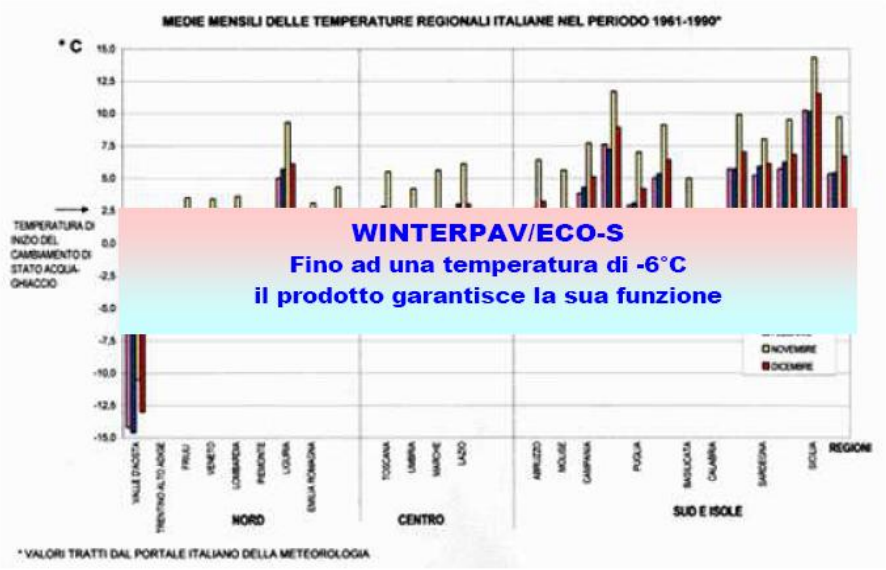
5. Conclusions

WINTERPAVE/ECO-S is a highly innovative product able to remarkably improve the road safety during the winter months as an optimal application for the wearing layers at high adhesion characterized by high specific surface of the aggregates (type SMA – Stone Mastix Asphalt -).



Considering the research described, it can be stated that we are in presence of a technology for the the realization of an auto-defrosting road paving system for bituminous mixes, both close and porous, which avoids or delays the formation of ice crystals adhering to the pavement surface.

Pavements containing Winterpave will limit the safety losses due to ice **adhesion**'s during the winter season. They will also provide the traditional systems (salt spreader and snowplow) with a longer periods of time to intervene during above average snowfalls. Ensuring the snow blanket doesn't adhere to the pavement surface ensuring easy removal by snowplows, if precipitations continue.

Unlike salt ,the presence of **WINTERPAVE/ECO-S** will not create undue problems in conditions of surface humidity, due to rain or condensation, when the air temperature is not typical of the winter period.

We conclude by saying that in recent years, the approach to planning, control and management of road infrastructures has undergone a deep transformation with the introduction of *performance criteria's* that each infrastructure, both new or old, should meet.

One of the main performances requirements is that every road infrastructure should consider **safety as a primary objective** and in this context, the control of slippery road surfaces, assumes a primary valence.

This sentence is integral part of Iterchimica's company philosophy and **WINTERPAVE/ECO-S** is a demonstration of that fact.