INTERNATIONAL SCIENTIFIC CONFERENCE

CIBv 2010

12 – 13 November 2010, Braşov

USE OF SLAG IN THE COMPOSITION OF SLURRY SEAL

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Abstract: This paper will track results of the introduction of slag as partial or total replacement of natural aggregates used to manufacture of slurry seal (SBFS). These results will be compared both with the permissible limits stipulated in the Norms AND IND 576 and 532, and with the results obtained using traditional natural aggregates.

Key words: slurry seal, slag, lidonit

1. THE NEED AND OPPORTUNITY OF THIS STUDY:

Slag notion first appeared in the year 350 BC in Greek physicist Aristotle's writings, as a material used to heal wounds.

In 1862, Emil Langen discovered latent hydraulic properties of granulated blast furnace slag, starting from 1880, the slag obtained in Bessemer or Thomas furnaces is used as phosphate fertilizer; in 1909, in Germany, is published the first standard on the use of blast furnace slag in cement industry, this are just some of the events gleaned from the evolution of "knowledge" of metallurgical slag.

Century after century, have found new applications of slag, but only in the twentieth century, when the big producers of iron and steel have faced the problem of huge amounts of real storage results in metallurgical slag, these materials drew the attention of researchers, who had to find industrial applications of slag. Very quickly this concept given to slag - recycled material - changed. Today the use of slag in the industrial sector is not only a alternative but a choice.

Large sums of money are involved in the study of slag to find new areas of use and even the technological development of ferrous metallurgy (or ferrous) failed to diminish too much, the quantity of slag produced annually worldwide.

Because "We haven't inherited the Earth from our parents, we borrow it from our children." Therefore efforts are being made in terms of encouraging increased use of slag in areas where skills were demonstrated, for efficient use of the natural resources.

In Romania, the idea of using the blast furnace slag in industries areas shrinks, unfortunately to the cement industry. With weak statistical documentation resources, we can not determine an approximate value of total annual production of blast furnace slag. Integrated iron and steel work built in Romania are known with certainty, at: Hunedoara, Resita, Deva, Targoviste Turda Plain, Calarasi, Tulcea, Galati, Suceava, Calan, Roman. It is certain that most of these integrated iron and steel works, after 1990 have remained the same, a small part of them were privatized, and another part have remained functional. Taking as the reference the year 1945, the statistical studies(study conducted in 11 countries in Europe) have shown that the production of steel have grown from 125.000 tons (1945) to 14.4 million tons in 1984, when it reaches a maximum, and reaches to almost 10 million in 2000 year.

Statistical studies have also shown that from year 1945 to 2000, in Romania, the slag from integrated iron and steel work has not been used ever (only the slag furnaces) and considering that it also obtained 250 kg of slag per ton of steel, until present statistical data from the same source shows that total steel production in Romania is of 342.3 million tons, while the slag from integrated iron and steel works reaches about 85.6 million tons.

If we also add the blast furnace slag "resources" we can appreciate how "rich" we are.

Integrated iron and steel work ISPAT-SIDEX (Mittal Steel) Galati has a total production of 3.5-4 million tons of steel annually, and, taking into account that from this quantity of finished product is obtained about 25% of steel plant slag, the annual steel plant slag is about 875000-1 million tons. At this amount is added also tons of blast furnace slag, stored in dump and left to cool freely in air and are, at this time, unused.

Areas of use so far accepted:

Road construction

• hot asphaltic sheet used in the execution of underlays, binder, wear,-domain applications for which the lidonit's qualities of roughness / excellent adhesion to the binder, bituminous binders compatibility, wear resistance and outstanding polishing are exploited;
• foundations, underlays with or without binder-application for which the high quality of compacting and wedging of aggregates are irreplaceable;
• road beds;
• annex Road Construction;
• repair and maintenance of roads.

Construction of the railway:

• execution of the foundations of the railway;
• ballasting of the railway lines;
• maintenance and repair of railway infrastructure and superstructure.

Hydrotechnic Construction - the basic qualities for use in this area are related to high density of these aggregates:

• bevel or dams;
• protections for banks;
• restoration of waterways rivers channel;
• as hard synthetic aggregate in hydraulic concrete.

Civil engineering:

• foundations;
• synthetic aggregates for normal and heavy concrete.

Agriculture:

Improve soil acidity and soil remineralization - having a high alkaline, metallurgical slag are used successfully in agriculture.

The research program will track results through the introduction of slag as partial or total replacement of natural aggregates used to manufacture of slurry seal (SBFS). These results are compared both with the permissible limits stipulated in the Norms AND IND. 576 and 532, and the results obtained using traditional natural aggregates.

At the end the research program will draw conclusions and will make recommendations on the possibility of using slag in the composition of slurry seal.

2. HISTORY OF APPLICATION OF SLURRY SEAL WORLDWIDE

In the early 1930s, a layer consisting of a mixture of fine aggregate, bitumen emulsion, and water was lying on a road in Germany. Proved to be a new approach, a new and promising technique in maintaining road surfaces, and marked the beginning of development of Slurry seal.

Technology of slurry seal execution was used for the first time in Canada in 1960 as street maintenance and due her efficiency this technology has expanded so that currently is used in many European countries.

Later in that decade, everyone begins to experience at a large scale this technology. Although by 1960 the technology was not used in a large scale, with the introduction of improved emulsifiers and flow machines, showed a real interest in the use of bitumen emulsions for a wide variety of applications. Were made continuous progress in methods of mixing and bedding site aggregates and bitumen emulsions with machines that were becoming more efficient, which made that the slurry seal to become an inexpensive and fast solution to maintaining the friction surface. As a treatment for anything from private roads to public roads, highways, airport runways, parking and various other paved surfaces slurry seals are now widely used worldwide.

3. APPLICATION OF SLURRY SEAL IN ROMANIA

3.1. Domains application

The slurry seal intended execution routine road maintenance for roads with technical Class II-IV, clothing bituminous or cement concrete. The slurry seal are applied only on roads with adequate load capacity.

The slurry seal applies also to road asphaltic layers made from recycled hot or cold, according to Normative AND IND 576 and 532.

Gaps and degradations that can be fixed by applying slurry seal are:

a) at asphaltic sheets, on:

- Porous surface, ground or aging;
- Cracks;

-Irregularities in longitudinal profile and / or transversal under 2 cm;

Fig. 1 Irregularities in longitudinal profile

b) at cement concrete sheet, on:

- Porous surface or wafers;

- Peels, cracks, crevices;
- Irregularities in longitudinal profile and / or transversal under 2 cm.

For areas with irregularities ranging from 1-2 cm, measured 3 m straight edge, the work is done in two layers, the first layer acts as a layer of readjustment.

The slurry seal does not apply if the existing bumps are caused by a phenomenon of creep at the existing asphaltic sheet.

Also, the slurry seal doesn't apply on asphaltic sheets presenting phenomenon of bitumen expand.

The slurry seal doesn't increase bearing capacity of pavement.

3.2. Aggregates used - physical and mechanical characteristics

Natural aggregates used in the implementation of slurry seal are the following:
- Sort sand crushing 0-4;
- Sort chippings 4-8 and 8-10.

[2] They must come from rocks minimum class B SR 667, showing a high resistance to polishing and to meet the quality requirements of Table.1.

[3] Different types of varieties of natural aggregates should be stored in their silos, concrete platforms, equipped with division walls, to avoid impurities.

Table 1: Aggregates characteristics

Nr.crt	Characteristic	Sortul			Analysis Method
		0-4	4-8	6-10	
1	Granules containing: Remaining on the upper sieve [d (max)],% maximum Passing through the lower sieve [d (min)],% maximum	 5 -	 5 10	 5 10	 STAS 730
2	Form factor,% maximum	-	25	25	STAS 730
3	Impurity content: - Foreign objects, - Fractions containing less than 0.1 mm,% maximum - Clay(VA) max.	Not allowed _ -	 1.5 2	 1,0 2	STAS 4606 SR 667
4	Los Angeles car wear % Maximum	-	20	-	STAS 730
5	Freeze-thaw resistance: - Gelivity coefficient,% maximum - Maximum sensitivity to frost%	 - -	 3 25	 3 25	 STAS 730
6	Activity coefficient:: - Crushed sand fractions with more than 8% Q-0, 1 mm - Crushed sand over 8% from 0 to 0.1 mm fraction	 1.5 2,0	 - -	 - -	STAS 730 STAS 730

4. COMPARATIVE CHARACTERISTICS OF AGGREGATES FROM METALLURGICAL SLAG WITH OTHER KNOWN AGGREGATES

Preliminary findings, theoretical analysis result of physical - mechanical characteristics comparison are:
- Mechanical strength falls within acceptable;
- Density greater than density as chippings.

Traffic behavior of slurry seal with aggregates from slag ferrous metallurgical plant - LIDONI will follow the traces of the experimental areas is achieved.

To highlight the advantages of using aggregates from ferrous metallurgical slag we present comparative physical and mechanical characteristics in the attached table.

Performance characteristics of artificial aggregates Lidonit compared with performance characteristics of certain categories of natural aggregates and acceptable values provided in the SR 667/2002 or euronorm requirements of SR EN 13 043, are listed in the following comparative table:

Table 2: Performance characteristics

Characteristic	Type of aggregate			Allowable value SR 667/2001	Lidonit according with SR EN 13043
	Lidonit	Granit	Gravel		
Gross Density (g/cm3)	3.3	2 8	2.6		declared value
Able loose pile density (g/cm3)	1.65	1.4	1.3	Not specified	Not specified
Compressive strength (% Mass) - mass loss measurement method	18	15	21	Max25	Not specified
Impact strength (% weight loss)	18	12	21	Not specified	SZ22
Resistance to freeze-thaw (% mass)	<1.5	<0.5	<2	Max.2	F2
Water absorption (% mass)	0.8-1.5	<0.5	<1	Not specified	WA242
Wear resistant drive Los Angeles (% mass)	<18	<12	<20	Max.18	LA20
Grinding ratio accelerated PSV	58	61	48	Not specified	PSV56
Adherence to the bitumen (%)	>90	>90	>75	Not specified	10% declared value-uncovered
Volumetric stability	<3.5	Not applicable	Not applicable	Not specified	V3.5

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Received October 31, 2010