

SLAG – UTILISATION IN ROAD CONSTRUCTION – EXPERIENCE AND SOLUTIONS

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1. INTRODUCTION

As the world population grows, so do the amount and type of waste being generated. Many of the wastes produced today will remain in the environment for hundreds, perhaps thousands, of years. The creation of nondecaying waste materials, combined with a growing consumer population, has resulted in a waste disposal crisis. One solution to this crisis lies in recycling waste into useful products. One answer to all of these problems lies in the ability of society to develop beneficial uses for these waste products.

The road-highway construction industry can effectively use large quantities of diverse materials. The use of waste by-products in lieu of virgin materials for instance, would relieve some of the burden associated with disposal and may provide an inexpensive and advantageous construction product. Current research on the beneficial use of waste byproducts as road-highway construction materials has identified several promising uses for these materials. Some of these materials include: Blast furnace and steel slags.

2. STEEL SLAG IN EUROPE

In Europe are produced annually around 15 Mil tones of steel slag, resulting from different type of steel technology (Figure 1). More than 75 % of steel slag was recycled in Europe (Figure 2.) in different kind of utilization in especial like raw materials.

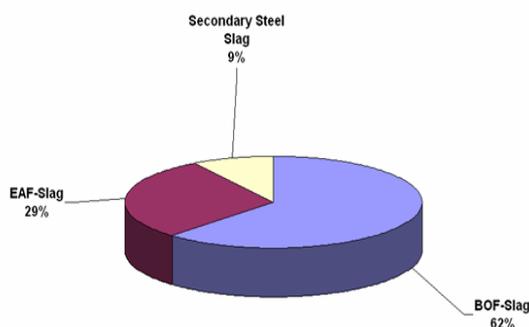


Figure 1. Type of steel slag

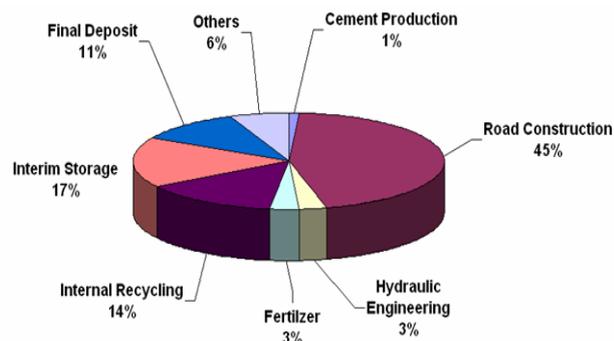


Figure 2. Slag utilization in Europe

2.1. European waste framework Directive

Present situation in the steel industry on material management give as an overview on the legal situation regarding the dealings with by-products such as slag and secondary raw materials on the basis of the European waste framework directive. Further on it describe the existing frameworks nebulous differentiation between waste and non waste (by products, when ceases waste to be waste) that lead to a flood of court procedures and to a discrimination of by-products and products made of recycled materials. Metallurgical slag is given as an example for a purposeful produced by-product in the steel industry which replaced primary raw materials and thus saving resources. Typical product criteria are described. Finally the proposal on the revision of the waste framework directive of the

European Commission and those presently discussed in Parliament and Council is evaluated regarding the necessary clarification:

- ✚ when a substance is excluded from the waste legislation as (by-)product, or
- ✚ when it ceases to be secondary raw material



Figure 3. Waste management hierarchy

A discrimination of by-products and products made of recycling material compared to products made of virgin material is not acceptable and contrary to the aim of sustainable management. On the contrary the usage of by-products and secondary raw-materials must have priority.

European Waste Catalogue does only name unprocessed slag as a waste, European Waste Shipment Regulation (NO 259/93) - GREEN LIST, GC 070 exclude processed slag from the waste list:

“Slags arising from the manufacture of iron and steel (including low alloy steel) excluding those slags which have been specifically produced to meet both national and relevant international requirements and standards.”

Green list substances shall be generally excluded from control procedures of the regulation since such waste should normally not present a risk to environment.

Principles of European Waste management say that steel slag has to be recycled (Figure 3.).

3. DESCRIPTION OF THE EXPERIMENTAL SETUP

3.1. Steel slag treatment process

Main slag processing is mechanical treatment of cold slag, the principle of slag processing are in Table 1.

Table 1. Main slag processing

Steel slag type	Treatment	
Hot slag from EAF	Cooling by water spraying	Quick cooling is important for technical and environmental properties (Figure 4)
Raw slag with steel	Iron separation	Steel recovery pays for the slag treatment (Figure 5)
Raw slag	Crushing and screening	Crushing and screening gives different products (Figure 5)
Slag products	Road aggregates rip rap chippings	Products differ only in grain size distribution (Figure 6.)



Figure 4. Cooling area with water spraying



Figure 5. Instalation of slag treatment SPS Hunedoara

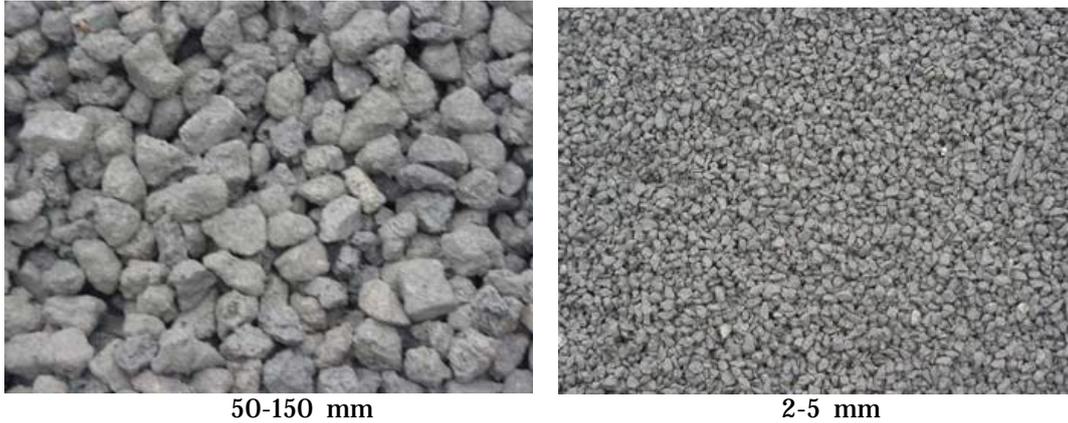


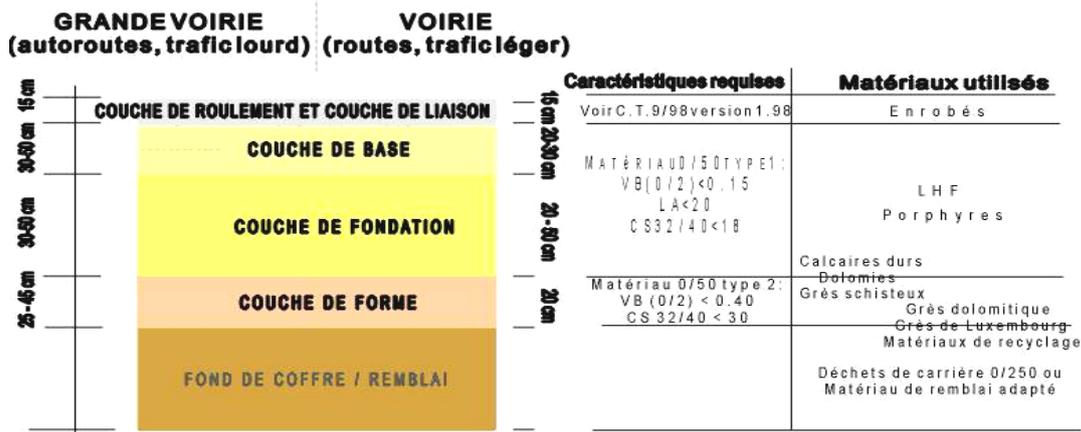
Figure 6. Slag products

3.2. Steel slag in Road construction

CLOOS Luxemburg had more than 100 years experience in utilization of slag in road construction, an examples of road layers (Figure 6.)

Slag crushing aggregates can be used in all layers of the road, in Romania; SPS homologated the shape, foundation, basic and binder layers and are in course of homologation the utilization of slag in asphalt layer. Here will be used cold slag treatment procedure for obtain good results.

Terminologie des couches et performances des matériaux utilisés



Remarque: La couche de base en grande voirie est à mettre en oeuvre en 2 couches.
La couche de fondation est à mettre en oeuvre par couches d'épaisseur de max. 25-30 cm.
Les fuseaux granulométriques des matériaux 0/50 sont conformes aux fuseaux pour type 1 resp. type 2.

Figure 6. Slag road layers

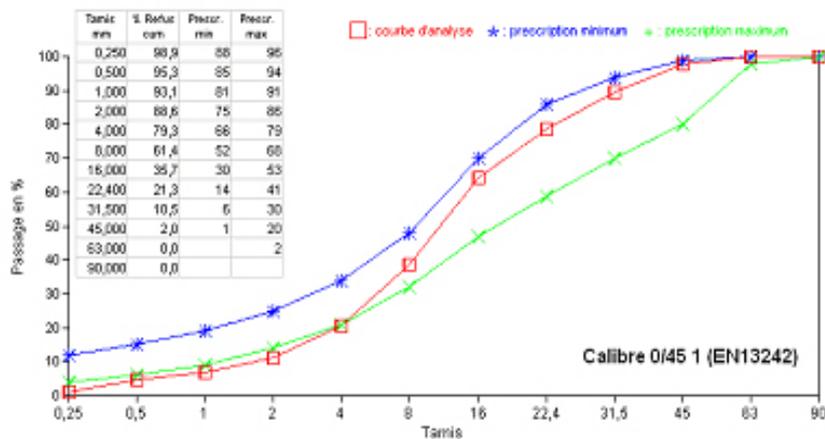


Figure 7. Slag aggregate 0/45

In Figure 7. we can see red line, property of slag product 0-45; and minimum and maximum requirement of EN 13242,

Example of slag utilization in road construction in Hunedoara is the 4 bands road between Deva and Hunedoara (Figure 8), where the basic, foundation and binder was made from slag aggregates from Buituri Slag Dump, processing by SPS. Unfortunately the Romanian road designers and constructors don't understand yet to use this waste; by-products existing in Hunedoara in Slag Dump in quantity of 70 Mill. Tones.

SPS continue the researches regarding slag utilization in road construction with University "Politehnica" Timisoara – Road Construction Department, now in researches of Slag roads comportment in different charges starting with County roads, Villages roads, technological roads, and sure Highway.



Figure 8. Slag road construction; Hunedoara - Deva

4. ANALYSIS OF RESULTS AND CONCLUSIONS

4.1. Product Certification and Quality Control

Steel slag has to undergo a quality control process like any other process (Table 2.), steel slag is an artificial stone, with the request property for road construction, and other utilizations: concrete production, fertilization, hydraulic construction, building foundation, etc.

Table 2. List of technical test

No.	INDICATORS	VALUE
1	Bulk density according to DIN 52110	Average value: 2,06 g/cm ³ for grain size mixture 0/32 and 0/45
2	Proctor density according to DIN 18127	Average value: 2,47 g/cm ³ for grain size mixture 0/32 and 0/45
3	Fines	In grain size range 0,0 – 0,063 mm from 0,2 to 0,4 weight.-%.
4	Destruction by beating SZ 8/12	Desired value 18,0 weight.-% for chippings
5	Destruction by beating SD 10	Desired value 26,0 weight.-%
6	Polished stone value (PSV)	PSV 60, chippings for asphalt
7	Frost resistance	Limit value 3,0 weight.-%
8	Volume stability	Limit value 5,0 vol.-%
9	Inner angle of incline	Average value 40 °



Figure 9. Conformity Certificate

Slag Processing Service SA Hunedoara (CLOOS Luxemburg is main shareholders with 80% of shares), start the work in ArcelorMittal Hunedoara Slag Dump, with chemical and physical tests of the slag, make in Luxemburg (80 tones of samples taken from different places from slag dump was send with tracks). After this was start the treatments of old slag: crushing and screening, iron separation, aggregates rip rap chippings, with 500.000 tones/year capacity Installation.

Conformity Certificate for slag aggregates utilization in Romania (Figure 5.), was obtain by SPS in 2006, was certificate that the products "Crushing Aggregates from Steel Slag" 0-4; 4-8; 8-16; 16-31,5; 31,5-63; si 0-63, produces by SPS in Slag Dump Buituri Hunedoara, are in accordance with: EN 12620/2002, EN 13242: 2002/AC:2004, Utilization domain: construction of: roads, civil and industrial buildings, hydraulic and earth construction.

4.2. Comparatives cost of slag roads and virgin materials roads

We analyze comparatives structure of road layers; classic and two alternatives for basic and foundation layers, (Figure10.) mentioned that wear layer in all three situations remain the same asphalt mixture and the existing shape also.

Thickness	Layer – CLASSIC
5 mm	Wear - asphalt mixture
20 mm	Basic - natural crash stone
30 mm	Foundation -Ballast 0-63 mm
X mm	Shape - existing

Thickness	Layer- Alternative 1	Layer- Alternative 2
4 mm	Wear - asphalt mixture	Wear - asphalt mixture
15 mm	Basic - slag 0-63 mm	Slag - optimal mixture stabilized with: 0.5 ciment and 8% water
20 mm	Foundation -Slag 0-150	
X mm	Shape - existing	Shape - existing

Figure 10. Comparative layers classic-slag roads

The comparative costs in “LEI” of all three variants (Figure 11.):

1. Classic system road (virgin materials)
2. Alternative 1 road system with slag
3. Alternative 2 road system with slag and cement

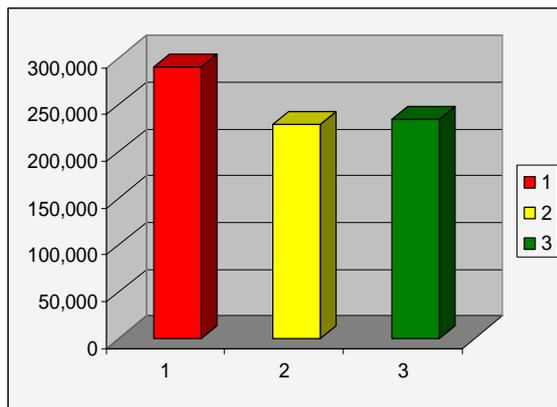


Figure 11. Comparatives cost of the roads

So as that the partial slag roads analyze are with 24% chipper that classic roads. If the road will be executed integrally by slag products like in Luxemburg, Germany, France, etc. the cost reduction is around 40%.

Conclusions: We can construct with the same amount 140% more roads.

This is not the single reason for using slag, the durability, stability of the roads is better and not the last we save virgin materials, recycling the slag and ensuring the slag dump disappear.

Use of steel slag is absolutely necessary in Europe to reduce costs and to comply with environmental laws

- Slag use in Europe has a long tradition.
- European law asks for recycling of steel slag.
- European legislation makes it sometimes difficult to bring slag products to the market.
- Process technology is known and proven.
- Slag products can be certified and have to undergo a quality control procedure.

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