Recycling Waste Grit in Mix Asphalt

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Solid waste disposal is a significant to overhead in a shipyard environment. In many areas of Galati the disposal capacity is being reduced and the cost of disposal is continuing to climb. The study of the behaviour of bitumen mixtures is an old subject in the literature. Many specialists have been trying to replace the sand with recycled materials resulting from blasting ship parts. The main purpose of this study is obtaining a bitumen mixture with a good behaviour to long use. The grit is an abrasive blasting material (ABM), having an angular form, used in ship repair processes prior to the application of coatings. It is produced by the pulverization of molten steel, followed by a series of thermal and mechanical treatments in order to give the product its final characteristics. The shipyard in Galati generates annually thousands of tons of used blast grit and they dispose of it in landfills or directly into the Danube as a usual practice. We intend to find possibilities of disposing the wastes produced by shipyards, our research being focused on achieving the sustainable development requirements of the civil society. Environmentally speaking, recycling spent ABM has the potential to significantly reduce waste generation while saving money.

Keywords: mix asphalt, grit, recycling, shipyard

The road industry requires a significant amount of non renewable materials and energy. The sheer size of the energy and material investment dictates that a better understanding of the environmental and economic aspects of the use of virgin aggregate versus recycled abrasive blast material might lead to a more sustainable future for the road construction sector. Recycled materials of interest to asphalting (asphaltic mixture) process are obtained from the shipyard industry, namely the preparation of metal surfaces and other ship repair processes prior to the application of coatings [1-5].

The production of huge quantities of sandblasting waste results in heavy pollution of industrial sites like shipyard areas, when the availability of landfills is diminished and the disposal costs are expensive. Furthermore, used steel grit may be considered a hazardous waste because it often contains traces of heavy metals, including residues of rust accumulated in the abrasive material, and residues of paint coatings, which have toxic compounds, as polychlorinated biphenyls (PCB) [6, 7].

Several studies have been carried out, concerning the development of recycling procedures for used blast grit, focused on the industrially produced abrasives, (steel grit and shots), which are characterized by their durability, high density and the large number of effective uses (i.e. steel grit: 50-100, sand: 4-10) [8].

The theoretical and experimental research made use of granulometric analysis, optic microscopy and SEM-EDX, following the unanimously accepted standards of quality for exploitation by using it in asphalt.

Proposals for using the material obtained from recycling of grit wastes in stabilized mixtures with binders used in roads asphalt, the shipyard studied being able to benefit from economic advantages by reducing costs allocated to the collection, transport and disposal grit wastes.

Surface preparation

The single most important element that can influence paint performance is the quality of surface preparation. For optimum service life, the surface must be completely free of all contaminants that might impair performance and should be treated as such to assure good and permanent adhesion of the paint system. The quality of surface preparation has a direct relation with the lifetime of a system. Even when using surface tolerant paints it cannot be emphasized enough that better surface preparation always results in longer lifetimes [9].

Surface preparation has two stages: primary and secondary and aims to removes algae or impurities, rust, corrosion products, and foreign substances on the ship surface before applying primer (fig.1) [1].

Preparation standard for paint steel surfaces ISO 8501/ 1: rust grades and preparation grades of uncoated steel substrates after overall removal of previous coatings:

Quality surface A- metal is covered with rust or other deposits results while browsing but without showing signs of oxidation.

Quality surface B - metal is covered with rust or other deposits results while browsing, shows slight traces of oxidation.

Quality surface C - metal is covered with rust or other deposits results while browsing strongly oxidized.

Quality surface D - metal is strongly oxidized surface is corroded in depth.

The sandblasting in first step (fig. 1a and b) removes rust, primer and coatings, leaving an exceptionally cleaned surface and secondary (fig. 1c and d) removes old coatings, opens the pores, preparing the surface for a new penetrating primer.

Surface roughness, often shortened to roughness, is a measure of the texture of a surface.

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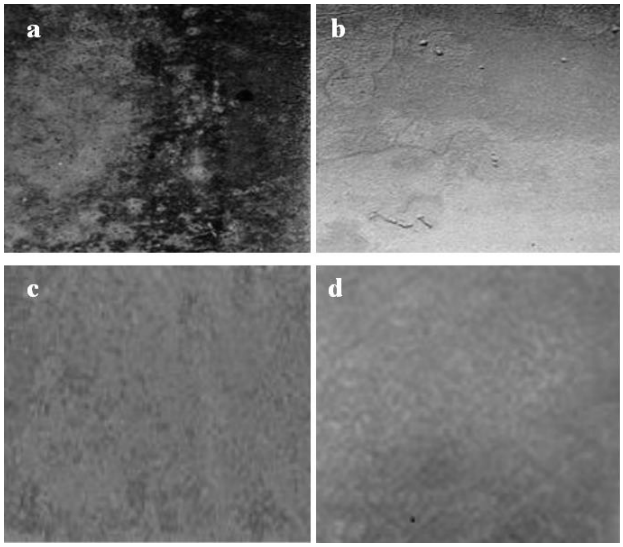

Fig.1. Surface preparation, sandblasting steel grit GH: a, c - before and b, d - after

conductivity of water that has been used to wash a certain small area of a (blast) cleaned surface [9].

Spherical grit pellets are produced from steel wire cold worked with medium carbon content, or stainless steel, according to standards. The study concerning the recycling of used grit appeared because of the necessity of solving the great storage problems, to the fines paid for the uncontrolled storage and the big waste taxes.

Steel grit is crushed steel shot. They have sharp edges that help cleaning the surfaces easily. They are used for different applications in ship building. Standard hardness grades [8]: GL Grade 53-58 HRC; GP Grade 58-63 HRC; GH Grade 64 HRC Min (table 1).

Under the circumstances the reduction of the pollution level in the naval field by raising the level of valorization of the grit waste and the controlled storage represents an important problem in the environment protection policy [11].

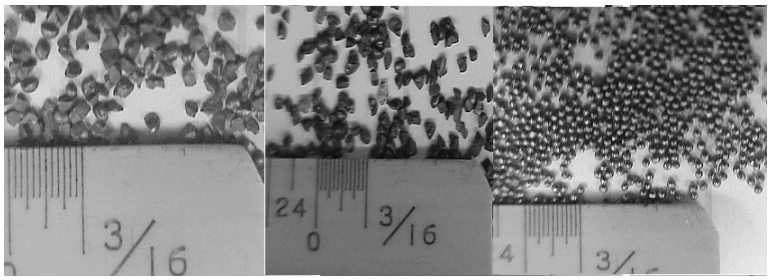

Fig.2. Steel grit GH 50

Material		*Chemical composition [%] (density 7,4 g/cm3)*					*Hardness [HV]*
		C	Mn	Si	P	S	
Class	GP	0.75-1.20	0.60-1.10	0.60-1.10	Max. 0.04	Max. 0.04	450-560
	GL	0.75-1.20	0.60-1.10	0.60-1.10	Max. 0.04	Max. 0.04	600-700
	GH	0.75-1.20	0.60-1.10	0.60-1.10	Max. 0.04	Max. 0.04	800-950

Table 1
STANDARD CHARACTERIZATION OF ABRASIVE MATERIAL, GRIT

Before the sandblasting process must be examined the rust layer formed the ship, to which the surface preparation in the shipbuilding and repair industry.

Abrasive blasting

The sandblasting process is an effective way to clean products and remove unwanted layers of material. Depending on the equipment setup, sandblasting can be used to clean abrasive jet of particles in a compressed air, remove surface contaminants: algae, salinity or impurities, rust and old paint. Sandblasting can also reclaim or restore tools and hardware that are prone to rust or dulling, like metal files and saw blades. This process also paves the way for preparing surfaces for other processes such as welding, coatings, painting and plating (fig. 2).

Different degrees of surface cleanliness are possible and depend in part on the surface condition prior to treatment and also to the length of time for which the surface is exposed to the abrasive jet. In addition to cleaning the surface, the abrasive particles will impart a surface roughness to the steel [9, 10].

However, prior to blasting, steelwork should be degreased and all weld spatters removed. If salts, grease or oil is present on the surface it will appear to be removed by the blasting process, but this is not the case. Although not visible, the contamination will still be present as a thin layer, and will affect the adhesion of subsequent coatings. Any presence of salts can be checked by measuring the

The separation of granulometric fractions was made by waste screening, for fractions separations according to granule dimensions, using screens of different dimensions. Separate granulometric fractions have the following dimensions: 0.18; 0.07; 0.05; 0.01mm. The screen is laid on a white surface, on the screen remaining only rough fraction. The sample on the screen is removed and the quantity gone through the screen is weighed. The basic technical characteristics for the solid materials that mostly determine the properties and their quality are: composition, granulometry, density, the specific surface and pore structure. The cognition of these characteristics make possible the parameters determination of the sand blasting with the optimum efficiency/output. To establish the recycling channel, the used grit properties were determined using granulometric analysis.

Experimental part

Materials and methods

Bitumen is a material needed in mixtures, because of its capacity of aggregating minerals. The bitumen used for roads, as well as aggregating mineral granulites, must also be stable in time and water resistant. The bitumen mixture must not be very flexible in the summer and very rigid in the winter.

Natural aggregates are materials in the composition of bitumen mixture. Natural aggregates used for roads can be: broken stones (obtained in quarries, by breaking and

sorting out rocks), grinding sands (also from quarries) and natural sands (from riverbeds or ballast-pits). All these processes of extraction of natural aggregates have their costs, which are to be found in the final cost of the asphalt mix.

Obtaining an optimal composition of bitumen mixture supposes choosing an optimal mix of aggregates, filler and bitumen, in order to have the highest possible durability.

Samples were made in wooden boxes by depositing successive layers of materials while complying with the quality and height requirements.

Studies were made on samples of bitumen mixture produced in the laboratory, and consisted of rigidity trials and fatigue resistance trials. Natural aggregates were replaced by waste grit, with adequate granulation. The procedures were the same as in concrete and asphalt Vega Station in Galati (way of loading and compaction, temperature, bitumen type, bitumen mixture), in order to obtain certain correlations and to determine different parameters.

These experiments contribute to improving the knowledge of bitumen mixtures that replace natural aggregates with waste grit.

The road infrastructure in Romania is poor, which calls for major investments in this sector and development in the future. Construction of public asphalt roads is based on the use of specific materials, such as binder and aggregates, deposited in successive layers.

High cost of bitumen (350-400 euro/t) of aggregate composition, favorite recipes are low (4.5%) in bitumen. Bitumen is the most expensive material of all construction materials. Asphalt road maintenance may be more expensive because of the upward evolution of international oil prices. Oil is the raw material in the bitumen industry, product used for paving roads. How crude bitumen is dependent, as the end product obtained by distillation chain, operators believe that the domestic market could suffer from the increase in international price and constructive use of cement as a variant on Romanian roads could cost much less. Preliminary data and final results were the subject of a comparative study of works of literature known. In terms of composition, grit used, can be placed in the SR 174-1/2002 (link layer) [12], SR 7970/2001 (base coat) and STAS 10473-1/1987 (ballast stabilized), STAS 1338/2-87 - Roadwork.

Following studies, Sousa et al. noticed that the dimension of aggregates plays an important role in the fatigue behaviour of bitumen mixture. The bitumen mixture had a higher resistance when the content of small aggregates was bigger [13]. Regarding the granulometric curve, Carswell et al. noticed that a mixture with a continuous granulometric curve has a higher resistance to fatigue [14].

Samples were made in some wooden boxes by depositing successive layers of materials, while complying with the quality and height requirements, the base layer and the granular mineral aggregates over which asphalt was poured.

Results and discussions

Samples prepared in the laboratory have different properties from mixtures produced in asphalt plant for a number of reasons. Hot mix asphalt concrete is produced by heating the asphalt binder to decrease its viscosity, and drying the aggregate to remove moisture from it prior to mixing. Typically, asphalt concrete is 4-8% bitumen. The recycling of waste into hot mix asphalt is not a new concept. A wide variety of materials have successfully been substituted for some percent of the normal ingredients without adverse effect on the asphalt quality [15, 16].

EDX analysis is a technique used for identifying the elemental composition of the specimen, or an area of interest thereof. The EDX analysis system works as an integrated feature of a scanning electron microscope SEM, and cannot operate on its own without the latter (figs. 3, 4 and table 2) [1].

EDX analysis indicates the particles composition as well as the elements' distribution in the examined area. When using spent grit as a substitute for normal aggregate, the aggregate must comply with both performance and environmental requirements. If the metals concentrations in the spent grit are not excessive, the concentrations in the asphalt will be very low. Wastes grit containing solvents should not be used and wastes grit with high metals concentrations may pose health risk to asphalt plant personnel.

The components of bitumen mixture influence its characteristics:

-every component influences the final output in a certain proportion;

-because of its composition (aggregates, filler and bitumen), we can say that the bitumen mixture has three states: the solid state (aggregates), the viscous state (binder) and the gaseous state (air pockets);

-the characteristics of the binder influence the physico-mechanical properties of the mixture;

-the rheology of the mixture is closely connected with the rheology of the binders;

Elements	*Weight percent, %*	
	Sample Grit 30%	*Sample Grit 90%*
Fe	73.87	68.83
Si	3.99	5.25
Al	0.93	1.09
Na	2.26	1.63
O	18.95	23,20
Total	100,00	100,00

Table 2
EDX COMPOSITION OF THE SAMPLES

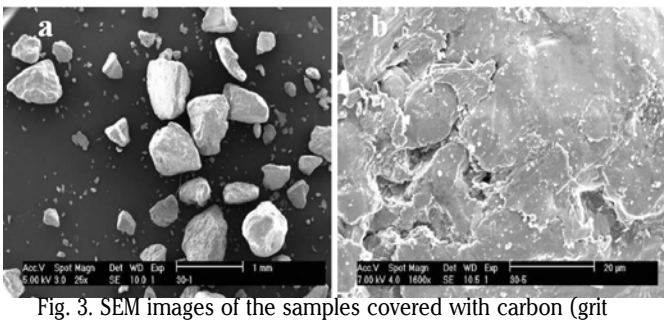

Fig. 3. SEM images of the samples covered with carbon (grit used 30%): a – 25X and b – 1600X

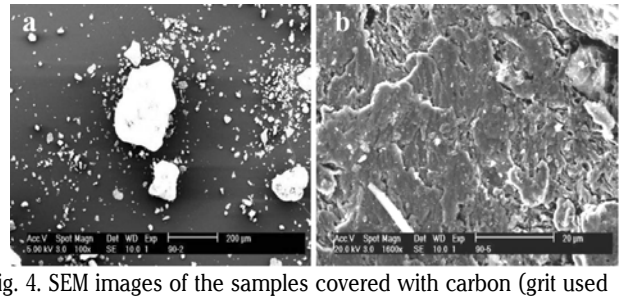

Fig. 4. SEM images of the samples covered with carbon (grit used 90%): a – 100X and b – 1600X

Fig. 5. Utilization of waste grit [16]

-the rigidity of the mixture is influenced by the component materials.

Having in view the projects for the airports, we can say that the granulometric analysis of the bitumen mixture proves that it is between the limits of SR EN 13108-1 for asphalt concrete.

Among environmental policies, waste management plays an essential part, because of the production growth and, implicitly, of the quantity of waste resulted, with negative impact on the environment. The diminishing of new material resources, higher costs implied in the exploitation of deposits with a reduced content of useful substances, the rapid growth of the prices of raw materials and of energy, as well as world crisis of some raw materials are only a few of the arguments for intensifying and developing the activity of recycling and utilization of waste grit.

Using already processed materials implies important energy savings in comparison with using raw materials.

The objectives of the present study were:

-encouraging the reduction of the amount of waste by showing the polluting effects and the costs of cleaning the affected areas;

-research on possibilities of utilization of wastes;

-presenting a long-term management strategy of supplying the sandblasting waste grit to be used for the asphalt mix.

As well as improving economic conditions, waste management assumes to identify and remove ecological damages provoked by dangerous residues. On one hand, all possibilities of reduction of wastes and other hazardous substances must be considered; on the other hand, we must obtain an ecological advantage in using some fractions of the waste, by re-introducing them in the production cycle (recycling). Using spent ABM in hot mix asphalt to replace part of the fine aggregates used in the production of conventional hot mix asphalt has several environmental benefits.

Theoretical and experimental research presented in the paper was called for by the importance of recycling grit wastes. Proposals for using the material obtained from recycling of grit wastes in stabilized mixtures with binders used in roads asphalt, the shipyard studied being able to benefit from economic advantages by reducing costs allocated to the collection, transport and disposal of grit wastes.

Conclusions

Recycling spent ABM has the potential to significantly reduce waste generation while saving money. The paper presents the research results made for the propounded solution could be the large scale use of stabilized mixture technology (treated granular aggregate with puzzometric binding agents using used grit), following the example of advanced countries (in our country the roads rehabilitation problem needs huge amounts of material, aggregate, binding materials, difficult to be provided from traditional resources).

In terms of environmental protection, the grit processing targets are:

- control and reduction of soil pollution by using clean technologies. The installation implies the crushing and the granulometric selection of the raw grit, wet process (having watering installations mounted on the conveyor belts which carry out the dusting);

- protection of the natural resources (the products resulted after the processing of the resulted grit are aggregates used in the following domains: road, railway, hydro technical and civil construction as an alternative to the traditional aggregates of natural rock exploited in quarry), the cost of the grit waste is minimum.

In the wake of the researches made on the elements of the composition of the analyzed grit it has been concluded that these materials are valuable. Their nontoxic aspect derives from the fact that in its oxidic-mineralogic composition, none of the presented substances has a negative impact upon the environment.

The future directions of research are specialized laboratory study of the asphalt mixtures, related to climate and traffic types and expansion behaviour of asphalt mixtures. Studies estimate a greater variety of recipes used in asphalt pavement and the underlying layers of roads.

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