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EXPLOITATION AND PROCESSING OF TECHNICAL STONE FROM QUARRIES PLJEŠEVAC NEAR KISELJAK

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ABSTRACT

Today, technical stone is a material that is used on a huge scale, and its annual consumption in the world is expressed in thousands of millions of tons. The demand for construction, such as houses, hospitals, hotels, schools and so on, has expanded, especially in developing countries. One of the key elements that increases the demand for such products is the numerous government infrastructure projects and maintenance programs. All levels of government in Bosnia and Herzegovina strive to implement good infrastructure, because in this way they enable trade, support industry, connect workers with jobs, and in this way bring hope for prosperity in these areas. The paper gives a brief overview of the production and processing of dolomite from the "Plješevac" quarry near Kiseljak as a positive example from the practice of "production and processing from raw material to final product".

Key words: quarry, dolomite, aggregate, technical stone, exploitation, processing

INTRODUCTION

If there was no production and processing of technical stone, there would literally be nothing around us. There would be no modern roads, ports, airports, buildings, schools, houses, hospitals, etc. If we know that for the construction of an average house, about 400 tons of aggregates are needed, for an average school, about 3,000 tons, for a kilometer of highway, about 30,000 tons [1], then it is clear to us what an important role the production and processing of technical stone plays both in our country and in the world.

Currently, about 90% of the total production of stone aggregates in Europe comes from natural sources, from quarries and gravel pits. The remaining 10% of European aggregate production comes from marine deposits, by recycling industrial waste such as slag and ash, and by recycling construction waste [2], (Figure 1).

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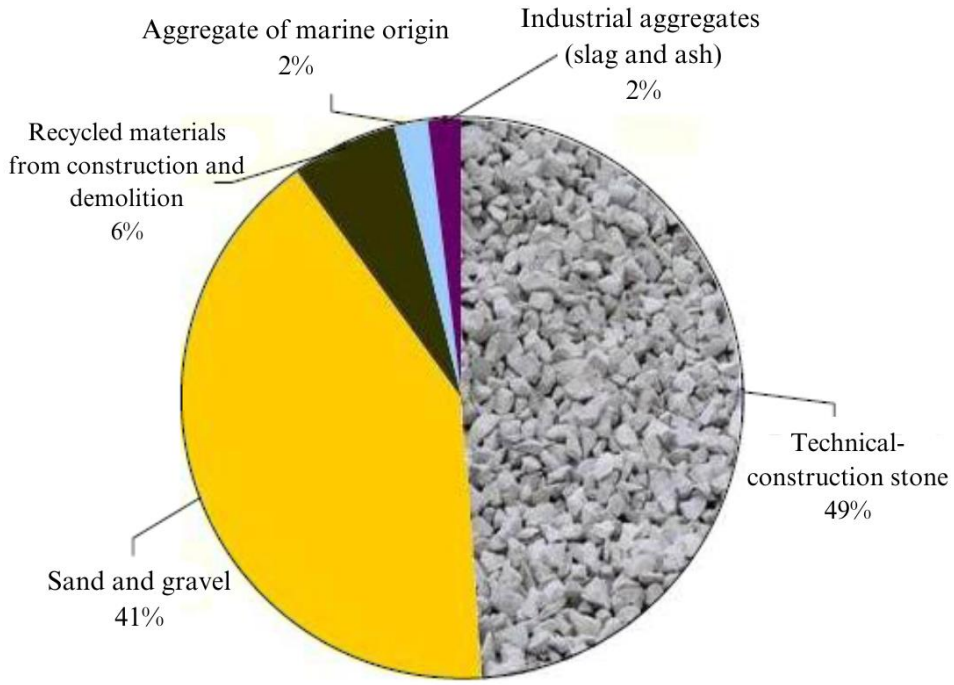

Figure 1. Production and sources of stone aggregates in Europe [2]

The European aggregates industry produces three billion tons per year, worth more than 30 billion euros. These aggregates are produced in 26,000 quarries across Europe, which belong to around 15,000 companies, so the production and processing of aggregates mainly consists of small and medium-sized companies. Every European citizen consumes about six tons of aggregates annually, and the industry of production and processing of technical stone employs about 187,000 people, so this sector is by far the largest non-energy extractive industry in Europe [1].

Given that Bosnia and Herzegovina is a developing country, the role of the construction industry should ensure rational, economical and fast construction of construction facilities [3]. In the Federation of Bosnia and Herzegovina, there are no precise data on the number of quarries that are in operation [4]. In the territory of the Federation of Bosnia and Herzegovina, 11 different mineral raw materials are currently being exploited, which are used as technical - building stone. These are: gravel, quartz diorite, quartz keratophyre, diabase, peridotite (lherzolite), spilite, limestone, dolomite, carbonate breccias, amphibolite and marble [3]. Limestones and dolomites belong to sedimentary rocks, while the rest are of magmatic origin.

Dolomite is a monomineralic carbonate rock composed of dolomite minerals. Chemically pure dolomite contains 30.41% CaO, 21.86% MgO and 47.83% CO2. In the form of admixtures in dolomite can be: calcite, magnesite, siderite, opal, chalcedony, clay minerals, gypsum, quartz and other minerals. Although dolomites have a wide range of applications: the industry of refractory materials, as melters in ferrous metallurgy, in the production of glass, cement, paper, paints and varnishes, rubber, in the pharmaceutical and ceramic industries in the territory of the Federation, it is exploited in 33 deposits and used as a technical-construction stone for making concrete and concrete accessories. The ratio of total balance reserves of dolomite mineral raw material by individual cantons is shown in Figure 2.

The "Plješevac" quarry near Kiseljak is a dolomite quarry that has been in existence since 1963 until today in a smaller or larger production capacity. Currently, the Plješevac quarry is one of the largest quarries in FBiH due to its annual production and processing of technical stone (dolomite) of approximately 650,000 tons. The location of the Plješevac surface mine is located about 15 km southeast of Kiseljak and about 25 km from Sarajevo, west of the settlement Rakovica on the Plješevac hill. Traffic and transport conditions are quite favorable considering that the deposit is connected to the regional asphalt road Sarajevo-Kiseljak. The connection with the regional road implies two roads 2.0 km long, each of which consists of a good macadam road of 0.5 km and an asphalt road of 1.5 km. The narrower location of the Plješevac dolomite deposits belongs to the village of Rudnik at a distance of approx. 2.0 km. The villages of Tulica, Stanjevac, Košelji and Zabrđe are located in the wider area of the deposits. The location of the quarry is isolated from the surrounding settlements. The area around the surface mine is covered, for the most part, by coniferous forest, much less by meadows. The surrounding hills prevent the dispersion of

solid dust particles over wider areas [5].

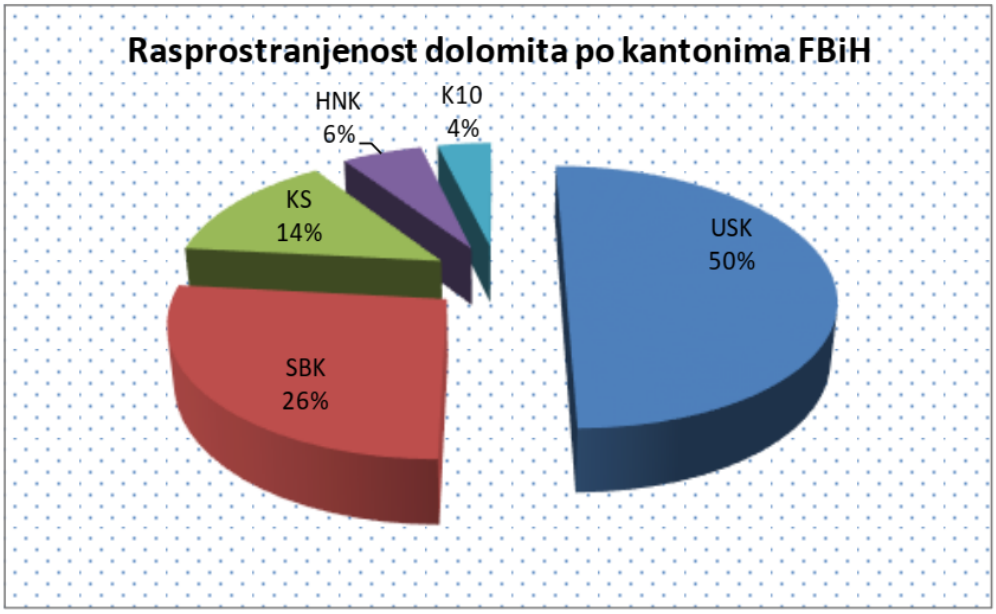

Figure 2. Distribution of dolomite in cantons [3]

The highest elevation of the terrain is 913.0 m, a.s.l. and is located on the site of the Plješevac mountain, and the lowest is 796.0 m above sea level. and is located on the plateau where the separation and accompanying facilities are located as part of the production complex of the Plješevac surface mine near Kiseljak. Figure 3 shows the spatial location of the Plješevac quarry near Kiseljak.

Figure 3. Plješevac dolomite quarry near Kiseljak

1. EXPLOITATION AND PROCESSING OF TECHNICAL STONE FROM QUARRIES PLJEŠEVAC KOD KISELJAK

The surface exploitation of technical dolomite stone at the Plješevac quarry is based on very favorable natural and created technical-technological and other conditions. Decisive influence on the choice of mining mechanization structure at the Plješevac quarry has natural and technical - technological factors.

In natural factors:

- physical and mechanical characteristics of dolomite,
- shape and dimensions of the outline of the quarry and
- terrain topography.

In the technical - technological characteristics:

- the capacity of the quarry and the maximum size of the input piece into the crusher,
- intensity and dynamics of quarry development in terms of plan and height, and location of processing capacities,
- applied technology for exploitation and processing and
- supply of driving energy.

The project solution for the exploitation of dolomite at the Plješevac surface mine adopts the following parameters:

- number of working months in a year..... $N_{mo} = 12$
- number of shifts per day..... $N_{shf} = 2$
- number of working hours in a shift ..... $N_{h/shf} = 8$
- effective use of working time..... $k_v = 0,85$
- number of working days in a month..... $N_{wdmo} = 24$

From the stated conditions, it follows that the annual fund of effective working time amounts to:

$$T_g = N_{mo} \times N_{shf} \times N_{h/shf} \times N_{wdmo} \times k_v = 12 \times 1 \times 16 \times 24 \times 0,85 = 3.916,00\ h_{ef}/year \quad (1)$$

The designed hourly capacity of 300 t/hef of the installed plant is realistic and confirmed in the trial operation of the plant, which amounted to 280-350 t/hef. The annual production capacity for the Plješevac dolomite surface mine amounts to:

$$Q_{per\ year} = T_g \times Q_{t/h} = 2.448,0 \times 300,0 = 734.400,00\ (t/year) \quad (2)$$

Laboratory testing has determined that the basic mass of the Plješevac quarry is made up of dolomite, while the rest are minerals with a negligible contribution. Table 1 shows data on the chemical composition, while Table 2 shows the physical and mechanical properties of dolomite at the Plješevac quarry near Kiseljak.

Table 1. Chemical composition of dolomite at the Plješevac quarry near Kiseljak

Loss on ignition	CaO	MgO	SiO_2	Al_2O_3	SO_3	CO_2	Na_2O	K_2O	P_2O_5
46,84 %	32,64%	20,04%	0,24%	0,09%	0,05%	43,95%	0,022%	0,009%	0,003%

Table 2. Physical and mechanical properties of dolomite

Σ_S	Dry compressive strength	25,54 N/cm^2
σ_v	Compressive strength in a water-saturated state	23,26 N/cm^2
g	Frost resistance	0,026 %
χ_d	Specific mass	2,8 g/cm^3 (2,83-2,74)
h	Abrasion resistance	20,99 cm^3/50cm^2
S	Sulfate and sulfide content	0,00 %
U	Water absorption	0,416 %
χ_z	Volumetric mass	2,63-2,74 g/cm^3

It follows from the previous results that the dolomite of the deposit "Plježevac" has good qualitative characteristics, both in terms of chemical content and physical-mechanical characteristics. Based on these indicators, their spectrum of application was determined: construction-technical stone, stone aggregate for the production of concrete and mortar, for the production of lower bearing layers (buffer) in road construction and as a filler in other industries.

The technology of performing works on the production of dolomite

The conditions of exploitation include the whole of technical and economic components through the synthesis of quantity and quality, position and shape of the deposit, and technical conditions for the use of useful components [6]. The dolomite bed is covered with a thin layer of humus up to one meter thick. Removing the humus cover is done with a crawler excavator or a bulldozer in short steps from top to bottom. The project envisages the following technological phases of the works:

1. Drilling and blasting,
2. Loading of demined material directly into trucks and transport of demined material to the processing plant.

The general peculiarity of this type of exploitation is discontinuity, whereby drilling can coincide with loading and transport. The dynamics of the works are adjusted to the production program so that once the excavation in one excavation zone is completed, the excavation of the next one can be started immediately. Figure 4 shows the loading of demined material on the floor after drilling and blasting.

Figure 4. Loading of materials after blasting on the floor

Technology of performing works on dolomite processing

"Baumit Kamen" d.o.o. which carries out the exploitation and processing of dolomite at the "Plješevac" quarry near Kiseljak, installed a modern separation of crushing and classification within the quarry. Figure 5 shows the technological scheme for the processing (crushing and grading) of trench dolomite at the "Plješevac" separation, while Figure 6 shows the modern crushing plant installed at the quarry.

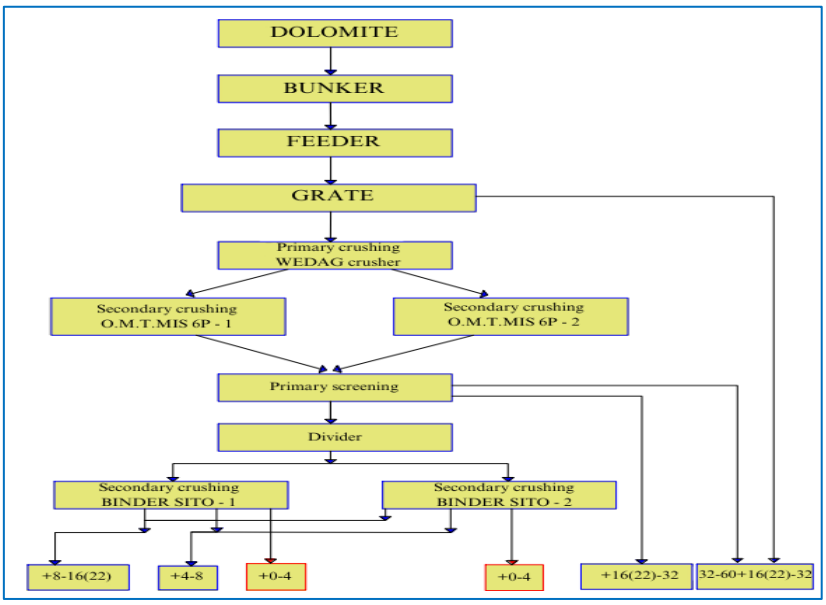

Figure 5. Technological scheme of trench dolomite processing at the separation "Plješevac"

Figure 6. Dolomite crushing and grading plant at the Plješevac quarry

On separation from trench dolomite after crushing and grading, aggregates of the following coarseness are produced: 0 - 4; 4-8; 8 - 16; 16-32; 32-60 and separated tampon. Table 3 gives an overview of the share of individual products obtained from trench dolomite.

Table 3. Participation of individual products after crushing and classification

0 – 4 (mm)	4 – 16 (mm)	8 – 16 (mm)	4 – 8 (mm)	Separated buffer	Other products	Total (%)
35	12	14	11	16	12	100

The participation of aggregates 4-8 (mm) in the production of concrete mix is negligible, and it was necessary to find a solution for the mentioned aggregate so that they would not be "buried" with it. "Baumit Kamen" d.o.o. Sarajevo, as a daughter of the Austrian company for the production of construction materials, made the decision to build production plants for various types of fillers in 2006, so that aggregates that are not sold directly at the quarry will undergo secondary processing in a new plant located in the immediate vicinity of the quarry.

Baumit's factory in Bosnia and Herzegovina has been in operation since 2008, using its capacities for the production of powder products. Today, over 90% of all powder materials that Baumit places on the BiH market are domestically produced. When it comes to the range of products, Baumit production in Rakovica currently produces over 20 different items in the categories of interior and exterior plasters; ceramic and facade adhesives; screed; masonry mortar; dry compacted concrete mixtures. New products are continuously introduced into production, following all contemporary trends and market needs. With the aim of additional modernization and safe development, Baumit invests year after year in new technologies in production and expansion of infrastructure capacities. To ensure that nothing is left to chance, the Baumit factory has two modern laboratories for the analysis of raw materials and finished products. Professional staff and modern equipment enable at all times an adequate response to challenges in terms of quality and performance analysis of materials and raw materials. Figure 7 shows a modern plant for the production of fillers, which is one of the leading manufacturers of facades and building materials both here and in Europe.

Figure 7. Baumit filler production facilities d.o.o. [7]

CONCLUSION

When we talk about the production of aggregates from a quarry, in most cases we think of the degradation and devastation of a certain relief zone. However, to the extent that the production of aggregates goes "hand in hand" with environmental protection, in that case we have prosperity and development while preserving all the components of the environment.

The planned investments in infrastructure should significantly contribute to the strengthening of both the construction sector and those branches of the processing industry that are closely related to construction, which is in direct correlation to the greater needs of aggregates on the market. The most favorable conditions for the realization of mineral raw materials are where the location of the exploitation site and the market coincide, that is, where the realization is carried out. The "Plješevac" dolomite deposit has a very favorable position, bearing in mind that it is located in a narrow zone of the Sarajevo area, which justifies it as the leading producer of aggregates and all types of dolomite fillers in this area. In particular, it should be noted that Baumit Kamen d.o.o. in its many years of practice, it treats all measures and regulations related to occupational health and environmental protection as part of the technological process.

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