Journal of Mining and Metallurgy, 42 A (2006)

DRAFT SOLUTION OF PRIMARY CRUSHING AT LIMESTONE AND STONE AGGREGATES PROCESSING PLANT FROM DEPOSIT "SUVODO"A.D. – JELEN DO

Dragan S. RADULOVIC[#], Velimir ANTANASKOVIC, Branislav IVOŠEVIC, Slavica MIHAJLOVIC

Institute for Technology of Nuclear and other Mineral Raw Materials, Franse d' Esperea 86, Belgrade, Serbia

(Received 23.6.2005.; accepted 18.9.2006.)

Abstract

This paper gives a presentation of primary crushing at stone aggregates production plant from deposit "Suvodo". The paper has been developed from The Main Mining Project of the new processing plant for limestone and production of stone aggregates from deposit "Suvodo"-A.D.-Jelen Do. First problem to be solved at primary crushing was the removal of waste rock being occurred in the useful component by mining. This one together with other problems has been solved in the laboratories of ITNMS and further on, at the operating plant itself.

Key words: *limestone, primary crushing***,** *aggregates, waste.*

[#]Corresponding author: d.radulovic@itnms.ac.yu

1. Introduction

Increased needs for stone and stone aggregates used in construction industry, which has revived after a longer period of stagnation in Republic of Serbia, have brought to the opening of a larger number of small quarries, which together with big stone mines and “Jelen Do” as one of them, have tried to fulfill market demands by the increase in production. After privatization of “Jelen Do”a.d., carried out by the Croatian “Nexe” group, new owner wanted to increase the processing capacity and to modernize the production taking into account commercial reserves and market needs. In order to meet those demands, the already existing plant has been reconstructed, while completely new equipment has been purchased for the new production plant for crushing and sizing of limestone at “Suvodo” deposit. Project planning of the new processing plant and elaboration of the Main Mining Project with the previous capacity of 250 t/h have been confided to ITNMS [1]. Thus total capacity of the processing plant with the reconstructed part amounts about 500 t/h. Limestone processing involves primary crushing and removal of waste rock, secondary and tertiary crushing and sizing of the finished products. Processing equipment has been connected by the system of conveyor belts, thus enabling transfer of products through process phases as well as transfer of finished products to the appropriate dumps [2]. According to working regime, scheme projected this way enables production of aggregates of the following class sizes: -63+32 mm; -32+16 mm; -16+8 mm; -8+4 mm and -4+0 mm. Related to market placement of finished products, the scheme includes possibility for coarser classes to be transported back at the primary crushing which increases the share of class -4+0 mm up to 100 % related to entry mass of secondary crushing [2, 3]. Having terrain configuration in view, technical solution should be provided to overcome the height distinction of 155 m, i.e. loading of raw material at primary crushing elevated on 480 m above sea level while secondary crushing and sizing at 325 m above see level.

2. Data on limestone deposit “Suvodo” - Jelen Do

Excerpt from elaborate of limestone quality and reserves "Suvodo" Jelen Do (DP "Geozavod – Nemetali" – Beograd, 2001.)

2.1. Deposit location

Limestone deposit “Suvodo” near Jelen Do, lies in the central part of Serbia by the highway Beograd – CaCak – Uzice. It is 28 km far from Cacak and 12 from Pozega. In administrative view it belongs to Pozega Municipality. Morphologically, terrain is hilly with steep slopes and mountainous horsts with the highest peak of 710 m and the lowest of 305 m. Besides deposit itself flows river Zapadna Morava with its tributaries Moravica, Djetinja, Bjelica and Skrapez. From the southeast the deposit is confined by Zapadna Morava, from the southwest by stream Suvodo and from the northeast side by Papratiska river. Communication and transport conditions are very good, while the asphalt road Cacak-Uzice is only 200 m far, likewise railway Cacak-Uzice which is connected to Beograd-Bar railway.

2.2. Geological data

Complexity of geological structure within wider area of the limestone deposit “Suvodo” near Jelen Do, is presented by the Paleozoic schists of the zone Krstac-Cestobrodica, the rocks of Mesozoic complex , sedimenary Neogene and Quaternary complex. Medium Triassic sediments appear in more facies as limestones stratified in thick beds and stratum rocks, massive and dolomitic limestones and limestone with cherts. Facies of massive and dolomitic limestones presents bearing series of the limestone deposit “Suvodo”. Steep slopes are thick with breccias and debris of limestone [1].

Geological structure of the deposit itself is rather simple. Productive series floor is presented by shaly, marl-limestone facies which belongs to Werfenian–Campil substage. Its tickness varies from 300 m , declining towards the south board, thus it amounts about 15 m in places. Limestones are of uniform quality i.e. with an even distribution of basic components. In hydrological view, there is no danger from breakthrough of underground waters.In engineering-geological view, limestones from the deposit “Suvodo” are worthwhile working area in regards to stability of slopes. Only limestone debris could present small and local unstable masses which could be moved by cutting.

2.3. Geological prospective activities

Prospective activities were executed in more stages at certain intervals in 1977, 1982 and 1984/86. Besides geological, geodesist works were performed, as well as prospective drilling and raw mineral quality analysis with the calculation of reserves and techno-commercial evaluation of the deposit “Suvodo” [1].

2.4. Limestone quality and application

On the basis of chemical, mineral, petrologic, physical, mechanical and technological quality analysis, limestones from the deposit “Suvodo” could be used in industry of:

- lime,
- sugar refining,
- building material (aggregates for producing of concrete and asphalt concrete)

On the basis of the laboratory analysis, in accordance with the valid YU Standards, limestone from the deposit “Suvodo” fulfills the quality conditions for the aggregates production used for:

1. production of under-supporting mechanically compressed (tampon) layers JUS.Y.E9.020,
2. production of under-supporting road layers of bituminous material by hot-treatment - JUS.Y.E9.028,
3. production of over-supporting layers of bituminous material by hot-treatment for all road categories - JUS.Y.E9.021,
4. production of weary asphalt-concrete by hot-treatment for roads with light and very light traffic-load- JUS.Y.E4.014,
5. production of cement-concrete mixtures:
   - massive concrete,
   - reinforced concrete,
   - pre-stressed concrete,
   - concrete with surface quality -JUS.B.B2.009.
6. production of under-layer of cement-concrete road base-JUS.Y.E3.020.

2.5. Chemical composition of limestone "Suvodo"

Chemical composition of limestone from the deposit "Suvodo" has been determined in the Laboratory for Chemical Analysis of ITNMS, at twelve different samples. The samples were without presence of waste material as per determination of the quality of the finished products and their further application according to the composition of certain elements.

Table 1. Chemical composition of limestone

No.	Compound	Composition (%)
1.	CaO	53,5-55,5
2.	MgO	1,0-2,0
3.	SiO_2	0,3-0,5
4.	R_2O_3	<1
5.	K_2O+Na_2O	<0,3

Table 1 shows high percentage of CaO in certain parts of limestone deposit, up to 55,5% (56% theoretically), which is high quality limestone.

2.6. Mean values of physical-mechanical properties of limestone "Suvodo"

These values are taken from the elaborate done by "Geozavod-Nemetali"- Belgrade. Mean values of physical-mechanical properties are given at the following table:

Table 2. Mean values of physical-mechanical properties of limestone "Suvodo"

No.	Physical-mechanical properties		Mean value
1.	Compression strength (Mpa)	In dry state	124
		In water saturated state	105
		After freezing	92
2.	Resistance to wear by scraping cm3/50 cm		22,66
3.	Water absorption %		0,20
4.	Freezing resistance		Resistant
5.	Bulk density with cavities and voids t/m^3		2,69
6.	Bulk density without cavities and voids t/m^3		2,72
7.	Bulk volume coefficient		0,989
8.	Porosity %		1,00

2.7. Geological reserves

Calculation of limestone reserves "Suvodo" as technical-building stone and carbonate material has been evaluated with the use of:

- parallel vertical profile method as basic method,
- block method as a control one

Total geological reserves of limestone "Suvodo" amount about 26 million m^3 i.e. about 70 million t (calculated with bulk density = 2.69 t/m^3). Within open workings contours lies about 23 million m^3 of limestone i.e. balance reserves amount about 60 million t. By exploitation losses of 3 %, reserves amount about 22 million m^3 i.e. 60 million t of limestone. Contour coefficient of waste removal for draft solution of open workings equals K_k=0,2 m^3/m^3. By year capacity of limestone exploitation of 400.000 m^3, the exploitation period is about 50 years [1].

3. Experimental work

Experimental work was carried out in order to determine the method for waste removal from the raw material, limestone, otherwise it could spoil the quality of the finished products when chemical and physical – mechanical properties are of concern. Share of waste could be minimized at the very start by appropriate working method and its loading on dump tracks, but it wouldn't guarantee thorough elimination of waste [5, 6]. Therefore, it should be done at the operating plant. While waste rock is consisted of clay components with different impurities and soil with varied organic ingredients, and as the plant operates almost entire year in all weather circumstances, the solution of the problem must be very effective. Specifically problematic was the period of the year in which the moisture was higher, when it came to agglomeration of clay components and adhesion of finer pieces of limestone and waste at the useful component. To prevent this and to bring down negative aspects at the lowest dimension possible, it has been decided to put vibrating screen in front of the primary crusher. Selection of vibrating screen must be very careful, as per fact that it has to satisfy two opposite claims, on one side to remove the biggest part of the waste from the raw material, on the other side, to minimize the loss of useful mass component as undersized [5, 6, 7, 8].

Vibrating screen aperture has been determined experimentally, by taking starting sample at the open works after mining, both samples, smaller classes of limestone and waste sample. Starting sample taken at the open works and composed this way (smaller classes and waste), was delivered to ITNMS , with mass weight m= 220 kg , and tested on the series of sieves, then chemically analyzed on CaO and waste content. The results of the chemical analysis are shown at the table 3.

Table 3. Chemical analysis of sample of smaller classes and waste by classes

Class size, mm	M,%	CaO, %	R_2O_3, %
+60	3,43	54,22	0,32
-60 +50	4,12	53,86	0,41
-50+40	7,21	53,45	0,47
-40+30	9,82	50,27	0,59
-30+20	23,55	37,41	1,17
-20+0,0	51,87	26,31	4,26
Input	100,00	35,32	2,59

In Table 3 it is given CaO content by class sizes at sample consisted of smaller classes and waste. On the basis of size distribution of the sample and chemical analysis of class sizes, it is evident that class -30+0 mm should be removed from the raw material as it presents waste by its chemical composition. This problem is solved by installing of vibrating screen with aperture of 30 mm, undersize which presents waste is conveyed to special bin.

4. Plant operating data

According to project task and Investitor's requests, Limestone and Stone Aggregates Production Plant is being projected for the following conditions:

- Capacity of raw limestone 295 t/h
- Waste quantity 45 t/h
- Capacity of primary crushed limestone class –200+32 mm 250 t/h

4.1. Technological scheme

On the basis of the previously shown data experimental results (under points 3 and 4) and theoretical data [2, 3, 4, 5, 6, 7] the following technological scheme of primary crushing with the mass flow-sheet has been adopted (Figure 1.).

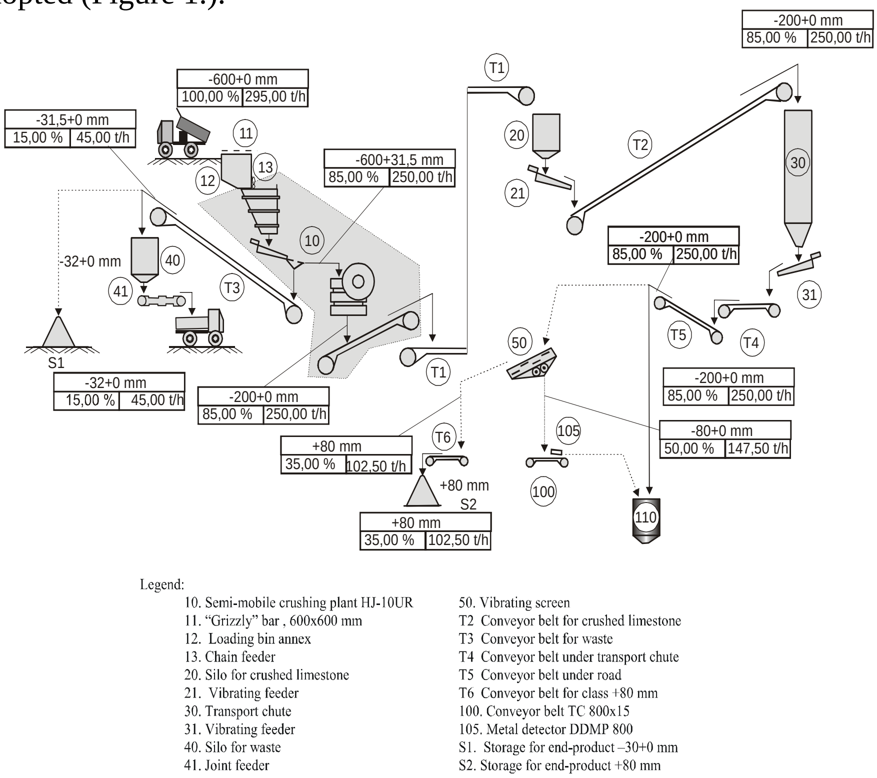

Fig. 1. Technological scheme of mass flow of primary crushing at the deposit "Suvodo" [1]

4.2. Description of work of primary crushing and waste removal plant

Calculation and selection of equipment were executed on the basis of the technological scheme and mass flow-sheet (Fig. 1.), according to given capacity [1, 6, 7, 8, 9, 10]. Short description of technological scheme of primary crushing and material flow at the deposit "Suvodo" is given bellow. Raw limestone from the open pit has been driven by dump trucks, capacity 35 t, to the loading bin of semi-mobile plant for primary crushing (pos.10). Semi-mobile processing plant was constructed by Svedala Arbra, type HJ-10UE. It has been located on the plateau with loading bin annex , with height of H=8,5 m. Annex to loading bin has been constructed in accordance with technical solutions adopted at the Project Bureau-ITNMS, to enable unloading of the dump truck in whole. To protect the facility from non-gabarit pieces, stationary steel screen i.e. "grizzly bars" (pos. 11) aperture 600 x 600 mm, was added. Joint feeder (pos.13) was mounted on the annex to loading bin as to protect from the sudden influx of material.

From the loading bin via vibrating feeder with the screen 32 mm, limestone is dosed into jaw crusher. Undersized product (class – 32+ 0 mm) is waste, which is transported by conveyor belt (pos. T_3), length L=39,0 m, width B=650 mm to Silo for accepting of waste (pos. 40). Silo is of total height H=30 m (operating 23 m), width D=4,4 m, operating volume V=252 m^3 , located by the road. To discharge the Silo i.e. to load the waste on trucks for waste transport, on the bottom side of it, a plate feeder is mounted (pos. 41) length L= 4,56 m and width B= 1,34 m. In the case waste contains a high percentage of moisture, the same will be transferred from conveyor belt (pos. T3) over double-deck chute with overlap, to storage (pos. S_1) which is located by the silo from which it is further drives to a trash pile. Oversized product of the screen of vibrating feeder goes to jaw crusher. Crushed material product (class–200+ 0 mm) by means of transport belt (consisting part of a plant) is transferred on conveyor belt (pos. T_1), length L= 25,0 m, width B=800 mm, and then to Silo (pos. 20). The Silo is of total height H=18,6 (operating height 15 m), width D=4,4 m, operating volume V=170 m^3. To discharge the Silo and to dose material on conveyor belt (pos. T2), on the bottom side of it, vibrating feeder is mounted (pos. 21) type EME-S9U. Conveyor belt (pos. T_2) is with negative inclination of 5°, length L= 83,0 m, width B= 800 mm, and it transported material from Silo (pos. 20) to Shaft (pos. 30). Above shaft, an annex of reinforced concrete is constructed, height H=3 m with diameter. D=2,8 m. Total shaft height is H=81,7 m. The height of vertical part is H=75,7 m, diameter of light opening D=2,8 m. Inclined (exit) side of shaft is under 35° height H=6 m and diameter D =5 m. On the bottom side of shaft were mounted two vibrating feeders (pos. 31 i 32) type WMM 12/8 which load limestone on conveyor belt (pos. T_4), length L= 66,64 m, width B=800 mm, and further to conveyor belt (pos. T_5). The length of conveyor belt (pos. T_5) is L = 34,0 m, width B = 800 mm with inclination of -2°. From conveyor belt (pos. T_5) limestone is dosed on one-deck vibrating screen (pos. 50) type TK13.20.3V, aperture 80 mm, based on platform.. Oversized product (class +80 mm) via conveyor belt (pos. T_6) is stored (pos. S2) which is material for limekiln. Undersized product (class –80+0 mm) via conveyor belt (pos. 100) is transferred to Silo (poz.110) i.e. to secondary crushing. If the product doesn't go to limekiln, then it is transported from conveyor belt (pos. T_5) directly to conveyor belt (pos. 100) towards Silo (pos.110) i.e. to secondary crushing. Access to semi-mobile plant from the levels on the open pit is about 500 m long, while from plateau where secondary and tertiary crushing are elevated (325 m above sea level), the access is by road cut trough, which passes by the Silo for waste (pos. 40) with one arm connecting shaft (pos. 30) with transformer station while other arm connects semi-mobile plant with open pit.

4.3. Draft solution for primary crushing

Draft solution for primary crushing was done on the basis of the following elements:

- Location conditioned by the open works development,
- Previously purchased semi-mobile plant for primary crushing type HJ-10UR Svedala Arbra
- Previously built transport facilities for crushed limestone, from primary crushing to secondary crushing (shaft, tunnel under shaft, tunnel for transport to silo for secondary crushing),
- Silos, on behalf of Investitor.

4.4. Draft solution for primary crushing and waste removal at the open works"Suvodo"

General data:

- Capacity of primary crushing 295 t/h,
- Waste quantity (–30+0 mm) 45 t/h
- Capacity of crushed limestone (–200+30 mm) 250 t/h
- Plant works 14 hours per day (two working shifts);

- Capacity of crushed limestone 4.130 t/day
- Waste quantity (–30+0 mm) 630 t/day
- Capacity of class (–200+30 mm) 3.500 t/day

After taking into consideration a number of proposed “solutions” , expert teams form Jelen Do (Investitor), Mining-Geological Faculty - Belgrade (Technical control of project documentation) and ITNMS - Belgrade (Projectants) have adopted the following technical solutions:

4.5. Primary crushing plant - data

For primary crushing of limestone at the open pit, it has been purchased semi-mobile plant produced by Svedala Arbra type HJ-10UR, which is consisted from the following equipment (by catalogue data):

- Jaw crusher type 10580, aperture 105x80 cm, exit aperture 10 x20 cm
- Vibrating feeder with screen type VMOT 48/1, aperture for waste separation 30 mm
- Conveyor belt for crushed material (–200+30 mm)
- Conveyor belt for waste transportation (–30+0 mm)
- Plant capacity 350 t/h for bulk materials and 250 t/h for rocky materials
- Plant dimensions
  - Total length B = 15.100 mm
  - Distance between carrying plates A = 6.800 mm
  - Total height C = 6.450 mm
  - Width D = 4.900 mm
  - Entry cage volume V = 21 m^3
  - Plant mass (with entry cage) Q = 56 t
  - Electro-motor force P = 132 kW

Equipment disposition on the terrain, Figure 2., has been presented as draft solution with adopted Investitor’s requests in the view of capacity, plant location, products assortment, technological needs and technical possibilities of the selected equipment.

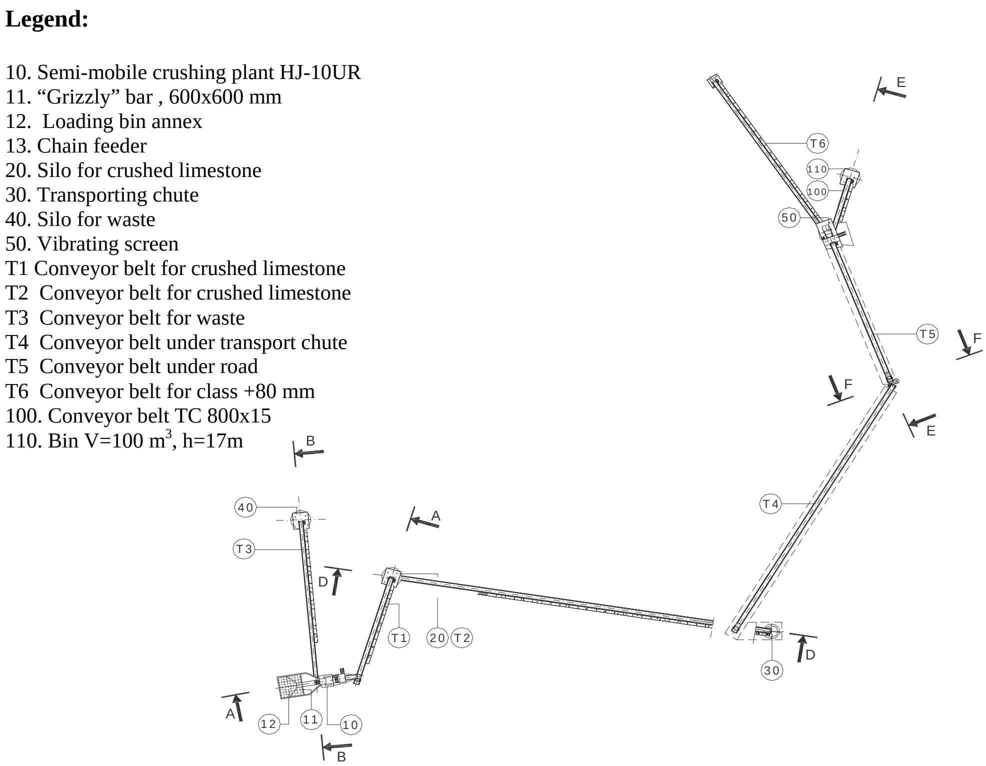

Fig. 2. Disposition of equipment for primary crushing [1]

5. Conclusion

This paper gives elementary data on raw material quality and quantity from deposit “Suvodo- Jelen Do”, conditions and draft solutions for projecting of primary crushing at the plant, which are the part of the Main Mining Project **“Limestone nad stone aggregates processing plant from deposit “Suvodo”, Jelen Do. a.d. - Jelen Do”.**

This project has been positively evaluated by the side of verification commission**,** equipment adopted and partially shown in the paper (primary crushing) is being mounted, while plant itself should be started within October 2005.

6. References

1. "Main Mining project of limestone and stone aggregates processing plant from deposit “Suvodo”, Jelen Do. A.D.- Jelen Do", Archive ITNMS-a, Belgrade, (2005).
2. V. Pavlovic, "Transportation and export in mines", Editor Civil engineering book, Belgrade, (1963).
3. R. Borovic, "Transportation equipment in Mineral Processing", Editor Faculty of Mining and Geology, Belgrade, (1985).
4. N. Weiss, ″SME Mineral Processing Handbook″. American Institute of Mining, Volume I, (1985).
5. B. Kolonja, D. Knezevic, “Transport in mineral Processing” Editor Faculty of Mining and Geology, Belgrade, (2000).
6. M. Grbovic, N. Magdalinovic, "Process equipment crushing and grinding for mineral materials", Bor, (1980).
7. S. Pustric, "Estimate and selection crushing, screening and grinding equipment for mineral materials", Mining Institute, Belgrade, (1974).
8. Mechanic engineering Aleksinac, Production catalogue, (2005).
9. Metso minerals, Production catalogue, (2004).
10. B. Brankovic, Lj. Andric and the others, "Mobile plants for recycling of construction waste material", Editor ITNMS, Belgrade, (2002).