DIMENSIONING THE COAL FACES AND USE OF THE DESIGN SOFTWARE IN THE USED TECHNOLOGICAL CRITERION FROM OLTENIA'S LIGNITE COAL PITS

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ABSTRACT: *Over 90% of the Romania's lignite reserve is located in the region of Oltenia, which is why this area is given special attention in the country's coal resources.*
Because the lignite deposit of Oltenia is comprised of 1-8 exploitable coal layers, their capitalizing calls for urgent arrangements to ensure rational exploitation under conditions of total safety, minimum losses and efficiency.
The technology used the coal pits of North-Western Oltenia is the technology of excavation, transport and dumping in a continuous flow by using the complexes of excavation, transport and high-capacity dumping.
The theme of this paper is of particular importance because the rhythmic operation in complete safety, is necessary both for sizing and keeping within the bounds of acceptable values, throughout the process of excavation of the geometric elements of the coal faces, marked by: the height of benches, slope angle and width of berms and the calculation of the excavated volume.
Geometric dimensions of the benches of the open pits, the height of benches, slope angle and width of berms shall be calculated and shall be based on: the massif structure that forms the benches; physical-mechanical characteristics of rocks from the bench; working conditions, characterized mainly by mining and extraction methods applied; functional parameters of the mechanical equipment used to perform various operations on the coal face etc.
For this study it was necessary a broad field for task tracking, measurement, research and design elements of the coal face, for land survey and a desk activity by: processing of topographic data, making the date base for the drills, usage of a mining design software, laboratory analyses on physical and mechanical properties of rocks and numerous specialized studies. In the final part, we bring some contributions to elucidating the issues of special importance for the lignite coal pits of Oltenia, coming up with data, graphics, formulas, solutions and concrete dimensioning of coal faces in terms of using technology in a continuous flow.

KEYWORDS: Bench sizing, coal face, coal pit, bucket wheel excavator, Oltenia mining basin

1. FEATURES OF OLTENIA MINING REGION

The mining area of Oltenia is located in South-Western Romania, in the counties Vâlcea, Gorj and Mehedinţi, in the hilly areas, going over a long stretch of about 120 km, which successively across the valleys between the Danube and the Luncavăţ.

Geological research and mining practice have highlighted the fact that Oltenia' s lignite deposits present some peculiarities from one area to another, which imposed their grouping in areas with variable expansion.

By the geographical and geological criteria, the economic area of South-Western Oltenia was split into five mining basins: Rovinari Basin; Motru Basin; Jilţ Basin; Berbeşti-Vâlcea Basin; Mehedinţi Basin.

2. WORKING TECHNOLOGIES APPLIED IN THE COAL PITS OF OLTENIA

2.1. Discontinuous working flow technologies

Characteristic of this technology is the fact that the equipment used for excavation and transport acts discontinuously, being served by the transport equipment which have a working cycle consisting in a discontinuous activity.

Over time the Oltenia mining basin, where over 80% of lignite reserves are located in the hilly area, it has been used the the discontinuous flow technology in small coal pits which have prepared the coal pit for introducing the continuous flow technology.

2.2. Continuous flow technologies

Today we are witnessing an expansion of the continues action excavators in the coal pits with hard rocks, due to the need of increasing the output and labour productivity.

In the continuous flow technologies, which applies to the rocks of a low strength, the excavation operations, transport and dumping runs continuously and the equipment can be assembled in various technological schemes and production workflows.

Bucket wheel excavator

The bucket wheel excavator is the most important type of continuous excavator used on the mining sites. This type of excavator exceeds in both its simplicity and productivity the one bucket excavators and the ones with several cups like bucket-chain excavators.Since the last activity and so far from the Oltenia mining basin, it has been proved that the most appropriate equipment for the extraction of stripping and coal is the bucket wheel excavator.

In the coal pits from Oltenia, nowadays are used the bucket wheel excavators type SRs 470, SRs 1300, ESR_c – 1400 30/7 and SRs 2000.

In the coal pits of Oltenia, the transport is made by belt conveyors, equipped with continuous flow technologies for coal and sterile as well.

The belt width is between 1200 – 2250 mm and speed of 4.19 – 6.15 m/sec, having an hour transport capacity of 2500 – 12500 m^3/hour.

The transport systems of the working benches ensure the transport of the excavated masses to the coal yards as well.

The spreaders of Oltenia mining basin have a capacity of 2500 m^3/h, with an arm of 50 m, 4400 m^3/h, with an arm of 60 m, 6300 m^3/h, 6500 m^3/h and 12500 m^3/h with an arm of 90 m. For the directly dumping, are used the dumpers with an arm of 120 m and 170 m, which take the material from the last bench of the coal pit.

3. SIZING THE COAL FACES

For sizing the geometric elements of the benches need to be taken into account: the physical-mechanical characteristics of the rocks, the working conditions characterised by the extracting and exploiting method and the functional parameters of the equipment used to perform various operations.

Geometric dimensions of the benches i.e. the height of benches, slope angle and width of berms shall be calculated and shall be based on: (Predoiu I.C, 2012)

- structure of the massif that forms the benches;
- the physical and mechanical characteristics of rocks from the bench;
- working conditions, characterized mainly by the methods of mining and extraction technologies applied;
- technological parameters of the equipment used to perform various operations on the front, etc.

Height and pitching of the berms

Determination of the benches height can be done in two ways: one, taking into account the physical and mechanical properties of rocks to be extracted, and another practice, which takes into account the equipment and technologies.

The way forward in solving this problem is to determine the height of the bench after both criteria and to accept and work on site with the minimum height that will ensure the stability of slope angle and safety of machinery placed on the fronts and on the berms.

Determination of heigth and pitching of benches and coal faces by the nature and physical and mechanical features of the rocks

The main geo-technical indices of rocks and mixture of rocks, used in the stability calculations are: **apparent specific gravity (γa)** also called **volumetric weight**, **cohesion (c)** and the **sliding angle (φ)**. In the case of a minimum resistance surfaces, along which it can develop slips and crushes, need to determine cohesion and friction of the rocks on these surfaces too.

Over time, in the mining basins of Oltenia, deep drillings have been made and sampled, which have undergone tests to determine the physical and mechanical properties of rocks. These samples are estimated in the hundreds on the perimeter and thousands throughout the area.

For this paper, we have studied the nature of the rocks on exploitation perimeters we have extracted the summary table (table 1) with minimum and maximum values for all types of rocks found in the Oltenia area.

Table 1 – Physical and mechanical features of rocks from Oltenia coal pits

Type of rock	Volumetric weight, γ_v [kN/m³]	Cohesion, c [kN/m²]	Sliding angle, φ [degrees]
Clay	19.0-21.0	21.0-48.0	16-23
Carbonaceous shale	15.6-19.2	50.0-70.0	30-34
Rich clay	18.8-20.1	40.0-65.0	22-27
Loam	18.8-20.8	14.0-32.0	15-22
Adobe	19.9-20.4	20.0-40.0	13-21
Sandy marl	19.2-20.5	24.0-52.0	23-27
Clay powder	18.5-20.7	16.0-22.0	10-17
Gouge	18.4-19-9	12.0-20.0	17-19
Loam sand	17.0-20.0	5.0-16.0	24-27
Close sand	17.5-19.0	4.0-12.0	22-26

Calculation of the bench height performed in rocks of low and very low strength can be done after a series of analytical procedures, which take into account both the slope geometry, the physical-mechanical properties of the rocks, and the shape surface of potential slip, the final results being shown in table 2.

The useful mineral substance (lignite) from the coal faces has the following physical-mechanical features (table 2):

Table 2 – Physical-mechanical features

Useful mineral substance	Volumetric weight, γ_v [kN/m^3]	Cohesion, c [kN/m^2]	Sliding angle, φ [degree]
Coal (lignite)	12.5	80	25

Because in practice, the coal faces of the coal pits are made up in majority of cases by the combination of rocks, we resorted to the real height of the bench size (equations 1, 2, 3,4) (figures 1, 2,3), (tables 2, 3, 4) by taking the weighted average of the values of the main physical and mechanical properties of rocks (c, γ, φ), (s = 1, 2) for various working fronts encountered in practice:

$$C_{med} = \frac{\sum C_i \cdot h_i}{\sum h_i} \quad (1)$$

$$\gamma_{med} = \frac{\sum \gamma_i \cdot h_i}{\sum h_i} \quad (2)$$

$$\varphi_{med} = arctg \frac{\sum tg\varphi \cdot h_i}{\sum h_i} \quad (3)$$

➢ **Example 1:** **Table 3** – Rocks of the extraction bench

Type of rock	γ_v	***k***	φ	***h***
Clay	2	2.83	16	**10**
Loam	1.98	1.91	24	**5**
Carbonaceous shale	1.92	4.16	15	**4**
Coal	1.25	6.66	25	**1**
Weighted average	**1.94**	**3.06**	**18.34**	**20**

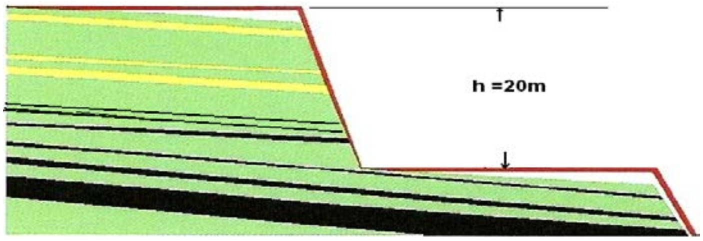


Fig.1. Coal face and geological profile, bench IV, E 1400 -11M, Pinoasa coal pit

Checking with the ratio:

$$h_{ad} = \frac{2k \sin\alpha \cos\varphi_1}{\gamma \sin^2\left(\frac{\alpha - \varphi_1}{2}\right)} \quad (4)$$

Table 4 – Height calculation for different slope angles

k	α	φ	γ	h_{ad}
3.06	**50**	18.34	1.94	**30.83**
3.06	**55**	18.34	1.94	**24.80**
3.06	**60**	18.34	1.94	**20.51**
3.06	**65**	18.34	1.94	**17.30**
3.06	**70**	18.34	1.94	**14.82**

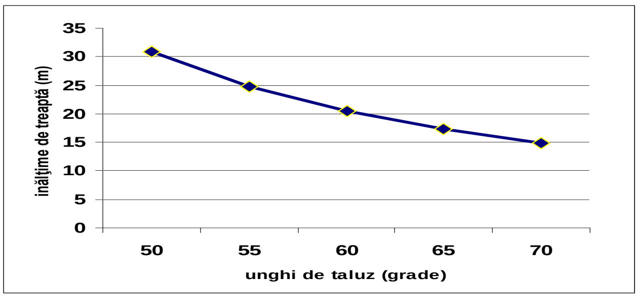
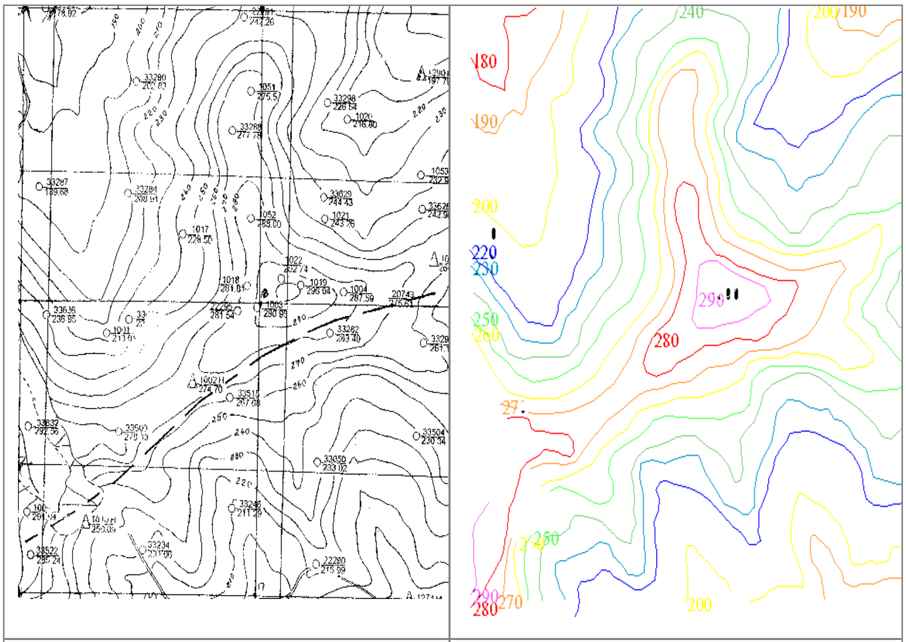


Fig. 2. Height variation h_{ad} according to the slope angle



- a) A4 scan contour of the map site plan
- b) A4 scan digitized contour with associated colours

Fig. 3. Presentation of an A4 scan

In this case it is observed that the maximum height for the front slope angle α = 700, is h ≈ 15 m, and as the slope angle decreases, the front height increase to a value more than 30 m.

4. USE OF DESIGN SOFTWARE (SURPAC VISION)

4.1. Presenting the methodology of making a virtual model [6]

To achieve virtual modeling of the deposit, the following procedures must be followed:
- collecting all data and other information necessary for the model;
- the construction and validation of the database containing the information about the lithological columns of drilling and geological model. This involves interpreting the pattern, quantity and quality of resources.
- the software package that was developed three-dimensional model of the lignite deposit area Pinoasa NORTH (area taken as a case study) is called Surpac Vision. This program is designed for computer modeling of the real world. The system is used for creating, editing and updating virtual models electronically.

Using this program geologists can create geological models, which can then edit, track a three-dimensional environment and update according to the mining works in reservoir modeling. Engineers can model mining operations also can update according to their evolution. Surveyors can make accurate models of a topographic surface. All these models are interrelated and allow the calculation of reserves volumes of content and other useful minerals from which it can make detailed plans to exploit the deposit of solid minerals.

This program works with data collected in the field of drilling and mining. All data used by the program are stored as strings. A string is a sequence of points in space of coordinates X, Y and Z. The series of points may represent an element of the fact, for example a terrain surface, a volume, etc.

As the drawing paper is made in several lines, which in this context is a picture of an item, and the row is the same, but with the difference that they are represented in three-dimensional space and can be rotated, viewed from the diverse angle, enlarged, reduced and so on.

All the points that define a range, have their coordinates and a numerical identifier. String that contains these points also is assigned a numerical identifier unique.

4.2. Working mode [7]

To represent the deposit from Pinoasa North perimeter was used in the following methodology:
- collect data in the archives of Tg-Jiu Mining Division Branch on the investigated area, the data being collected from existing wells and mining.
- data format from classic paper in digital format in order to build database.
- geological database contains three tables, namely Table "collar", which contains data about boreholes (coordinated reached final depth of drilling and well completion keyword - vertical, linear or curved); table "survey" includes information on how to conduct drilling, containing its deviations and Table "translation" in which to find data on existing rocks in the investigated area.

Additionally, the database can contain other tables on stratigraphic columns of each drilling and chemical analysis.

- creating the database involves entering information on drilling wells ie the coordinates of the starting point of the wellbore, the odds that drilling has intercepted coal layers, thickness of coal layers intercept and slope of these layers, corrected for deviation of the probe.
- to create the database were introduced over 15,000 records relating to drilling, to offset them, even if they were considered vertical stratigraphic columns of wells, the data being retrieved and translated from the classic paper electronically. Besides transposition electronic data, we performed several calculations to obtain the data necessary to create the database. Using existing data in the database using Surpac Vision software package were generated graphics, three-dimensional stratigraphic columns of wells, surface terrain and roof plans and the strata encountered nesting area.
- to achieve the digital terrain model took A0 plan situation and I scanned A4. After making the necessary scans, move to digitize contour related to each part A4.
- in figure 7 is shown a scan inside the perimeter studied with an area of 1,000,000 square meters.

The following images are presenting selectively different results that can be reached: (figures 4÷8).

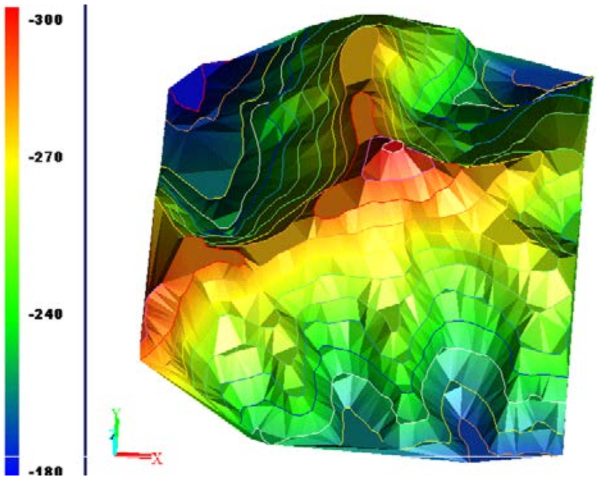
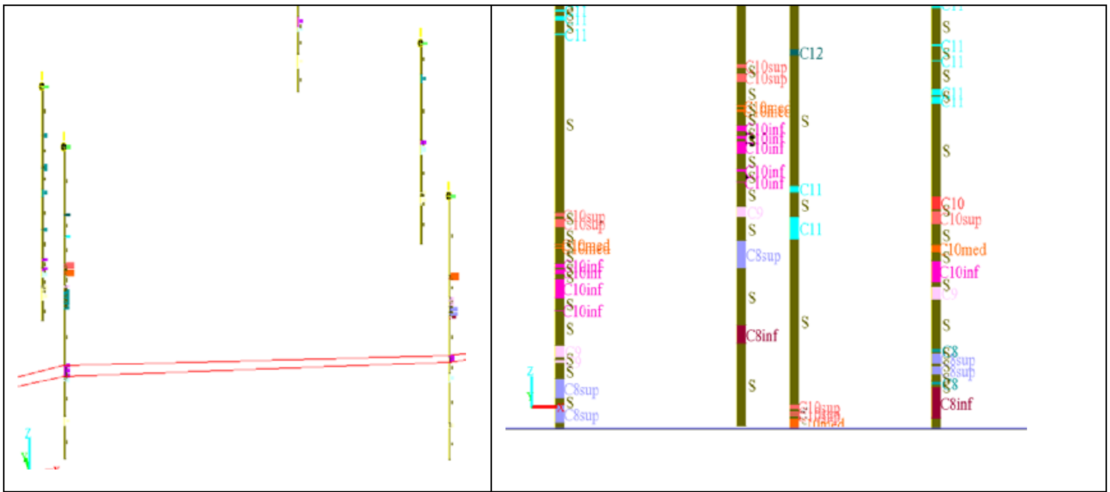


Fig. 4. DTM (Digital Terrain Model) of the previous scaned surface, using SURPAC



- a) section between two drills
- b) interception of layers for 4 drills
- division of layers into beds

Fig. 5. Details about the lithological column of the drills

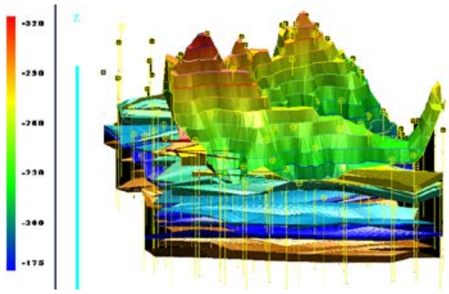


Fig. 6. DTM of the surface, drills and coal layers

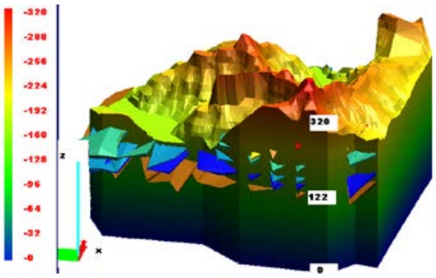


Fig. 7. Building a SOLIDE with the surface and layers of the perimeter

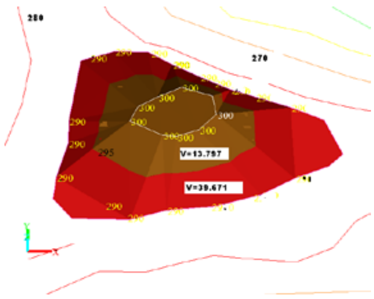


Fig. 8. DTM Rogojelu Hill, level 290-300 (volume calculation)

5. CONCLUSIONS

- For dimensioning the geometrical elements of the benches it need to take into account of: physical and mechanical properties of rocks, the conditions of work according to the extracting and exploiting method and functional parameters of the equipment used to perform various operations.
- Calculation of the benches height performed in rocks of low and very low strength can be done after a series of analytical methods which take into account both the slope geometry and physical-mechanical properties of the rocks, and the shape of the potential sliding surface.
- The height of the benches, determined on the basis of physical-mechanical properties of the rocks, it is often a few tens of meters, which cannot be supported in practice, always taking into account the possibilities for work and safety in operation of the equipment.
- By comparing the results obtained with the help of topographical measurements, with the values of the coal face height, depending on the front end slope angle, with the main characteristics of bucket wheels excavators, as well as with the results of the analytical processes, based on nature and physical-mechanical properties of the rocks that make up the bench, evidenced by the fact that the machinery of the Oltenia coal pits operate in a safe and secure mode.
- As a result of measurements made on the basis of specialized studies and systematic observations on the behavior of the slopes and coal faces of the Oltenia coal pits, it has been concluded, depending on the height of the benches where the bucket wheel excavators were working, values of the active slope, as follows:

$h \leq 10$ m , α_{slope} lateral active 50-65°; α_{slope} front end active 55-70°;
$h = 10\text{-}22$ m, α_{slope} lateral active 50-60°; α_{slope} front end active 55-70°;
$h > 22$m, α_{slope} lateral active 50-55°; α_{slope} front end active 55-65°.

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