RESEARCH ON LOAD CARRYING CAPACITY OF BASE TERRAINS OF THE WASTE DUMPS IN JIU VALLEY

Maria LAZAR, ***Prof.Ph.D., University of Petrosani***
Adrian FLOREA, ***Assoc.Prof.Ph.D., University of Petrosani***
Florin FAUR, ***Assist.Prof.Ph.D., University of Petrosani***

ABSTRACT: *Because the base terrains on which are located the waste dumps in Jiu Valley are different in terms of geological structure and form, overcoming their carrying capacity can lead to repressions or in extreme cases landslides. In cases where underneath the base terrains on which are located the waste dumps there are active or abandoned mining works interference may occur leading to a significant decrease in the initial carrying capacity. This paper examines the carrying capacity of the terrain on which are built the waste dumps storing large volumes of material.*

KEY WORDS: *base land, waste dumps, carrying capacity*

1. PURPOSE AND OBJECTIVES OF THE PAPER

As a result of exploitation of hard coal in mines located in the Jiu Valley results significant amounts of waste rocks, derived from opening and preparation operations, but also from coal preparation processes. The waste rocks are deposited in dumps of various sizes, placed on level ground or on slopes. Although dumps building projects envisaged topsoil stripping (for reasons of stability, increasing the carrying capacity of the base land, and for reasons of environmental protection), in most cases the dumps were formed without fulfilling this requirement, the direct foundation of the dumps being the topsoil.

Field observations have shown that in addition to superficial or deep sliding phenomena of slopes, the base land is affected by discharge phenomena, which indicates that the carrying capacity is exceeded, especially during periods with precipitations. The purpose of this paper is to determine the carrying capacity of the base land of active dumps that stores important volumes of rocks and identify measures to be taken in order to avoid discharge phenomena and damage adjacent areas or underground mining works.

Currently, there are 64 waste dumps in Jiu Valley that stores a volume of about 37 million m^3, occupying an area of over 250 ha [2]. Due to a lower activity in underground coal mining, most of these dumps were closed, being in different phases of rehabilitation and/or preservation. Among the active dumps, those that store large volumes of rocks are owned by mining units Lupeni, Uricani and Lonea and the dump owned by Coroeşti Coal Preparation (table no. 1)

Table 1 Characteristics of the waste dumps with volumes over 400000 m^3

Waste dump	Mining unit	Surface, m^2	Present volume, m^3
Branch 3	M.E. Lupeni	62700	1360108
New Funicular	M.E. Uricani	27000	547329
Branch 2	E.P.C.V.J.	112000	2573889
Lonea 1	M.E. Lonea	23000	426119

To achieve the goal, we started from the study of the existing documentation and direct observations in the field, new samples collected at the scene were analyzed in the laboratory, and the results were compared with those of existing stability studies and statistically processed. The carrying capacity of the base land was determined based on current regulations [7] and analyzed according to the pressure exerted by each dump in part, at natural humidity and saturation of the deposited rocks.

2. NEGATIVE GEOMINING PHENOMENA

Most dumps in Jiu Valley suffered deformations, from erosion to deep landslides, affecting also the base land by discharge phenomena.

2.1. Branch 3 – M.E. Lupeni

The dump Branch 3 is located between Boncii and Renghii hills, being a dump located on slopes. It is one of the dumps where geotechnical work necessary for setting the foundation, topsoil removal, scarification of base land or construction of twinning steps were not performed. Failure to carry out these works, plus the almost total absence of work necessary for capturing and routing the surface and even underground waters (springs), makes possible to appearance of instability phenomena such as landslides, discharge and erosion.

The main types of deformations present on the dump Branch 3 are represented by compaction, erosion, land slides and discharge of the base land [5].

Compactions are normal, of stabilization, due to compaction of the dumped material under its own weight and due to circulation of heavy equipments, and also occur as a result of the dumping technology which does not provide a very high degree of compaction of the mixture of rocks. They have generally a favorable action on the stability reserve by reducing the slope angle and the height of the dump, but also by increasing the compaction and cementing the dumped material, with positive effects on shearing strength of rocks.

In addition to normal compaction inside the dump's body, there are present some phenomena of subsidence with ground breaking (in steps) of the base land. The presence of these phenomena are due to underground mining activity, respectively the work fronts of Barbateni mine, and they appear downstream of the southwestern slope of the dump [5].

Erosion occurred as a result of mechanical action of surface water from rainfall and the lack of catchment and routing works, which led to the formation of gullies of different sizes, depending on the intensity of the runoff and the degree of compaction of the dumped material (photo 1).

a b

Photo 1 Erosion phenomena on the northeastern (a) and southwestern (b) slope of the dump

The dump quite frequently is affected by landslides on the slopes, occurring both in the dump, as well as through the base land, due to the tilt surface of contact, the presence of topsoil in the foundation and water infiltrations that wets the rocks and reduce their strength characteristics. The sliding surfaces are, regularly, of the progressive type and cylindrical-shaped.

Besides these slides of the heap, there must be mentioned some breakage and slippage of the slopes in the surrounding areas. It was considered that these were caused by underground mining activities.

Discharge of rocks occurred in the base land, at the boundary of the slope sliding area in the southwest part of the dump (photo 2), and they occurred due to transmission of the slipping through the direct foundation (topsoil) by pushing rocks from the bottom of the dump [5].

Photo 2 Discharge of rocks through the base land in the slipping area

Works for combating negative geominig phenomena were minimal, summarizing to the leveling and terracing works executed to restore the dynamic balance of active and passive forces in the area affected by the landslide.

In the area of the angular station, no significant instability phenomena were observed, outside rocks settling slips occurring where the limit height of the formation cone and the slope angle are exceeded. Not even in this area there were not executed works for foundation improving and the expanding of the dump towards the lake formed in the area of the hydraulic manifold causes a very weak interaction between the deposited rocks and direct foundation. For this reason, there is a risk of plastic flow phenomena occurring on the base land [1, 3], formation of dynamic shocks by sliding a larger amount of material in the lake, which may affect the stability of hydraulic manifold and uncontrolled discharge of water from the lake.

2.2 New Funicular – M.E. Uricani

The dump consists of three main bodies. Following field observations and mapping the area it was found that the three dump bodies, although their geometry is not uniform, are stable and there are no special deformation phenomena.

It can be seen, however, some geomining phenomena specific for waste dumps such as compaction of the dumped material, erosion and discharge of slopes and base land [5].

Erosion occur as a result of training the dumped material by runoffs, the dump being affected by such events on the side slopes (photo 3).

Photo 3 Erosion phenomena

Discharge of slopes and/or base land are the result of the transition of rocks in a plastic failure state, after which occurs a shift of argillaceous rocks from the dump and the base land under the influence of the dumped rocks weight. Such phenomena were observed more rarely in the case of ME Uricani dump.

2.3 The dump of Coroeşti Processing Plant

The dump has a relatively uniform geometry, due to technological works and geomorphology of the area in which it is located.

In terms of geometry, the waste dump is characterized by high values of the height and slope angle (often exceeding 30 m height and the slope angles are between 30 - 43º (photo 4). Due to geometric elements, land's morphology and by worsening the physical and mechanical characteristics of the deposited rock and the rocks from the direct foundation (represented topsoil), rainfall and the existence of lakes from which water seeps under the dump, the eastern slope was affected for a number of slides that have expanded and covered the road in the area (photo 5) [5].

Photo 4 Eastern and western slopes

Photo5 Sliding area on the eastern slope

Rainfall represents the main supply source of groundwater and existing streams on the two branches of the dump. Due to slow infiltration of water, wetting of the base rocks and deposited rocks in the lower part of the dump occurs, thus decrease their strength characteristics. If the precipitation are in the form of heavy rains, they have a destructive action by causing erosion [1, 3]. These phenomena are located mainly in shallow formation areas of the dump [5].

__2.4 Lonea 1 -EM Lonea__

The old dump of Lonea mine is affected by phenomena of ruptures, curls, thrusts and plastic slides of the slope and plastic failure phenomena of the base land, particularly in the north-east (photo 6) [5]. At the base of the new dump there were identified a number of water reservoirs, which are located along the abandoned conveyor route on a NW-SE direction, over a distance of 30-50 m (photo 7). The status of tensions in the area is explained by the absence of an appropriate geometry, improper geometrical parameters of slopes (19-20 m height and inclination of 30°-50°) and the presence of water seepage at the contact between the dump and the base land.

Photo 6 Discharge phenomena and slope ruptures

Photo 7 Ruptures, slides, discharges and gullies

In case of slow melting snow, water seeps to the bottom of the dump, and some drain to the surface and trains a portion of the dumped material.

3. PHYSICAL AND MECHANICAL PROPERTIES OF DEPOSITED MATERIALS AND BASE LAND BASED

Physical and mechanical characteristics (bulk density, cohesion and angle of internal friction) of earths are qualitative indices that respond to solicitations or the stresses that occur in the dumps and base land. Based on these values the size of the geometric elements of the dump and steps are determined.

Resistance characteristics are used in both the design and analysis of stability, but also in determining the carrying capacity of the base land. For this reason it is necessary to determine them rigorously, as the uncertainty on their values are transferred to the calculations. Strength characteristics of the material from the dumps and base land were determined in the earths mechanics laboratory of the University of Petrosani [5].

Since the values of these features vary within very wide limits, for the calculations were considered the statistical determined values (Table no. 2).

Table 2 Calculation values of the physical and mechanical characteristics

Rock type	Natural humidity			Saturation humidity		
	Volumetric weight γ_{nat}, (kN/m^3)	Cohesion, c, (kPa)	Angel of internal friction φ (grade)	Volumetric weight γ_{sat}, (kN/m^3)	Cohesion, c, (kPa)	Angel of internal friction φ (grade)
Branch 3 – ME Lupeni						
Waste material	18,7	31,38	27	19,4	25,49	23
Topsoil (dump's direct foundation)	18,0	33,34	26	19,2	24,51	21
New Funicular - ME Uricani						
Waste material	18,1	35,30	32	19,2	28,43	24
Topsoil (dump's direct foundation)	16,3	29,42	19	17,2	27,45	9
Coroeşti Processing Plant						
Waste material	17,2	27,45	26	19,1	14,71	12
Topsoil (dump's direct foundation)	18,2	34,32	20	18,2	19,61	14
Lonea 1 - ME Lonea						
Waste material	18,1	17,65	20	19,2	13,72	15
Topsoil (dump's direct foundation)	18,9	19,61	21	19,1	14,71	16

It is mentioned that laboratory measurements were made on both samples with the natural and saturation humidity.

4. DETERMINATION OF THE CARRYING CAPACITY OF THE BASE LAND

According to Normative for designing structures of direct foundation NP 112-04, 2005 [7], in the calculation of the carrying capacity of the base land the following condition must be satisfy:

$$P_{ef} \leq P_{cr} \quad (1)$$

were: P_{ef} – calculation value of the vertical action or the vertical component of total shares applied on the foundation base;

P_{cr} – calculation value of the carrying capacity.

The critical pressure what can be supported from the land was calculated on the basis of the national standards [4, 7], using the equation:

$$P_{cr} = \gamma^* \cdot B' \cdot N_y \cdot \lambda_\gamma + q \cdot N_q \cdot \lambda_q + c^* \cdot N_c \cdot \lambda_c \quad kPa \quad (2)$$

where: γ^* - volumetric weight of the rock layers under the dump, kN/m^3;

B' – reduced width of the dump base, m;

q – calculated overload acting on the side at level of the dump foundation, kPa;

c* - cohesion of the rocks layer under dump base, kPa;

N_y, N_q, N_c – dimensionless coefficients of the bearing capacity that depend on the angle of internal friction φ* of the rock layers under the dump;

λ_γ, λ_q, λ_c – shape coefficients of the dump base, depending on the reduced width and reduced length of the dump base.

On the basis of the geometrical and geotechnical characteristics and taking into account that overload q is null (because the dump is built directly on the land) have considered the following calculation values for the two cases: natural humidity of the rocks (table 3) and for water saturated rocks (table 4):

Table 3 Calculation elements and results – natural humidity

Halda	γ* kN/m^3	B' m	N_y	λ_γ	c* kPa	N_c	λ_c	P_{cr} kPa	P_{ef} kPa
Branch 3 – ME Lupeni	18,0	95	4,5	1,07	24,51	22	0,93	7589,94	622,62
New Funicular - ME Uricani	16,3	50	1,8	1,13	27,45	14	0,88	1654,84	1651,11
Coroeşti Processing Plant	18,2	150	1,9	1,11	19,61	14,2	0,89	4754,30	702,71
Lonea 1 - ME Lonea	18,9	48	2,0	1,16	14,71	16	0,84	1700,35	1785,36

Table 4 Calculation elements and results – saturated rocks

Halda	γ* kN/m^3	B' m	N_y	λ_γ	c* kPa	N_c	λ_c	P_{cr} kPa	P_{ef} kPa
Branch 3 – ME Lupeni	19,2	95	2,1	1,07	24,51	15,5	0,93	3910,05	645,93
New Funicular - ME Uricani	17,2	50	0,2	1,13	27,45	7,8	0,88	390,38	1751,45
Coroeşti Processing Plant	18,2	150	0,7	1,11	19,61	10,2	0,89	1855,11	780,34
Lonea 1 - ME Lonea	19,1	48	0,9	1,16	14,71	11,9	0,84	848,74	1893,86

It should be mentioned that in the calculations were considered the average sizes of waste dumps and their effective pressure was accepted as a uniformly distributed load.

Analyzing the two tables it can be seen that:

- Under natural humidity of the rocks deposited in the dump and the base land
  - the specific effective pressure generated by the dumps Branch 3 - ME Lupeni and Coroeşti Processing Plant do not exceed the critical pressure, with a covering safety factor;
  - the specific effective pressure generated by the dump New Funicular - ME Uricani is almost equal to the critical pressure;
  - the specific effective pressure generated by Lonea 1 dump is slightly above the critical pressure.
- Under saturation humidity of the rocks deposited in the dump and the base land
  - the specific effective pressure generated by the dumps Branch 3 - ME Lupeni and Coroeşti Processing Plant remains below the critical pressure;
  - the specific effective pressure generated by the dumps New Funicular - ME Uricani and Lonea 1 exceed by far the critical pressure value.

The results obtained by calculation are confirmed by the reality in the field, the most serious situation being obseved at Lonea 1dump, where deformation phenomena of the base land occurs frequently; especially in periods of excess moisture.

5. CONCLUSIONS

This paper was developed starting from field observations, which revealed that in some waste dumps from Jiu Valley deformation phenomena of the base land around them are present, especially in the form of discharge of rocks and plastic failure. The study includes four of the largest dumps, namely or Branch 3 -

ME Lupeni, New Funicular - ME Uricani, Coroeşti Processing Plant dump and Lonea 1 - ME Lonea. Research and calculations led to the conclusion that for the dumps New Funicular - ME Uricani and Lonea 1 - ME Lonea the carrying capacity of the base land is exceeded, especially during periods of heavy rainfall or snowmelt. The main cause of these phenomena is the fact that the dumps were built without removing the topsoil, and the ratio between the stored volume of rocks and the occupied area is unfavorable.

REFERENCES

[1] **Băncilă, I.** - *Geological engineering,* vol. I and II, Technical Publishing House, Bucureşti, 1981.

[2] **Fodor, D., Baican, G.** - *The impact of mining industry on the environment*, Infomin Publishing House, Deva, 2001.

[3] **Florea, M. N.** - *Landslides,* Technical Publishing House, Bucureşti,1979.

[4] **Lehr, H**. - *Foundations. Calculation Samples,* Ed. Technical Publishing House, Bucureşti, 1967.

[5] **Rotunjanu, I., Lazar, M. s.a**.,- *Stability studies for the active waste dumps belonging to the mining subunits within CNH- Petroşani, 2005;*

[6] *** *Specific rules of labor protection for minerals extraction in open pits. Technical requirements for the design, development and conservation of waste dumps. Ministry of Labour and Social Solidarity, Bucureşti, 2000.*

[7] *** *Standard for the design of direct foundation structures NP 112-04, 2005.*