THE STABILITY ANALYSIS OF INTERNAL OVERBURDEN DUMP REINFORCED WITH GEOSYNTHETIC IN OPEN PIT MINE "KOSOVA"

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ABSTRACT

This paper discusses the slope stability analysis of internal overburden dump called "East Dump" in open pit coal mine "Kosova". In this dump continually occurrence slide of the materials that have been dumped (yellow and grey clay). For solution of the dump stability problem, firstly current situation of the dump is analyzed, then dump design and in the end dump design - slope reinforced with geosynthetic/geogrid. The primary aim of design of internal overburden dump is to provide effective stable working conditions for tow stackers. The slope stability and factory of safety was analyzed in selected location along the slope by using limit equilibrium method, such is Bishop's method. The analysis has been done using Mohr-Coulomb model by using GGU-STABILITY software. Finally, an economical, sustainable and stable dump angle and height was analyzed for a safe dumping.

Keywords: dump stability, factory of safety, bishop's method, geosynthetic.

INTRODUCTION

Lignite as the energy capital resource of Kosovo participates with 97% in the total electricity production. According to a draft government strategy estimated coal resources throughout Kosovo reach about 12.5 billion tons, of which 8.6 billion tons in economic terms are considered profitable for exploitation, and according to a World Bank report of 2005, coal reserves estimated 15 billion tons. So Kosovo calculated the fifth country in the world in terms of coal reserves.

Open pit coal mines in Central Kosovo are the main source of electricity, with an annual production of about 7-9 million tons of lignite coal.

Power requirements are much higher, but the condition of coal mine, power plants, electrical grid, mechanization makes this impossible.

Various deposit of lignite in Kosovo is very suitable conditions for exploitation. Overburden-coal ratio approximately 1.5:1.

The removal of overburden is the first step in a coal winning operation, so as to expose underlying coal for excavation. The overburden material being a non-marketable product, it is removed and dumped safely and economically [1].

Overburden dumps can be external dumps created at a site away from the coal bearing area or it can be internal-dumps created by in-pit dumping concurrent to the creation of voids by extraction of coal.

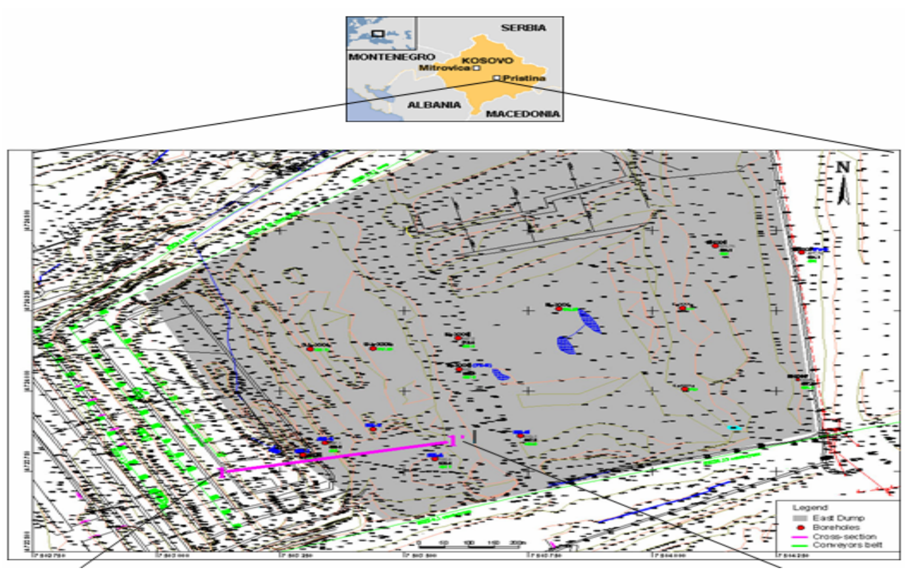

Figure-1. Location map of the internal "East Dump" and boreholes for the geotechnical investigations.

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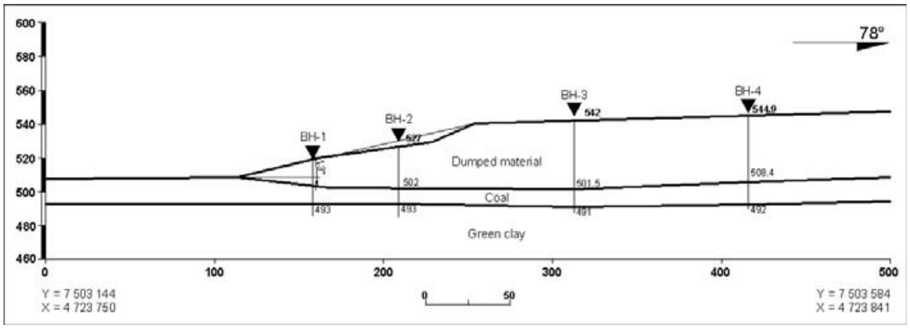

Figure-2. Representative cross-section 1-1': materials type in the overburden dump.

THE SLOPE STABILITY ANALYSIS

The geology, ground condition and the nature of the material is the major influencing factors in stability analyses. Stability analysis were carried out on the representative cross-section 1-1' of dump to determine safe slopes and bench widths for stacker and other heavy machinery to operate on the dump without risking infrastructure or human life. For the exiting condition slope stability analysis was analyzed using the Bishop circular failure method (Figure-3).

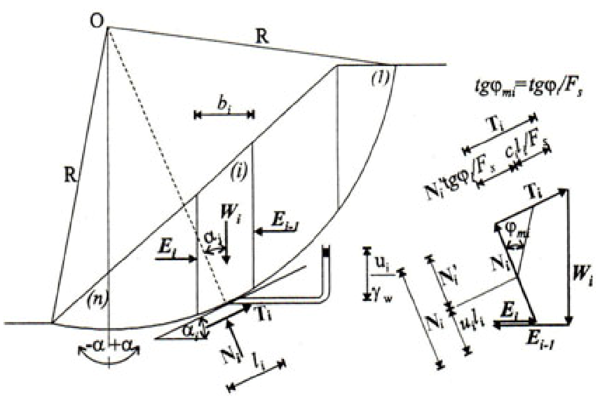

Figure-3. Forces on a typical slice - Bishop's method.

The Bishop solution for the factory of safety (FS) is obtained in the form:

$$FS=\frac{1}{\sum_{i=1}^{n}W_i\cdot\sin\alpha_i}\sum_{i=1}^{n}\left[c_i\cdot b_i+W_i\left(1-r_u\right)tg\varphi_i\right]\frac{1}{m_{\alpha_i}} \quad (1)$$

$$m_{\alpha_i}=\cos\alpha_i\left(1+\frac{tg\alpha_i\cdot tg\varphi_i}{Fs}\right) \quad (2)$$

where

c = cohesion
φ = angle of friction
r_u = pore pressure coefficient
FS = factory of safety (FS > 1.30)

Current dump condition

Slope stability analysis for current dump condition is carried out for following geometrical, physic-mechanical and hydro-physic parameters:

- slope inclination angle α = 13°,
- dump height h = 42 m,
- γ = 16.52 kN/m^3, c = 3.87 kN/m^2, φ = 9.7°,
- pore pressure coefficient r_u = 0.00-0.30.

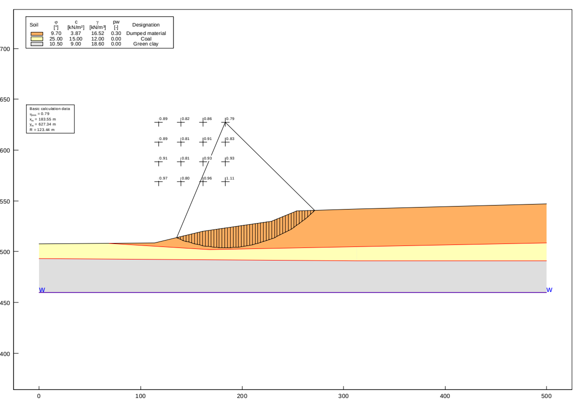

Figure-4. A typical stability analysis results for current dump condition FS = 0.79.

Dump design considerations

In order for the stacker to efficiently spread overburden materials, the dump must provide a suitable working surface for the stacker to operate [1]. The dump design included the following slope geometry parameters:

- 28° bottom and top side slope,
- maximum slope heights of H = 45 m from bottom side and h = 15 m for top side slope,
- operational bench width for stacker b = 80 m.

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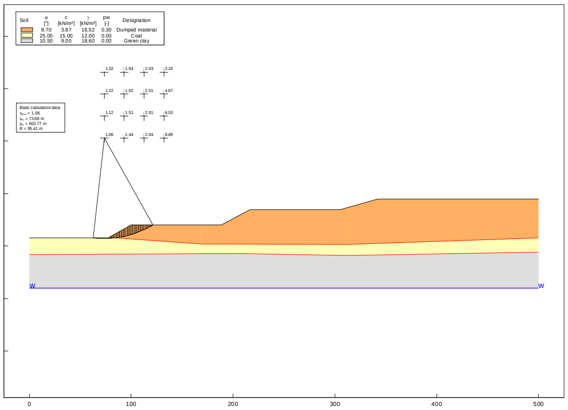

Figure-5. A typical stability analysis results for dump design considerations FS = 1.06.

Table-1. Results of slope stability analysis.

Pore pressure coefficient r_u (kN/m^2)	**FS for current dump condition**	**FS for dump design considerations**
0.00	1.03	1.25
0.10	1.00	1.18
0.20	0.89	1.12
0.30	0.79	1.06

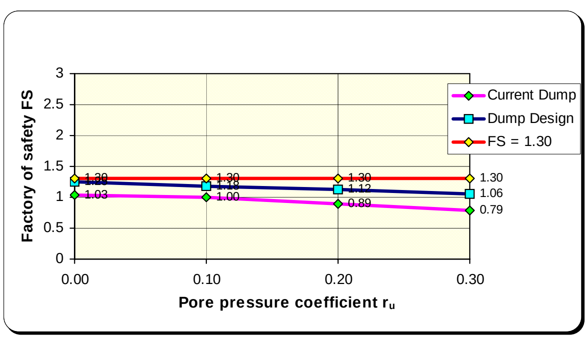

Figure-6. Graphical presentation of FS in relation to r_u.

For mining environments a factor of safety of 1.30 is considered to be sufficient.

GEOSYNTHETICS

Geosynthetics are the generally polymeric products used to solve civil engineering problems. Most geosynthetics are fabrics or sheets of various sizes, strengths, and textures. They are generally made of plastics such as polypropylene, polyethylene, and polyester [2]. Geosynthetics can be divided into four main categories: geotextiles, geogrids, geomembranes and geocomposites. It is convenient to identify the primary function of a geosynthetic as being one of: separation, filtration, drainage, reinforcement, fluid containment, etc.

Slope reinforcement design using geogrids

Geogrid reinforced slopes can be an economical alternative to conventional slope design.

Soil reinforcement using high tensile strength inclusions can increase the shear resistance of a soil mass. This strengthening permits construction of soil structures at slope angles greater than the soil's angle of repose and/or greater than would be possible without the reinforcement (Bonaparte *et al*., 1987).

Figure-7. Geogrids.

Geogrids are placed in layers during construction to intercept and stabilize potential slip surface. Geogrid soil reinforcement impart tensile strengths to the soil, thereby increasing the slopes overall factor of safety against sliding or rotation (Figure-8).

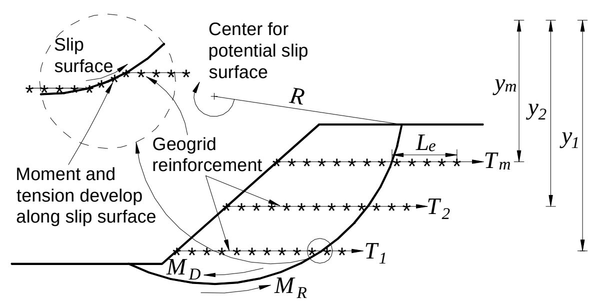

Figure-8. Geogrid reinforcement of soil.

$$FS = \sum \frac{\text{Resisting moment}}{\text{Driving moment}} = \frac{M_R}{M_D} \quad (3)$$

The factory of safety for a reinforced slope is expressed as:

$$FS = \frac{M_R + \sum_{i=1}^{m} T_i \cdot y_i}{M_D} \quad (4)$$

where

T_i = allowable reinforcement strength
y_i = appropriate moment arm(s)
m = number of separate reinforcement layers

For the internal overburden dump is required to determine:

a) the factory of safety without geogrid reinforcement,
b) the factory of safety with a high-strength geogrid of allowable tensile soil T_{allow} = 200 kN/m', and
c) the factory of safety with three layers of the same geogrid placed at 3 m interval.

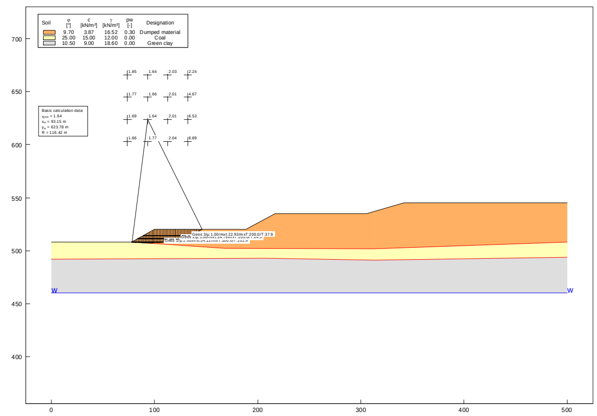

Figure-9. Circular slip analysis for reinforced slope.

a) Slope without geogrid reinforcement: FS = 1.06.
b) Slope with a geogrid along base with sufficient anchorage: FS = 1.26.
c) Slope with three layers a 3m interval from base, all of which have sufficient anchorage behind the slip surface: factory of safety FS = 1.64.

The length of geogrid extending beyond assumed failure surfaces is L_e=2-3 m.

CONCLUSIONS

In this paper, two main topics related to internal overburden dump stability study: slope stability analysis without and with geogrid reinforcement.
For current dump condition are obtained: FS < 1.10 for r_u = 0.00 and FS ≤ 1.00 for r_u = 0.10-0.30.
For dump design considerations: FS < 1.30 for r_u = 0.00 and FS < 1.20 for r_u = 0.10-0.30.
Slope reinforcement design using geogrids:

- unreinforced slope FS < 1.30, and
- reinforced slope with geogrids FS > 1.30.

Obtained values of the factors of safety show that reinforced soil using geogirds is very effective technique, because geogrids are light, flexible, strong, durable and very easy to install.

The use of geogrids technique has not been applied in the Kosovo coal mining industry as yet.

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