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Slope Stability Analysis for the Design of a New Lignite Open-Pit Mine

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Abstract

The paper presents geotechnical engineering studies for the design of a new lignite open-pit mine in central Poland. The lignite deposit occur in a deep tectonic rift formed in Mesozoic rock characterized by complex geological conditions. The rift is approximately 10 km long, 1 km wide and 50-250 m deep and filled with Neogene and Quaternary sediments. The design of the open-pit mine required geotechnical analysis to reveal possible problems that may occur during its construction and operation. The author of this paper had opportunity to perform slope stability studies and geotechnical analyses within the project conducted by Poltegor-Institute. The calculation procedure enabled determination of slope stability on the design of excavation and spoil dump. It included 21 analyses using Flac v.7 of which 14 regarded the slopes of the pit, 6 the slopes of the external spoil dump and one covered both areas. The results indicated that the factor of safety F_s ranges 0.75-1.65 for the pit and 1.12-1.60 for the dump. In risk areas slope inclination were lowered due to likelihood of developing of landslide processes. These included spoil dump area close to S-8 road. Due to relatively limited geotechnical data in same areas especially on northern slope and western part of spoil dump detailed geotechnical investigations will be necessary. The instability problems can be caused by the groundwater conditions and the presence of high compressibility organic peats in the spoil dump bedrock layers. Comprehensive identification and monitoring of geotechnical risks for the mine slopes and storage of overburden should be a continuous process. This activity should start from the beginning stages of construction and should be conducted also during exploration and continuing to mine final reclamation to reduce potential natural hazard impact on mining and the natural environment.

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1. Introduction

Lignite opencast mining has a significant contribution to the production of electricity in a number of European countries. Germany, Greece, Poland, Czech Republic, Bulgaria and Romania, produce approx. 96% of lignite in the European Union, a total of 433.8 mln t [4, 11]. In Poland 30% of electricity is produced from brown coal and it is one of the cheapest sources of energy. Over 45 billion tons of lignite was documented in Poland till this time. Till now only 2.6 billion were mined. Some of the older lignite mines will end the current deposits in the near future. The largest Belchatow mine will end production in 2038, the Turow mine a few years later. The plans to build a new coal mines were not finally decided but it requires in advance detailed recognition of geotechnical engineering conditions. Lignite mining in Poland, due to high, 200–300 m exploitation depth is often associated with geohazards. In the paper slope stability analyses for the design of a new mine in Zloczew are described. The preliminary design project of this mine was realized in 2014 by Poltegor-Institute [2]. The exploitation of lignite layers in a deep tectonic rift will require mining of large volume of limestone and marl rocks located on the south slope. The geotechnical engineering part of the design focused on description of potential geohazards. Paleolandslide deposits located on the South slope and low strength clayey soils on the North slope could pose slope stability problems during the coal exploitation. Others geotechnical problems could be connected with storage of large masses of overburden on the external spoil dump. Complex geological structure, rainfalls, changes in groundwater levels, seismic shocks and karsts processes could influence stability of slopes [10]. In the paper, conclusions connected with these problems together with the results of analysis are presented.

1.1. Localization and engineering geology conditions

The lignite deposit is located in Zloczew 4 km NW to the town at a distance of 52 km west to the Belchatow, in central part of Poland. The mine will be located in a tectonic rift, 1 km wide and length of 10 km. The rift of WWS-ENE direction is filled with Neogene and Quaternary sediments. It has an average depth of 150–250 m, maximum depth exceeds 341 m [5, 6]. Rift is intersected by numerous transverse faults of the NW-SE directions. The Mesozoic bedrock layers are represented by Upper and Middle Jurassic limestone's and marls. The main geological structures were formed during tectonic movements in the late Cretaceous period and Paleogene, when the area was uplifted and cut by a large network of faults. The complex Neogene Miocene and Pliocene age series of sandy loams and lignite's is filling the rift reaches a thickness from a few to more than 300 m. The thickness of coal varies 20–60 m, except in the central parts of the deposit where it reaches up to 114 m (average 46.2 m). Quaternary sandy and clayey sediments reach 110.8 m (average of 30–40 m). The average relation of overburden to lignite is 4.6:1. Total lignite resources are estimated at 876 mln tons. The design open-pit slope inclinations on the S-slope varied 1:2.4 - 1:3.1, on the N-slope 1:5.5 - 1:6 and on the external dump 1:4.7 - 1:6.6 [2]. The location of the designed pit and spoil dump, together with location of performed slope stability analysis is presented on Figure 1.

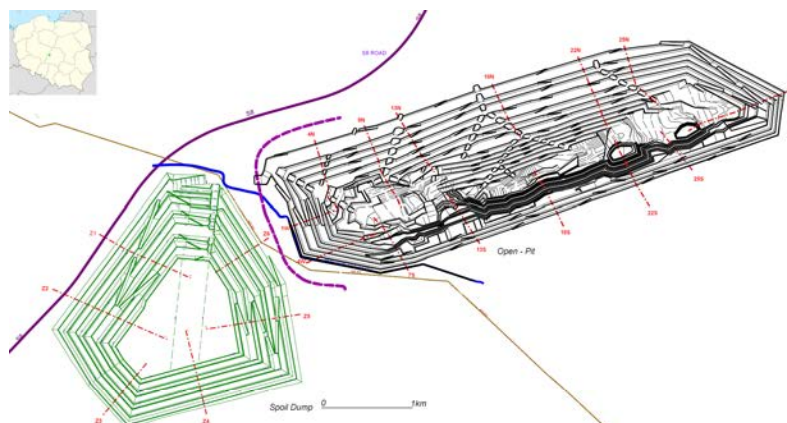


Fig.1. Location of the design open-pit and spoil dump and slope stability analysis [1].

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