Mine Waste Dumping and Corresponding Environmental Impacts at Chinh Bac Waste Dump in Vietnam

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ABSTRACT

One of the most important coal producing regions of Vietnam is the Quang Ninh province located in the north of the country. The Chinh Bac dump site operated by the Nui Beo Coal Company (NBCC) is situated in the Quang Ninh province and receives solid mine waste from the Nui Beo open pit coal mines that is dumped as sidehill fill. In the past, waste produced by the Nui Beo open pit coal mines has been dumped without considering environmental impacts. Environmental problems at the dump site are dust emissions into the air and contaminated surface water flow during the rainy season. Dust is produced during the transportation and dumping of the mine waste as well as drilling and blasting of the overburden. Seepage of the rain water occurs at some points through the dump. Cracks are present at the top of the dump and can pose serious stability problems with high pore water pressure values.

The dump has dimensions defined on the base of local experience only. Detailed monitoring and slope stability analyses are therefore required in order to ensure more stable dump dimensions to prevent unnecessary land degradation, avoidable environmental impacts and to ensure the workers safety. The RAME (Research Association Mining and Environment Vietnam) team is dealing with the environmental problems and developing concepts for the environmental protection at the coal mine waste dumps in the north of Vietnam. The Institute of Mining Engineering I (RWTH Aachen University) is coordinating and developing concepts for the stabilization of the mine waste dump together with the Chair of Geotechnical Engineering (RWTH Aachen University), Brenk Systemplanung as well as the Vietnamese group of companies VINACOMIN (Vietnam National Coal Mineral Industries Group) in the framework of RAME. The following paper describes the dump site, the environmental problems with emphasis on stability risks and the developing of stabilization concepts for the Chinh Bac waste dump.

INTRODUCTION

Open pit mines of Nui Beo Coal Joint Stock Company of VINACOMIN (Vietnam National Coal – Mineral Industries Group) produce anthracite coal in Quang Ninh province in the north of Vietnam. Waste rock is produced through the removal of overburden. The overburden forming waste to be dumped at Chinh Bac is removed from two open pit mines i.e. open pit mine number 11 and open pit mine number 14 of Nui Beo Coal Joint Stock Company. The dump site is located close to both open pit mines.

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Geologically the open pit mines are located within the lower sub formation (T₃n-r hₙ₁) of the Hon Gai formation. In addition to the coal seam, this formation contains sandstone, siltstone, conglomerate, gritstone and coaly shale. The formation consists of 15 members. The thickness varies from 50m to 420m for various members of the sub formation in different areas. The members have coarse grained sediments at the beginning and fine grained coal bearing sediments at the end (Anon., 2001). The average individual thickness of the coal seam of Nui Beo open pit mine is between 7m to 50m. The dip angle of the seam on average is 30°. The average stripping ratio at the mines is 5m³/t. (BBK I, 2008).

Conventional mining method is used for the removal of overburden. Old Russian (1960’s) manufactured drilling machines are used to drill the holes for blasting in addition to relatively new Swedish manufactured machines (Drebenstedt, et al., 2004). The old machines have low efficiency and drilling is accompanied with the emission of dust. Blasting is carried out using ANFO as explosive and blasting is also accompanied with dust emissions and vibrations which are problematic especially for the nearby residential areas. Secondary blasting is done if the size of the particle is more than 1.5m. The blasted overburden is loaded with shovels and is then transported to the dump site using trucks. Around 40 trucks are used for the overburden transportation. The amount of overburden to be transported in one trip is approximately 30 tons and the transportation distance is 5 km. Water is sprayed on the haulage roads to prevent the emission of dust. If water is not sprayed in time, the transportation of the waste through trucks leads to the emission of dust. No proper scheduling system exists for the trucks and shovels. Idle times are therefore sometimes available for trucks and shovels during the loading of the solid mine waste (BBK I, 2008).

CHINH BAC WASTE DUMP AND ENVIRONMENTAL PROBLEMS
The solid waste rock of Chinh Bac dump consists of sandstone (40-50%), siltstone (30-40%), clay stone (5-10%) and conglomerate (the rest proportion). The size range of the particles varies from 1mm to 1.5m. Although secondary blasting is done for the comminution of the larger particles, still sometimes the size of the largest solid waste particle to be hauled and dumped can be as large as the size of the hauling truck. The topsoil has not been removed before the start of the dumping at Chinh Bac mine waste dump. The base of the dump therefore consists of the topsoil. Thickness of the soils in the area is 5m on average. The soils in the area are alluvial with grain size varying from 0.0025cm to 2cm (BBK I, 2008).

The mine waste has been dumped since 2005 on Chinh Bac dump site. In 2005 around 13.5 million m³ solid mine waste was dumped on the site. The planned mine waste to be dumped in year 2008 is approximately 11.1 million m³. According to the current dumping plans, 15 million m³ of additional the mine waste will be dumped till the end of 2010 when the dumping will be decommissioned. As the stripping ratio is comparatively high at these open pit mines, the amount of solid waste produced is also quite high as compared with the production of coal. The total area covered by the dump is about 107 hectares at present. The maximum height of the dump is 256m AMSL (above mean sea level). Currently the slopes are as high as 130m with a general slope angle of 32°. Some areas of the dump consist of about 50m high benches with a slope angle of 27° while others have 10-20m high benches with slopes angles from 30° to 40°. The planned final
dimensions are 20m to 25m high benches. These dimensions have been defined on the base of experience according to which the maximum single bench height can be 30m (BBK I, 2008).

Figure 1. End-dumping at Chinh Bac.

The overburden is dumped as sidehill fill i.e. on the edge of the hill. The dumping method employed is end-dumping (material is dumped with truck back at the edge of the dump as shown in Figure 1) and back-dumping (material is dumped at the edge of pile and then pushed by the dozer which is shown in Figure 2) (Camm, 2000).

Figure 2. Back-dumping at Chinh Bac.

Normally, the solid mine waste is dumped directly with the truck i.e. no dozer is employed for pushing the material. If there is some amount of subsidence near the crest of the dump, the trucks dump the waste material near the subsided area. The dozer is then used to push the material down the slope. The subsidence has never been monitored near the crest of Chinh Bac dump (BBK I, 2008).

In sidehill fill dumping, segregation of waste dump particles occurs. The finer particles stay at the upper part and the coarser particles move towards the toe of the dump. As the dump advances horizontally, layers are formed parallel to the dump face. Due to the finer and coarser particles segregation, larger particles reside at the bottom side so that the drainage paths are available for the water movement at the base of dump in end-dumping (Marcus, 1997).

Chinh Bac dump is located within the monsoonal region having rainy and dry seasons. The rainy season starts in April and lasts till October. High amount of rainfall is observed in the region in July and August. In these months the rainfall can nearly be 700mm per
month and daily amount can reach to more than 200mm. With rain fall, seepage has been observed at various points of the dump especially near the bottom. But it has never been monitored in terms of quality and quantity. The water (surface run-off, interflow and seepage) from the dump flows into the ponds of nearby Ha Lam mine and open pit number 11 of Nui Beo Coal Company. The pH value of the water at one of the water collecting ponds was 3 which indicates high acidity of the water. Another environmental problem is the emission of the dust (Figure 3). Dust is not only emitted during drilling and blasting. Especially the transportation and dumping of the mine waste is a major dust source. Sometimes the haulage paths are sprayed with water but no dust preventive measure is applied during and after dumping (BBK I, 2008).

![Dust emission during dumping.](image)

The wind flows produce dust clouds which can be easily observed at the dump site. The emitted dust also reaches the nearby residential areas causing problems.

The problems of the dust at the dump site are being dealt by the Institute of Mining Engineering I at RWTH Aachen University, Brenk Systemplanung and CBM (Gesellschaft fuer Consulting, Business und Management mbH) together with VINACOMIN.

**STABILITY RISKS**

One major environmental problem is the existence of stability risks at the dump site. As there were no proper plans for the removed topsoil from the mine site to be used for the dump covers for vegetation later on (like mine wastes in western countries), it is therefore possible that this topsoil has been dumped along with solid mine waste. In sidehill fill dumping if the layers of overburden also contain layers of some type of weak material e.g. removed topsoil materials, its saturation with water from rain can lead to the start of the failure of the slope. It is believed that initial failures at the end-dumped coal mine waste dumps in British Columbia could have originated because of the saturated or nearly saturated foundation material layers inside the dump (Dawson, et al., 1998). Stability risk therefore exists due to the possible weak material layers inside the Chinh Bac dump.

Small and large cracks (Figure 4) can be found at the top of the dump site. The width of the cracks is sometimes more than 10cm. The subsidence is also observed at the crest areas of the Chinh Bac dump (BBK I, 2008). The existence of the cracks along with the subsidence and the additional weight of the mine waste at the crest area due to further
dumping from trucks can lead to the situation where the chances of an edge collapse have to be at least considered (Camm, 2000).

![Image](207x549 to 405x687)

Figure 4. Cracks near the crest of the dump.

During rainy season, water moves in through the cracks inside the dump. When this water moves inside the dump, it can increase the pore water pressure causing stability problems of the dump. Also movement of the water through the topsoil which was not removed before the start of the dumping at the bottom of the current dump can lead to a weak foundation. The weak foundation also increases the risk of the stability of the dump (Menson, 2006).

**SOLUTION FOR STABILITY RISKS**

Research is underway to develop the stabilization concept for the dumps at Institute of Mining Engineering I together with Chair of Geotechnical Engineering, RWTH Aachen University and Brenk Systemplanung along with VINACOMIN under the umbrella of RAME. For developing stabilization concepts, proper drilling and trial pits will reveal the inside structure of the dump for various types of materials. The geotechnical characteristics of different types of materials are to be found for slope stability analyses. Mineralogical and geochemical analyses of the mine waste will reveal the amount of contaminants. For high amounts of contaminants, treatment should be made before the dumping. Such an analysis can also lead to the identification of various parts of the waste for purposes like materials for road construction. If it is economical, some part of the waste can be utilized for other use which will reduce the amount of waste for dumping. The monitoring of various parts of the dumps is needed to be performed to find the possible movements at the dump site. Monitoring of the cracks and slope stability analyses results will reveal the of stability situation of Chinh Bac dump. If the stability situation is already satisfying, no further action is needed. If not, new standards and bench dimensions are to be defined.

**CONCLUSIONS**

In the past, mine waste dumping was accompanied by the environmental problems like dust emissions and contaminated water. Stability risks are present on Chinh Bac dump site due to the past dumping practices. Detailed investigations are essential for the exact stability situation and defining the new bench dimensions for the dump site. The future dumping according to the new standards and bench dimensions will certainly result in the prevention of stability risks existing on the site thereby minimizing the land degradation.
and enhancing the safety of the workers. Most economical and locally applicable environmental protection measures for dust, waste water and stability risks are essential for a successful rehabilitation of the waste dump in future.

REFERENCES


