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## Application of EarthZyme® Biological Enzyme Road Building Technology in Field Management of Shengli Open-pit Coal Mine

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**ABSTRACT:** Road building plays a very important role in the production of open-pit mines, technical conditions of road transportation is not only directly related to the production safety and efficiency of the mine, but also an important symbol to measure the field management level of the mine. EarthZyme® is a new road building material that is applicable to the clay-based soil. The surfactant, electrolyte, and the enzyme of EarthZyme® can react with clay composition of the soil, discharge the water by transforming the bound water to free water, and bond the soil particles and sand closely together so as to render the clay soil weakened in water absorption and achieve the effect of road hardening. Encouraged by the success of the demo road in 2013, we built up 10 km EarthZyme® mine road in 2014. It has been shown that the road works well in flatness, strength and other performance indexes. It is a benefit for resuming production after the rain and reducing the operation cost. Meantime, it is significant in cost control, energy conservation and environment protection.

*Keywords:* EarthZyme® biological enzyme; road building; field management; open-pit coal mine; safety production

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The road of an open-pit mine is an important infrastructure of the mine production system. The technical status of the transport roads is closely related to the safety and the efficiency of mine's production; it is also a measure of the level of mine site management [1]. Road building plays an important role in the operation of an open-pit mine. Following the expansion of production scale and the increase of the transport vehicles, the road quality becomes a critical factor that affects the operation cost [2]. EarthZyme®, a biological enzyme, is a new road building material that is applicable to the clay-based soil. The surfactant, electrolyte, and the enzyme of EarthZyme® can react with clay composition of soil, discharge the water by transforming the bound water into the free water, and bond the soil particles, sands, and gravels closely together so as to render the clay-soil weakened in water absorption and eliminate the strong hydrophilicity of clay due to its negative charge, achieving an effect of road hardening. In 2013, Shengli Open-pit Coal Mine tested a 500 m road with the use of EarthZyme®. After one year of the field trial, it has been proved that the strength, flatness and other indicators of the EarthZyme® road are all satisfactory. In the first half of 2014, Shengli Open-pit Coal Mine purchased EarthZyme® through bidding and implemented 10 km EarthZyme® road transformation by the end of September. Short after the use of EarthZyme® road, it has been demonstrated a significant decrease in the vehicle fuel consumption and tire consumption, according to the cost analysis of the third quarter. The economic advantage is very obvious.

### 1. Introduction of Shengli Open-pit Coal Mine

Shengli Open-pit Coal Mine is located in the central-western part of Shengli coalfield area, 6 km from the city of Xilinhot, possessing the rich reserves, reliable resources, and favorable mining conditions. The coal is lignite of low ash, low sulfur, low phosphorus, and medium calorific value of combustion. Infrastructure construction of the mine was started on April 20, 2004, with a scale of 20 Mt / a, and completed in 2011. At Shengli Open-pit Coal Mine, above the #5 coal seam roof, the stones mainly consist of gray, gray-white, gray-green, gray-purple, purplish red glutenins and conglomerates, including some thin layers of mudstone, siltstone, fine sandstone, and coarse sandstone; the average thickness of that is around 45.9 m.

The rock layers sandwiched between in #5 Seam and #6 seam are mainly the gray, dark gray mudstone and siltstone; with an average thickness of 59.7 m. The rock stripping above the #5 seam and between the #5 ~ #6 seams are all using the Single Bucket - Truck technology.

The rocky overburden and coal are mainly of soft rock, in which the soft rock of compressive strength <6.0 MPa accounted for 89%. The mineral composition of mudstones from the bottom of #6 seam was inspected by Infrared Spectroscopy test, revealing montmorillonite content of 13% to 63%, generally 40%; kaolinite content of 12% to 25%; illite content of 5% ~20%. Because of the high hydrophilicity of montmorillonite, poor water stability, and the swelling-contracting property with/without water, to maintain the stability of the slope is a serious challenge.

## 2. Current road building technologies

- 1) The main road building The main road shall be in service for intense traffic flow for a long time. The quality requirement of the main road is high. The overburden of the open-pit mine composed principally of mudstones, the main road building adopts the single-story pavement structure, see Figure 1. First, CAT D10T bulldozer levels down the ragged field produced after the excavator shoveling. Then, with the aid of dump truck, CAT D10T bulldozer lays a layer of overburden 30 ~ 50 cm in thickness. The gradation is the natural grading of the overburden blasting. Finally, the grader modifies and compacts the road surface.

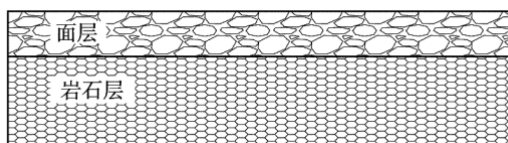


Fig. 1 The single-story pavement structure

- 2) Temporary ramp building The temporary ramp is the 200 m sections from the shoveling face to the main road and from the main road to the dumping face. These two branches' construction uses the tracking method [3]. At the dumping site, make use of the roadbed when CAT D10T bulldozers reserved when dumping, followed by a grader for leveling. When the power shoveling face advances, the CAT D10T bulldozer is following up to ensure the quality of the two sections.

## 3. EarthZyme® road building

### 3.1 EarthZyme® introduction

Adding EarthZyme® to the clay-based soil can increase the density of the soil, reduce free water in the compacted soil matrix. EarthZyme® consists mainly three components:

- 1) Ion solution. It reacts with the clay minerals, reducing the water portion that has relatively weak linkage force with the clay particles. The ionic solution helps to shrink the diffuse double layer and to get higher soil density under the same pressure.
- 2) Surfactant. It reduces the viscosity of water and improves the water lubrication in the compaction process. The upshot is a denser and drier status of the soil. Moreover, it makes the clay particles arranged more neatly, so as to diminish the permeability of compacted soils. The surfactant is also the carrier of the ion solution and the enzymes.
- 3) Enzymes mixture. They promote the ion exchange between the clay particles and the ion solution.

These three components work together on the clay component of the soil during road construction. Compared with the soil without EarthZyme® treatment, using EarthZyme® is easy to make the soil to achieve a high density with conventional

construction equipment. The high density, in turn, will make the clay particles arranged more neatly and bonded more closely so as to significantly improve the road strength, wear resistance, endurance, and other indicators.

### 3.2 EarthZyme® work principle

Clay particles are negatively charged, the positively charged part of a polarized water molecule is therefore likely attracted to the surface of negatively charged clay particles. A weak ionic bond is formed between the polarized water and the clay particle.

This is the mechanism why the free-water-bearing, clay-based soil tends to swell and the strength of which decreased [4]. The thickness of the diffusion double layer depends on the chemical reaction of clay minerals and the water in pores. Through manipulation of the chemical reaction between the clay and the polarized water can shrink the thickness of the diffusion double layer [5].

EarthZyme® takes advantage of its huge ion exchange potential to shrink the diffuse double layers, abating the water absorption capacity of the soil, descending the water content in clay-based soil, and boosting the density of compacted soil. The surfactants facilitate the ionic solution to penetrate into the soil capillary structure, thereby promote the ion exchange process. The surfactant also acts as the carrier for the enzymes. Enzymes help to enhance ion exchange between different clay minerals, ensuring the EarthZyme®'s versatility.

When the EarthZyme® is mixed with clay-based soil, the bound water in the soil will be transformed into the free water and be discharged, resulted from the ion exchange mechanism, and then be discharged. The clay in the soil bonds the soil particles, sand and others closely together. The surfactant in EarthZyme® plays a dual role in soil stabilization. It can temporarily reduce the surface tension and the viscosity of water, conducive to the compaction process. This lubrication effect is leading to get the distributed soil structure where the soil porosity minimized. The effect on the clay molecules by EarthZyme® road building material is demonstrated in Figure 2. The reduction of surface tension also lessens the requirement on the water-bearing condition for achieving the best soil compaction. The combination of the shrinkage of diffusion double layer and the reduction of surface tension ameliorates the best soil moisture content by about 1% ~2%. Therefore, it is the surfactant that significantly eliminates the porosity and gets a dense fine grain soil structure where the particles attach more closely.

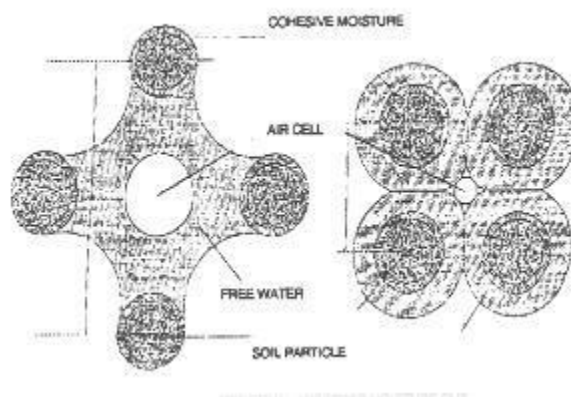


Fig. 2 The effect on the clay molecules by EarthZyme® road building material

The combination of high compaction (porosity and capillary structure reduction) and distributed soil structure (parallel distribution) greatly decreases the soil permeability and greatly increases soil strength (bearing capacity). The biological degradation of EarthZyme® engenders the surfactant decomposition and rebuild the surface tension of water, making the binding water (liquid bridge) more compact. This will result in a stronger inward compression pressure to augment the soil matrix

structure strength, to reduce the gap between clay particle, to strengthen the covalent bond and ionic bond, and finally bring about the hardening and solidifying of the compacted soils so that the EarthZyme® road surface holds a long service time. This process most occurred in the first 5 ~ 7 d, and lasting for 28 d.

A reduction in porosity also helps to increase the adhesion and the Van der Waals forces between the clay molecules [5]. Increased density and accompanying adhesion enhancement of the clay structure, combined with clay particles parallel distribution created a support surface that improves not only the strength but also the uniformity. This synchronism prevents the clay particles from re-adsorbing water to impair the soil strength. Soil matrix distribution further enhances this effect. Distributed soil structure is beneficial in reducing the permeability, the number of interconnected pores, thus restricts the water transportation in the soil and makes the compacted soil more stable [6], so that the road is more enduring with its low water absorption and high uniformity. The EarthZyme® implements the soil structure improvement within 28 days. After then, EarthZyme® will degrade, leaving no residue in the soil, no influence on the chemical composition of the soil itself. It is completely green and environment-friendly material.

### 3.3 EarthZyme® road building

Shengli Open-pit Coal Mine uses local soil in site for road building which saves the cost of materials transportation in current road building process. First, the grader-scraper loosens the road surface (rough loosening), and then the Wirtgen W2200 - 3800SM surface mining machine executing the further loosening (fine loosening). After the loosening, EarthZyme® is sprayed over the road surface, following further loosening; spraying again, and loosening again. Finally, modifying and compacting.

### 4 EarthZyme® applications and results

Since the third quarter of 2014, Shengli Open-pit Coal Mine has built 10 km of EarthZyme® road (pavement width of 30 m). After the construction of EarthZyme® road, the fuel consumption of trucks decreased by 17.4%. Based on the fact that the comprehensive transporting distance of the overburden is about 3.2 km, if 80% of the overburden transportation is using EarthZyme® road, the annual savings of fuel is 3.9 million L. Given the price of 6 yuan per liter, the annual savings of fuel costs could be 23.4 million yuan.

The road maintenance costs, tire loss, etc. will also be significantly diminished. Using the soil at the field for road building, saves the direct costs of construction. EarthZyme® road is of high hardness and high bearing capacity. Smooth road surface needs only limited maintenance workload. The muddy situation of the road in rainy days has been significantly ameliorated. The road seepage rate is greatly reduced and the resuming time after rain is shortened. Moreover, the dust of EarthZyme® road surface is less than ever.

EarthZyme® road significantly improves the surficial roughness of the mine road, helps the vehicle moving more stable by saving the frequent vehicle braking and vehicle vibration owing to the poor roughness condition in the traditional roads. The safety issue and the transportation accidents induced by the vehicle mechanical damage are also restricted. Thanks to the excellent pavement strength, density and other properties of the EarthZyme® road, the load scatter of vehicle transportation is limited. There is rarely the mud boiling and the formation of obvious ruts. The dust in the opencast decreased more than 60%, significantly reducing the concentration of dust on the production site, improving the visibility of the site; thereby reducing the risk of occupational diseases and potential safety hazards or accidents due to the high concentration of dust and dust-raising.

### 5 Conclusion

EarthZyme® is a new biological enzyme road building material that is applicable to the clay-based road. Encouraged by the EarthZyme® field test, Shengli Open-pit Coal Mine carried out a large-scale transformation of mine road with EarthZyme®. In spite

of the short history in service of the EarthZyme® road, a significant economic and environmental advantage have been demonstrated. EarthZyme® road construction process is an important innovation for the existing mud-rock mine road construction technology. It can be widely used in mudstone-based mine road building.

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