



## Stability of Slopes and Embankments of Coarse Man-Made Soils

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### Abstract

The suitability of soils for the construction of subgrade is determined by their road-building properties. For this purpose coarse, sandy and sandy loam soils are the most suitable. Many coarse man-made soils are formed during mining. These soils undergo significant changes in composition, structure and texture of natural minerals under the influence of weather and climatic factors. Coarse man-made soils may differ by petrographic composition and metamorphism of minerals. These multi-component systems are composed of fine-grained components and large particles varying in strength, water and frost resistance. The aggregate strength characteristic was taken as an integrated criterion for the assessment of embankment subgrade based in part on the capabilities of the test and also the need for the creation of a dense structure for multi-component coarse soils. From this, a technological classification for coarse soils was developed. The problem of using coarse soil in embankments is the possibility of soil settlements occurrence due to the large space between the particles and due to the impact of weather and climate factors. For ensuring a stable structure of subgrade, such coarse soils should be either isolated from the influence of weather and climatic factors or the structure of the subgrade should be made dense non-settling properties by means of technological solutions that envisage filling the entire space between the large particles with fine-grained materials (e.g. pit-run fines). The design solutions are developed depending on the type of coarse soil. This will protect the embankment body from the effects of weather and climatic factors, namely: wetting-drying and freezing-thawing.

To ensure durability and stability of the embankment slopes, technological solutions for creating a single strong structure were developed. Effective subgrade structures that take into account the characteristics of these materials and ensure their sustainability and stability were developed basing on the results of coal waste research.

*Keywords:* man-made soils, coal waste, aggregate strength rate, stability, embankment structure

## 1. Introduction

For the construction of roads hundreds of millions of cubic meters of soil are needed. These raw materials are extracted from quarries which occupy large areas of potentially fertile land. At the same time, coarse man-made soils which amount is measured in billions of cubic meters are accumulated on the land surface. One of the ways of their utilization is the use in road construction.

Coarse man-made soils are non-cohesive particles of rock containing more than 50% of particles of more than 2 mm in size. Except for crushed stone, screening, pebbles and gravel, coarse soils include secondary products of mining industry such as crumbled rock of ore mining and processing enterprises and coal waste (hereinafter referred to as coal waste). The above coarse man-made soils are sufficiently homogeneous material from each source of extraction except for coal waste.

Multiple dump pits, slagheaps where huge amounts of coal waste are stored, are the specific feature of industrial regions of Ukraine. It should be noted that only 5% of the total volume of coal mining and coal-cleaning waste was utilized. It is used to fill underground space of abandoned mines and for the production of some types of construction materials.

Using coal waste as construction material in the engineering practice solves simultaneously the problem of liquidation of dump pits and brings significant economic and ecological effect. All coal mining regions have practical experience in using coal waste in road construction, for example, the construction of a highway bypass round Donetsk in the direction of Zaporizhzhia (Fig. 1). For the first time this technology was tested at the construction of a road bypass round Luhansk (Mishina, 2011; Vyrozhemsky, 1987).



**Figure 1:** Construction of a highway bypass round Donetsk in the direction of Zaporizhzhia

## 2. Using Coarse Man-Made Soils in the Embankments

### 2.1 Coal Waste Characteristics

Coal waste is divided by source of extraction, type of fuel, plasticity number of mineral matter, content of fuel, grading and chemical and mineralogical composition, softening interval and the degree of swelling.

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