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Geomechanical Tasks Solving in Modelling of Temporary Support Parameters in Sochi Tunnels

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Abstract

Mining method in tunnel construction requires a proper choice and justification of the type of a temporary support. This aspect is highly related to choosing of an appropriate tunnel excavation assembling method. Features of a temporary support influent various factors which tunnel construction process depends on. The study provides relevant Geomechanical tasks defined using Mathematical Modeling. The Department of Tunnels and Undergrounds of Petersburg State Transport University elaborated particular design models and conducted calculations using Finite Element Method to solve a number of Geomechanical tasks occurred during construction of Sochi Tunnels. The study finds out that the project-provided measures did not fully prevent an emergence of soil collapsing zones, though the mountain pressure was totally accomplished by the temporary support in this particular researched case.

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Keywords: Geomechanical tasks; tunnels; temporary support; excavation stability

1. Introduction

Sochi is the largest recreational area in Russia. Moreover, the city is a political and economic center of the Black Sea coastal region in Russia. Three years have passed since the great opening of winter Olympics. This magnificent event was preceded with a colossal widescale reconstruction and redevelopment of the city. The great number of sports and infrastructure facilities were built in only 7 years located in two clusters: the coastal area (Imeretinskaya Lowland) and the mountain region (Krasnaya Polyana) [2].

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Maintenance of these objects is unimaginable without high-developed transport infrastructure. In conformity with the Federal program of Olympic facilities construction, widescale transport infrastructure projects were carried out making it possible to receive successfully up to 6.5 million visitors a year [2].

One of the most significant objects developed by the program is the Federal highway A-148 called “Kurortniy Avenue Understudy”. The track is designed according to the parameters of the first category of roads without any same-level intersections with local roads. The highway with a continuous car flow is one of three main transport arteries of Sochi; it obtains four lanes (two in each direction) and seven adjacent interchanges. These options provide maintaining of the project-base velocity mode at least 75 km/h (47 mph) on the entire route. The track of “Kurortniy Avenue Understudy” includes tens of overpasses and 15 tunnels [2].

Participation of the PGUPS Department of Tunnels and Undergrounds was determined by the necessity to solve various problems occurred during the highway “Kurortniy Avenue Understudy” construction.

2. Approaches to the Choice of the Temporary Support Type

In tunnel engineering, especially within the mining method – the choice and justification of the temporary support type are considered to be the key aspects closely related to an upcoming choice of the tunnel excavation assembling method, would it be the full-face method or partly developed in a certain order [1]. The type and the structure of the temporary support providing major safety aspects during an excavation are significantly important factors defining the laboriousness and the duration of tunnel construction.

In order to ensure conformity of structural parameters of a temporary support to the geological conditions and the chosen tunneling method it is essential to analyze the bearing capacity of all its components in an interaction with the soil mass at all stages of an excavation cycle [1].

3. Justification of Using Full-face Driving Conducted with Finite Element Method for Sochi Tunnel N.8

3.1. The Goal of the Studies

The main aim of the studies was to justify an ability to use the full-face driving at the approaching opening site to the Tunnel N.8. The soil mass accommodating the heading is represented by argillite and heavy loam. The soil thickness upon the heading at the near-portal area is only 2 m. The task was to assess the stability of a widespan tunnel face (12m width, 11,3m height span), held with combined temporary support: concrete arch vault support with a forepoling maintaining the excavation face and the top heading. The forepoling is made of metal and fiberglass pipes [1].

The analysis of the stability of fixed excavations was completed with mathematic 3D models using Finite Element Method. Calculations were conducted using “Solid Works/Cosmos Works” software implementing solutions of deformable bodies’ statics tasks. The calculation complex is certified in Russia and used to solve various engineering tasks [1, 2].

3.2. Design Model

The soil mass and the lining were modeled as volumetric prismatic finite elements of the *“SOLID”* type, arches – as shell elements of the *“SHELL 4”* type, forepoling of the top heading – with the *“BEAM 3D”* type of bar elements obtaining mutual nods with soil elements, and the tunnel face support – as elements of the *“TRASS 3D”* type. This approach to mountain geomechanics tasks solving provides a number of advantages over traditional methods of contact tasks solving because it allows to consider all the constructive and technological features of the support.

Sizes of the selected fragment of the soil mass in a cross-section were 31.5 m by 17.5 m. The length of the soil mass fragment in the longitudinal direction (21 m) was determined by length suitable for 6 cycles of an excavation (7 m) and the size of the soil pillar in front of the heading (14 m). With considering symmetry of the task regarding YZ-plane, a half of the soil mass fragment with an excavation was taken for calculations, Fig. 1.