About Methods of Additional Mining Pressure Figuring while Reconstruction of Tunnels

M. Moistsrapishvili, I. Ugrekhelidze, T. Baramashvili, and D. Malaguradze

Abstract—At the end of the 20th century it was actual the development of transport corridors and the improvement of their technical parameters. With this purpose, many countries and Georgia among them manufacture to construct new highways, railways and also reconstruction-modernization of the existing transport infrastructure. It is necessary to explore the artificial structures (bridges and tunnels) on the existing tracks as they are very old. Conference report includes the peculiarities of reconstruction of tunnels, because we think that this theme is important for the modernization of the existing road infrastructure. We must remark that the methods of determining mining pressure of tunnel reconstructions are worked out according to the jobs of new tunnels but it is necessary to foresee additional mining pressure which will be formed during their reconstruction. In this report there are given the methods of figuring the additional mining pressure while reconstruction of tunnels, there was worked out the computer program, it is determined that during reconstruction of tunnels the additional mining pressure is 1/3rd of main mining pressure.

Keywords—Mining pressure, Reconstruction of tunnels.

I. INTRODUCTION

The requests towards modern road infrastructure gave rise to an interest in the questions such as effective reconstruction of artificial erections existing on line roads.

For the reconstructing of existing roads, to raise their cargo capacity and to finish the whole modernization of roads infrastructure successfully, it is necessary to pay special attentions to the questions of old artificial erections. For instance: at present, on the roads in Georgia 70% of artificial erections are old or out of order as well as their technical parameters and normative don’t meet international standards. On main line roads, supporting erections like: bridges, road-hubs and tunnels need permanent monitoring with modern technical remedies. And the issue of renovating existing erections still is under the question and it represents object of research which has its objective reasons. For instance; one of the reasons of renovating existing erections is that its remoteness question became actual during the last 20-30 years, which coincided destabilization processes in Georgia.

In accordance with the construction norms, the measurement of mountainous pressure is only reglamented during the constructions of new tunnels.

Capital repairs of the tunnels and reconstructions have the specific particularities which should be taken into the consideration. The practice of tunnel constructions makes it vivid that these characteristics consist of two-stage mountainous pressure character [1]-[7].

The tunnel construction practice shows that the specific features are stipulated by the two-stage character of mining pressure [1]-[7].

The first stage covers the process of distribution of natural tension, resulting in its turn formation of cracks, conditioned by extraction of the rocks of specific volume form the arrays and their falling down into the tunnel. In order to avoid any falling of the rocks there should be built permanent support in advance. It should be emphasized that construction of such permanent support does not exclude formation of the falling arch, as during the qualitative interaction between the array and the support some empty spaces are left anyway behind the permanent support, in particular between the support and the rock; that is why the loading of the support at the first stage is determined by formation of the falling arch above; the volume of this arch may be determined on the basis of the formula of M. Protodyakonov [8]-[9].

\[ q_1 = \gamma h \]  \hspace{1cm} (1)

where \( \gamma \) is the bulk density, \( t/m^3 \); \( h \) is the height of the arch of falling, \( m \).

After the formation of the arch of falling in this theory (hypothesis of arch of falling) the permanent loading influencing on the support does not change but equals to the weight of the rock encompassed in the scopes of the arch of falling.

The array beyond the scopes of arch of falling is deemed as hard and it has no influence on the loading of the support. After formation of the arch of falling the balance of new tensed character will be formed in the array.

The tunnels reconstruction or their major repairs repeated violation of the array balance takes place, it stipulates extension of inelastic area and increase of its loading.

According to the above mentioned, final loading, influencing the reconstructed support may be defined by the
Relative crack module equals to the division of the distance between the excavation mal (L) and cracks (l).

According to the literature data, the classification of the mining rocks as per their crack creation ability is enlisted in the Table I below [16]:

<table>
<thead>
<tr>
<th>Classes of rocks</th>
<th>Meanings of mining array qualitative characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L, m</td>
</tr>
<tr>
<td>Without cracks</td>
<td>-</td>
</tr>
<tr>
<td>Low cracked</td>
<td>0,5-1,5</td>
</tr>
<tr>
<td>Cracked</td>
<td>0,25-0,5</td>
</tr>
<tr>
<td>Deeply cracked</td>
<td>0,1-0,25</td>
</tr>
<tr>
<td>Multipartite</td>
<td>-</td>
</tr>
</tbody>
</table>

Following indications are provided in the table: L - distance between the cracks; V - average volume of the rocks blocks cracked; Ke,m - cracks emptiness ration; η - cracks relative module.

The loading (q2) on the second stage of mining pressure may be expressed according to its dependence on (3) and (6) in the following formula:

\[ q_2 = \frac{1}{4} \gamma L_2 (4/3 r - \pi/2) \]  

(7)

where \( L_2 \) is the excavation mal during reconstruction, \( m \);

Taking into consideration that the additional loading in the formula (2) may be expressed as

\[ q = q_2 - q_1 \]  

(8)

As a result of number of transformations we will have:

\[ q_{ad} = \frac{1}{3} \gamma L_1 r (L_2/L_1 \cdot 0.755 \eta^{0.178} - 1) \]  

(9)

where \( L_1 \) is a tunnel mal before the reconstruction.

Thus, as a result of the tunnel reconstruction the formula defining the final meaning of the mining pressure in compliance with (2) and (9) will have the following form:

\[ q = q_1 + \frac{1}{3} \gamma L_1 r K_{mov.cont} (L_2/L_1 \cdot 0.755 \eta^{0.178} - 1) \]  

(10)

The formula (9), when \( L_1 = L_2 \) will have the following form:

\[ q_{ad} = \frac{1}{3} \gamma L_1 r K_{mov.cont} (0.755 \eta^{0.178} - 1) \]  

(11)

I.e. the major influencing factors on the additional loading volume are:

- Relative module of the rocks’ crack ability;
- The contained in the 11-th formula indicates that the tunnel should be reconstructed with saw that will maximally exclude any movement of excavation contour; the measures enabling the mentioned are the following:
  - Application of cracked concrete;
  - Monolithic and pressed concrete application;
  - Application of accumulated support.

Timely filing in of the empty spaces behind the support
should be made by the solutions made of rapidly strengthening cement; Fig. 1 shows the relationship between the additional loading and the time of engagement in the working process for the support.

Fig. 1 Interrelation between the additional loading and the time for engagement in the working process for the support

According to the method above there was developed the computer program; this program enabled to calculate the rock’s crack ability ratio, the module of relative deformation of cracking ability; ratio, that envisaged the movement of the contour during the tunnel reconstruction, rock bulk density according to the variable parameters in order to gain the additional loading; the outcomes of one of the versions are given in the Table II and the Figs. 2, 3.

![Fig. 2 Interrelation between the additional loading ($q_{add}$) and the module of relative deformation of cracking ability ($\eta$)](image)

**Table II**

INTERRELATION BETWEEN THE ADDITIONAL LOADING ($q_{add}$) AND THE ROCKS’ CRACKING ABILITY RATIO ($K_{cr}$) IN CASE OF ONE RAIL RAILWAY

<table>
<thead>
<tr>
<th>$K_{cr}$</th>
<th>$L = 10m$</th>
<th>$L = 20m$</th>
<th>$L = 30m$</th>
<th>$L = 40m$</th>
<th>$L = 50m$</th>
<th>$L = 60m$</th>
<th>$L = 70m$</th>
<th>$L = 80m$</th>
<th>$L = 90m$</th>
<th>$L = 100m$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.09</td>
<td>0.13</td>
<td>0.19</td>
<td>0.23</td>
<td>0.27</td>
<td>0.31</td>
<td>0.34</td>
<td>0.37</td>
<td>0.40</td>
<td>0.43</td>
<td>0.45</td>
</tr>
<tr>
<td>0.1</td>
<td>0.13</td>
<td>0.19</td>
<td>0.23</td>
<td>0.27</td>
<td>0.31</td>
<td>0.34</td>
<td>0.37</td>
<td>0.40</td>
<td>0.43</td>
<td>0.45</td>
</tr>
<tr>
<td>0.2</td>
<td>0.26</td>
<td>0.37</td>
<td>0.47</td>
<td>0.55</td>
<td>0.62</td>
<td>0.69</td>
<td>0.75</td>
<td>0.81</td>
<td>0.86</td>
<td>0.92</td>
</tr>
<tr>
<td>0.3</td>
<td>0.39</td>
<td>0.56</td>
<td>0.70</td>
<td>0.82</td>
<td>0.93</td>
<td>1.03</td>
<td>1.12</td>
<td>1.21</td>
<td>1.29</td>
<td>1.37</td>
</tr>
<tr>
<td>0.4</td>
<td>0.51</td>
<td>0.75</td>
<td>0.93</td>
<td>1.10</td>
<td>1.24</td>
<td>1.37</td>
<td>1.49</td>
<td>1.61</td>
<td>1.72</td>
<td>1.83</td>
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<tr>
<td>0.5</td>
<td>0.64</td>
<td>0.93</td>
<td>1.17</td>
<td>1.37</td>
<td>1.55</td>
<td>1.72</td>
<td>1.87</td>
<td>2.02</td>
<td>2.16</td>
<td>2.28</td>
</tr>
<tr>
<td>0.6</td>
<td>0.77</td>
<td>1.12</td>
<td>1.40</td>
<td>1.64</td>
<td>1.86</td>
<td>2.06</td>
<td>2.25</td>
<td>2.42</td>
<td>2.59</td>
<td>2.75</td>
</tr>
<tr>
<td>0.7</td>
<td>0.90</td>
<td>1.31</td>
<td>1.63</td>
<td>1.92</td>
<td>2.17</td>
<td>2.40</td>
<td>2.62</td>
<td>2.83</td>
<td>3.02</td>
<td>3.20</td>
</tr>
<tr>
<td>0.8</td>
<td>1.03</td>
<td>1.49</td>
<td>1.87</td>
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<td>2.48</td>
<td>2.75</td>
<td>2.99</td>
<td>3.23</td>
<td>3.45</td>
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<tr>
<td>0.9</td>
<td>1.16</td>
<td>1.68</td>
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<td>3.37</td>
<td>3.63</td>
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</tr>
<tr>
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<td>1.87</td>
<td>2.33</td>
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<td>3.43</td>
<td>3.74</td>
<td>4.04</td>
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<td>4.58</td>
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During the reconstructing and capital repairing of the existing tunnels, between additional loading and support in working during time it is determined the peculiarities of forming of mining pressure and it is established that additional mining pressure which was formed during reconstruction of tunnels is proportional to the module of relative deformation of the cracking ability and amounts to more than 1/3 of the major loading.

REFERENCES


