About Methods of Additional Mining Pressure Figuring while Reconstruction of Tunnels

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

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 renovation existing erections is that its remoteness question became actual during the last 20-30 years, which coincided destabilization processes in Georgia.

M. Moistsrapishvili is with the Georgian Technical University. Tbilisi, Georgia 0175 (e-mail: m.moistsrapishvili@gtu.edu.ge).

I. Ugrkhelidze is with the Georgian Technical University, Tbilisi, Georgia 0175 (e-mail: irinaugre@rambler.ru).

T. Baramashvili is with the Georgian Technical University. Tbilisi, Georgia 0175 (e-mail: tea.b@mail.ru).

D. Malaghuradze is master student of the Georgian Technical University. Tbilisi, Georgia 0175 (e-mail: d.malaghuradze@gtu.edu.ge).

II. THE PECULIARITIES FORMING OF MINING RESSURE DURING THE CAPITAL REPAIRS OF TUNNELS AND DURING THE RECONSTRUCTIONS

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].

$$q_1 = \gamma h \qquad (1)$$

where γ 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

formula:

$$Fq = q_1 + q_{ad} K_{mov.cont.} \quad (2)$$

where q_1 is the loading of the support by a mining pressure based on the first stage of the tunnels operation t/m²; q_{ad} is an additional loading, caused by a maximal extension of inelastic area t/m²; $K_{mov.cont.}$ is a ration, envisaging the movement of the contour.

The meaning of the ration $K_{mov.cont}$ significantly depends on the reconstruction works method. When the reconstruction works method excludes any possibility of movement of the contour, then $K = 0$; generally, it is changed and varies within the scopes of 0-1 (0,1÷0,3 when the cracked concrete is applied; 0,5 – in the case of pressing concrete, 0,7÷0,8 - in the case of accumulated support and 1 – in the case of monolithic support).

Final loading (q) may be determined on the basis of the formula of A. Labas, I. Liberman, K. Rupeneit and other authors [10]-[13]

We applied the formula of K. Rupeneit:

$$q = 1/4\,\gamma L(\,4/3\,r - \pi/2) \quad (3)$$

where γ is the bulk density, t/m^3; L excavation mal, m; r relative radius of inelastic deformation, which is defined by a formula:

$$r = R/R_0 \quad (4)$$

where R is the radius of inelastic area, m; R_0 excavation radius or half mal.

Taking into consideration that during the reconstruction there is no reaction of its support and during initial construction of the tunnel no significant deformation of the excavation counter had a place, the radius of inelastic area`s relative deformation may be defined by the following interaction:

$$r = [1 + ((\partial H(1 - sin\varphi) - c \cdot cos\varphi)/c \cdot tg\varphi)]^{1-sin\varphi/1-sin\varphi} \quad (5)$$

where H is the excavation hollow, m; φ is the internal friction angle, degree; c is the grip on weakened spaces, t/m^2.

Additional extension of the empty spaces between the excavation contour and the support during the tunnel major repairs or reconstruction stipulates extension of the radius of inelastic area. The volume of relative radius of inelastic area is significantly depended on the level of cracks formation, accordingly, its new expression in general may be stated as the following [14]-[15]:

$$r' = r \cdot K_{cr} \quad (6)$$

where r is the relative radius of inelastic area complying with the first stage of the mining pressure formation process, m; K_{cr} is the ration envisaging the module of relative crack creation module, (η), %.

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 I
MINING ROCKS CLASSIFICATION ACCORDING TO THEIR CRACK ABILITY

Classes of rocks according to their cracking ability	Meanings of mining array qualitative characteristics[1]			
	l, m	V, m^3	K_{cr}	η
Without cracks	-	10-20	0,5	6
Low cracked	0,5-1,5	0,1-5	0,5-2	6-12
Cracked	0,25-0,5	0,01-0,1	2-5	12-25
Deeply cracked	0,1-0,25	0,002-0,01	5-10	25-60
Multipartite	-	0,002	10-20	60

[1]Following indications are provided in the table: l- distance between the cracks; v - average volume of the rocks blocks cracked; K_{cr} - cracks emptiness ration; η - cracks relative module.

The loading (q_2) on the second stage of mining pressure may be expressed according to its dependence on (3) and (6) in the following formula:

$$q_2 = 1/4\,\gamma L_2(4/3\,rK_{cr} - \pi/2) \quad (7)$$

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

$$q = q_2 - q_1 \quad (8)$$

As a result of number of transformations we will have:

$$q_{ad} = 1/3\,\gamma L_1 r(L_2/L_1 \cdot 0.755\eta^{0.178} - 1) \quad (9)$$

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:

$$q = q_1 + 1/3\,\gamma L_1 rK_{mov.cont.}(L_2/L_1 \cdot 0.755\eta^{0.178} - 1) \quad (10)$$

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

$$q_{ad} = 1/3\,\gamma L_1 rK_{mov.cont.}(0.755\eta^{0.178} - 1) \quad (11)$$

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

η- 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.
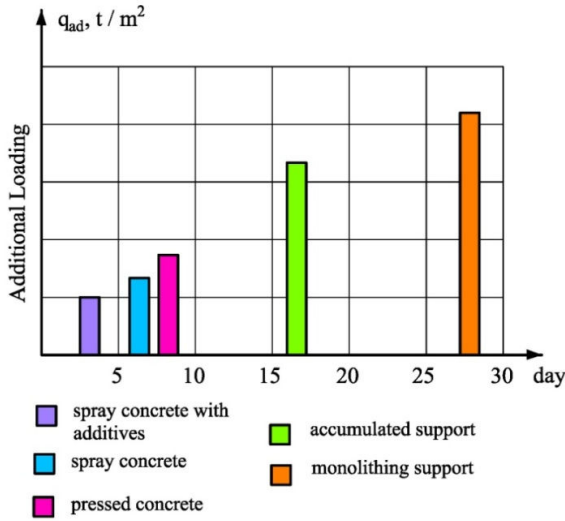

Fig. 1 Interrelation between the additional loading and the time for engagement in the working process for the support

of the crack 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.
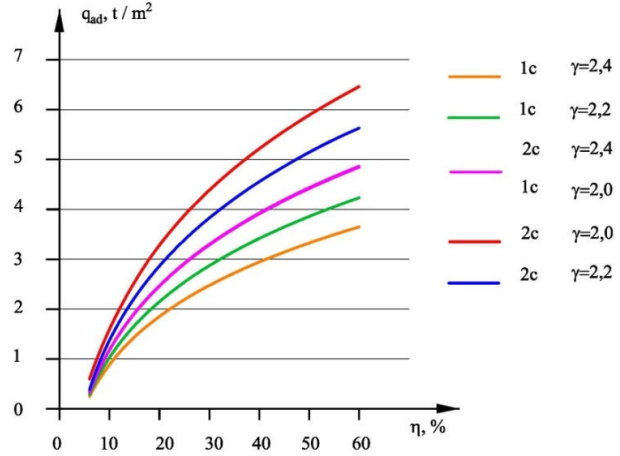

Fig. 2 Interrelation between the additional loading (q_{ad}) and the module of relative deformation of cracking ability (η)

According to the method above there was developed the computer program; this program enabled to calculate the rock`s crack ability ration, the module of relative deformation

TABLE II
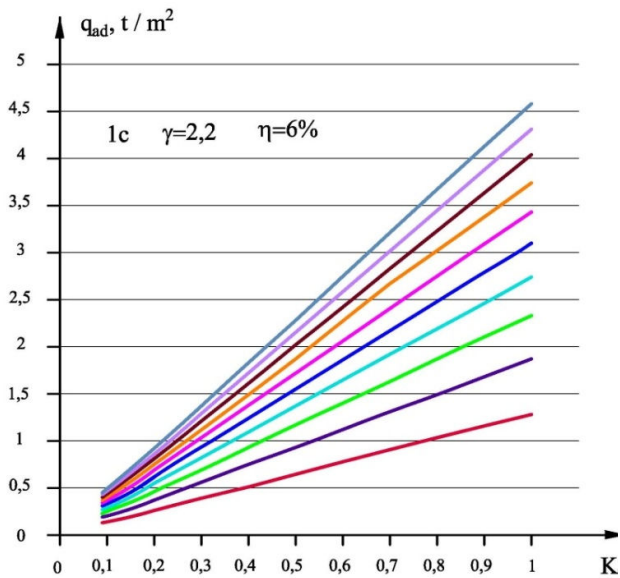INTERRELATION BETWEEN THE ADDITIONAL LOADING (q_{ad}) AND THE ROCKS` CRACKING ABILITY RATIO (K_{cr}) IN CASE OF ONE_RAIL RAILWAY

K_{cr}	Additional loading (q_{ad})t/m^2									
	$L = 10m$	$L = 20m$	$L = 30m$	$L = 40m$	$L = 50m$	$L = 60m$	$L = 70m$	$L = 80m$	$L = 90m$	$L = 100m$
0.09	0.13	0.19	0.23	0.27	0.31	0.34	0.37	0.40	0.43	0.45
0.1	0.13	0.19	0.23	0.27	0.31	0.34	0.37	0.40	0.43	0.45
0.2	0.26	0.37	0.47	0.55	0.62	0.69	0.75	0.81	0.86	0.92
0.3	0.39	0.56	0.70	0.82	0.93	1.03	1.12	1.21	1.29	1.37
0.4	0.51	0.75	0.93	1.10	1.24	1.37	1.49	1.61	1.72	1.83
0.5	0.64	0.93	1.17	1.37	1.55	1.72	1.87	2.02	2.16	2.28
0.6	0.77	1.12	1.40	1.64	1.86	2.06	2.25	2.42	2.59	2.75
0.7	0.90	1.31	1.63	1.92	2.17	2.40	2.62	2.83	3.02	3.20
0.8	1.03	1.49	1.87	2.19	2.48	2.75	2.99	3.23	3.45	3.66
0.9	1.16	1.68	2.10	2.46	2.79	3.09	3.37	3.63	3.88	4.12
1	1.28	1.87	2.33	2.74	3.10	3.43	3.74	4.04	4.31	4.58

[12] Churadze T. "Construction of Surami pass railway and tunnel," // Transport Construction. №10. Moscow: 2005, p.p. 29-32. (In Russian).
[13] Ardashev K.A., Akhmatov V.I., Katkov G.A. "Methods and devices for investigation of rock pressure," Moscow: Nedra, 1981. (In Russian).
[14] Borisov A.A. "Mechanics of rocks and massifs," Moscow: Nedra, 1980. -360 p. (In Russian).
[15] Brednev V.A. "Numerical realization of geo-mechanical model of mines supports interaction with rocks massif" // TulPI. — Tula, 1986. p.p. 105—107. (In Russian).
[16] Bulichev N.C. "Mechanics of underground structures in examples and tasks: Reference book for HIEs," Moscow: Nedra, 1989. -270 p. (In Russian).

Fig. 3 Interrelation between the additional loading (q_{ad}) and the rocks` cracking ability ratio (K_{cr}) in case of one-rail railway

III. CONCLUSION

During the reconstructing and capital repairing of the existing tunnels, between additional loading and support in working during t-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

[1] V. Khrapov. "Tunnels and underground railways," Moscow: Transport, 1989. -383 p. (In Russian).
[2] Liberman Yu.M. "Pressure on support of permanent workings," Moscow: Nauka, 1969. -119 p. (In Russian).
[3] Rupeneit K.V. "Some issues of rock mechanics," Moscow: Ugletechizdat, 1954. -384 p. (In Russian).
[4] V.G. Khrapov. "Tunnels and underground railways," Moscow: Transport, 1989. – 235 p. (In Russian).
[5] Labass A. "Pressure of rocks in coal mines," //"Issues of theory of rock pressure", Moscow: Gosgortechizdat, 1961. (In Russian).
[6] T. Churadze (with co-authors). "Technological assessment of transport-construction and design decisions," //Transactions of Georgian Technical University, №3(427), Tbilisi, 1999, p.p. 49-52. (In Georgian).
[7] VNIMI, VNIIOMShS of Ministry of Mining Industry of USSR. "Guidelines to design of underground mines and calculation of support," Moscow: Stroyizdat, 1983. -272 p. (In Russian).
[8] "Issues of theory of rock pressure," Under the general editorship of A.A. Borisov. Moscow: Gosgortechizdat, 1961. - 300 p. (In Russian).
[9] T. Churadze (with co-authors). "Experimental method for technological assessment of transport-construction and design decisions," //Transactions of Georgian Technical University, #3(427), Tbilisi, 1999, p.p. 52-57. (In Georgian).
[10] T. Churadze (with co-authors). "Analysis of railway investigation, planning and construction technological processes," //Transactions of Georgian Technical University, #3(427), Tbilisi, 1999, p.p. 102-107. (In Georgian).
[11] Churadze T. "Construction of by-pass way on pass site," // Problems of Applied Mechanics. №1(14). Tbilisi, 2004, p.p. 76-80. (In Russian).