PHYSICAL MODELING OF THE FIRE ON THE MODELS OF HORIZONTAL AND INCLINED ROAD TUNNELS

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We have scheduled to study important technological parameters of ventilation under fire conditions on physical models of different scales of road tunnels. Modeling will be performed on the tunnel models of G. Tsulukidze Mining Institute and of Georgian Technical University. These models complement each other and help us to determine the regularity of the variations in a critical velocity, a back layering length, and a gradient-factor. Physical modeling results will be compared with numerical modeling results obtained using full-scale modern engineering software packages Pyrosim and Fluent to allow new results to be used for specific tunnel geometry, location and topology.

The critical velocity is defined as the minimum longitudinal ventilation velocity to prevent reverse flow of smoke in case of fire. The back layering length is the distance at which toxic products of combustion spread upstream of the fire when the ventilation velocity is lower than the critical velocity. Gradient-factor is defined as a grade correction factor, to be applied for estimated fires in sloping tunnels.

The report presents projects of experimental tunnels, as well as methods for conducting experiments and analyzing the results obtained [1, 2]. The control values for the experimental tunnels are given in Tables 1-3.

Depending on the modeling scale (1:40; 1:60) the calculations of firepower in the nature and on the model, as well as the amount of heat released and the gas consumption are given in Table 1.

Table 1

Firepower in the nature and on the model

Firepower in according modeling scales 1:40 and (1:60)		Natural gas consumption, m^3/h [l/h]	Heat released on the model, MJ/h
In the nature, MW	On the model, kW		
5 (5)	0.494 (0.179)	0.05313 [53.13] (0.01928 [19.3])	1.778 (0.646)

In the nature air velocity fluctuation range equals between 0.2-6.0 m/s. 0.2 m/s is the minimum speed to ensure turbulence in the tunnel, and 6.0 m/s - the maximum permissible speed in accordance with construction regulations and rules. The variation of velocities for the models is given in the Table 2.

Table 2

Firepower in the nature 5 MW

Modeling scales 1:40 and (1:60)				
Air speed in the nature, m/s	Air speed on the model, m/s	Tunnels cross-section, model [nature], m^2	Air consumption on the model, m^3/h	Increment of air temperature on the model, ^0C
6.0 (6.0)	0.949 (0.780)	0.04 [64] (0.027 [95.7])	136.6 (74.2)	96.4 (8.9)
3.0 (3.0)	0.474 (0.390)	0.04 [64] (0.027 [95.7])	68.3 (37.1)	192.8 (17.8)
1.0 (1.0)	0.158 (0.130)	0.04 [64] (0.027 [95.7])	22.8 (12.4)	578.6 (53.4)
0.5 (0.5)	0.079 (0.065)	0.04 [64] (0.027 [95.7])	11.4 (6.2)	1157.2 (106.8)

Table 3

Firepower in the nature 30 MW

Air speed, scale 1:60		Tunnels cross-section, model [nature], m^2	Air consumption on the model, m^3/h	Increment of air temperature on the model, ^0C
Nature, m/s	Model, m/s			
6.0	0.780	0.027 [95.7]	74.2	53.4
3.0	0.390	0.027 [95.7]	37.1	106.8
1.0	0.130	0.027 [95.7]	12.4	320.4
0.5	0.065	0.027 [95.7]	6.2	640.8

Fire power and air velocity on the model and in nature are calculated according to the formulas

$$\frac{Q_m}{Q_n} = \left(\frac{l_m}{l_n}\right)^{2.5}, \qquad (1)$$

$$\frac{U_m}{U_n} = \left(\frac{l_m}{l_n}\right)^{0.5}, \qquad (2)$$

In the formulas the index m corresponds to the model; n - nature; Q - Heat dissipation rate, MW, kW; l - length, m; U -air speed, m/s; l_m = 12 m; l_n = 480 m for scale 1:40; l_m = 12 m and l_n = 720 m for scale 1:60. The remaining values are shown in Tables 1-3.

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