CHARACTERISTICS OF ROCK PRESSURE MANIFESTATIONS ON REINFORCED-CONCRETE TUBULAR SHIELDS

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Commercial tests of reinforced-concrete tubular shields at the 8 and 3-Novaya collieries in the Kuzbass included a study of the interaction of the support with the country rocks and caved rocks and determinations of the value and character of the stresses on this type of canopy. The value and character of the stresses on ZhTShch shields were established from deformations of the reinforcing rods, the concrete, and dynamometers on control beams. The latter were located so as to obtain the maximum amount of information from the whole area of the canopy.

To measure the load due to caved rock, each control beam of the test shields was equipped with reinforcement strain gauges and reference marks. For this purpose sensing elements of resistance strain gauges were glued on one to three reinforcement rods, located in the zone of maximal tensile stress, in five cross sections. Indicator reference points were concreted into the walls of control tubes.

Duplicated measurements of loads due to deformations of the fittings and concrete give a sufficiently accurate picture of rock pressure manifestations.

The value of the longitudinal loads on the shield beams was determined from deformations of the dynamometers, installed on the roof side of the seam and fixed to the end disks of the control tubes. Deformations of the rod reinforcements and dynamometers were measured with an IID-2 instrument, those of the concrete by an SUI-II indicator prop.

Table 1 gives the values of the loads on reinforced-concrete tubular shield canopies for seam thicknesses of 5.0 and 5.5 m, from data of these observations.

The intensity of the load on rigid sectional, flexible nonsectional, arch-type, and other designs of shield canopies can be determined with a certain amount of error (correction factor 0.6) on the basis of field data [1, 3, 5] from the graph in Fig. 1:

\[ P_{av} = 1.7 \text{ m tons/m}^2, \]

where \( m \) is the size of the shield in terms of seam thickness in meters.

<table>
<thead>
<tr>
<th>Shield design</th>
<th>Shield size, ( \text{mm}^2 )</th>
<th>Load on shield, ( \text{tons/m}^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZhTShch-500 (model I)</td>
<td>( 30 \times 5.0 )</td>
<td>11.5</td>
</tr>
<tr>
<td>ZhTShch-500 (model II)</td>
<td>( 30 \times 5.5 )</td>
<td>13.0</td>
</tr>
</tbody>
</table>


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With m = 5.0-5.5 m, according to (1) the load on reinforced-concrete tubular shields will therefore be 8.5-9.4 tons/m^2, but the actual loads on ZhTShch shields are 1.3-1.35 times higher than $P_{av}$.

Figure 2 plots the empirical regression lines of the load on reinforced-concrete tubular shields versus the rate of advance. The root-mean-square deviation of the load is 2.3 tons/m^2 for the ZhTShch-500 shield (model I) and 2.6 tons/m^2 for the ZhTShch-500 (model II) shield.

According to [2], the overload coefficient $k_1$ is

$$ k_1 = \frac{\bar{p} + 3 \sigma}{\bar{p}} = 1.6. \quad (2) $$

The value of this coefficient is included in the formula for selecting the cross sections of the load-bearing members (tubes) at various shield dimensions in terms of seam thickness.

Table 2 compares the calculated loads $P_{calc}^f$, obtained from a formula including an overload coefficient $k_1^{calc} = 1.6$, and a coefficient $k_2 = 1.3$, allowing for exceeding of the average loads on ZhTShch shields, with the calculated loads $P_{calc}^t$ determined from formulas of M. M. Protod'yakonov and E. Ya. Makhno [4].

The $P_{calc}^f$ and $P_{calc}^t$ values, calculated from (3) and (5), respectively, display close agreement. In this case the value of $P_{calc}^f$ is greater than that of $P_{calc}^t$ by the value $k_2 = 1.3$. When the values of the loads calculated from (3) and (4) are compared, the $P_{calc}^t$ values are clearly too low.

Bearing in mind that the formulas for reinforced-concrete load-bearing members of annular section ensure a safety factor of 1.45-1.60, we established the maximum load on reinforced-concrete tubular shields: for shield dimensions in terms of a seam thickness of 5.0 m, 29.5 tons/m^2; for a seam thickness of 5.5 m, 33.3 tons/m^2. With such a load-bearing capacity of ZhTShch shields, the probability of failure is virtually excluded. With the experience gained in practical use of reinforced-concrete tubular shields, the values of $k_1$ and $k_2$ will naturally be made more accurate.

The results of the interaction of reinforced-concrete supports with the adjoining rocks do not differ qualitatively from those obtained in previous investigations on other shield supports. We established that the load is redistributed both along and across the seam strike and that in some cases the caved rocks sag. A number of the laws of rock pressure manifestation on ZhTShch shields were also elucidated.

With a shield advance of 0-15 m the load increases from 3-5 to 12-24 tons/m^2, owing to caving of the "cushion." With a shield advance of 15-40 m, when caving of the coal pillar and detritus above the shield is completed, the load is stable within the indicated limits. With a shield advance of 40 m or more, the mean load was 15-20 tons/m^2 and in some cases the peak load reached 30 tons/m^2. Some of the peak loads were due to caving of the roof; this is confirmed by measurements of longitudinal loads on the shield's load-bearing members.