Temporary mechanized gate roof support in the YapiTec mine

J Korski
FAMUR S.A., Armii Krajowej 51, 40-698 Katowice, Poland
E-mail: JKorski@famur.com.pl

Abstract. For more than sixty years in all the world are trials of gateroad temporary mechanized roof supports in mechanized development operation have been conducted unsuccessfully. A case study – temporary mechanized gateroad roof support implemented in one of the entrances/drifts development in the turkish coal mine Yapi Tec Maden from the construction to 12-month practical experiences in practical use as described in the article. The review of gateroad roof support for different purposes is presented in article as a background or circumstances for the described case study. The YapiTec trial of the company own temporary mechanized gateroad roof support is discussed in comparison with second mechanized gateroad face without temporary mechanized roof support and same mining conditions during comparable time.

1. Introduction
For about 60 years, attempts have been made to implement mechanized roof supports for general use as temporary roof supports in narrow mechanical mining faces, enabling the separation of the mining operations with a narrow face roadheader and making the final gate roof support.

The first such solution was implemented in narrow stopes (stopping faces) in the American state of Pennsylvania, where the final support of the excavation consisted of bolting [1,2]. Later, in the European coal basins of Germany and the UK, numerous attempts were made to apply temporary mechanized face roof supports for working with the roadheaders. The main goal of such actions was to extend the available time of cutting with a roadheader, as the erection of the final roof support (or bolting) in the face required the roadheader cutting operation to be stopped [3,4,5].

It was recognized that the use of a temporary mechanized roof support in the face will allow for the final gate roof support to be made at a certain distance from this face and in a place where there is more space and less mechanical devices in operation. Despite the failures of such attempts, works and real actions have been still undertaken to develop new solutions for mechanized temporary roof supports for the purpose of drilling the gates by means of the roadheaders [6]. It should be noted that the available literature on the subject practically ignores the issue of the use of temporary mechanized gate roof supports in the roadheading [7,8].

The only known and widely applied solution of temporary mechanized gate supports in the roadheading are Bolter-Miner machines produced by several manufacturers, which use different roof supports being an integral part of the roadheader and forming a temporary roof support [9].

General overview of the gate roof supports classified according to their purpose and a case study, i.e. experience with the use of a temporary mechanized gate roof support in one of the currently driven dipheadings providing access to the lignite deposit in the Turkish YapiTec Maden mine near the city of Tuncbilek in the West Anatolia is presented below. This case is very interesting as it is possible to compare the results obtained in two headings being driven in the same mining and geological conditions, but with use of different mechanization systems. On this case study is easier to understand why, after
more than 60 years of trials and experiences of mechanized temporary roof supports anywhere was successfully implemented really useful solution. This article is the trial for explaining reasons of those.

2. Mechanized gate roof supports: types and functions

Nowadays, there are several types of mechanized roof supports in the gateroads (Figure 1), depending on the purpose of their intended use:

- Temporary mechanized roof supports used during the gateroad development/driving as a device enabling the final roof support to be made outside the face area without stopping the cutting operation.
- Mechanized gate roof supports securing the roof at the crossing with the longwall (LW entrance).
- Mechanized gate roof supports securing the gates forward the longwall face in operation [12].

There have been and are still in use various solutions of the gate roof supports intended for various purposes, but temporary mechanized supports in the headings driven with the roadheaders have not been successful.

![Mechanized gate roof support - typology](image)

**Figure 1.** Mechanized gate roof support - typology.

Mechanized gate roof supports, regardless of their intended use, are applied in mining operations with mechanical rock cutting, where there is a potential performing of two operations parallelly: mechanical mining and securing the heading/gate for its expected lifetime.

2.1. Temporary mechanized gate roof supports as protection of the face/heading immediately after exposure

This type of roof supports was already in use in the late 1950s as a way to increase productivity, first in room and pillar systems with the roadheader cutting. The necessity to secure the roof with anchors forced the cutting machine to be stopped during this operation. The solution indicated was the use of a mechanized advancing temporary support that enabled to transfer the roof anchoring operation beyond the face area (behind the temporary roof support area) and to perform it simultaneously with the cutting of the face. The first solution applied was the Dowty Rodjo Shield casing used in the USA as a temporary roof support in the faces of the room & pillar system excavated with a Continuous Miner (Figure 2).
The implementation of continuous miner machines with a linear cutting head made the Dowty Rodjo Shield roof support lose its technical justification. For this reason, for a better use of the cutting machine - the continuous miner, multi-face room & pillar systems were used, where the cutting machine, after exposing the roof to a safe depth, travelled to the adjacent face, and a self-propelled bolting machine drove into the abandoned face to bolt/anchor and thus to secure the roof. Time losses related to the passage of the Continuous Miner between individual faces, were limited by implementing faster driving mode (the so-called tram speed).

Based on these roof support solutions, attempts were made in the British mining industry to use aggregates for drilling roadways with a rectangular cross-section (Figure 3). The mechanized support was a temporary roof support behind which a rectangular yield support was constructed.
In the following years, numerous attempts were made to use temporary mechanized gate supports also for the faces with different types of the final steel support. There were designed and tested different solutions as an independent roof support or as an aggregate – roadheader integrated with temporary roof support (mostly with steel arches as final roof support). As an example Westfalia Lunen designed mechanized temporary roof support in both versions (independent and integrated with roadheader). Voest Alpine Bergbautechnik designed and introduced in Germany AVSA aggregate – milling gallery cutter-loader integrated with temporary roof support. This solution was tested with bolts or steel arches as a final roof support. Any of those solutions anywhere did become widespread [10].

Temporary mechanized roof supports being an integral part of the Bolter Miner machines became widely used [11].

2.2. Mechanized gate roof support in LW entrance

Mechanized gate roof support in the longwall entrance became a solution intended to secure the gateroads at the entrance to the longwall. There are many different solutions for such roof supports, one of which is shown in Figure 4.

This type of roof supports did not solve all the problems related to the longwalls with the gates with steel arch supports. An attempt to solve this problem was the mechanized gate roof support with steel arch support at the crossing with the longwall, presented in 2020 [12] (Figure 5).

Figure 4. One of typical solutions of gate roof supports from FAMUR S.A.

Figure 5. New solution of gate support set [11].
Mechanized gate supports for gateroads with rectangular (or trapezoidal) cross section and with an anchor support are widely used, enabling a full mechanization of operations at the entrance to the longwall.

2.3. Mechanized gallery support in the gate forward to LW face
In Chinese ultra-high (over 6 m high) mechanized longwalls, independent, yield supports were used, advancing in the gateroads ahead of the face front. In these gateroads, various types of anchoring with various anchors/bolts are applied, and for additional protection of such a gate ahead of the face front in the area of the strongest impact of operational pressure, mechanized advancing supports were applied (Figure 6) [12]. Such supports are used in both gates, but they differ depending on the purpose/intended use of the gate.

![Figure 6](image_url)

**Figure 6.** Roof support at longwall face and headgate and tailgate face-end outby T-junctions [13].

The applied supports with a rectangular cross-section and a large free cross-section under the roof support enable a free air flow and an installation/placement of the necessary devices.

![Figure 7](image_url)

**Figure 7.** Mechanized gate roof support forward longwall face in ultra-thick longwall face (LW) in Chinese coal mine.
Such roof supports enable a safe and reliable operation of very high longwalls while providing high productivity and safety (Figure 7). Ultra-high longwall faces equipment is very expensive.

3. **Temporary roof support of the dipheading being driven in the YapiTec Maden mine (Turkey)**

In 2019, the opening/development of the Turkish YapiTec Maden coal mine deposit in western Anatolia began. The access to the mine will be provided by two dipheadings driven from the surface, which are drilled with roadheaders. The investor has extensive experience in drilling tunnels with reinforced shotcrete lining. This is probably why in one of the dipheadings, a temporary mechanized support for the face was used with the final roof support of reinforced shotcrete (sprayed concrete lining) (Figure 8).

![Figure 8. Entrance to drift with temporary mechanized roof support in The YapiTec mine.](image)

The Ukrainian KP-42 (YaMZ) roadheader works in the heading face. Cutting conditions are: soft shales with clay slices or clay for cutting.

3.1. **Temporary and final roof support**

A combination of several solutions has been selected as the final roof support of the transport dipheading:

- Following the moving mechanized roof support, the roof and the sidewalls of the heading are anchored with steel bolts with the additional welded steel mesh being applied (Figure 9).
Figure 9. Bolter installed on advanced platform behind the roadheader and mechanized temporary roof support.

- Following the anchoring of the sidewalls and of the roof heading, a reinforcement is assembled of welded trusses made of reinforcing rod, in the form of an arched "roof bar" and straight sidewall props (Figure 10).

Figure 10. Prefabricated elements of shotcrete reinforcement.

The main reason for the application of the above-mentioned steel trusses is the planned use of diesel suspended monorail as a means of transport in this mine, and it was found that the anchoring of the
monorail suspension slings in the local conditions (clay and clay-shale) may be insufficient. It was planned to install the truss square sets with spacing of 2 or 3m.

After installing the truss square sets, the roof and sidewalls of the heading are to be covered with shotcrete.

After an exposure of the roof and of the sidewalls, a temporary hydraulic powered support was used as the preliminary protection of the heading.

3.2. Temporary roof support and collaborating devices

The temporary mechanized support applied in the YapiTec Maden mine was developed and produced in the production plant (MarBeyaz Makina), belonging to the same capital group as the mine under construction. The mechanized support is composed of three steel frames with a shape adapted to the intended shape of the heading (straight vertical sidewall parts and an arched roof part), each frame stands on 4 hydraulic props. The frames are connected with each other by means of horizontal hydraulic cylinders (6 cylinders between each pair of frames), these cylinders are intended to move the frames (possible movement in both directions). There is a folding platform/bridge built-in from each side, on the vertical part of the frame, enabling to carry out some maintenance and other operations without an exposure to a contact with the roadheader in operation (Figure 11).

![Figure 11. Temporary advancing gallery roof support in entrance drift development I YapiTec Maden.](image)

To avoid a collision with the moving roadheader and its belt conveyor, the advancing working platform has been built behind the mechanized support, with embedded bolting machine and the manipulator for assembling the prefabricated steel reinforcement (Figure 12).
Figure 12. Advancing working platform for bolting and reinforcement assembly with the manipulator.

The main purpose of using this advancing working platform was to enable uninterrupted operation for workers to carry out anchoring and assembling the prefabricated reinforcement in comfortable and possibly stable conditions.

3.3. Temporary mechanized gate roof support and results of its application after 12 months

After 12 months of using the mechanized temporary gate roof support, it is possible to compare the results achieved when it was applied and the results of the dipheading driven with the modernized AM-50 roadheader, but without using a temporary mechanized support in the heading face. AM-50 is smaller and less powerful than Ukrainian KP-42 in face with mechanized temporary roof support. By September 2020, approx. 300 m of the dipheading had been driven with the use of the mechanized support and approx. 600 m of the other heading. The use of the mechanized support caused (among other reasons) the worse result of the dipheading drivage with this support. The main reasons for the decrease in drilling yield (advancing rate) are specified as follows:

- Low efficiency of the roof and sidewall anchoring system resulting from the type of rocks surrounding the heading (clays, clay shales), resulting in the need to stop cutting operations until anchoring/bolting is completed,
- The movement of the mechanized roof support and the inevitable “pumping” of the roof with the support caused the process of rock stratification to begin and, consequently, there were difficulties with drilling holes for anchoring,
- The cutting capability (advancement) of the roadheader is much greater than the possibility of performing all forms of securing the heading.

4. Conclusion

A low efficiency (advancing rate) of the dipheading drivage with the roadheader and the temporary gate support in the YapiTec Maden mine once again points to erroneous assumptions in the planning of the drilling process with the use of such a mechanization system. In the author's opinion, the application of the temporary gate support in drilling of headings with the roadheader and the use of the final yield support (e.g. arch) is burdened with a logical error (fallacy).
As in previous mechanized, temporary roof support solutions main reasons of problems in Yapi Tec mine are:

- Temporary roof support advancing is “pumping” and fracturing roof strata. As a result roof bolting is difficult and delayed.
- Adopted from tunnelling temporary mechanized roof support needs space for assembling and disassembling – in tunnel development drilling is starting from surface to surface. In underground mining at least one of gallery (incline, drift) is underground and it is problem how to exchange temporary roof support to final in the end of gallery.
- There is problem with inclination or direction change with mechanized temporary roof support – it is impossible to change direction or inclinations immediately.
- It’s impossible to prepare side entrances from the face in time of drilling gallery with Roadheader and mechanized temporary roof support.

Generally, they are main reasons explaining why mechanized temporary roof support are dead end in gateroad development.

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