

## Mechanization of reinforcing gate supports in the zone of longwall inlet

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**Słowa kluczowe:** górnictwo, chodnik przyścianowy, obudowa chodnika, skrzyżowanie ściany z chodnikiem, podciąg, obudowa zmechanizowana

**Abstract:**

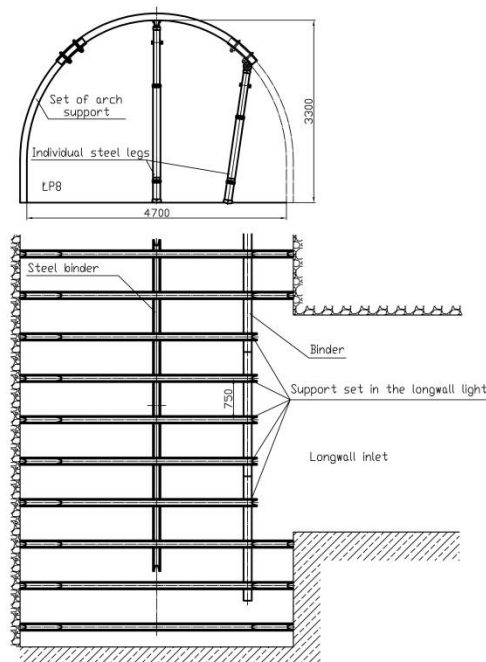
Known and used methods of reinforcing the load-bearing capacity of gates in the zone of crossing between longwall and gate are presented in the article. Characteristic features of equipment (special support unit), used in this zone are discussed. A new design of a special support, eliminating basic disadvantages of present solutions, are proposed.

**Streszczenie:**

W artykule przedstawiono znane i stosowane sposoby wzmacniania nośności obudowy chodników przyścianowych w strefie skrzyżowania ściany z chodnikiem. Omówiono charakterystyczne cechy urządzeń (sekcji obudowy specjalnej) stosowanych w tym rejonie. Zaproponowano nową konstrukcję obudowy specjalnej eliminującą podstawowe wady dotychczasowych rozwiązań.

### 1. Introduction

In the Polish hard coal mining industry the crossing between longwall and gate is an area of concentrated activities connected with a longwall advance. It mainly results from a fact of using support arches in the gate and a need of disturbing a continuity of this support, exactly in the zone of the longwall inlet. The side-wall elements of gate support must be removed to enable pushing out the armoured face conveyor drive to the gate. In this case it is needed to additionally reinforce the gate support in this zone [1]. A fragment zone displacement of disassembled side-wall arches, requiring a necessity of continuous rebuilding of reinforcements of gate supports, causes significant difficulties. These activities, performed in exceptionally difficult conditions, are mechanized only to a small extent. A labour consumption, connected with maintaining the crossing between longwall and gate, often takes over 30% of the time spent on a realization of all the jobs, done in the longwall, and it is the decisive factor about the longwall production capacity [3]. Simultaneously the crossing between longwall and gate is an area of increased rock mass impact [2], which is an additional decisive factor about the safety of miners working there at a continuous reconstruction of gate arches, connected with a longwall advance. In the zone of crossing between longwall and gate the biggest number of accidents happens. In the result a maximal reinforcement of the support of the crossing between longwall and gate is attempted. Mining, geological and mechanization factors force a use of different systems of gate support reinforcements [12. 13]. So called steel binders connecting the set with disassembled side-wall elements and the full set (Fig. 1) are used most frequently.



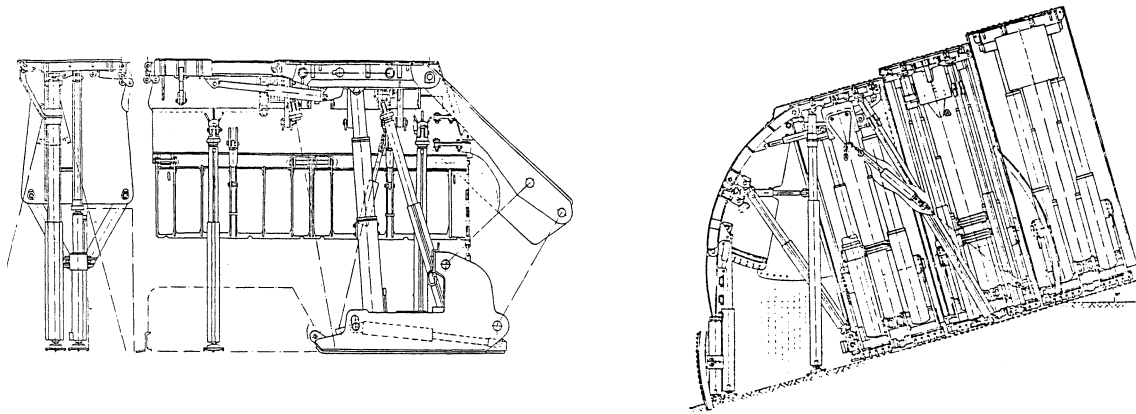
**Fig. 1.** Most frequently used method of reinforcing gate support [Authors' elaboration]

The binders are supported with individual legs and their presence in the crossing zone impedes not only the miners' passage but also a relocation of machines, in particular of the conveyor, when the longwall advances. In difficult geological conditions all the sets of arch supports are supported. A construction of binders and their advance requires an employment of a bigger number of employees in the most dangerous zone of the longwall. Significant difficulties, connected with a construction of the gate support reinforcement, in particular with its advance together with an advance of the longwall, caused a need of searching methods of mechanizing the activities connected with a reinforcement of the gate support in the crossing zone.

## 2. Mechanization of activities in the area of the crossing between longwall and gate – a present situation

Bigger and bigger production capacity of longwall systems causes that the cutting machine must wait for a reconstruction of the crossing zone at the longwall face end. Due to that some attempts to mechanize the activities, connected with ensuring a right protection of this zone, are undertaken [15]. The most frequently used solution consists in conducting in the gate a self-advancing mechanized crossing support unit. This unit is raised under the basic gate support, but its canopies reach outside the zone of disassembled side-wall arches.

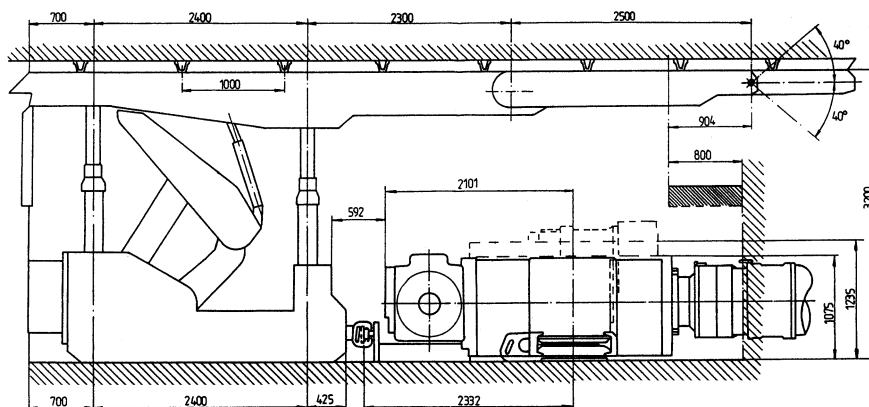
The mechanized crossing support unit was applied at the Marcel Mine at the turn of 1990 and 1991 for the first time in Poland (Fig. 2).



**Fig. 2.** Crossing support unit applied in the Marcel Mine [4]

The unit was designed at KOMAG as a modification of the FAZOS-22/44-Oz extreme support unit. It was a four-leg unit with an elongated sequence of canopies, enabling to support the gate roof in the longwall light and the roof before the longwall face. The canopies were equipped with arched side shields, deflected with rams, shielding the gate side-wall. A correct operation of this unit required an elimination of the gate arch support set before the sequence of canopies of a mechanized unit. An application of this type design enabled to install powered roof support units at the full length of the longwall face together with the gates. Difficult conditions, occurring in the longwall face, in particular the longwall inclination and changes of its length did not make it possible to eliminate the arch support set in front of the unit and it was impossible to conduct the support unit in the gate axis. After a disassembly of arched side shields the unit was used as the first support unit in the longwall face.

In 1993, at the Staszic Mine the first three-segment mechanized crossing support 6L420T (Fig. 3), delivered together with other equipment of the longwall system by the MECO International Company, was applied. Each of the three segments, stabilized by the lemniscate system was equipped with two legs. The front legs of all the segments were additionally stabilized, in relation to the bases, with special clamping rings.



**Fig. 3.** 6L420T crossing support unit by MECO International [4]

This unit became a prototype of new designs of the mechanized crossing support units based on three segment, enabling a self-advance of the unit and when it is possible a collaboration with the conveyor drive base. Such a collaboration is possible when the conveyor drive is located in the gate. A majority of new solutions of mechanized crossing support units has a three-segment construction. A few construction designs of this type unit were developed by the leading producers of powered roof support units in Poland (GLINIK, FAZOS, TAGOR) [6 , 9] . Similar solutions are used in the world mining industry [5 , 14 , 16].

The main disadvantage of units, modelled after the MECO support, is their small longitudinal stability. A big weight of the canopy sequence, pulled out far to the front, at heavy components of the

lemniscate system, located among the legs makes the unit tilt to the front during the advance. Not before raising the unit in the gate, the whole construction is stabilized and active supporting of the gate support by the front deflecting canopies is possible.

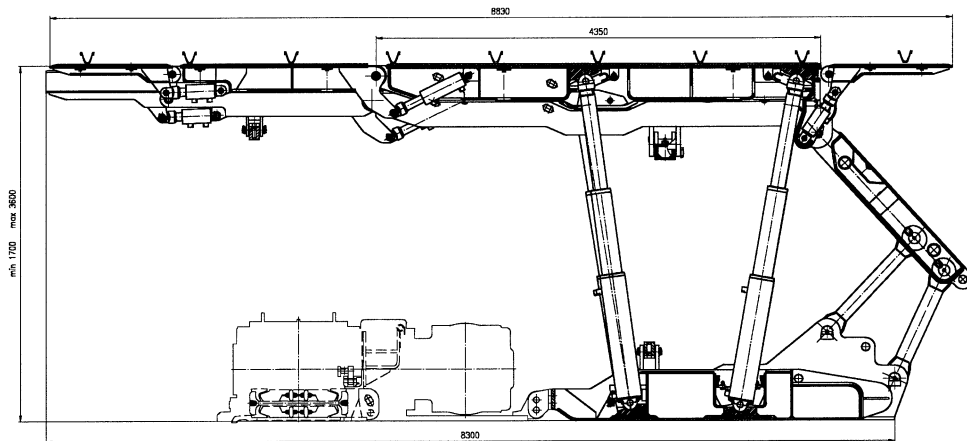
Aiming at an elimination of the disadvantage, known already from the three-segment mechanized crossing support unit, in 1995 at the KOMAG Institute the KSK-18/37-Pz unit (Fig. 4) with the lemniscate system, situated behind the rear row of hydraulic legs which had a very advantageous impact on the weight distribution and thus on the unit stability, was designed.



**Fig. 4.** KSK-18/37-Pz mechanized crossing unit [15]

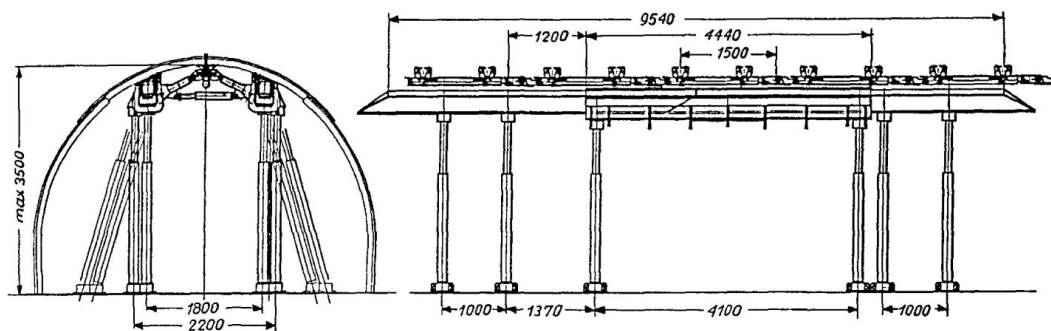
The lemniscate stabilization unit connected the unit external segments with a joint gob shield and a rear connector. A stability of the central segment was ensured by hydraulic rams connecting its main canopy with the main canopies of external segments. The external segments had two hydraulic legs each, supporting the main canopies. In the central segment three legs were installed; two of them supported the main canopy, but the third one – the rear canopy. The main canopies of external segments were equipped with the deflecting – advancing canopies and front canopies supported with rams. The KSK-18/37-Pz support unit was subject to operational tests at the Zofiówka Mine and it was also operated at the Mysłowice-Wesoła Mine.

Taking into consideration the experience resulting from the tests of the KSK-18/37-Pz unit at the KOMAG Institute in 1996, the GSW-17/36-Pz unit (Fig. 5) was designed. It was a for-going modification of the previous design. The advancing canopies were eliminated which simplified the design significantly. The canopies of similar construction and of the same length were used in all the segments. The main canopies were elongated considerably obtaining a bigger load-bearing capacity in the distance of about 2000 mm before the front legs, whereas in the KSK-18/37-Pz unit the deflecting canopies of a small load-bearing capacity were installed. Longer deflecting and front canopies were assembled in the GSW-17/36-Pz support unit which enabled to protect the gate at the bigger length. In the central segment the leg, supporting the rear canopy, was eliminated and a ram was applied instead. The unit could be self-advanced or in connection with the conveyor drive base. It could also support the drive advance, unfortunately this construction has not been implemented.



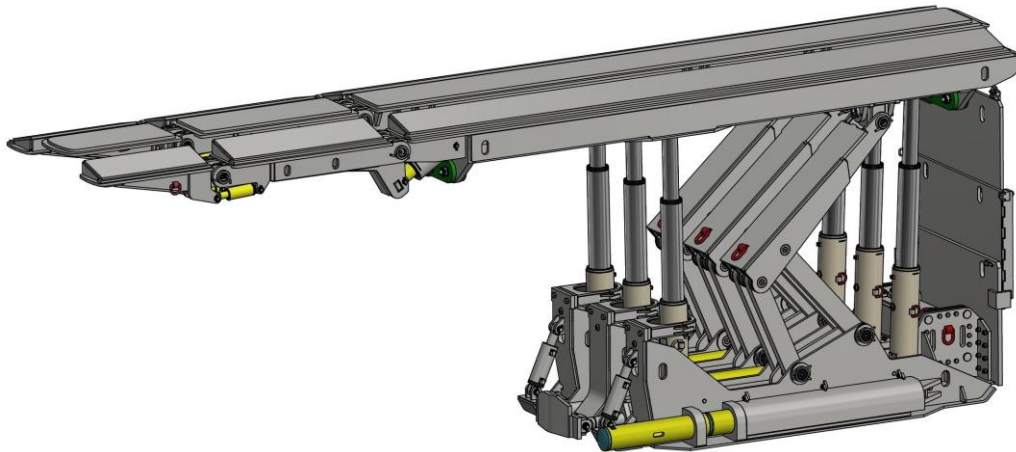
**Fig. 5.** GSW-17/36-Pz mechanized crossing support unit [15]

Three-segment unit with a stabilizing lemniscate system, located among the legs, is the only type of the mechanized crossing support, used at present. Some other constructions of different types also appeared, i.e. constructions of FZOŚ FAZOS S.A. and Główny Instytut Górnictwa (Central Mining Institute), POS-V9 (Fig. 6) made in 1998 and implemented for operational tests in the Wujek Mine [7]. A unit of this support consisted of two sequences of supporting beams, supported with legs and hung on a sequence of track beams through arms and trolleys. The track beam was fitted to the gate support set with holders adapted to a given type of sections. The supporting beams consisted of three parts: front, central and rear ones. The rams, used for a support unit advance, were situated among these parts. Two parts of canopies were always raised by the legs during the advance and the third one was advanced with use of the track beam. The basic disadvantages of this construction included a necessity of constructing a special track beam along the gate axis, lack of the gate support at the length of the advancing canopy part which was performed within a given moment and impeded conducting of the support in the non-linear gate.



**Fig. 6.** POS-V9 chock crossing support [7]

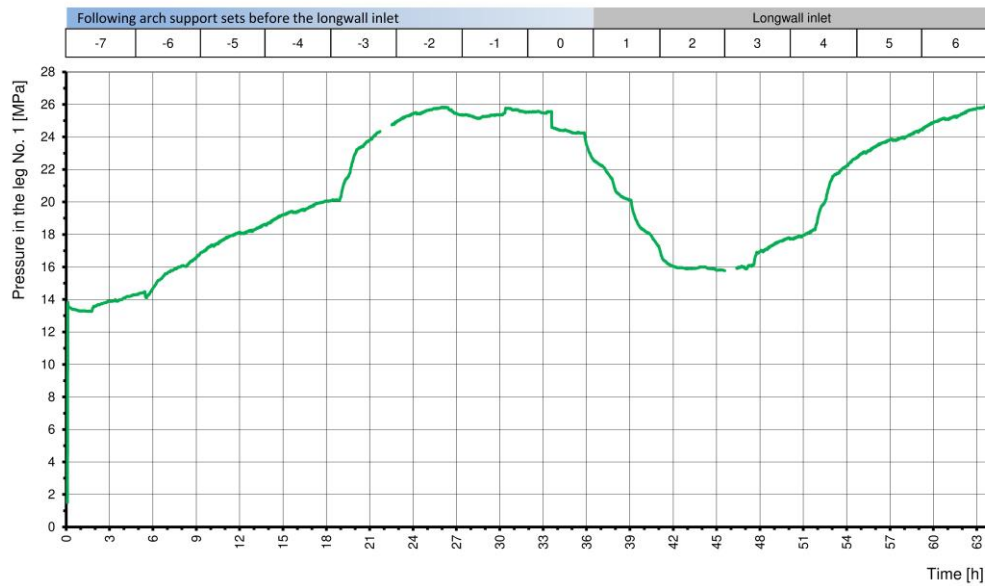
A three-segment unit was also designed at the KOMAG Institute (Fig. 7). It was modelled after the first units of this type due to an appearing demand from mines which needed this type of units.



**Fig. 7.** Model of mechanized crossing support unit [Authors' elaboration]

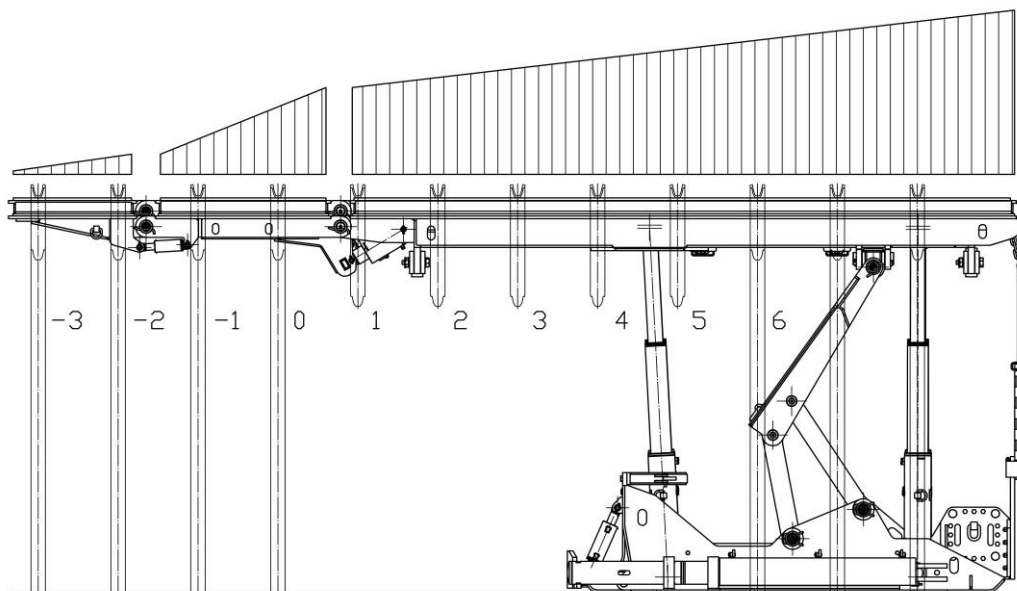
Several solutions, increasing functionality and stability, were used in this unit. In comparison with other units of this type a new unit has a lighter construction.

Three-segment units containing a lemniscate stabilization system, are characterized by a significant weight reaching even 90000 kg [6]. The front parts of this type units, supporting the gate support along the longwall light and on the segment before the longwall light, has a small load-bearing capacity in comparison with the rear part. A mechanized crossing support is indeed an additional support of the crossing zone but in the longwall light, at disassembled side-wall arches, it should be treated as basic support. Besides, in front of the longwall light an increased impact of the rock mass on the gate arch support occurs and exactly in this zone a bigger load-bearing capacity of additional support is needed [11]. In 2001 and 2002 some tests of forecasted loading of the additional support reinforcing the gate support in the crossing zone with the longwall [15] were conducted. One of available monitoring methods of the gate support was applied [8, 10]. The load, transmitted to the additional support through the set of the arch support in the gate, was measured during longwall mining operations. Binders clamping the canopy elements of a few adjacent arch support sets were used on the crossing of the longwall and gate, and the following sets were supported by individual hydraulic legs of SHC type. The pressure, reflecting the load transmitted by the arch support under clamping, was recorded. Setting of legs was started in the distance of about 10 m before the wall and the measurements were conducted until the longwall passed the measurement segment. The test results showed that the load transmitted by the arch support set to a measurement leg increased when the longwall was getting nearer and nearer, reaching the biggest values at the length of 3÷4 sets before the zone of disassembled side-wall elements of the set. A reduction of load on a few sets with disassembled side-wall elements occurred in the longwall light and then a following load increase was experienced, when the goaf zone was getting nearer and nearer to the measurement leg (Fig. 8). The gate behind the longwall was liquidated.



**Fig. 8.** Course of pressure in the measurement leg [15]

In Fig. 9 a graph of load-bearing capacity of individual canopies of the three-segment unit is shown for a comparison. In Fig. 9 individual sets are marked with the numbers in accordance with the numbers accepted at the graph shown in Fig. 8. The units of this type have the smallest load-bearing capacity exactly in the zone, where a big one is most needed. It should be assumed that in extreme cases the set of gate support before the longwall light may be clamped. In the result, despite having a heavy unit of a powered roof support unit on the crossing, it is not possible to resign from an additional reinforcement of the gate support before the powered unit.



**Fig. 9.** Comparison of load-bearing capacity of individual canopies in a crossing support unit [Authors' elaboration]

### 3. New concept projects

All figures, charts, schematics, and photographs should be named as figures in the text and numbered consecutively with Arabic numerals. Each figure should have a brief caption describing it and, if necessary, a key to interpret the various lines and symbols on the figure.

Knowing the basic advantages and disadvantages of the methods of the gate reinforcement in the zone of the crossing with longwall, used at present, some research and development work was undertaken at the KOMAG Institute to elaborate a new construction, having the advantages of the former solutions and at the same time eliminating the disadvantages. For a new design solution it was accepted that a set of canopies should ensure a uniform support of the gate support in the zone of crossing between longwall and gate, incorporating also the segments before and behind the longwall light. The equipment should be self-advancing, of a light construction and it should be possible to operate it in a non-linear gate. No supporting legs should be installed along the longwall light, and the legs themselves cannot impede the miners' passage and cannot collide with other equipment located in the crossing zone.

Taking into consideration the accepted assumptions, it was rejected to follow the existing three-segment construction of a very big weight. It was assumed that the components, having contact with the gate support set (canopies), should be in the number of three. Only such an assumption enables a continuous support of the set during an advance (walking) of the construction. It was also assumed that the canopy beams should cover full length of the whole crossing zone and should be supported with legs at the ends, outside the longwall light. In the case of such an assumption the canopies (sequence of canopies) should have the length of about 7500 mm.

The equipment (self-advancing binder), whose central canopy is situated in the gate axis, was designed. The canopy is equipped with a symmetrical bracket of the legs and with the clevises for deflecting the legs (Fig. 10). At the bracket both sides there are rollers which make support points for the lateral canopies during their advance.

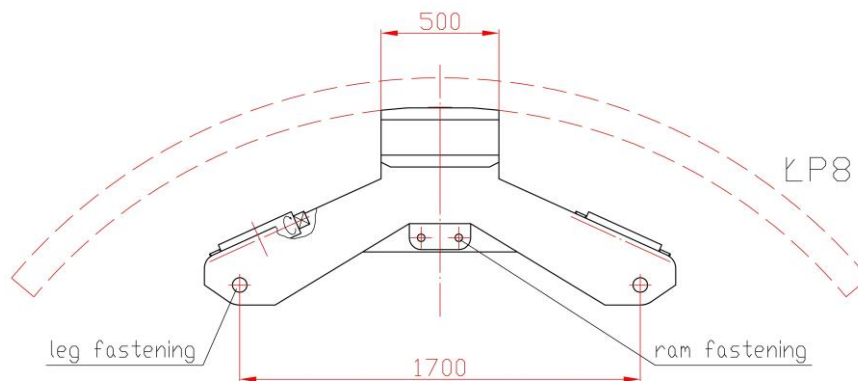


Fig. 10. Central canopy of the binder [Authors' elaboration]

The lateral canopies connected with a joint bracket being also a support for the legs, are situated at both sides of the central canopy. The bracket is equipped with clevises of rams for deflecting the legs. An assembly of lateral canopies for the LP8 profile is shown in Fig. 11. Due to shape differences of different size LP sets, the lateral canopies are installed on the bracket in a self-aligning way, with a possibility of its adjustment to the shape of canopy set element.

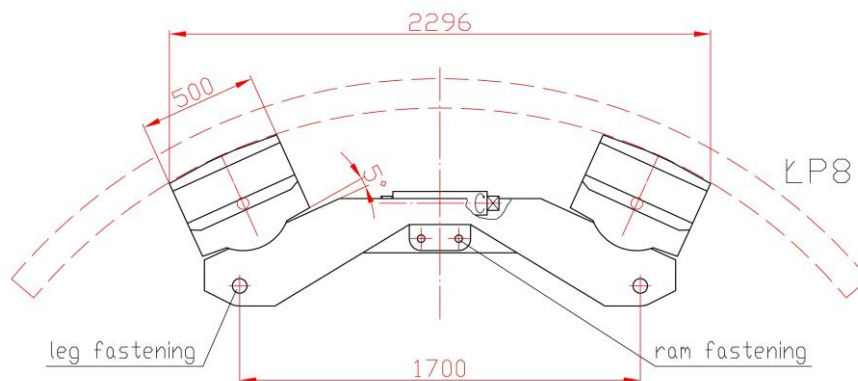
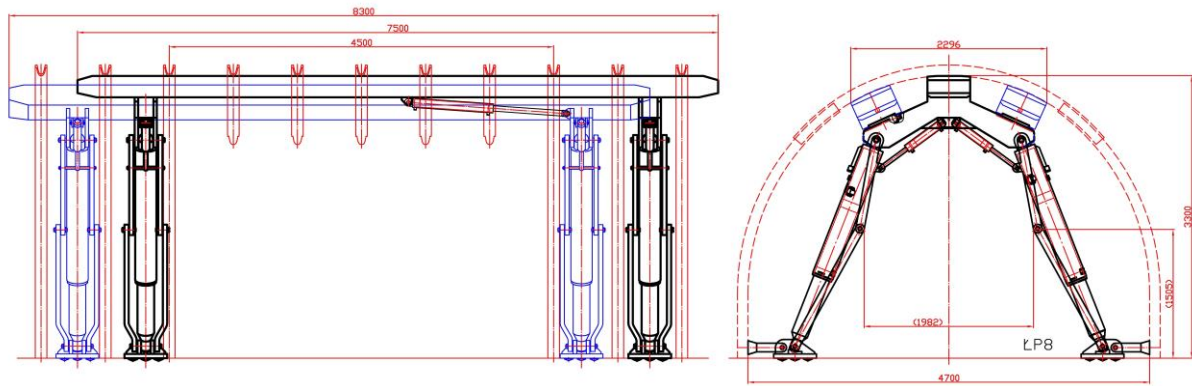


Fig. 11. Assembly of lateral canopies of the binder adapted to LP8 set [Authors' elaboration]

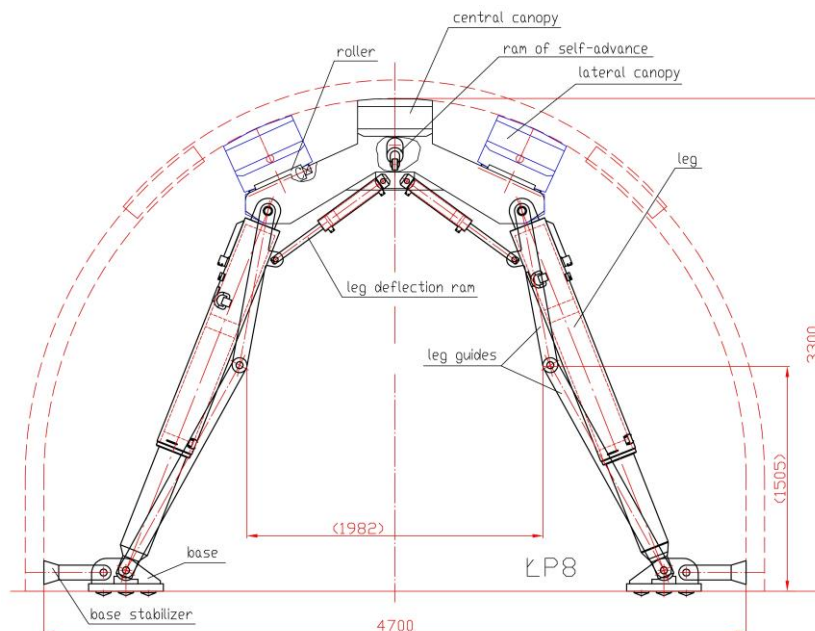


The central canopy and the assembly of lateral canopies, equipped with hydraulic legs, are situated on the bases forming two assemblies connected with the self-advancing ram (Fig. 12).



**Fig. 12.** Collaboration scheme of binder assemblies with gate support set [Authors' elaboration]

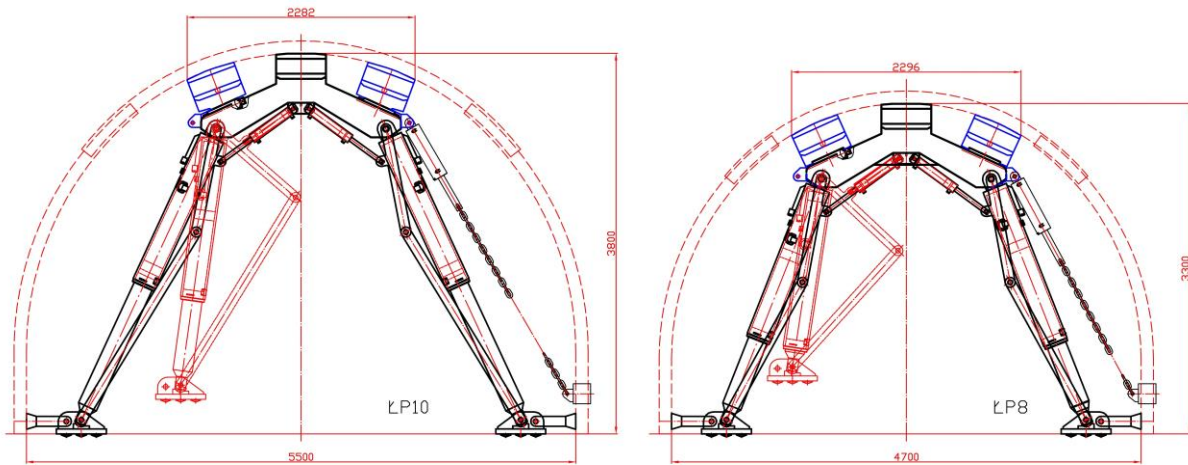
During the support of the arch support set the canopies of the binder are raised with eight hydraulic legs – four legs for the central canopy and four legs for the assembly of lateral canopies. During an advance e.g. of the central canopy, its legs are lowered and the canopy lowers till it leans on special rolling elements of the brackets of lateral canopies. A further lowering of the legs causes their raising together with the bases. After the legs are raised, it is possible to correct an angle of their position, controlling the rams operating together with special connectors. These connectors reduce a risk of generating lateral forces in the legs. In the consecutive step it is possible to advance the central canopy to the front together with the legs and the ram connecting the central canopy with the bracket of lateral canopies. In the same way an advance of the assembly of lateral canopies, together with the legs, is realized. Fig. 13 shows a construction and elements forming a support for the canopies of the binder. Special bases of the legs, increasing the surface of their leaning on the floor, are equipped with stabilizers which facilitate proper positioning of the legs in the gate. Each stabilizer leans on a few adjacent side-wall elements of the gate support set.



**Fig. 13.** Construction of assemblies supporting the binder canopies [Authors' elaboration]

A construction of the binder enables an application of an additional mechanism facilitating a removal of the following elements of side-wall sets of the gate support. To realize this task the lateral canopies are equipped with clevises for fastening the rams, which enable to tear out the side-wall

element of gate support from the floor (Fig. 14) using a chain with an appropriate holder. This operation is one of difficult ones, but indispensable to be performed in the crossing zone. At present no dedicated equipment is used for its assistance.



**Fig.14.** Adaptation of the binder for a removal of elements of gate support set [Authors' elaboration]

To ensure a correct collaboration of the binder with the gate support set at an unavoidable non-linear course, a possibility of dividing individual canopies into parts is introduced. Interconnections of these parts, enabling a minor deviation of their axes, facilitate an advance of the binder along the gate.

#### 4. Summary

The KOMAG Institute of Mining Technology has been developing the design of powered roof supports for many years. In the first development stage it was the only supplier of technical documentation for a production in the Polish mines and in a certain period also a production on foreign markets (Russia, China, India, Hungary). The basic solutions of the FAZOS-12/28-Oz and GLINIK-08/22-Oz powered roof supports were developed just at KOMAG. Similarly as in the case of mechanizing the crossing zone of the longwall and gate, the first construction of the mechanized crossing support unit in Poland was generated at KOMAG.

In the article a new approach to solving problems, related to maintaining the overall dimensions and the load-bearing capacity of the gate in the direct vicinity of the extracting longwall, is presented. The suggested solution enables a significant reduction of time indispensable for a reconstruction of equipment on the crossing when the longwall advances and thus to reduce or even eliminate the cutting machine down-time at the face ends. An additional advantage of the offered equipment consists in aiding a disassembly of the side-wall elements of the gate support in the longwall light.

In the designing processes of powered roof support units the KOMAG specialists use the latest versions of the CAD Autodesk Inventor software and advanced computational software based on the FEM method. They enable to elaborate and check basic parameters of designed constructions already at the designing stage.

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