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ŁPW STEEL ARCH SUPPORT – DESIGNING AND TEST RESULTS

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Abstract
Increasingly difficult geological-mining conditions make it necessary to seek new and effective ways of securing roadways. The new types of support must meet very high strength requirements and must have very high load-bearing capacities. These two conditions were taken into consideration when an ŁPw type steel arch support was designed. High strength of the arches was obtained through using steel of improved mechanical parameters, while high load-bearing parameters were obtained through shaping elements of the support arches. The works were conducted within the framework of the targeted research project no. 6ZR8 2008 C/07012 undertaken by Huta Łabędy SA, Institute for Ferrous Metallurgy and Central Mining Institute between 2010 and 2012.

Key words
support, load capacity, research, project

1. INTRODUCTION

Continuous deterioration of geological and mining conditions in hard coal mines and, an increase in the load affecting the support are the result of several factors: the growing depth of mines, former exploitation, geological disturbances and rock mass tremors. Also, the use of workings of greater and greater cross sections, which is associated with the size of mining machinery and equipment has a significant influence on the increase in the load. In such a situation, it is necessary to use roadway supports of high load-bearing capacity parameters to provide a sufficient level of safety. It is also important to use the parameters of support fully, which may be obtained through improving the conditions of how individual support arches work, through the use of tight lining between the support and the rock, proper setting on the floor and proper setting against its sidewalls (Konopa, Sawka 1987; Pacześniowski 1997; Skrzyński et al. 1999). Additionally, in cases of a support consisting of yielding support arches it is important to use friction joints appropriately, according to the value, distribution and character of the load. The above mentioned issues are the result of economic reasons. Coal mines, adapted to the realities of the free market, are forced to lower their costs of production. It is one of the reasons for searching for, and testing new, more effective ways of securing roadways and for the full exploitation of the currently existing solutions. To meet these demands, designers and producers of supports constantly expand the range of available solutions to optimal supports to given geological-mining conditions. That is how a wide range of types of arches of a roadway support, made of different sizes of V profiles, and of steel of diversified mechanical parameters (Katalog…) have been developed.

A yielding steel arch support is a basic type of roadway support used in Polish coal mines. Its main element is a steel frame made of V-shape profile arches of the following weight factors: 25, 29, 32, 34 and 36 (weight of 1 meter of a profile). It is necessary to note that, at present, the most common ones are arches made of V29 and V32 profiles. Support arches have the biggest share of generating costs of supports since they are the heaviest elements. Thus, lowering costs of the support (both material costs and building costs), must be associated with reducing the number of support arches, as they have the biggest influence on the amount of steel used in the support. A massive share of the steel used in given elements of a support (per a linear meter of a support at 1-meter pitch) is shown in Figure 1. Figure 2, in turn, shows the distribution of material costs of particular elements in 1 meter of a support. As the presented graphs show, the simplest and most effective way to improve the cost effectiveness of the solutions applied and to lower the unit weight of a support is increasing the distance between arches, as their share both in the total price and the total weight of a support exceeds 60%. The aim can be achieved without losing anything of the load-bearing capacity of a support.

As it is seen, lowering the amount of steel used in a roadway support is tightly associated with its pitch. Increasing it without taking any additional action leads to lowering the load capacity of the whole support. In such cases, to maintain an appropriate level of safety, it is necessary to apply arches of greater load capacity – of improved shape or made of steel of improved mechanical parameters. Such an approach was chosen in targeted research project no. 6ZR8 2008 C/07012, undertaken between 2010 and 2012 by Huta Łabędy SA, Institute for Ferrous Metallurgy and Central Mining Institute.

One of the first stages was preparing, firstly, the chemical composition of a new grade of steel of high mechanical parameters and, secondly, the technology of rolling profiles made of the steel. The second stage includes designing new support arches made of the new grade of steel to use the high strength of the elements optimally. The scope of actions of given contractors is presented in the form of a scheme in Figure 3.

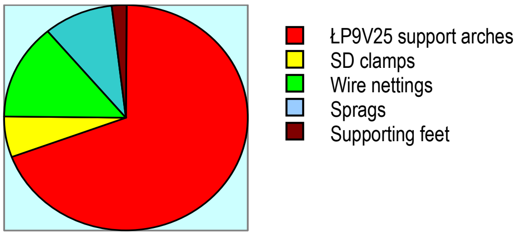

Fig. 1. Share of steel in particular elements in total weight of support (Rotkegel et al. 2005)

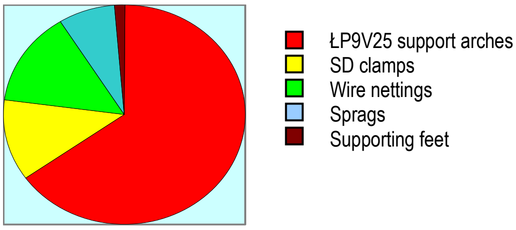

Fig. 2. Distribution of material costs of support per 1 meter of working (Rotkegel et al. 2005)

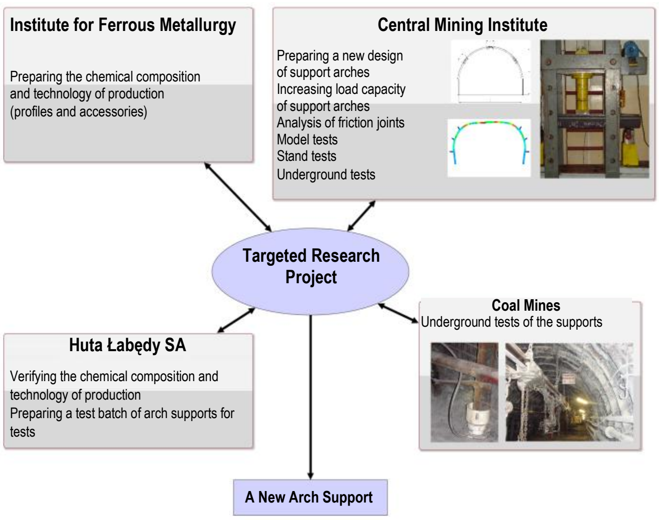

Fig. 3. Delegation of tasks undertaken within the framework of the targeted research project

2. NEW DESIGN OF SUPPORT ARCHES

The most important task undertaken within the framework of the targeted research project was designing a steel arch support of high load-bearing capacity with the use of the new grade of steel. As the characteristics of the work of yielding support arches ŁP shows, operating load capacity F_N (yielding) is 45–55% of the maximum load capacity of support arches F_{max}. In accordance to the standard of PN-G-15000/05, the extent of use of the maximum load capacity of support arches is expressed with the coefficient $k_4 = F_N/F_{max}$. Thus, to use the maximum load capacity of support arches properly, it is necessary to increase the values of both parameters which affect the 'enhancing characteristics' of stiffened and yielding arches. The concept of the actions is presented in Figure 4.

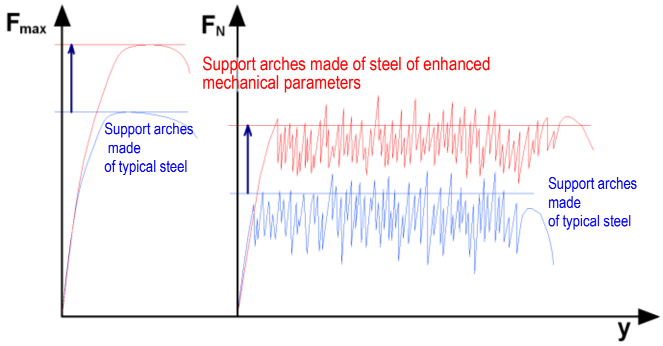

Fig. 4. Essence of enhancing characteristics of support arches: F_{max} – maximum load capacity of support arches (stiffened), F_N – operating load capacity of support arches (yielding), *y* – lowering support arches

Increasing the value of the load-bearing capacity of yielding support arches facilitates exploiting the strength of given elements (arches) more efficiently. Yet, when the strength is exploited excessively, it leads to stiffening support arches, as their load capacity and functionality disappear even after small deformations. It means that it is necessary to find an optimum value of coefficient k_4 – at which support arches have the greatest value of operating load capacity (F_N), and still retain their load-bearing capacity. The next issues are: shaping friction joints properly and choosing clamps to obtain the intended value of coefficient k_4.

To rectify the issues, numerous analyses and stand tests of friction joints were conducted. They included tests of both the straight segments of the profiles and the whole support arches. The research and analyses show an obvious fact that friction joints transfer bigger loads when the third clamp is used in a joint. An even greater increase in load capacity is observed when 'lens' effect (the gap between flanges of mating arches) is eliminated. The gap renders the contact and, as a result, the friction between the mating arches lessens in the area beyond the ends of the friction joints, as it is presented in Figure 5.

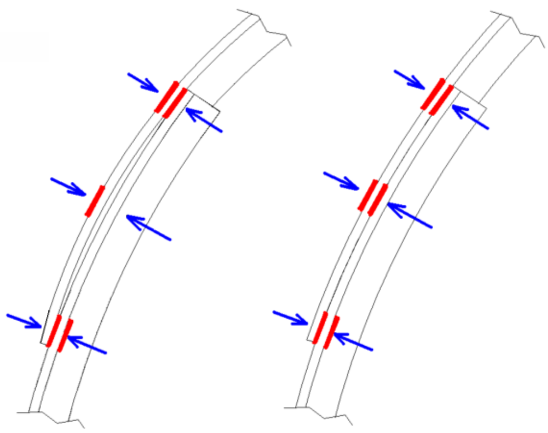

Fig. 5. Increase in the number of mating surfaces in friction joint through eliminating 'lens'

To change it and eliminate the effect, it is necessary to ensure the identical curvatures of mating elements. The newly