MultiScience - XXX. microCAD International Multidisciplinary Scientific Conference
University of Miskolc, Hungary, 21-22 April 2016, ISBN 978-963-358-113-1

# RESEARCHES REGARDING THE USE OF LAMINATED PROFILES FOR THE SUPPORT OF JIU VALLEY MINE GALLERIES IN ORDER TO INCREASE THEIR OPERATIONAL PERFORMANCES

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**ABSTRACT**

The paper brings forward the issue of the determination of the physical and mechanical characteristics of the laminated profile used for the support of galleries in the coal industry in order to improve the constructive and functional solutions of the support of the gallery cross-section during their lifespan.

The comparative results derived from the equivalence of the laminated profiles used in the Jiu Valley Coal Basin are also presented.

**KEYWORDS**

Support, galleries, laminated profiles, equivalent comparison, performance, exploitation.

## 1. INTRODUCTION

One of the most important conditions for efficient mining consists in the stability of the mine work and maintaining it at a full operational level during the entire service with minimum maintenance costs.

In order to ensure a continuous operation of Jiu Valley mines, every year, an important amount of works needs to be undertaken in different geo-mining conditions, which are characterised by soft rocks which have an advanced degree of cracking to hard rocks and variable depths comprised between 300 and 1000 meters.

Therefore, the technical solutions comprised by the designs related to the location, protection, support and the mining technology used, especially the ones for the opening of the mine, need to be diversified according to the specific geo-mining conditions. Moreover, the exercised intensity of the pressure of the mine, its main directions and its effective values need to constitute one of the decisive factors when adopting different technical and safety solutions for the supports.

The existent practice highlights the fact that, independently from the location depth of the work, the properties of the rock, the value and respectively the acting direction of the pressure of the mine, in order to support the mine opening works the metallic profiles SG 18, SG 23 (rarely SG 29) were generalised and the support made of concrete and cinderblocks with a thickness of 300-500 mm.

## 2. GENERAL CONSIDERATIONS REGARDING METALLIC SUPPORTS

The metallic supports are made of laminated profile elements of different shapes (train rail, pokal profiles, T profiles, double T, bell shaped, cradle shaped, U

DOI: 10.26649/musci.2016.110

profile) of high quality steels with yield strength comprised between 3000 and 5000 daN/cm$^2$, and tensile strength between 5000 and 7000 daN/cm$^2$.

The metallic support is destined to be used for mine opening and priming works with different geometric shapes (straight walls and curved circular ceilings) carried out in rocks with different roughness coefficients.

The appreciation criteria of the laminated profiles destined for use in horizontal mine works are the following:

- profile efficiency expressed through the relation between the resistance module $W_x$ and the weight per meter of the profile, g:

$$\eta = \frac{W_x}{g} \tag{1}$$

The efficiency of the laminated profile is in direct proportion with the value of $\eta$ .

- The bending factor m represents the relation between the bending resistance of the laminated profile $\sigma_i$ and the resistance module $W_x$:

$$m = \frac{\sigma_i}{W_x} \tag{2}$$

- The coefficient of symmetry given by the relation of the modules of resistance $W_x$ and $W_y$, relation which needs to be as close to 1 as possible:

$$s = \frac{W_x}{W_y} \tag{3}$$

- The economic criterion $\eta_e$ represents the relation between the maximum bending moment $M_i$ and the product between the weight per meter of the profile (g) and the cost of one meter of laminated profile (a):

$$\eta_e = \frac{M_i}{g \cdot a} \tag{4}$$

According to Table 1, the quality appreciation criteria of the laminated products are assessed based on related geometric and material properties enumerated above.

Table 1 Quality appreciation criteria

| Criterion | Value | | | |
|---|---|---|---|---|
| | V21 Poland | THN 21 Bulgaria | THN 21 Czech | SG 23 Romania |
| Profile efficiency $\eta = \frac{W_x}{g}$ | 2.92 | 2.87 | 2.87 | 2.89 |
| Bending factor $m = \frac{\sigma_i}{W_x}$ | 0.17 $\sigma_i$ | 0.017 $\sigma_i$ | 0.17 $\sigma_i$ | 0.015$\sigma_i$ |
| Coefficient of symmetry $s = \frac{W_x}{W_y}$ | 0.96 | 0.94 | 0.94 | 0.94 |
| Conclusion | Product quality is compatible | | | |

## 3. COMPARATIVE ANALYSIS OF THE SG 23, THN 21, TH21 AND V21 LAMINATED PROFILES

### *3.1 Comparative analysis of dimensional characteristics*

The analysed laminated profiles are bell shaped, their dimensional characteristics are shown in Figures 1, 2, 3. The first conclusion is that the constructive dimensions of the same shape four laminated profiles are very close allowing the connection of the elements with bridles for the SG 23 profile.

The second conclusion is that the weight of the THN 21, V21, TH 21 laminated profiles is 10% less, for a section of the profile 10% smaller. Therefore the difference between these two parameters will influence the resistance characteristics, but the value of this influence is insignificant.

### *3.2 Comparative analysis of resistance characteristic*

The resistance characteristics depend on the type and quality of the steel used for the manufacturing of the laminated profile as well as its dimensional characteristics.

The steel used in the analysed laminated profiles is the same, there are no quality differences, which will influence the bearing capacity of the supporting elements.

The SG 23, THN 21, V 21 and TH21 laminated profiles have very similar resistance characteristics, the difference between them is about 10%, while the values of the appreciation criteria are identical for s, or slightly different, i.e. 1.137% for η, respectively 1.17% for m).

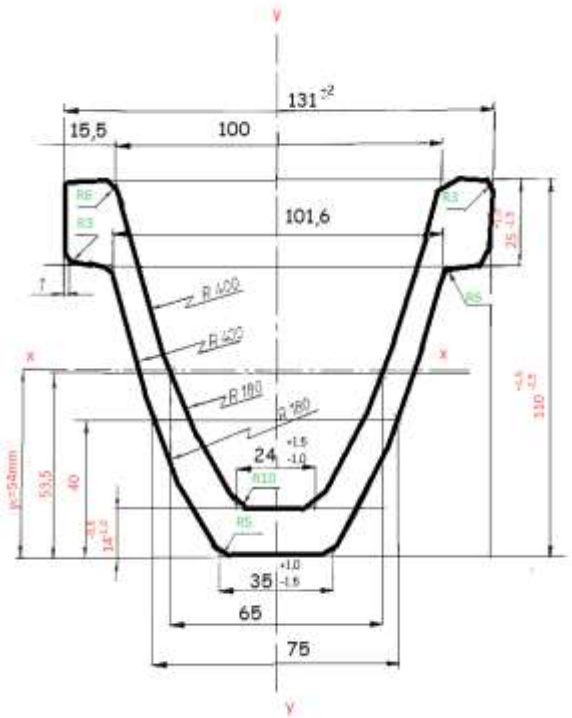


Figure 1
SG 23 – Romania Laminated Profile

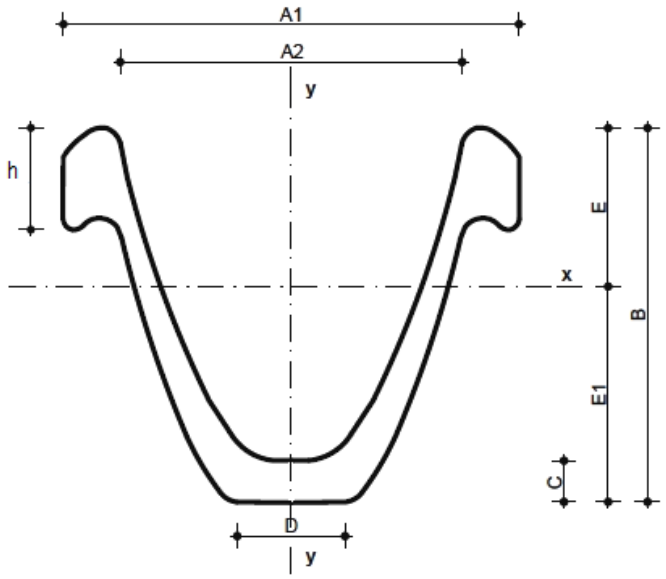


Figure 2
THN21 and TH 21 - Bulgaria, Czech Laminated Profiles

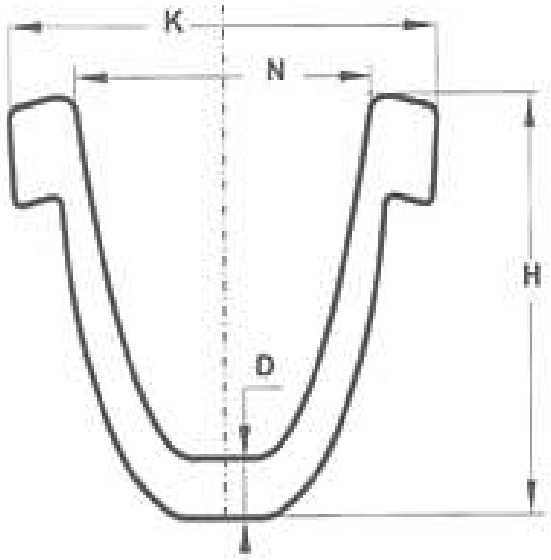


Figure 3
V21 – Poland Laminated Profile

### *3.3 The bearing capacity of the support frame*

The bearing capacity of the support frame is the main factor while determining the reinforcing step and it depends on the cross-section of the laminated profile (S), on the yield strength ($\sigma_c$) and the dimension of the mine working, respectively the width of the bedstone (2r), according to relation, with k -safety factor :

$$q = \frac{S\sigma_c}{r\ k} \cdot \frac{t}{unit}$$

The bearing capacity is determined for all four types of laminated profiles::

- for SG-23, with : S= 29.9 $cm^2$; $\sigma_c$ = 3500 daN/$cm^2$ ; r = 2 m (for GDM -11 gallery profile); k=3.5 safety coefficient

$$q_{SG\,23} = \frac{29,9 \cdot 3500}{2 \cdot 3,5} 10^{-3} = 14,95 \quad \frac{t}{unit}$$

- for V-21, with S= 27 $cm^2$; $\sigma_c$ = 3500 daN/$cm^2$; r = 2 m; k=3.5

$$q_{V21} = \frac{27 \cdot 3500}{2 \cdot 3,5} 10^{-3} = 13,5 \quad \frac{t}{unit}$$

- for THN-21 and TH-21with S= 26.65 $cm^2$; $\sigma_c$ = 3500 daN/$cm^2$; r = 2 m ; k=3.5

$$q_{THN21} = \frac{26,65 \cdot 3500}{2 \cdot 3,5} 10^{-3} = 13,3 \quad \frac{t}{unit}$$

From the exposure of the bearing surface of the three laminated profiles in relation to the SG23 one it results that they have a 10% reduced bearing surface mainly due to the cross -section which is smaller with 2 to 3 $cm^2$.

## 4. CONCLUSIONS

The objective of the researches carried out was the establishment of a correspondence between the SG23, THN21, V21 and respectively TH21 laminated profiles, highlighting that the four profiles are equivalent according to the following aspects:

- the dimensional characteristics of all profiles are almost the same. In fact the superior opening of the cradle is the same, i.e. 10 cm, the difference of 4 cm present for the total opening of the profile is given by the values of the lateral ribs, which are more visible for the SG23 profile;
- the steel used for the manufacture of the profiles has the same characteristics, i.e. DIN 21544, respectively DIN 21541-85;
- the characteristics of the resistances $W_x$ and $W_y$ have different values which are comprised within reduced limits (9-10%) influenced by the smaller cross section of THN21, TH 21 and V 21 (26.65-27 $cm^2$) profiles compared to 29.9 $cm^2$ for the SG23 profile;
- the bearing capacities, theoretically determined, are much more reduced than the bearing capacity of the SG23 profile, with approximately 10%.
- testing the THN21 laminated profiles with the use of two types of bridles highlights the fact that there are differences between the loads which develop almost the same sliding. Therefore considering the use of U shaped bridles (Poland) the same sliding is obtained but with larger loads.
- the differences between load-sliding operations are determined especially by the quality of the material used for the bridles, on the contact surface between the superior chord plate and the laminated profile, as well as by the constructive particularities of the polish bridle.

Finally it is appreciated that the TH21, THN21, V21 laminated profiles may be used for the mining conditions of Jiu Valley being able to replace the lack of SG23 profiles.

Considering the use of proper bridle, made of high quality material, with a larger contact surface, the bearing capacity of the frame increases by 30-40%.

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