NEW TYPES OF LAMINATED PROFILES FOR THE CONSTRUCTION OF SLIDING METALLIC SUPPORT REINFORCEMENTS

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ABSTRACT: The present construction of the sliding metallic supports used in underground excavations supposes the connection of components (the beam and the two props) with openings between the shoulders of the laminated profiles, which gives to the system during loading the effect of decalibration of the construction by compressing the superior element (the beam) and splitting the inferior element (the prop) with all the unfavourable events to follow regarding the seize up (jam) at the level of the clamps of the sliding of the elements and the stiffening of the support.

Considering the improvement of the construction and increasing its safety as well as the malleability of the metallic support, the paper brings forward new laminated profiles for the execution of support elements, i.e. safer and more performant elements regarding the cross section and the connection, which together with the proper binding elements may contribute to meeting the competition objectives by creating a modern and competitive equipment in order to increase the efficiency of the execution and operation of underground excavations.

The new construction of the presented laminated profiles implies the change of the shape of the actual laminate and the increase of its resistance characteristics while carrying out the binding and the complete and permanent contact between the elements for the entire sliding race.

KEY WORDS: underground excavation, massive rock, metallic support, laminated profile, bearing index, profile decalibration, contact between limbs, mass per metre, binding elements, sliding elements.

1. INTRODUCTION

In the construction brought forward, the native sliding metallic support used for underground mining implies the connection of composing elements (the beam and the two props), with openings between the shoulders of the laminated profiles (the case of the former laminate SG 18 respectively the actual one SG 23), which gives to the system during loading the effect of decalibration of the construction, by compressing the superior element (the beam) and splitting the inferior one, namely the prop, with all the unfavourable vents to follow regarding the seize up (jam) at the level of the clamps of the sliding of the elements and the stiffening of the support.Considering the improvement of the construction and increasing its safety as well as the malleability of the metallic support the paper brings forward new laminated profiles for the execution of support metallic elements which imply the change of the shape of the actual laminate and the increase of its resistance characteristics while carrying out the binding and the complete and permanent contact between the elements for the entire sliding race. By replacing the presently used support with the new one, the constructive-functional deficiencies are eliminated, estimating the increase of the competition and ensuring the compatibility with the actual and future

requirements in locating and carrying out the excavations, considering a 30% increase of the bearing capacity of metallic support frames, ensuring a more controlled and constant sliding of the elements at the level of the binding and reducing until the complete elimination of costs assigned for operation and maintenance.

2. THE EVOLUTION OF LAMINATED PROFILES USED FOR THE CONSTRUCTION OF METALLIC SUPPORTS

Nationally manufactured laminates which are currently used in underground mining bring forward difficulties per meter and static and different resistance characteristics, but with identical cross sections, chute like, which imply the realisation at the joint of an incomplete contact between the support elements, respectively between the beam and the metallic props, only between the flanks, leaving free spaces between the flanges – as it is the case of SG 18 and SG 23 laminated profiles (Figures 1 and 2).

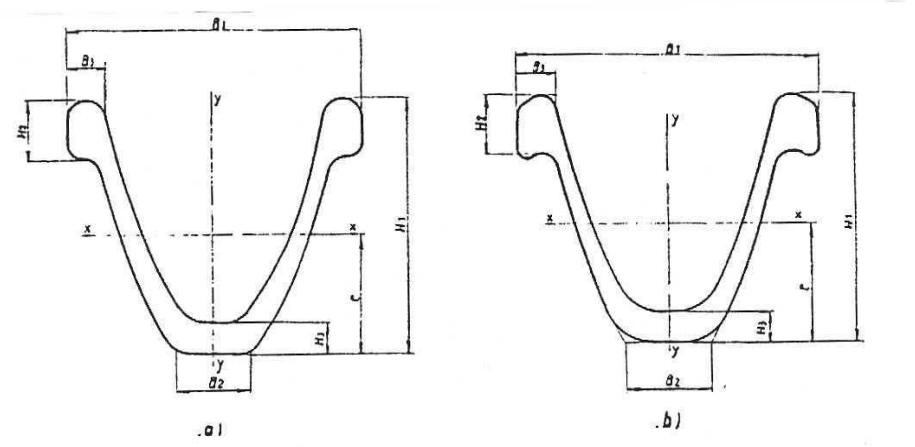


Figure 1. The shape and main constructive dimensions of SG laminated profiles:
a – profiles SG-18 and SG-23; **b** – profile SG-29

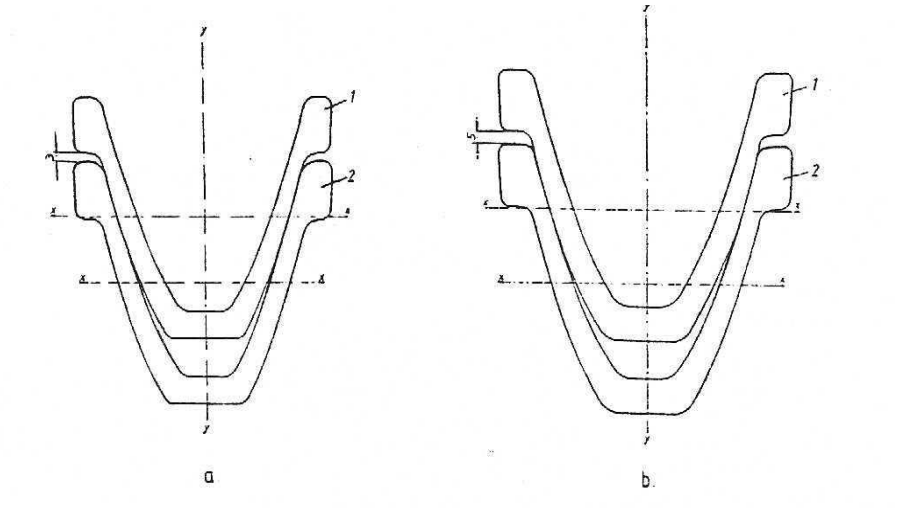


Figure 2. Twinning of SG-18 (a) and SG-23 (b) laminated profiles: **1** – superior profile (beam);
2 – inferior profile (prop).

Therefore, during the operation (sliding) of the support elements, the appearance and exertion of the decalibration phenomenon of the laminates at the twinning is favoured, inconveniently due to the intertwining of profiles, by splitting the (extending) the inferior profile (the prop) and compressing the superior one (the beam). The decalibration tendency of the profiles is becoming more significant due to the large breadth and the reduced width the two laminated profiles have as a base, compared to the international types of laminated profiles. [1], [2], [3].

In order to eliminate this unfavourable aspect, in a previous period, for carrying out the mine works in Jiu Valley, there was the experimental manufacture and use of a SG-29 laminated profile (Figure 1.b), the cross section of which was improved, the twinning of the support elements being foreseen as a complete penetration of the inferior profile into the especially designed troughs of the superior profile (Figure 3).

Considering the resistance characteristics, the SG-29 laminate disposes of superior static measures compared to the SG-18 and respectively the SG-23 laminates, but its measures are more reduced compared to the measures of the laminated profiles used internationally for difficult locations of mines, similar to those met in coal mines in Romania.

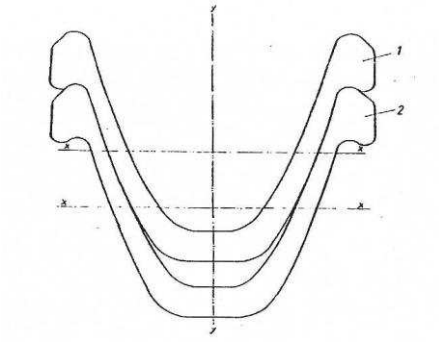


Figure 3 Twinning of the SG-29 laminated profile: **1** – superior profile; **2** – inferior profile

Together with the aspect of non-correlation of the form of the cross section of the three native laminated profiles with optimum operational requirements for a constant resistance operation of the metallic supports, as the depth of the mine works increases while the mining conditions are getting worse, the bearing capacity of the supports are situated below the minimum imposed conditions. Therefore it is appreciated that the optimum operation and maintenance of the galleries imply increased and useless amounts of materials, including them among the mine works with free sections of up to 14 m^2, with roughly 35% over the anticipated ones, the total operation and maintenance expenses being exceeded with over 65 %.

3. NEW LAMINATED PROFILES USED FOR THE EXECUTION OF METALLICREINFORCEMENT SUPPORTS

Given the constructive and operational inconveniences of the native metallic supports made of laminated profiles, respectively SG profiles, namely SG 18 and SG 23, the researches have been reoriented towards the assimilation of new types of laminates, more performant and safer for the execution of supports based mainly on the realisation of the joints' contact and on the level of the shoulder through the troughs created at their base for this purpose.From the wide range of laminated profiles used by several developed mining countries for the execution of metallic supports, which has recently become of interest, with proposals of being assimilated and implemented in geo-mechanical conditions specific to coal mines, are observed considering the following types of laminated profiles (Table 1), their appointment being based on the possibilities to import them in order to use them in experiments and assimilate them to specific mining conditions existent in the two coal basins [1],[3].

Table 1 Type and characteristics of laminated profiles which undergo analysis and are appointed for the execution of the support

No.	Type of profile / Country of origin	Cross section (cm^2)	Linear weight (kg/m)	Static resistance characteristics			
				I_x, (cm^4)	W_x, (cm^3)	I_y, (cm^4)	W_y, (cm^3)
1	2	3	4	5	6	7	8
1	THN 21 / Bulgaria	20.92	26.65	324	60	410	64
2	V 21 / Poland	21.0	27.0	341	61.3	398	64
3	V 28 / Poland	28.0	35.6	626	97	687	95
4	V 34 / Poland	34	43.3	850	126	870.7	113.8

The proposal to assess and assimilate laminated profiles, resides in the fact that after the seize of the internal production by Hunedoara Ironworks Plant in 2013, namely that of the SG-23 laminate, it was decided to import, experimentally, certain similar profiles considering the constructive and resistance characteristics with possibilities to use them safely having the required bearing capacity for the existent constructions.

The THN21 (Figure 4) laminate was therefore chosen and acquired through a company dealing such products, laminate which based on the equivalence studies proved to be in line with the requirements and the technical characteristics of the local SG-23 laminate [3].

The THN 21 laminate is a part of the THN series laminates manuafactured according to the German norms DIN 21544 – 85, which implies the use of 31Mn4 steel the chemical composition of which does not foresee the use of vanadium while the content of carbon reaches 0.28%. The substitution therefore of vanadium or any other alloy in the chemical composition, for the improvement of the ferro-crystalline structure of the used steel, is realised therefore by delivering the laminate in a normalized state, namely hot rolled steel with the sole purpose of improving the roughness of the steel (its), as well as the increase content in carbon. The "N" used in within the symbol of the profile confirms the delivery state, namely improved / normalized execution state, through the application of the normalisation procedure.
Based on the equivalence / compatibility analysis carried out with the acquisition of this type of laminate, the following statements were therefore brought forward [2], [3]:

- The shape of the THN 21 laminate is that of a trough, similar to the shape of the SG-23 profile, the difference being, as the result of the research has shown, the flute carried out at the base shoulders of the laminate, in order to obtain the contact of the profiles (namely the support beam and the two props) resulting therefore the decalibration effect which occurs in the case of the native laminated profile. The shape of the THN 21 laminate with the flute carried out at the base of the shoulder is similar tto that of the internationally used laminated profiles comprised by the TH series manufactured according to the DIN 21555 – 80 German requirements, respectively the SG-29 laminate assimilated and experimented into the mines in Jiu Valley.
- The weight of the THN 21 new laminated profile is 20.92 kg/m 10% lower than the weight of the SG-23 laminate resulting in an equivalent abatement of the cross section representing therefore 26.65 cm^2, compared to 30 cm^2 of the SG-23 laminate. Following the reduction of the cross section respectively the amount of metal with approximately 3 kg/m of profile considering the THN 21 laminate the constructive dimensions are therefore reduced, aspect which implies straight from the beginning the use of the correct type of clamp which is different from the classic native one which has been used for more than 50 years.;

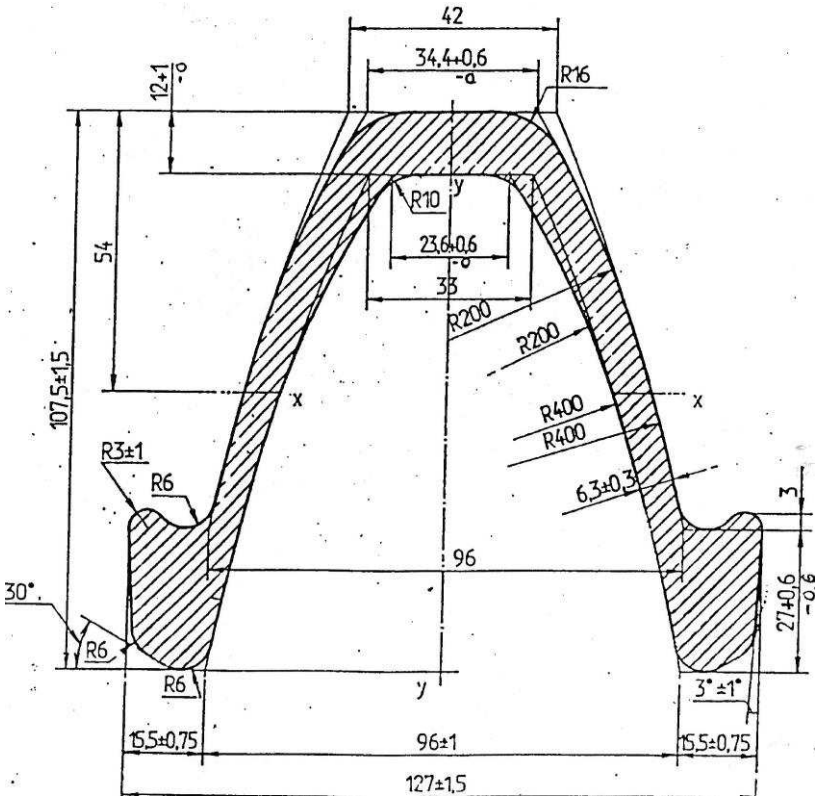


Figure 4 Shape and constructive dimensions of the THN 21 laminated profile

- Considering even the conditions in which the characteristic dimensions are reduced, the resistance characteristics of the THN 21 laminate are close to the ones of the SG-23 laminate meeting therefore the delivery requirements imposed by the DIN 21544 – 80 German norms and regulations;

In what the equivalence of the THN 21 laminate with the delivery provisions foreseen by the German norms and regulations regarding the length of the laminating rods, the chemical composition, the macroscopic degree and respectively packaging and branding is concerned, it implies that the norms be respected through exact statements comprised in the Quality Certificate, document which will accompany the product during the expedition as well as statements included in the Conditions of contract.

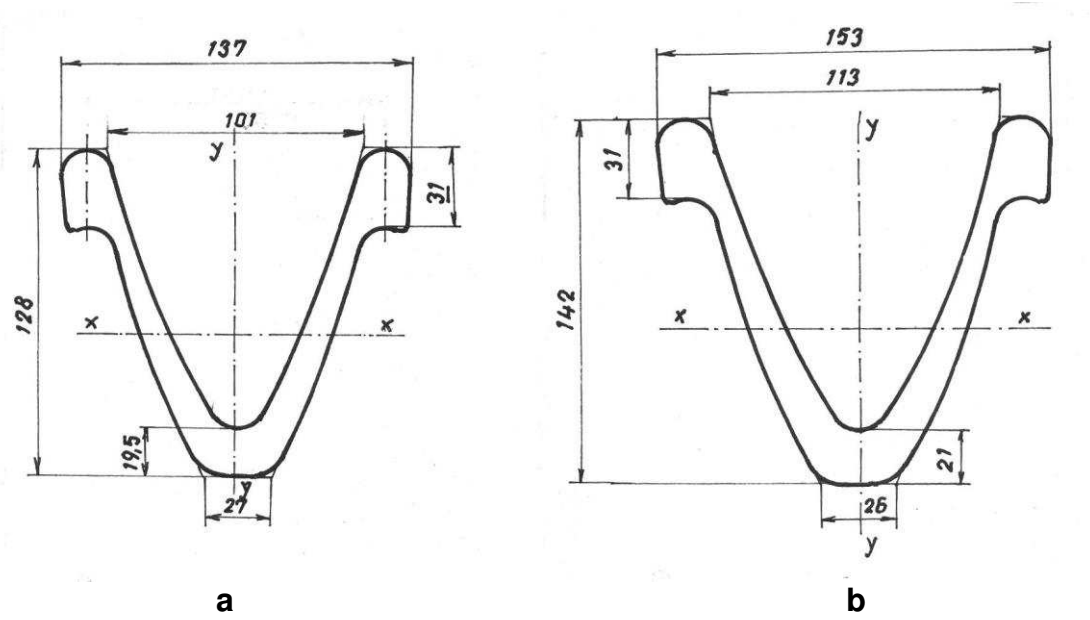
The conclusions brought forward by the equivalence studies carried out on the two types of laminate emphasise the possibility to acquire and use the new type of laminate for the construction of the metallic support of underground excavations conditioning therefore that its technical and quality prescriptions regarding the manufacture meet the provisions of the DIN 21544 – 80 German norm, restrictions which are to be considered by the manufacturing / supplying company.

The researches carried out for the assimilation of the new type of laminate have been directed towards superior profiles according to their weight, the acquisition of which might be possible from European countries which are known for their continuous extraction of coal (e.g. Poland). Therefore the two Polish manufactured category V laminates, namely the V28 and V35 laminates, were chosen to be studied and analysed respectively acquired and used. (Table 1, Figure 5).

The orientation towards analysis and use for the construction of the support of the two types of laminate is based on the concordance between superior resistance characteristics with the intensity of the pressure of the underground mine, for superior intensities as the depth of the mine increases and the roughness of the rocks is reduced having a high degree of alteration in time, on the type of clay, shale and brownstone, specific of Jiu Valley mines [3], [4].

Moreover, the proposal to analyse the two laminates considers their specific construction which implies a reduced thickness of its base compared to the other types of profiles used internationally, including the natively manufactured laminates. The constructive particularities of the two laminates allow together with the specific connection of the profiles at the collar resulting the reduction of the decalibration effect of the profiles, manifested through the interpenetration of the profiles as is the case of internal production laminates.

Considering the resistance and constructive efficiency of the V28 and V34 laminated profiles compared to those of the native profiles, the following statements are brought forward:



a **b**

Figure 5 Shape and constructive dimensions of the new profiles proposed for the execution of the support:
a - 28 laminate; **b** – V34 laminate

- Superior static characteristics, compared to most of the laminates used worldwide.
- They meet the stability condition $\frac{I_x}{I_y} \leq 1$.
- Bearing capacity with superior bending.
- Superior bearing indexes compared to the TH-58 laminates used worldwide.
- Superior resistance at the base, with the reduction of the local tangential tensions and the decalibration effect which occurs at the joints of the actual bearing construction.

The result of the assessment highlights the superiority of the V28 laminate, i.e. with 6.4% more than the SG-29 laminate, considering a reduced weight and less metal used, 1 kg/m, i.e. 17.9% less than the SG-23 laminate and 25.5% less than the SG-18 laminate.Also, being one of the medium to high laminated profiles according to their weight, the superiority of the V34 laminate is therefore observed, being 6.5% better than the V28 laminate and respectively 12.5% and 3.03% better than the currently used laminated profiles, i.e. SG-29, SG-23 and SG-18.

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