

## PROPOSAL OF APPLICATION OF SYNTHETIC ROPES IN FORESTRY

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### Abstract

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Work offers information about synthetic ropes which represent suitable alternative to steel ropes. Our goal is to create a work that could serve as a basis for use such ropes in forestry of countries in Central Europe and mainly for the purpose of further empiric research. Synthetic ropes will be described by synthesis of information from several markedly different spheres. We also use information which we have obtained from self consultations with the manufacturer of synthetic ropes in Trenčín. In this paper, we meet the basic question about material of whose are synthetic ropes manufactured and describe its basic properties. We would like to fill the gap in the field of specialised literature which does not pay sufficient attention to this area. We focused on comparing of currently used steel ropes with synthetic ropes, and we determined their advantages and disadvantages. As the method for comparison we chose several technologies – skidder technologies and skyline logging system which are mechanisms for collecting wood. We chose mechanisms which are typical for forestry of central Europe like skidder LKT 81 T and skyline logging system Larix 3 T. Based on all information, we formulated concrete recommendations for forest usage as there are several significant differences between use and care of steel and synthetic ropes.

Keywords: synthetic rope, UHMWPE, LKT 81 T, Larix 3T

### INTRODUCTION

The ropes are well known in forestry for a long time and they are closely associated with the skidding of wood. Their importance is confirmed by many papers dealing with particular issues of steel wire ropes. The paper is aimed on special type of rope – synthetic rope.

There is strong trend of progress in sphere of science and technology, visible in whole world. This phenomenon is inseparable part, of any country, which wants to proceed and be competitiveness (Matúška, 2013). The biggest problem with question about synthetic ropes in countries of Europe and especially in Slovakia is lack of specialised literature. Web pages of various commercial producers offer many information, but this information is inadequate for professionals. This lack is serious problem, because this theme is important and this technology has a wide range of practical applications, not only in forestry

(Course, 2002). In foreign countries the situation is completely different, especially in the US. United States of America are significantly advancing in theory and applications of synthetic ropes in many different spheres of economy. This technology is absolutely new in Slovakia and very actual in other forestry developed countries. Combined with the ergonomic benefits we can say that the timeliness of this topic is very high (Garland *et al.*, 2003; Strong, 2008).

The main object of this work is to point out the advantages of a complete change of wire ropes for synthetic ropes in some parts of forestry. The work describes main material UHMWPE from which the ropes are made. We want to fill the gap in forestry literature and arouse interest in this advanced and highly actual issue. The aim of comparison of synthetic ropes with steel ropes on specific forestry machines is demonstrated in the results of the work.

## MATERIAL AND METHODS

We chose logical methods instead empirical research, with regard to fact that this topic is absolutely new and nearly unknown in Slovakia. We provide exact conclusions, based on these results and information. We conducted synthesis of information from several different spheres:

- medicine,
- chemistry,
- physics,
- rope making industry,
- forestry.

We also conducted comparison of properties of various rope types. Except synthesis we applied comparison too. Comparison allow us to draw justified and substantiated conclusions and determine which properties of individual observed ropes are equal and which properties are better or worse than the other (Horáček, Ristvej, 2007). The comparison allowed us to say conclusion that one kind of rope is better than other in observed trait. Comparison consisted from definition of important characteristics and their confrontation. We use modified characteristics by Horek (2007):

- weight,
- strength,
- price,
- elongation.

In question of practical application of synthetic ropes for forestry we dealt with information which was researched in Oregon state university. After processing of the data we formulated practical advices for forestry which are supported by the exact research. We proposed set of important recommendations in one work instead of repetition of specific and partial information. We also used information obtained from self consultations with the manufacturer of synthetic ropes, the Gleinstein company in Trenčín.

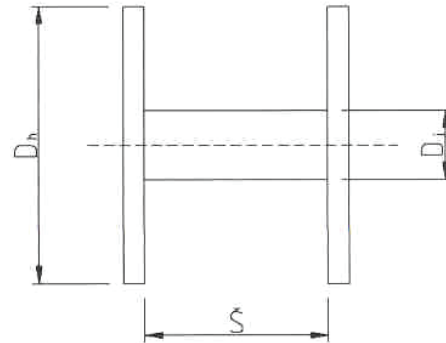
We decided to define the requirements according to the Slovak and Czech authors like Horek (2007), Lukáč (1996, 2001), Štollmann (2009) and other authors. We set two groups of forestry machinery, which use ropes for their operation (timber skidding):

- skidders (LKT 81 T),
- forestry skyline system (Larix 3 T).

We chose skidder technologies because of frequency of their use for skidding of timber. For example there are about 1400 cable-skidders used in France (Cacot *et al.*, 2006). We chose the skyline logging because the terrains with slope higher than 40% are very frequent in Slovakia. There are more than 50% of the forests at these slopes (Matúška, 2011). After choosing of suitable mechanism for the group, we analysed ropes which are used by them. Next we found appropriate equivalent from synthetic ropes and then calculate length of this rope due to the change of diameter. For this calculation we use the following equation:

$$\text{Length} = \frac{3.14 \times (D_h^2 - D_i^2) \times \xi}{4000 d^2}.$$

Explanation of the equation is in Fig. 1.

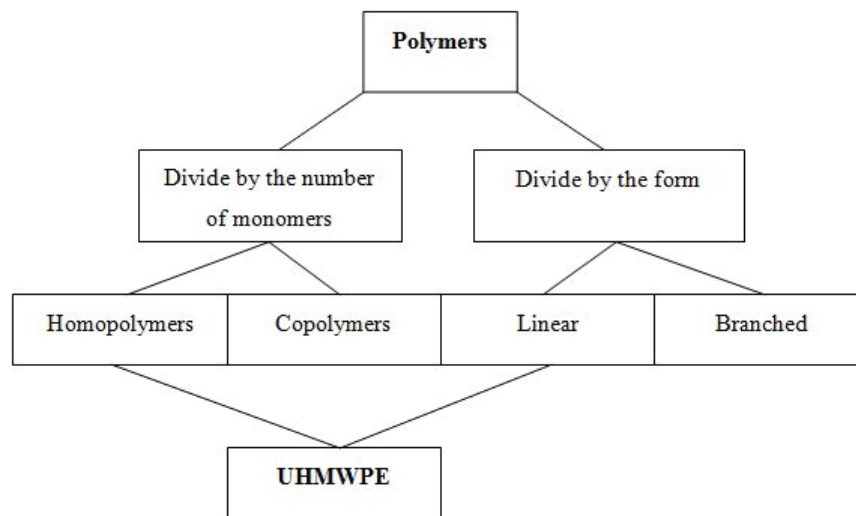


1: Explanation of pattern

We chose the ropes which are made from UHMWPE material, specially made from the dyneema SK – 75 fibres. In our case the material was represented by the specific types of ropes. All the samples were represented by 12 strands ropes (Leonard *et al.*, 2003). Reason for chose of those ropes is fact that 12 plait ropes was applied in United States of America and in France on skidders (Pilkerton *et al.*, 2003). We specially chose those ropes:

- AmSteel blue – this rope is example of successful application of synthetic rope in forestry. We chose next kinds of synthetic ropes based on properties of this rope as extreme strength, minimal elongation and low weight.
- DynaOne – is UHMWPE rope with the geothane coatings for enhanced resistance to damage especially against weathering and abrasion. This rope is resistant without the use of additional security components. This rope has very similar properties to wire ropes except the weight which is significantly lower.
- DynaOne HS – is synthetic rope which is additionally thermally stretched for enhanced break load and minimized constructional stretch and diameter. Equally like previous rope DinaOne HS has geothane coatings for better resistance. This rope has similar or better properties than steel rope with only 1/8 weight of wire rope.

We chose steel wire ropes basis of their real application on chosen forestry machinery. It was wire ropes Seal 114 with metal core and Seal 114 with textile core. This rope according to STN 02 4341.41, which is about 114 wire steel ropes with metal core



2: Schematic classification of UHMWPE

(49 wires). It's six strand rope with  $6 \times (1 + 9 + 9) + d49$  construction. Strands has outer layer of wire with larger diameter and thus increases their resistance to abrasion. Because of metal core ropes has better resistance against shock damage but on other side they are less flexible than ropes with textile core (STN 02 4341).

UMHW component is official abbreviation for material, which full name is ultra high molecular weight components (Kurtz, 1996).

Second possible name is UHMWPE, where added signs PE indicate polyethylene. Basic characteristic of UHMWPE is that it is linear homopolymer (Kutz, 2004). Main group is in our case named **polymers**. Meaning of this word we can define when is it divided in two parts. First in poly (many) and second is mers (parts), this parts are linked by chemical covalent bonds. These bonds can be creating by one or more monomers. Accordingly, we distinguish homopolymers and copolymers. The bonds are divided according the shape to **linear** and **branched** (Fig. 1).

In stage of raw material, which often has a form of dust we cannot talk about ropes or any other final products (Soles, 2004; Mittal, 2011). But we can describe properties of this material, enabling it to application in considerably different spheres. Many producers describe also identical properties of UHMWPE, these properties was summarized by Harle (2001):

- High impact strength – it's almost unbreakable material.
- Low weight – easy manipulation without any special gear.
- Does not conduct electric current – is a suitable insulator.
- Highly resistant against abrasion – abrasion resistance of UHMWPE is better than steel, some manufacturers indicate 10 to 15 times higher resistance.

- Low coefficient of friction – UHMWPE not request additional lubrication.

## RESULTS AND DISCUSSION

### Proposal of Synthetic Ropes for Skidder Technologies (LKT 81 T)

Regarding the proportion of cable skidding in Slovakia, the LKT (50% share of all skidding) and the UKT (about 40% share of all skidding) are the most important technologies. The most widely used skidder in Slovak forestry is the LKT with power 73.6 kW well known as the LKT 81, or 81 T (Lukáč, 1996). Other types, such as John Deere, Valtra and others are used rarely. Therefore, we selected the LKT 81 T, which is according to us the best representative of our skidding. This skidder is also used in many other countries in Europe like Czech Republic, Russia, Germany and others. The LKT 81 T use skidding rope and winch with these properties (Štollmann, Slugeň, 2009):

- Retracting force in the rope – 70k N,
- Uncoiling force in the rope – 118 N,
- Rope – SEAL, STN 02 4341.41,
- Rope length on winch – 77 m, Ø 14 mm, Seal 114 + 49.

The criteria defined in the Materials and Methods are provided in table (Tab. I) for individual ropes. We know two break strengths for Seal rope 114 + 49. First is for 1 570 MPa strength and second for 1 770 MPa strength, we chose 1 770 MPa strength, because there is strength which often offer vendors.

For practical application we chose highlighted rope diameters, from 10 mm to 16 mm. Comparison of rope characteristics is presented in the pictures (Figs. 3–5). We compared dependences of weight – diameter, strength – diameter and price – strength.

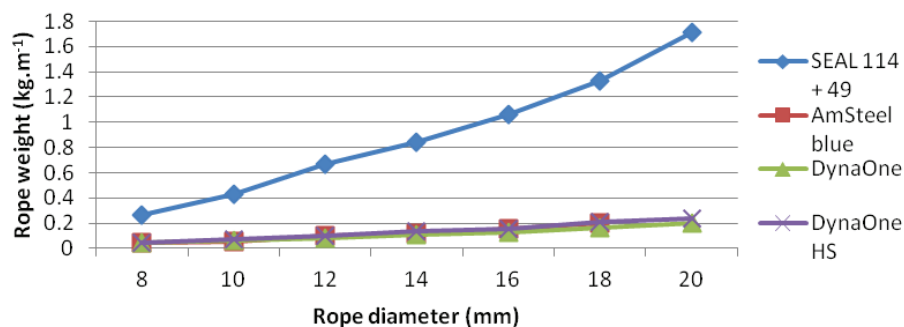
Fig. 3 shows development of weight and diameter. Predictably the steel rope Seal was the heaviest. The properties of all proposed synthetic ropes were

## I: Observed properties for specific kinds of ropes

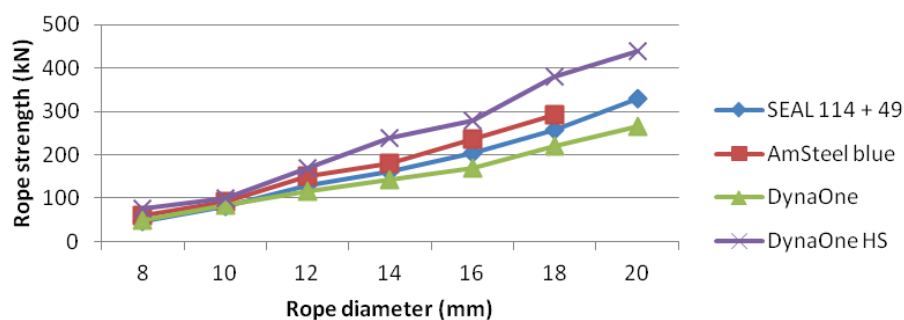
Rope diameter (mm)	SEAL 114 + 49			AmSteel blue			Rope length on winch (m)
	weight (kg.m <sup>-1</sup> )	strength (kN)	price (€·m <sup>-1</sup> )	weight (kg.m <sup>-1</sup> )	strength (kN)	price (€·m <sup>-1</sup> )	
8	0.26	46,22	0.88	0.04	60.80	2.10	135
10	0.43	82.40	1.35	0.06	93.16	3.25	108
12.5	0.67	128.70	1.66	0.10	151.02	3.62	86
14	0.84	161.70	1.98	0.12	180.44	5.57	77
16	1.06	203.60	2.58	0.15	235.36	7.48	67
18	1.33	257.20	3.32	0.20	293.22	-	60
20	1.71	329.40	4.03	-	-	-	54

Rope diameter (mm)	DynaOne			DynaOne HS			Rope length on winch (m)
	weight (kg.m <sup>-1</sup> )	strength (kN)	price (€·m <sup>-1</sup> )	weight (kg.m <sup>-1</sup> )	strength (kN)	price (€·m <sup>-1</sup> )	
8	0.04	50.00	6.90	0.04	75.00	11,50	135
10	0.07	85.00	11.90	0.08	99.00	22.69	108
12	0.09	115.00	16.90	0.10	170.00	29.05	86
14	0.11	142.00	21.90	0.14	240.00	40.86	77
16	0.13	170.00	28.90	0.15	280.00	46.23	67
18	0.17	220.00	37.90	0.21	380.00	51.90	60
20	0.20	265.00	-	0.24	440.00	-	54



3: Weight dependence on diameter



4: Strength dependence on diameter

very similar; the differences were usually only a few grams. This figure highlighted fact, that synthetic ropes were dramatically easier for manipulation and their transportation. With regard on the results we cannot determine which synthetic rope is the best in the observed characteristic.

Fig. 4 confirms that value of strength closely depends on rope diameter. We can see general trend of increasing the strength together with diameter. This trend is fairly balanced in all types of ropes. The strongest rope was the DynaOne HS, which has an average strength 68 kN higher than

the Seal rope. Strength of the synthetic rope is about 29% higher than the Seal. The AmSteel blue rope was also stronger compared with steel rope. The average difference is about 22 kN, which is almost 12%. The DynaOne compared with Rope Seal in strength lags average of 23 kN, which is almost 14%. Therefore, it is necessary to apply the rope with a larger diameter for obtaining the required strength. We emphasize that we selected high quality steel wire rope with a steel core and a higher tensile wire (1770 MPa) for the comparison. The comparison demonstrated that the synthetic ropes can significantly outperforms the steel ropes in question of strength and they offer application ropes with smaller diameter for same operation. They also points out the significant impact of the manufacturing process and additional machining of synthetic rope to its strength when we consider that the ropes DynaOne and DynaOne HS are made from the same material. Therefore the DynaOne HS and DynaOne HS are the most suitable ropes in term of strength.

We took the information about the prices of the Seal rope from the website of the dealer interforst sk. We discussed prices for rope AmSteel blue with U.S. retailers, because we did not meet with any local distributors in Europe. For ropes DynaOne and DynaOne HS we found European distributor from whom we took the prices. The trend lines in Fig. 5 shows how the strength of the rope influences the growth of price of rope. The price of rope DynaOne HS makes this rope almost unsellable according to our opinion. Similar price development we can also see in the case of the DynaOne rope. On the example of price of AmSteel blue rope we can see that even the high-quality and innovative technology may be available at an affordable price, especially considering the price for what the Italian distributor offers the rope DynaOne HS. Development of the price of AmSteel blue is comparable with the price trends of Seal rope, what making rope AmSteel blue the most suitable alternative to steel rope. Inexpensively priced rope is steel rope Seal, the best

rope from synthetic ones according to the price was the AmSteel blue.

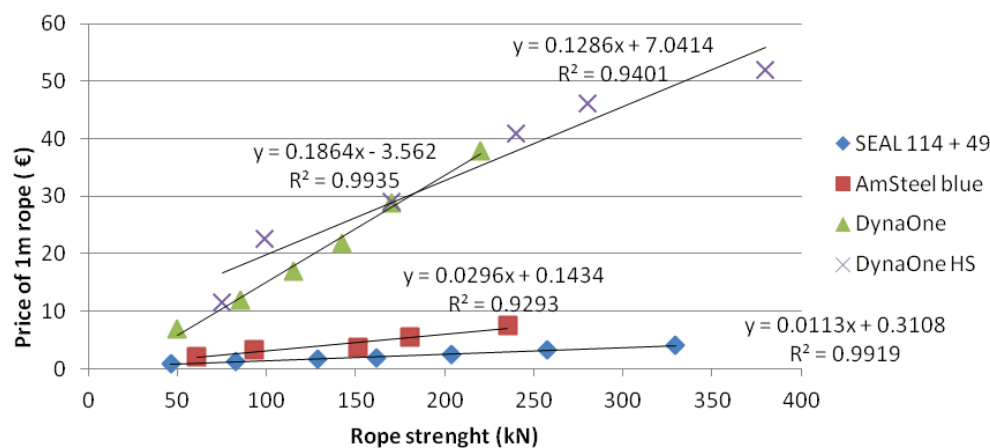
The last referenced feature is the elongation of ropes. The Elongation of the synthetic ropes according to Gleinstein is recorded up to 50% of the critical load. For the AmSteel blue rope is value of elongation indicated to 30% of its critical load. Overviews of elasticity of synthetic ropes are presented in Tab. II.

II: Overview of ropes elasticity

break load	DynaOne HS	DynaOne	AmSteel blue
	Elongation in %		
10%	0.30	0.60	0.46
20%	0.60	0.90	0.70
30%	0.90	1.40	0.96
40%	1.10	1.80	-
50%	1.30	2.20	-

We compared only elongation of synthetic ropes, because we had not relevant results about elongation of elongation of steel ropes. The tabular statement shows that AmSteel blue ropes and DynaOne HS reached similar values. DynaOne rope has an average of approximately 40% higher elongation than DynaOne HS. Compared to the AmSteel blue, the DynaOne rope underwent to greater elongation of about 28%. The difference between the ropes DynaOne HS and AmSteel blue was approximately 14% in favor of DynaOne HS. It is possible to determine the elongation of wire rope by the modulus of elasticity of the rope. It is directly affected by the strength of wires, rate of load and it may be estimated also by calculation or experimentally (Boroška, Molnár, 2006). In the question of elasticity we see room for both laboratory and terrain testing of different types of ropes and their comparison with the wire ropes.

**Selection of a particular type of synthetic rope:** Based on the results of comparison we recommended specific synthetic rope. Without



5: Price dependence on strength



regard to the price of rope, the most feasible alternative to the steel wire rope was DynaOne HS. But when we took into account the extremely high costs we did not consider its practical application as real. We considered that the most suitable rope for replacement was the AmSteel blue rope. This rope has only slightly worse properties as the DynaOne, but it is more affordable.

By using the Am Steel Blue or Dyna One HS rope with diameter 12.5mm we increased the winch capacity about 9.

### Proposal of Synthetic Ropes for Forestry Cable System (Larix 3T)

Ropes are an essential part of skyline logging for transmitting movement of the load, as well as anchoring the individual parts of forest cableways. According to the method of construction and ingestion, the ropes are divided into two basic groups (Lukáč, 1996):

- Moving (technology),
- Stationary (anchoring).

For stationary ropes we chose the most common ropes, steel ropes with 42 wires and with steel core, which are durable enough. For moving ropes we chose strong, durable and also flexible kinds of ropes. These requirements were fulfilled with rope Seal 114, with wire strength 1 570 MPa. It is the mostly used rope for forest cableways (Lukáč, 1996; Lukáč, 2001). We therefore considered the Seal 114 rope, with construction  $6 \times (1 + 6 + 12) + c$  and tensile wire 1 570 MPa. We chose the Larix 3T cableway as a model mechanization, for its universal use, as well as the benefits which it offers. The Larix 3T allows the tractor to move to high slopes, it is universal for skidding both up and downhill, offers

radio control and due to orbital rope, the haulback line is not necessary. The diameters of ropes and investigated characteristics are presented in the Tab. III. The actual cable system had five ropes and consists of the following types of cables (Štollmann, Slugeň, 2009):

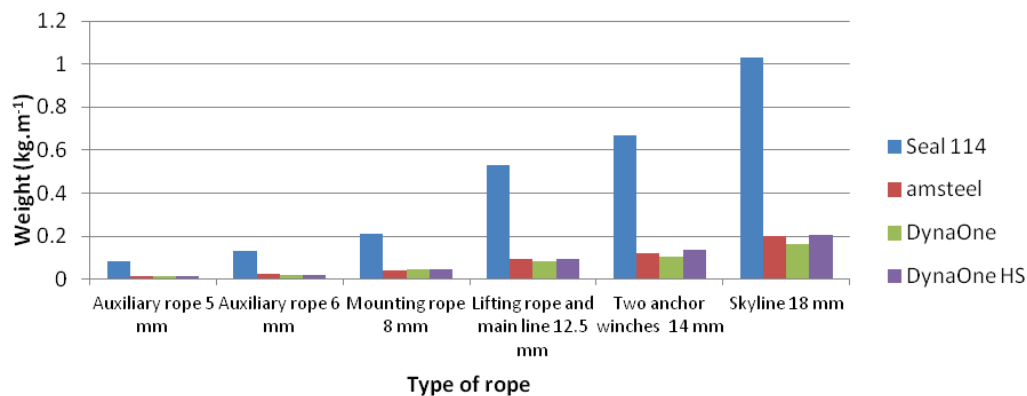
- Skyline 650m Ø 18mm,
  - Main line 1 475m Ø 12.5mm,
  - Lifting rope 220m Ø 12.5mm,
  - Auxiliary rope 500m Ø 5mm + 600m Ø 6mm,
  - Mounting rope 1 400m Ø 8mm polypropylene,
  - Two anchor winches 70m Ø 14mm.
- Basic parameters of ropes (www.slpkrtiny.cz):
- Load 3 000 kg,
  - Pull force / velocity Skyline 50 kN / 2.2 m.s<sup>-1</sup>,
  - Pull force / velocity Main line with load 26 kN / 2.1 m.s<sup>-1</sup>,
  - Pull force / velocity Main line without load 10 kN / 5 m.s<sup>-1</sup>,
  - Pull force / velocity Lifting rope 28 kN / 1.5 m.s<sup>-1</sup>.

We chose different types of ropes for comparison, on forestry cable system, where always were all four types of ropes. This way we could observe features for all ropes on forestry cable system Larix 3T. The results of the comparison are presented in Figs. 6–8.

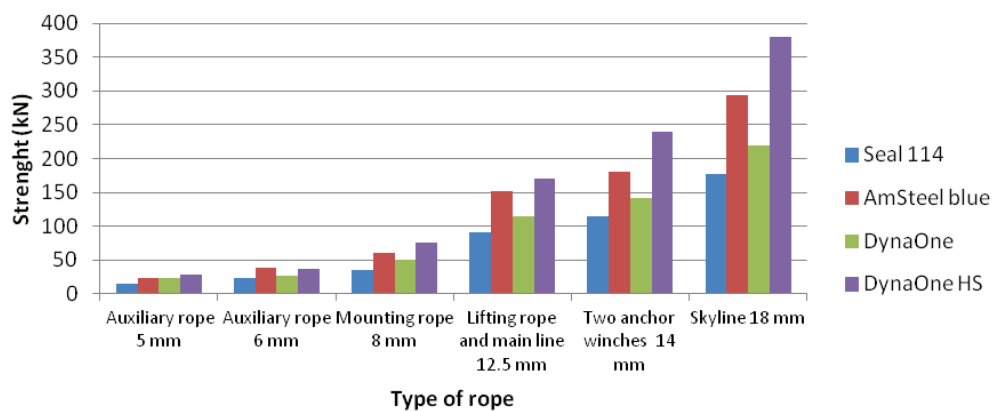
In Fig. 6, we can see weight development of the ropes. The skyline with diameter of 18mm and 1.03 kg.m<sup>-1</sup> was the heaviest, in the case of the steel rope. With regard on the need for 650m of rope, the final weight will be 669.5 kg, which we consider as a significant weight. Individual types of the synthetic ropes differed only slightly with

### III: Observed properties for specific kinds of ropes

Rope diameter (mm)	SEAL 114 (1570 MPa)			AmSteel blue		
	weight (kg.m <sup>-1</sup> )	strength (kN)	price (€·m <sup>-1</sup> )	weight (kg.m <sup>-1</sup> )	strength (kN)	price (€·m <sup>-1</sup> )
5	0.08	13.97	0.31	0.02	23.54	0.70
6	0.13	22.50	0.52	0.02	38.25	1.09
8	0.21	35.14	1.04	0.04	60.80	2.10
12.5	0.53	90.00	1.54	0.10	150.02	3.62
14	0.67	113.90	1.82	0.12	180.44	5.57
18	1.03	176.30	3.15	0.20	293.22	6.75
Rope diameter (mm)	DynaOne			DynaOne HS		
	weight (kg.m <sup>-1</sup> )	strength (kN)	price (€·m <sup>-1</sup> )	weight (kg.m <sup>-1</sup> )	strength (kN)	price (€·m <sup>-1</sup> )
5	0.01	23.00	2.90	0.02	29.00	5.30
6	0.02	27.00	4.10	0.02	37.00	8.05
8	0.04	50.00	6.90	0.04	75.00	11.50
12	0.09	115.00	16.90	0.10	170.00	29.05
14	0.11	142.00	21.90	0.14	240.00	40.86
18	0.17	220.00	37.90	0.21	380.00	51.90



6: Comparison of weight of specific ropes



7: Comparison of strength of specific ropes

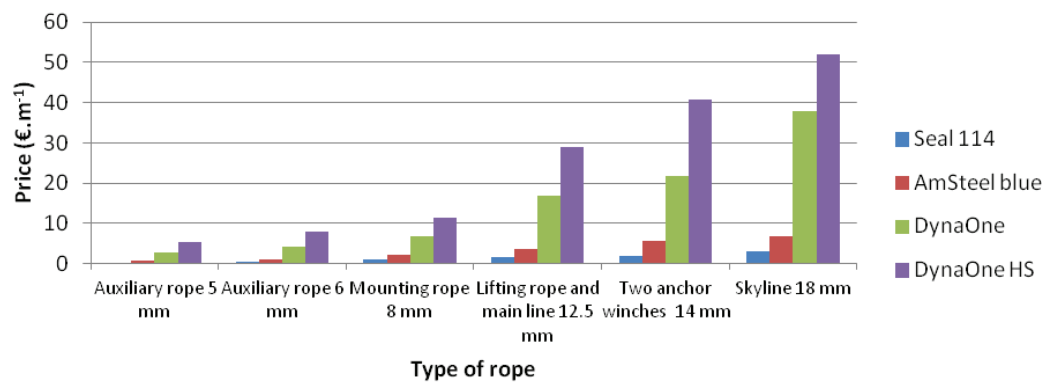
average weight about  $0.189 \text{ kg.m}^{-1}$ . Final weight of synthetic skyline was only  $122.58 \text{ kg}$ , thus less than 19% of weight of steel rope. The similar situation was also in the cases of other synthetic ropes, which weight was only 20% from weight of wire rope. When we looked for similar weight of synthetic ropes and steel ropes, we found out almost identical weights ( $0.205 \text{ kg.m}^{-1}$ ) of 8 mm rope Seal and 18 mm rope DynaOne HS, but the strength of the Synthetic rope was  $308 \text{ kN}$  and the steel one only  $35.14 \text{ kN}$ . Synthetic ropes with the same weight are nearly nine times stronger than steel wire, which is a significant difference.

Fig. 7 refers in detail about strength of individual ropes, where we can see the strength of individual types of ropes with the same diameter and function on the forestry cable way system. In all cases we can see that the steel rope is weaker than synthetic ropes. This difference is the lesser in the case of the DynaOne rope and the biggest was recorded in the case of the DynaOne HS. When we compared the average strength of ropes we came to the conclusion that synthetic ropes allowed the application of the smaller diameter for same activity.

The average difference between the Seal and the DynaOne ropes was  $21 \text{ kN}$ , (22%). The difference between steel cable and the AmSteel blue rope was more significant. The average value

of difference was near to  $49 \text{ kN}$ , so the synthetic rope was about 40% stronger than the steel rope. The strongest of the compared ropes was the DynaOne HS, whose strength was  $155 \text{ kN}$  in average, the average strength of the wire rope was  $75 \text{ kN}$ . This meant that an average difference was up to  $80 \text{ kN}$ . This difference is equivalent to  $8157 \text{ kg}$  load which was a very large difference. In percentage terms, the steel rope reaches only 48% of strength of the DynaOne HS. The biggest difference compared to the other ropes reached DynaOne HS in diameter, 18 mm that was used as the skyline. The second strongest rope was AmSteel blue, which had in average 80% of strength of the DynaOne HS. Graphical representation shows that this difference was the mostly influenced by the higher diameters of ropes (14 and 18 mm). It was caused by the fact, that if we add one mm of thickness on rope with bigger diameter (18 mm rope) we add much more material which is a bearer of the strength, as when we add 1 mm on rope with smaller diameter (8 mm rope). We proposed individual cables in following order: DynaOne HS, AmSteel blue, DynaOne and Seal 114 to 1570 MPa tensile wire according to their strength.

In Fig. 8 we can see an overview of the prices for particular types of ropes. As in the case of LKT 81 T we could say that prices for synthetic ropes were far beyond the price of the steel rope Seal 114.



8: Comparison of price of individual ropes

The Seal rope, which we considered in forestry cableway Larix 3T was cheaper than Seal 114 + 49 and therefore this difference was even more pronounced. From the synthetic ropes considering on price is again the best rope The AmSteel blue rope was considered as the best rope, when we regarded also the prices. But if we considered their advantages like longer lifetime, quick and easy splicing and benefits in term of ergonomics of work, we consider that price was well-founded (Cacot, 2008).

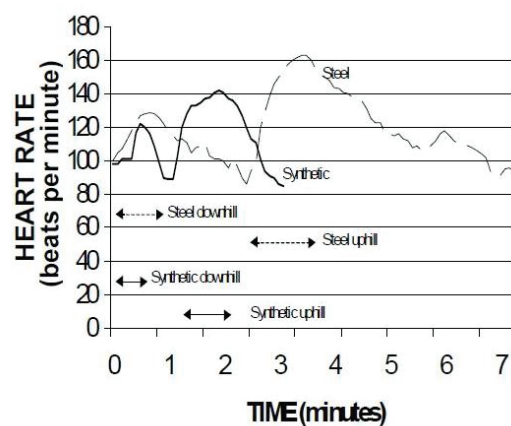
Because we were comparing the same types of synthetic ropes as in skidder technology, in question of elasticity please refer to the "Proposal of synthetic ropes for skidders technologies (LKT 81 T)", where the table report of this attribute is. Within the elasticity of synthetic ropes their next advantage was their high strength. This ensured that the use of breaking load is just partial and therefore their expansion will be low.

**Selection of particular type of synthetic ropes for Larix 3T:** When we chose a particular type of rope, we were in a similar situation as in the case of the LKT 81 skidder. The DynaOne HS rope was considered as the best rope also in this case, but its price was too high for real use. In the case of forestry cableways this problem was even more significant because we needed much more rope; therefore we were more skeptical about application of synthetic ropes than the skidder technologies. The AmSteel blue rope was again the best alternative to steel ropes, regarding the price and the fact that rope properties were better than those of the DynaOne. In the case of forestry cableways we favored the gradual replacement of ropes. The anchor, auxiliary and mounting rope should be replaced in the first step and rest of the cables in the next steps. Regarding the considerable diameter of skyline (18 mm), as well as its length (650 m) the replacement of the cables should be relatively expensive and therefore we considered that ropes should be practically tested at first. The same should be done for main rope, which length was 1475 m. Application of synthetic lifting rope DinaOne HS with 10 mm diameter can theoretically increase the capacity of the winch by 55 meters. That is due

to the fact that we used smaller diameter of rope with higher strength. This can substantially increase the working field.

### Work Efficiency and Ergonomics

Optimization of working conditions in addition to the positive effect on human health also increases productivity at work and makes it more effective (McCuauley-Bush, 2012). Pulling the steel rope into forest stand during the skidding process is considered as one of the most physically demanding kind of work in the forest and also among the heaviest works at all Messingerová *et al.* (2007, 2012). Measuring of the physical activity was based on measuring of the heart rate. The experiment was based on detecting heart beats while working with synthetic rope and steel rope. Employee manipulated the steel cable with a weight about fifty kilograms and the synthetic rope with a weight about eight kilograms. The employee worked in the slope about 25%. The graphic evaluation is presented in Fig. 9. We can see that the work carried out with synthetic rope was faster, with lower heart rate and also the recovery after the task is faster (Garland *et al.*, 2003). The need for a shorter period of recovery is a very important indicator, which is proof that work with synthetic rope is not only less



9: Comparison of the heart rate



strenuous, but the worker is also able to perform a significantly larger volume of work in less time.

### Advantages and Disadvantages of the Application of Synthetic Ropes

The greatest drawbacks of those ropes are:

- Too high purchase price.
- Tendency to cut the rope (Spong, Wang, 2006).

Susceptibility to cut can be eliminated by smart using and suitable planning of rope way. Avoiding to sharp edges and potential abrasive surface is essential (Hartter *et al.*, 2004). In the case of replacement of steel ropes by synthetic ropes the price is the main factor, which will slow down this process. But according to our opinion this disadvantage is fully compensated by advantages of synthetic ropes, which are presented in this work:

- increase of the work ergonomy (Pilkerton *et al.*, 2003),
- increase the work efficiency,
- increase the safety in the workplace (McCuauley-Bush, 2012),
- simplify splicing of ropes and eye splicing on the rope,
- greater strength of rope at the same diameter,
- the weight of the rope at the same diameter is seven times lesser,
- no corrosion of the cables,
- the cables do not warp, even after prolonged use,
- if correctly cared, this ropes may have four times longer life than steel ropes,
- it is theoretically possible to substantially increase the working field by applying of synthetic ropes (Tab. I). Larger working area enables to enhance work efficiency but also increases the risk of damage to the forest.

### CONCLUSION

Based on results of this work we became convinced that the application of synthetic ropes

in forestry is currently feasible, but at the same time we see the need for further research. Synthetic ropes are not only equal to steel ropes, but in the most of the monitored characteristics are synthetic ropes better than the steel cables (Roberts *et al.*, 2002). Besides price and specific susceptibility to cut we do not met any relevant and significant weaknesses of synthetic ropes, preventing their application in forestry practice. But that does not mean that they do not exist. The actual high price is in our opinion, associated with low frequency of application of synthetic ropes (Wagner *et al.*, 2011). We believe that if this frequency will increase, the prices will gradually decline. However the price decreasing process will be a long and gradual process (Jurečka, 2013). It is necessary to pay more attention to this field of research to increase the share of application of synthetic ropes. Commercially very successful rope AmSteel blue, which was applied in United States, is the proof of this idea. Its price exceeds the price of wire Seal approximately 2.4 times, which is very affordable price in comparison with the rope DynaOne HS. Another possible solution of too high price on the European markets is import from the countries where the prices are more favorable. We consider the replacement of cables of skidders and of small mechanization like iron horse and mobile winch for chainsaw as the most probable. Reason is mainly that we need smaller length of rope and therefore the initial investments will be lower compared with forestry cableways.

But we recognize that the steel ropes will have dominant position for long time not only in forestry but also in other sectors of our economy. A significant reason of this fact is in our opinion lack of the evidence-based information about synthetic ropes. The onset of new, and in many ways better technology, cannot come without information for potential buyer about advantages and disadvantages. The issue of synthetic rope offers many possibilities for further research.

### SUMMARY

This paper offers the information about synthetic ropes as a suitable alternative for steel wire ropes. We described these ropes from several points of view and compared them according observed properties. We described the basic properties of raw material which we consider to a determining factor with regard to features of the rope. We also defined and justified why we chose logical methods like synthesis and comparison. We designed specific rope, for each of the selected mechanisms, i.e. for skidders and forestry cable systems. The choice was made on the base of the results of the comparison. We have chosen the traits according to the Horek (2007) and subsequently we modified those traits. We considered the AmSteel blue synthetic cable as the best relative to the ratio of its features and price. Based on these results, we summarized the advantages which offer synthetic ropes in comparison with steel ropes. The main advantages of synthetic ropes are their weight in relation to the work ergonomy and the absence of its corrosion. In conclusion, we proposed a solution of the problem of high acquisition cost of synthetic ropes mainly by using of natural behaviour of the market economy (Kates, 2011).

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