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EVALUATION OF LOG LOAD WRAPPERS MADE FROM LARGER DIAMETER AND JACKETED SYNTHETIC ROPES

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This study tested ultra-high molecular weight polyethylene (UHMWPE) ropes for log load securement. Destructive testing of used rope samples done in a previous project found that the strength of these ropes decreased with use. To address this problem, the diameter of the synthetic rope was increased. In addition, a different type of rope with a UHMWPE inner core covered with a polyester protective jacket was tested. The outer jacket protected the inner core from dirt and abrasion which may help mitigate the loss in strength that occurs with use. Wrappers were put into service and tested for breakage after three and six months of use.

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1 BACKGROUND

Steel cables with sections of chain on each end are commonly used as wrappers or tie-downs to secure logs in trailers, as shown in Figure 1 (the term ‘wrapper’ is used throughout this report and refers to both types of applications). These wrappers can be heavy, making them difficult for a driver to throw over a log load. Some drivers develop shoulder injuries from throwing wrappers, which may make them unable to continue their current work. For others, the inability to throw a load wrapper over a load may act as a barrier to doing this type of work.

Figure 1. Load wrappers around log load

FPInnovations had previously conducted a study on log load wrappers made from Ultra High Molecular Weight Polyethylene (UHMWPE) rope, commonly referred to as synthetic ropes (Jokai, 2017). This study found that after six months or less of use, the tensile strength of the ropes decreased, in some cases to less than half of the original rope strength. Based on the observations made during this study, the decrease in strength appeared to be at least partly due to both external abrasion (from the logs) and internal abrasion (from dirt intrusion within the fibres). To help mitigate the loss in strength, the report suggested that users consider using a larger diameter rope, increasing the ropes' diameter by one or two sizes. For example, a 9.5 mm (3/8 inch) diameter rope would be replaced by one with a 11.1 mm or 12.5 mm (7/16 or 1/2 inch) diameter, while retaining the working load limit (WLL) of the 11.1 mm rope. Both the Cordage Institute and Cortland Company (the supplier of the ropes tested) suggested that increasing rope size could be a viable option to deal with the loss in strength. However, they stated that more work is required to determine if larger ropes retain sufficient strength to make them a viable option for log load securement. Since it appeared that the main cause for the loss of strength was dirt intrusion and abrasion amongst the fibres, it was decided to try a wrapper made from the same synthetic rope but with a polyester outer jacket.

2 OBJECTIVES

The objectives of this project were to determine if increasing the diameter of UHMWPE rope used for log load wrappers impacts its strength with use, and to determine if jacketed UHMWPE ropes retain their strength and are better suited for use as log load wrappers than the unjacketed ones that are currently in use.

3 METHODOLOGY

FPInnovations worked with four log transport companies, two in B.C. and two in Alberta. New wrappers made from larger diameter UHMWPE rope were purchased and provided to industry cooperators for use. Cooperators were asked to return half of the used wrappers after three months of service, and the other half after six months of use for destructive testing to determine the used ropes' tensile strength. The cooperators were Inwood Trucking, a contractor with West Fraser's Quesnel Division and Lobar Log Transport, a contractor with Canfor's Prince George operations, as well as two contractors working with Tolko's Slave Lake, Alberta operations.

3.1 Destructive Testing Procedure

Each sample was inspected visually according to Cortland's "Sling Inspection Guidelines" (Cortland Company Inc., 2011) to determine its condition and whether it was still considered suitable for service. Criteria for deeming a sample no longer suitable for service included severe abrasion (both internal and external), severed strands, hydrocarbon contamination and the presence of knots.

The break tests were conducted in accordance with the procedures established by the Cordage Institute and executed by Wesco Industries in Burnaby, B.C. Each sample was pre-tensioned to set the rope, and this was repeated ten times. They were then removed from the test machine to let any heat that was generated by the load cycling dissipate. The samples were then placed back in the test machine and slowly tensioned until they broke (Figure 2).

Figure 2. Rope in test machine

4 RESULTS

The tensile strength and in-service length for the wrappers made from the larger diameter, unjacketed Plasma rope (Figure 3) are shown in Table 1.

Figure 3. Log load wrapper made from 12.5 mm Plasma rope

Table 1. Break strength results of Plasma rope

Sample ID	Use (months)	Diameter (mm)	Initial tensile strength (kg)	WLL (kg)	Residual strength		Design factor
					(kg)	(%)	
157299-2	New	12.5	14 210	1 635	14 029	99	8.6
157799-4	New	12.5	14 210	1 635	11 123	78	6.8
157299-18	3	12.5	14 210	1 635	5 448	38	3.3
157299-16	3	12.5	14 210	1 635	8 671	61	5.3
157299-6	3	12.5	14 210	1 635	7 673	54	4.7

Sample ID	Use (months)	Diameter (mm)	Initial tensile strength (kg)	WLL (kg)	Residual strength		Design factor
					(kg)	(%)	
157299-1	3	12.5	14 210	1 635	8 808	62	5.4
157299-14	6	12.5	14 210	1 635	5 130	36	3.1
Unknown	6	12.5	14 210	1 635	4 722	33	2.9
R I	6	12.5	14 210	1 635	4 903	35	3.0
R2	6	12.5	14 210	1 635	4 949	35	3.0

The tensile strength of the larger diameter ropes decreased with use, as was seen in the earlier FPInnovations project. Generally, the more the ropes were used, the more strength they lost, or the weaker they became. The new wrappers had a tensile strength of 14 210 kg. The weakest wrapper broke at 4 722 kg, for a residual strength of 33%. Despite the low residual strength, it still had a design factor of 2.9, based on a WLL of 1 635 kg.

The used rope samples all had some level of internal and external abrasion from the logs and dirt. The dirt became trapped between the fibres, slowly abrading the rope, which was thought to be part of the reason for the loss in strength. Based on discussions with the manufacturer and the Cordage Institute, it was decided to try a different kind of rope, one that retained the inner Plasma core for strength with an outer polyester jacket designed to protect the inner core, as shown in Figure 4.

Figure 4. Log load wrapper made from DT rope.

Wrappers for field testing were made from Cortland's DT rope and provided to two BC cooperators for use. Samples were returned to FPInnovations after three and six months of use for destructive testing. The results are shown in Table 2.

Table 2. Tensile strength for new and used 12.5 mm jacketed DT rope

Sample ID	Use (months)	Diameter (mm)	Tensile strength (kg)	WLL (kg)	Residual strength		Design factor
					(kg)	(%)	
I2	3	12.50	9 500	1 635	5 766	0.61	3.5
I1	3	12.50	9 500	1 635	5 720	0.60	3.5
L1	3	12.50	9 500	1 635	5 720	0.60	3.5
L2	3	12.50	9 500	1 635	5 039	0.53	3.1
L3	3	12.50	9 500	1 635	4 949	0.52	3.0
I3	3	12.50	9 500	1 635	5 085	0.54	3.1
I4	6	12.50	9 500	1 635	4 949	0.52	3.0
L4	6	12.50	9 500	1 635	4 767	0.50	2.9
New	-	12.50	9 500	1 635	10 319	1.09	6.3

As was found with the unjacketed ropes, the jacketed ropes also lost some strength with use. However, after six months, the average tensile strength was reduced to 50% of the original strength, whereas for the unjacketed ropes it had decreased to 35% of the original strength. The jacketed rope retained a higher percentage of its original strength compared to the unjacketed rope, but the residual tensile strengths for both ropes were similar. This is because the new 12.5 mm Plasma had a higher initial breaking strength than the 12.5 mm DT rope. The DT rope has the same outer diameter as the Plasma, but this includes the protective outer jacket, which is there to protect the rope and does not significantly increase the rope's strength.

After the break tests were completed, the DT rope samples were sent to Cortland for further analysis. Their analysis found that the outer jacket did reduce the amount of inner abrasion, since most of the inner strands of the ropes' Plasma core were still a glossy white. The amount of inner and outer abrasion was not considered excessive for a used rope. Should the loss of strength with the DT rope continue to be a concern, Cortland recommends increasing the size of the rope from 12.5 mm (1/2 inch) to 14.3 mm (9/16 inch) diameter.

For comparison purposes, two steel cable wrappers were also tested for breakage. A used wrapper was taken from a B.C log truck and a new one was purchased. The results are shown in Table 3.

Table 3. Tensile strength of new and used steel cable wrappers

Sample ID	Use (months)	Diameter (mm)	Break strength (kg)	WLL (kg)	Residual strength		Design factor
					(kg)	(%)	
Wire rope	Unknown	7.90	4 449	Unknown	3 314	74	Unknown
Wire rope	New	7.90	4 449	3 630	4 720	106	1.3

Neither of these steel wrappers met WorkSafeBC Occupational Health and Safety Regulation Section 26.68 Subsection (4)1 that requires new wrappers to have a minimum break strength of

[1] https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-regulation/part-26-forestry-operations#SectionNumber:26.67. Viewed March 4, 2020.

5 455 kg (12 000 lbs), and therefore were not legal for use in B.C. The results are for comparison purposes only to show that even steel cable wrappers will decrease in strength as they wear.

5 DISCUSSION

With the larger, 12.5 mm (½ inch) diameter rope, a chain with a larger eye was needed so that the rope could fit through the eye. When the wrappers were made, the manufacturer used 9.5 mm (3/8 inch) diameter chain on both ends of the wrappers. However, the larger diameter chain made the wrappers too heavy and the BC cooperators refused to use them. Another option would have been to use 7.9 mm (5/16 inch) Grade 100 chain, which would have met the working load limit target of 1 635 kg. For the 12.5 mm (1/2 inch) Plasma rope, most of the results come from the Alberta cooperators who used them as tiedowns and did not have the heavy chain.

New wrappers were made using 7.9 mm (5/16 inch) Grade 100 chain. The stronger, higher grade chain allowed the use of a smaller diameter than with Grade 70 chain. The 12.5 mm Plasma or DT rope did not fit through the eye of the chain; therefore a connector was used (shown in Figure 5).

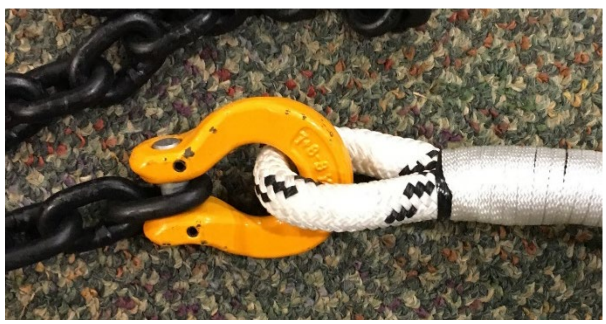

Figure 5. Yellow connector used to join the DT rope and chain

If these wrappers are commercially produced eventually, it is expected that a larger eye can be added to the chain by the chain manufacturer which would eliminate the need for this connector.

5.1 Frozen Ropes

During the winter, trucks often travel to a high elevation to pick up a load, and then return to a lower elevation to deliver the load to the mill. Temperatures can be below freezing at high elevations but above freezing in the valleys. The ropes can absorb water and road spray which can freeze at higher elevations. This was a problem that users of both different wrapper types experienced; and while the jacket of the DT rope may have helped keep some moisture from the inner core, it did not prevent it. It was worse when traveling on roads that were treated with dust abatement chemicals. One cooperator using the wrappers made from DT rope stopped using them for this reason. The freezing problem can be resolved if the ropes are stored in the cab when they are not in use, or in another location that protects them from road spray.

5.2 Experience with Wrappers made from Jacketed DT Rope

With the unjacketed ropes, co-operators mentioned that it was difficult to get the wrappers taut because they seemed to have excessive stretch. With use, the unjacketed ropes seemed to lose their set, causing the rope to swell and shrink which caused the excessive stretch. This was not a problem with the jacketed wrappers as they did not swell, and it was easy to get them tight with standard load binders. Users also noted that the unjacketed rope, would get snagged on logs when there were removed from the load. The jacketed ropes did not have this problem. The driver in Quesnel really liked the wrappers made from the DT rope but stopped using them because of their high cost.

5.3 Costs

Quotes for new wrappers made from 12.5 mm (1/2 inch) DT rope exceeded $200 each. The high cost may be a significant barrier to implementing these wrappers. Should the rope diameter be increased to 14.3 mm (9/16 inch), the price would be even higher. Wrappers made from unjacketed 12.5 mm (1/2 inch) Plasma rope cost significantly less, about $150 each, depending on their length.

6 CONCLUSION

For log wrappers or tiedowns made from UHMWPE rope, increasing the rope's diameter while maintaining the working load limit was a means to increase the residual tensile strength of the used wrapper. With unjacketed ropes, the residual strength after use, as a percentage of the new break strength, was similar to the results in the previous FPInnovations project. The tensile strength of the larger diameter rope was greater, since the larger rope was stronger to begin with. After use, load wrappers made from a jacketed UHMWPE retained a higher percentage of their initial breaking strength. The outer polyester jacket protected the inner Plasma core from abrasion and contamination. The jacketed rope was easier to tighten with conventional load binders and did not get snagged on the logs when they were removed. However, freezing and contamination from road spray were a problem with the jacketed ropes. This problem can be alleviated if the ropes are protected from road spray when they are not in use.

7 RECOMMENDATIONS

As per earlier studies (Jokai, 2017; Michaelsen and Careau, 2006), this study showed that the tensile strength of load wrappers made from UHMWPE ropes decreases with use. It is important that the suppliers and users of synthetic rope wrappers are aware of these findings and that they account for the decrease in strength that occurs with use. The recommended safety practices for use of fibre rope (Cordage Institute, 2015) recommends the selection of ropes that meet a design factor (DF) between 5:1 and 12:1. Note that the 5:1 DF used by most synthetic wrapper suppliers is at the low end of their recommendation. Based on the work done in this study, it is recommended that with unjacketed ropes, a design factor greater than eight be used, and for jacketed ropes, a design factor greater than 6 be used. Both recommended design factors are within the range recommended by the Cordage Institute. The lower design factor for the jacketed rope is because the jacket helps protect the ropes inner core from contamination and abrasion, which appear to be two factors that are causing the decrease in strength with use. Should users require a higher design factor, increasing the diameter of the DT rope from 12.5 mm (1/2 inch) to 14 mm (9/16 inch) would increase the design factor to 7.8.

The high cost of wrappers made from DT rope could act as a barrier to implementation. Further work with manufacturers should be done to look at ways to reduce their cost.

8 REFERENCES

Jokai, R., (2017) Evaluation of Synthetic Ropes for Log Load Securement. FPInnovations, Vancouver, B.C. Technical Report No. 9. 12 pp.

Cordage Institute. (2015). Guideline CI 1401-15 - Recommended Safety Practices for Use of Fiber Rope.

Cortland Company, Inc. (2011). Plasma 12x12 sling inspection guidelines. Retrieved from http://www.cortlandcompany.com/sites/default/files/downloads/media/manuals-plasma-12x12-sling- inspection-guidelines.pdf

Michaelsen, J., Careau, M. (2006). Evaluation of UHMWPE synthetic cables for securing roundwood on trucks. FERIC, Pointe Claire, Que. Internal Report IR-2006-12-18. 15 pp.

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