EVALUATION OF SYNTHETIC ROPE FOR STATIC RIGGING APPLICATIONS IN CABLE LOGGING

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ABSTRACT – Provides a descriptive assessment of synthetic rope in static cable logging applications. Applications include guylines, intermediate support lines, tree straps, and snap guylines. Problems and potentials from trials were assessed from observations of researchers and logging contractors. Synthetic rope works well as a replacement for steel wire rope for these static rigging applications. Loggers were more likely to try additional applications after using synthetic tree straps. Strength of the synthetic rope was the single largest concern with users. Initial cost was a significant drawback for most logging contractors who tried synthetic rope during this study. Additional research is needed to determine damage and wear criteria for synthetic rope.

INTRODUCTION

Steel wire rope is used for many logging applications. This material has served the forest industry well in terms of strength, durability, and longevity. Steel wire rope is difficult to use because of properties which make it stiff, heavy, and unyielding. These properties cause fatigue, exhaustion, and may contribute to worker injuries.

An alternative to steel wire rope is synthetic rope. Garland et al. (2002) showed the characteristics and properties of synthetic rope make it suitable for use in logging applications. However, the suitability of synthetic rope for logging applications needs to be evaluated to determine which synthetic ropes are suitable candidates for replacement of steel wire ropes.

The objectives of this study were to replace steel wire rope with synthetic rope for selected logging contractors to reduce workloads, improve efficiencies with cable logging, and determine the extent to which synthetic rope is suitable for use in static rigging applications. Longer term use by loggers was seen as an important means to assess the rope and find new problems and opportunities.

Few studies have addressed the use of synthetic rope for static rigging applications in cable logging. Takumi (1998) assessed the use of synthetic rope as guylines for a mobile tower yarder. Technora synthetic rope in this study was found to have sufficient strength and fatigue life to be used as guylines. However, it was difficult to estimate the fatigue life and strength loss from the appearance of the rope. The study also found the synthetic rope lost strength more rapidly than steel wire rope. The study used the number of cycles over a sheave as the basis for residual strength measurements.

Synthetic rope in our tests is Amsteel Blue[1] and is made from ultra high molecular weight polyethylene (UHMWPE Dyneema fibers) which makes it lightweight yet strong (The American Group, 1997). On average, synthetic rope weighs 1/9th that of the same nominal diameter steel wire rope. The high strength to weight ratio makes synthetic rope a suitable candidate for static rigging applications commonly used in cable logging.

The Amsteel Blue rope is constructed of synthetic fibers woven into a 12-strand braid. The twelve strand braid yields the maximum strength to weight ratio and is comparable in strength to steel wire rope, yet floats. This type of rope has a high flex-fatigue life and wear resistance compared to other products made from UHMWPE.

Cost is a factor to consider when choosing materials for static rigging applications. On average, synthetic rope costs 2-4 times as much as similar diameter steel wire rope. Logging contractors are cost sensitive and the cost for synthetic materials must return added benefits that exceed the additional cost.

Static rigging typically requires line lengths of 100 to 250 feet for various rigging conditions. Typically, these lines are used to guy tail trees at the far end of yarding corridors. Coiled lines are often carried to these locations where they are rigged. Intermediate supports also require rigging for both the intermediate support jack line and the guylines which stabilize the support tree.

Tree straps are used to hang blocks and other rigging in trees. The size of these tree straps is determined by the size of the skyline on the yarder. Typically a steel wire rope 7/8 inch diameter tree strap or larger would be required to meet the current Oregon Occupational Health and Safety Administration (OR-OSHA) safety code (www.orosha.org/standards/div_7.htm). Steel wire rope tree straps are difficult to bend around a small tree and keep positioned while securing blocks, shackles, and other rigging hardware. This presents a safety hazard for tree climbers.

APPLICATIONS EVALUATED

Our research focused on the use of synthetic rope for four static rigging applications. The applications were:

- Guylines
- Intermediate support lines
- Tree straps
- Snap guylines

Five logging contractors were supplied test samples of synthetic rope for one or more of the rigging components listed. The longest trial lasted from 1999 to early 2003 (3.25 years); however, the same contractor had used one or more types of synthetic rope for 5.5 years. Other trials with the remaining four contractors are still underway.

[1] Amsteel Blue is a product of Samson Rope Technologies, Ferndale, WA. www.samsonrope.com. Mention of trade names does not constitute an endorsement by Oregon State University.

GUYLINES

The need for lightweight, flexible guylines is recognized in the logging industry. A steel wire rope guyline of 5/8 inch diameter, 150 feet in length weighs approximately 111 pounds. A similar guyline made of synthetic rope may weigh only 18 pounds. The purpose of a guyline is to support or stabilize a spar tree, tail tree, intermediate support tree, machinery or equipment.

Loggers carry guylines up and down steep, treacherous hillsides to the location of intermediate support trees or to the end of a yarding corridor where they are used on tail trees. Garland et al. (2002) found times for carrying a 150-foot coil of steel wire rope and coil of synthetic rope for 150 feet downhill did not differ significantly; however, carrying steel wire rope uphill took twice as long as carrying synthetic rope uphill. Although the downhill carrying times did not differ significantly, there was an obvious safety advantage of carrying an object that weighed 18 pounds versus one that weighed 111 pounds down a 45 percent slope.

Figure 1. Synthetic rope guylines and strap supporting tail tree block

Ten guylines were placed into service during the study period. Two 5/8 inch diameter, 125-foot guylines were given to each logging contractor for use in their cable logging operation. The guylines were used on a Diamond D210 swing yarder, John Deere 330LC yoader[2], Koller K501 yarder, and a Howe-Line Mark IV yarder. This variety of conditions and range of logging equipment commonly found in the Pacific Northwest provided a good basis for evaluation.

Figure 2. Guyline wraps on a tree and shackled to another tree

Guylines were configured with two buried spliced eyes, one on each end of the guyline. Buried spliced eyes yield the ultimate breaking strength of the rope (specified for testing) and are the simplest end termination to create. Typically guylines are shackled back to themselves when they are rigged in a tree. This allows a simple and fast connection method (Figure 1.) The other end is brought down to a tree or stump where it is terminated. Often, several wraps are made on the anchor tree or stump to take up excess length and the guyline itself terminated at another tree or stump in close proximity. Once wraps are made (Figure 2), the guyline is terminated with another shackle. The termination process involves making wraps on the termination tree or stump, bringing the line back over itself and wrapping the line until the slack is completely removed. The line is then shackled back to itself (Figure 3). This method is a suitable technique for terminating synthetic rope guylines.

[2] A yoader is an excavator-based cable yarder with no guylines to stabilize the machine itself.

Figure 3. Termination of guyline with shackle

Guylines must be tightened to provide stability. Synthetic rope guylines may be tightened sufficiently by hand because it is possible to pull the guyline tight without much sag (deflection) in the guyline. It is not always possible to pull the sag out of steel wire rope guylines to properly position the tree for loading.

Another tightening process can be done using the twister strap that involves using a stick or similar object to reduce the overall length of the guyline. This method yields residual strengths of approximately 80 percent of double the catalogue breaking strength. Yet another approach is to use a rigging chain and come-a-long (ratcheting pulling device) commonly used to tighten steel guylines. A way to employ the rigging chain approach is to use the grab hook end instead of the open hook end of the chain. Once the guyline is tightened, the rigging chain can be removed from the guyline with ease.

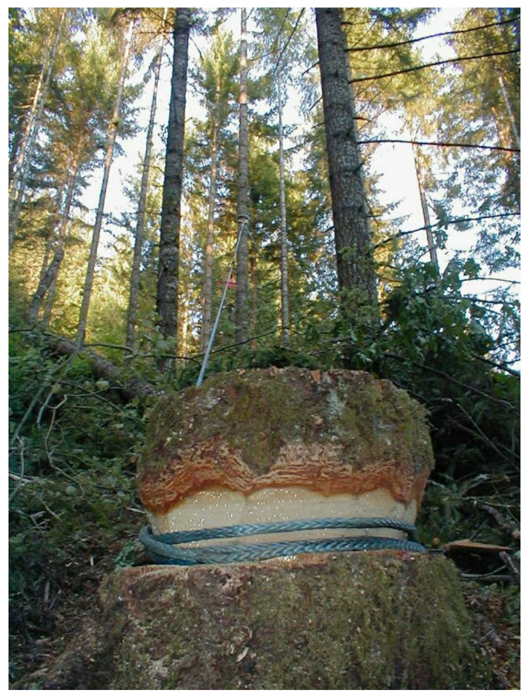

Figure 4. Synthetic intermediate support line

Testing of the residual strength of synthetic guylines was performed in a laboratory setting at Oregon State University. The guylines tested included both the 3.25 year use and the 5.5 year use ropes. The average residual strength for the 3.25 year use guylines (9/16 inch Amsteel Blue) was 15,341 pounds. The average residual strength of the 5.5 year use guylines (5/8 inch Amsteel Gray) was 16,720 pounds. The 3.25 year use ropes had a percent yield of 38% of the catalogue minimum breaking strength. The 5.5 year use ropes had a percent yield of 46% of the catalogue minimum breaking strength.

A potential benefit during rigging trees with synthetic rope may be the use of rappelling devices (used for rock climbing) to descend from the tree. Although not recommended in the current Oregon Division 7 Forest Activities Code, the use of a rappelling device such as a figure eight descender could reduce fatigue and rigging times by allowing the rigger to rappel down the tree instead of climbing down.

INTERMEDIATE SUPPORT LINES

Four trials were conducted to evaluate the use of synthetic intermediate support lines. The lengths tested included three 125-foot and one 250-foot intermediate support lines of 5/8 inch diameter synthetic rope. The most common rigging configuration consisted of attaching the intermediate support jack to the intermediate support line and terminating the support line at a stump or tree (Figure 4). Tightening and attaching the intermediate support line is similar to tightening a guyline.

A proper notch is needed when attaching synthetic rope to a tree or stump. If the cuts made to form the notch do not match, they produce a recess from the saw kerfs between the horizontal cut and the beveled cut. When a load is placed on the line, rope will "bite" into the recessed kerfs. This makes removal of the line difficult when heavy loading occurs during yarding. Matching the horizontal and bevel cuts of the notch avoids this problem.

TREE STRAPS

Three trials were conducted to evaluate the use of synthetic tree straps. One tree strap was configured in an endless loop design while the other two were configured as a single strap with a buried spliced eye at each end. The endless loop design was preferred by one logging contractor because the splice used to construct the endless loop actually increases the stiffness of the tree strap. The single strap with spliced eyes is a more common configuration found in the Pacific Northwest.

Tree straps are wrapped up in the tree above a branch whorl to aid in stability. A block is then attached directly to the tree strap or with the aid of a shackle (Figure 5). The tree strap may be configured in a basket design where the end is fed through the opposite end of the sling (endless loop), or the single strap with eyes are brought together and attached to the block. The tree straps used in this study were 7/8 inch diameter Amsteel Blue ™. The specific advantages of these two designs were not the focus of this study; however, the following observations came from the trials:

Figure 5. Synthetic tree strap, endless loop design

1) When constructing an endless loop design, the length of the strap when stretched should be no shorter than 6 feet. Any length shorter than this is unpractical for most tree sizes (14 inches – 26 inches) found in the Pacific Northwest.
2) The single straps with eyes were 20 feet long. The extra length of this design allowed the strap to be wrapped multiple times around the tree providing more stability than with a shorter strap.

Stiffness of material is a factor to consider when selecting a tree strap. Because steel wire rope is quite stiff, it is difficult to wrap around a tree, hold in position, and attach rigging. Synthetic rope can be wrapped around a tree quite easily and results in less rigging time. Garland et al. (2002) found that the time to rig an intermediate support tree was on average two minutes longer with steel wire rope than synthetic rope. This time difference was attributed to the increased difficulty (i.e. properties) of steel wire rope. The steel wire rope used was 5/8 inch diameter, considerably more flexible than 7/8 inch steel wire rope. Significant gains can be achieved with synthetic rope to replace the larger steel tree straps commonly used.

SNAP GUYLINES

One snap guyline was evaluated during this study period. The purpose of a snap guyline is to prevent the yarder tower from overturning backwards in case of skyline or mainline failure. The snap guyline is simply a safety mechanism for some yarder towers. The snap guyline was used on a Koller K300 yarder and was 5/8 inch diameter by 100 feet. The snap guyline was shackled to the top of the tower, and terminated at a stump or tree in the direction of the yarding corridor. It is usually only necessary to tension the snap guyline by hand. The light weight and ease of use might increase use of a synthetic snap guyline for logging crews.

DISCUSSION

This study evaluated the use of synthetic rope to replace steel wire rope in static cable logging applications. The assessment of each application was descriptive and based on observations made by researchers and logging contractors.

Synthetic rope guylines proved to be suitable for replacing steel wire rope guylines. The reduction in weight, ease of use, and simplicity in rigging are all benefits. The average breaking strength of two used 9/16 inch Amsteel Blue guylines was 38 percent yield (15,341 pounds) of catalogue minimum breaking strength. These guylines would have been suitable for use on skylines up to 5/8 inch diameter. The ropes tested for residual strength were of normal wear that is specified by the rope inspection and retirement guidelines set forth by The American Group (1997). Further research is needed to establish retirement guidelines for used synthetic rope guylines.

Visual inspection of the used guylines did not indicate any severed or cut strands. It is important to acknowledge that most logging equipment has sharp metal edges which can damage synthetic rope and reduce residual strength. Eliminating the contact with sharp metal edges will provide a longer service life from synthetic rope.

A technique used but not evaluated during the trials is the potential use of rappelling devices for descending trees. This approach should be further evaluated to determine the feasibility and implications for safety code inclusion.

Synthetic intermediate support lines have distinct advantages over steel wire rope. With steel wire rope lines, initial raising of the support jack often requires a come-a-long and can be a tedious process to raise the support jack to an acceptable height. With the reduction in weight, synthetic rope can be raised much easier and often without the aid of a come-a-long thus saving time and increasing efficiency. Wire rope uses u-bolt clips or Crosby clamps to secure guylines or intermediate support lines, while synthetic rope offers a reduction in the time spent rigging and de-rigging because a shackle is the only terminal connection. Other quick terminations may be on the horizon for synthetic rope as research continues.

Synthetic rope tree straps were immediately acceptable as replacement for steel wire rope straps. Once logging contractors felt comfortable with the strength and durability of synthetic rope in this application, they were more likely to try other applications such as guylines or intermediate support lines of synthetic rope. A pre-conceived notion about the strength properties was the largest factor of concern for loggers during these trials. The basket design and single strap with eyes were the only tree strap configurations studied during these trials.

Synthetic snap guylines are safety measures for cable logging and are easy and simple use. One logging contractor was more likely to use synthetic rope for this application due to the lighter weight of material and ease of rigging.

CONCLUSIONS

This preliminary evaluation of synthetic rope for use in static rigging applications shows synthetic rope to be suitable for replacing steel wire rope in these applications studied. Further analysis to determine damage and wear criteria is suggested to identify replacement criteria for ropes in various applications.

Cost of the synthetic rope is an initial drawback for most logging contractors. However, the benefits of using synthetic rope for static rigging applications in cable logging seem to outweigh this concern. Benefits such as decreased rigging times, reduced workloads due to lighter weight materials, ease of use, and a potential to increase production are factors to consider when assessing the cost-benefit ratio between steel wire rope and synthetic rope.

REFERENCES

Garland, J., J. Sessions, S. Pilkerton, and B. Stringham. 2002. Using Synthetic Rope to Reduce Workloads in Logging. Final Report, Worksite Redesign Program. Oregon Occupational Safety and Health Administration. Portland, OR.

Oregon Administrative Rules, Chapter 437, Division 7, Forest Activities Code (draft), Oregon Occupational Health and Safety Administration. Salem OR. www.orosha.org/standards/div_7.htm. Retrieved May 27, 2003.

Takumi, U. 1998. Application of Super Fiber Rope as a Guyline for a Mobile Tower Yarder. P. 70-75 in Proceedings of the IUFRO/FAO Seminar on forest operations in Himalayan forests with special consideration of ergonomic and socio-economic problems, Heinimann, H.R. and J. Sessions (eds.). Kassal University Press, GmbH. ISBN 3-933146-12-7. 160p.

The American Group. 1997. Marine and Industrial Ropes. Rope catalogue. Ferndale, WA. 39p.