FERIC FOREST ENGINEERING RESEARCH INSTITUTE OF CANADA

INSTITUT CANADIEN DE RECHERCHES EN GÉNIE FORESTIER

Technical Report No. 6
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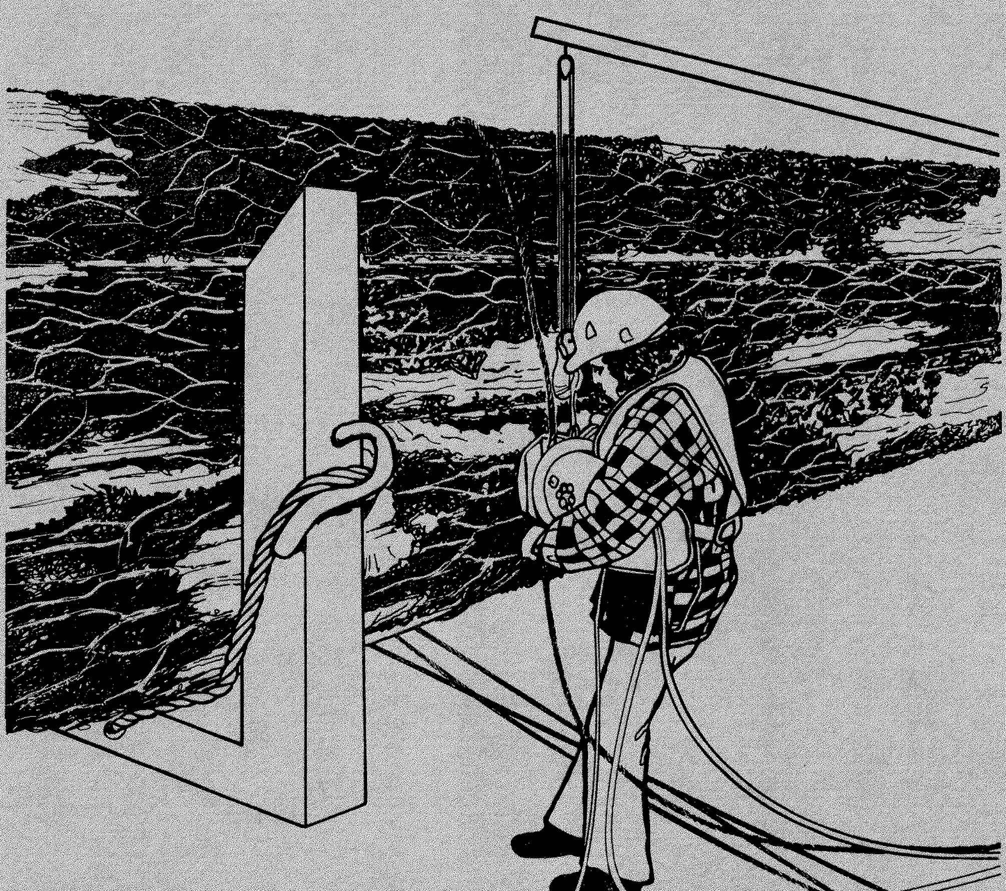
B.J. Sauder and K.A. Hallberg



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Foreword

This report presents results of the FERIC project dealing with the securing of log bundles during transport. The objective of the study was to develop and test an effective and economical alternative to presently used methods.

Mr. K.A. Hallberg gained considerable experience in this field during his employment with British Columbia Forest Products Limited and was employed as a consultant for the project. Mr. B.J. Sauder is a staff member of FERIC, Western Division, Vancouver.

Acknowledgment and thanks for their help and co-operation is given to A.C. Ross of Wire Rope Industries Limited, Vancouver; B. Walters of Hyseco Fluid Systems Limited, Vancouver; J. McKercher and W. Fedje of Millstream Timber Company; J.T. Parker and A. Walker of British Columbia Forest Products Limited; and, the employees of Millstream Timber Company and British Columbia Forest Products Limited who cooperated in the project.

Field demonstrations of the system took place at Crown Zellerbach's Courtenay division and Canadian Forest Products' Beaver Cove operation.

Summary

The costs incurred from log losses by sinkage and escape during water transport have encouraged the forest industry to increase the use of log bundles. The cost of producing and handling bundles can only be justified if the security of a high percentage of bundles is guaranteed. In most applications, good survival has been achieved with either the present wire rope strap using the wedge-type hook, or steel banding, but poor survival was encountered when bundles were loaded on self-loading, self-dumping barges.

This report describes the development and testing of a new method of securing bundles using wire rope and pressed aluminium sleeves that are applied with a portable hydraulic press. The pressed sleeve connection is designed to be at least 80 percent efficient. Investigations into the efficiency of the wedge hook now used showed that the connection had a maximum tensile strength of approximately 20,000 pounds (89 kN) compared to the 33,000 pounds (147 kN) tensile strength of the 5/8-inch (15.9 mm) 4×8 galvanized rope. As this 20,000 pounds (89 kN) tensile strength has proven adequate in certain applications, a ½-inch (12.7 mm) diameter 3×19 galvanized wire rope and pressed sleeve connection could be substituted for the 5/8-inch (15.9 mm) rope with the wedge hook.

Tests at Millstream Timber Company, Hatzic Lake (Mission) using ½-inch (12.7 mm) diameter rope and pressed sleeve on 3.5-cunit (9.9 m^3) pulp bundles subjected to calm water towing conditions resulted in 100 percent bundle survival. When used on large 20-cunit (57 m^3) bundles subjected to rough water towing conditions, from British Columbia Forest Products Limited, Port Renfrew, the same type of rope and pressed sleeve again resulted in 100 percent bundle survival.

Barge loaded bundles from Millstream Timber Company, Ucluelet, tested with both ½-inch (12.7 mm) 1 × 19 galvanized strand, and 5/8-inch (15.9 mm) 4 × 8 wire rope with pressed sleeves gave results of 99 percent and 95 percent bundle security respectively.

Some advantages of using the pressed sleeve connection are:

1. Reduced capital cost of bundle rope material.
2. Reduction in rope handling cost due to reduced bulk.
3. Ropes are more convenient to handle due to their smaller diameter and reduced weight.
4. Reduced log losses because of better bundle security.
5. Safer bundle breakdown procedure, since the rope can be cut at any point and there is no need for a worker to stand on the bundle.

Some disadvantages of the pressed sleeve connection are:

1. The need for specialized equipment including the press, a power source and some means of transport or installation.
2. Wire rope used should be pre-formed to allow for re-cycling.

Cost analyses indicate potential savings of 11 to 55 cents per cunit (4 to 19 cents per m^3) using the pressed sleeve connection, compared to other currently used methods of securing log bundles.

Sommaire

Le flottage de grumes en vrac entraîne parfois des pertes de bois considérables et coûteuses, et pour réduire ces pertes, les grumes destinées au flottage sont de plus en plus liées en ballots. Toutefois, les coûts additionnels de préparation et de manutention de ces ballots sont rentables seulement s'il en résulte une diminution appréciable des pertes de bois. Dans la plupart des cas, l'utilisation de rubans d'acier ou encore de cables d'acier avec crochets donne des résultats satisfaisants excepté lors du chargement de ces ballots sur les barges.

Ce rapport décrit les essais d'une nouvelle méthode pour lier les grumes en ballots en utilisant un cable d'acier dont les extrémités sont raccordées au moyen de douilles d'aluminium fixées par une presse hydraulique portative.

Les essais ont démontré que les raccords avec crochets conventionnels pouvaient supporter une force de tension maximale de 20,000 lbs. (89 kN) comparativement à celle de 30,000 lbs. (147 kN) d'un cable d'acier galvanisé de 5/8 po., 4x8 (15.9 mm). Comme une capacité de 20,000 lbs. (89 kN) est adéquate dans la plupart des cas, on peut utiliser un cable de diamètre plus petit, soit 1/2 po., 3x19 (12.7 mm) avec les douilles d'aluminium.

Au cours d'essais à la Compagnie Millstream Lumber des cables de 1/2 po., (12.7 mm) raccordés avec ces douilles furent utilisés pour préparer des ballots de 3.5 cunits (9.9 m^3) destinés au touage en eau calme. Les résultats furent très satisfaisants; il n'y eut aucune perte. Dans le cas de ballots de 20 cunits (27 m^2) toués en eau agitée, les résultats furent identiques. Durant le chargement des ballots de 6 cunits (16.9 m^3), transport sur barges et déchargement, les pertes furent de l'order de 1 pour cent pour ceux liés par un cable d'acier galvanisé de 1/2 po., 1x19 (12.7 mm) et de 5 pour cent pour ceux liés par un cable d'acier de 5/8 po., 4x8 (15.9 mm).

Parmi les avantages évidents de cette méthode, notons:

1. Le réduction du coût des matétriaux utilisés.
2. Une manutention plus facile des cables qui sont plus petits et plus légers.
3. La réduction des pertes de bois.
4. L'ouverture facile des ballots et une diminution du risque d'accident lors de la coupe des cables.

Il faut aussi noter quelques inconvénients, tels que la nécessité d'une source de pouvoir pour la presse hydraulique laquelle doit aussi être installée et transportée.

Dans l'ensemble, la rentabilité de cette nouvelle méthode a été démontrée; elle peut se traduire dans la pratique par des économies allant de 11 à 55 cents par cunit (4 à 19 cents/m^3).

Introduction

For many years bundles of logs transported in the water have been secured with either steel banding or wire rope. Various methods of joining the ends of the wire rope securing the bundle have been tried and are in use. The most common is the re-usable, 5/8-inch (15.9 mm), galvanized, bundle-wire rope with the wedge-type hook. These methods have proven satisfactory in the past when bundle booms were limited to transportation routes encountering little rough water. Generally, bundle ropes were removed from the booms by boom crews before the logs were delivered to the mill. The increase in the number of dryland sort operations and the need to reduce the loss of logs from sinkage and escape has caused the industry to greatly increase the use of bundle booming. Increasingly log bundles are being delivered directly to the mills.

In 1974 the industry began transporting bundled logs on ocean-going barges. The handling of bundles by present self-loading, self-dumping barges places higher strains on the bundling ropes than experienced in any other situation. Under these conditions the traditional bundling ropes have proven to be inadequate, and investigations were made to develop an effective and economic alternative for barge-loaded and rafted bundles.

Limitations of Present Bundling Systems

Steel Banding

Steel banding is used for bundling small logs delivered directly to mills and for logs sold to other companies. It is relatively cheap, and easy to apply and remove. On the other hand, its low strength makes it impractical for bundles of logs subjected to towing in rough water, or grounding when stored on tidal flats, or loading onto barges. Disposal of large quantities of used banding is a problem at some mills since the banding is usually non-returnable.

Bundle Ropes with Wedge Hook

The standard bundle rope is a 5/8-inch (15.9 mm) diameter 4 × 8 galvanized wire rope with a breaking strain of 33,000 pounds (147 kN)[1]. It is equipped with either a Manson or DC wedge hook. The Manson hook has grooves in the body of the hook to match the lay of the rope and a smooth wedge. The DC hook has the grooves in the wedge and a smooth body. The hook is attached to the end of the rope by means of a pressed ferrule. Bundle ropes are ordered in standard lengths to suit the largest expected size of the bundles. The manufactured ropes are supplied complete to the logging operations and can be applied anywhere, without special equipment.

To secure a bundle, the rope is placed around the bundle of logs and the running end is passed through the hook. It is pulled hand tight and the wedge is driven into the hook with a hammer. At the mill the wedge is hammered out and the bundle is released. Bundle ropes are returned in coils to the logging operation for re-use.

There are several inherent problems when using this type of bundle rope.

1. The standard bundle rope with hook does not perform satisfactorily on bundles transported by barge. Tabulation of seven barge loads by British Columbia Forest Products Ltd. showed 7.4 percent of the bundle ropes failed. Failure results in a considerable cost due to loss of logs and bundle ropes.
2. Additional expense is incurred at the processing plant if the hook is not on top of the bundle because:
   (a) the bundle must be "rolled"; or
   (b) the bundle rope is cut, resulting in a repair cost or loss of the strap.
3. Rope slippage through the hook is common during bundle transport. This unravels or kinks the rope, making it difficult or impos-

[1] Specifications for bundling materials are given in Appendix I.

sible to pass it through the hook when the bundle rope is re-used.

4. Bundle ropes must be ordered long enough to encircle the largest bundle. A tag end, 4 feet (1.2 m) or longer, is left on the average size bundle.

Initial investigation of rope failures showed that in many cases the hook slipped or broke. Tests were carried out by two separate agencies (Wire Rope Industries Limited and British Columbia Forest Products Limited) to check the efficiency of both types of wedge hooks when used with the standard bundle rope.

TEST 1:	
Sample No. 1 —	
Rope slipped through bundling hook, at	16,000 lb. (71 kN)
Sample No. 2 —	
Bundling hook fractured, at	18,400 lb. (82 kN)
Sample No. 3 —	
Rope slipped through bundling hook, at	17,000 lb. (75 kN)

TEST 2:	
Sample No. 1 —	
Rope slipped through bundling hook, at	8,000 lb. (35 kN)
Sample No. 2 —	
Rope slipped through bundling hook, at	10,000 lb. (44kN)
Sample No. 3 —	
Rope slipped through bundling hook, at	13,000 lb. (58 kN)
Sample No. 4 —	
Rope cut off by hook, at	23,000 lb. (102 kN)
Sample No. 5 —	
Rope broke at hook, at	28,500 lb. (127 kN)
Sample No. 6 —	
Two strands cut off by hook, at	17,600 lb. (78 kN)

The inefficiency of the wedge hook reduces the effective strength of the bundle rope, in the majority of cases, to less than 60 percent of the 33,000 pounds (147 kN) tensile strength of the wire rope.

Pressed Sleeve Connection

Development

The initial investigation and development for a new bundling system was carried out by Wire Rope Industries Ltd., Vancouver, and Hyseco Fluid Systems Ltd., Vancouver. The Western Division of Forest Engineering Research Institute of Canada assumed responsibility for development costs, testing, reporting results, and consultation on future developments. British Columbia Forest Products Ltd. acted as the co-operating company. Field tests were conducted at Port Renfrew and the Millstream Logging contract operations at Ucluelet and Mission.

The system tested employed an aluminium sleeve (in place of the wedge hook) applied with a portable hydraulic press. The system is similar to that used for steel banding but substitutes wire rope for the banding, and aluminium sleeves for the seals. The system has the convenience of banding but possesses greater strength and better re-cycling potential.

Tests were first conducted to establish the length and material required for a sleeve to produce the desired connection. A major consideration was the desirability of a single pressing operation. It is customary to apply steel sleeves with a series of pressings and rotation of the sleeves. Single pressing of the steel sleeves resulted in lengthwise splitting.

Aluminium sleeves were therefore chosen due to their lower cost, better availability, and the metal's behaviour and "flow" with single pressing. Electrolysis and the subsequent joint decay (in salt water) associated with the aluminium sleeve could present a future problem, but any joint showing severe decay could be cut out. Standard bundle ropes with wedge hooks are at present being repaired using aluminium sleeves with a minimal corrosion problem.

Tests showed the most efficient connection for ½-inch (12.7 mm) wire rope was achieved using one 2½-inch (63.6 mm) long Alumaloc sleeve. When applied on 3-strand, ½-inch (12.7 mm) diameter, 3 × 19 galvanized wire rope, connections of over 20,000 pounds (89 kN) breaking strain were achieved.

System Equipment

The press (Figure 1) has a weight of approximately 225 pounds (102 Kg), and a pressing capability of 142 short tons (1.26 MN). The hydraulic pump, a standard model producing 10,000 p.s.i. (70 MPa) can be powered by electric motor, air motor, or gas engine. For the field testing, an electric model was employed with a portable generator (Figure 2). The press was suspended from a counterweighted horizontal beam, which pivoted and revolved on top of a 5-foot (1.5 m) vertical post. The complete unit was mounted on the back of a ½-ton pick-up truck. The hydraulic pump and power plant were located in the truck box. It was evident throughout the tests that individually "customized" systems would greatly increase the efficiency of the bundling operation.

Initially the die heads of the press incorporated a cutting tool but this was found to be a hindrance. Cutting blade breakage and the weakening of the dies, due to the need for a cutter blade receiving groove, resulted in the decision to eliminate this feature of the press.

It was found that the 142 short ton (1.26 MN) press was not adequate to press a single-sleeve connection on 5/8-inch (15.9 mm) diameter wire rope. Using two 2-inch (50.8 mm) long sleeves, connections with strengths of up to 34,900 pounds (155 kN) breaking strain were achieved. As this strength may be required for barge-loaded bundles, a 200 short ton (1.77 MN) hydraulic press which weighs 325 pounds (147 Kg) has now been developed to produce the single-sleeve connection.

The initial tests used two types of ½-inch (12.7 mm) diameter wire rope: 6 × 26 black and 3 × 19 galvanized. Subsequent barge tests used returned ½-inch (12.7 mm) diameter wire rope, 5/8-inch (15.9 mm) diameter 4 × 8 galvanized wire rope and ½-inch (12.7 mm) diameter 1 × 19 galvanized strand. The latter was supplied and applied by Millstream Timber. The strand is not pre-formed and is therefore non-returnable.

Accessories that increased system efficiency during the field tests included:

1. a 12-inch (0.3 m) slightly "S"-bent pry bar (tire iron) for clearing the sleeve from the die after pressing (not necessary with non-sticking dies);
2. a modified pair of "Vise Grips" pliers to hold the overlapped wire together and stop the sleeve from slipping down the wire. These were found useful when two men were employed and one person pre-set the second wire while the other operated the press.

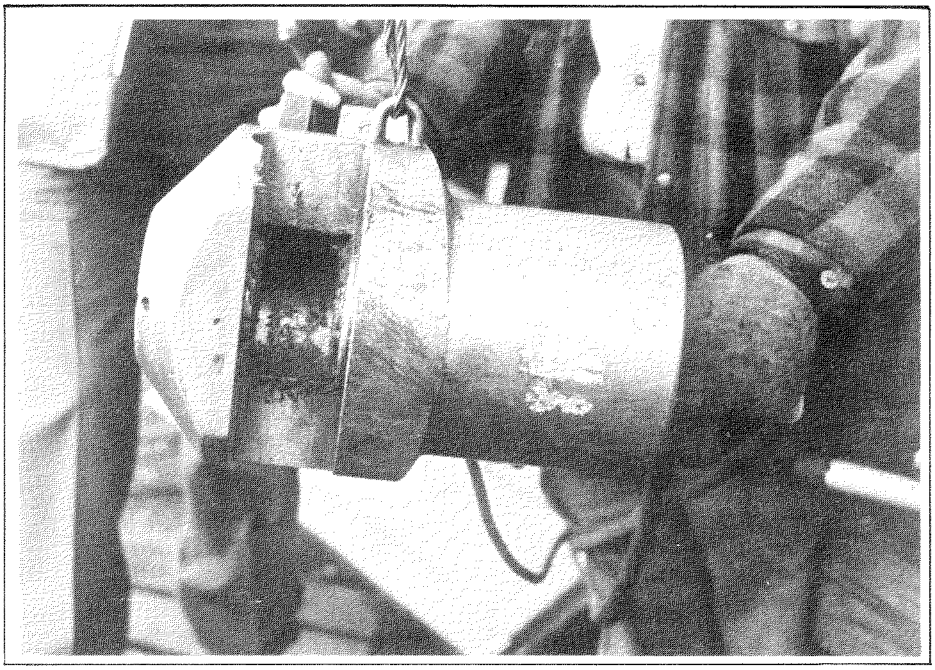


Figure 1. 142 short ton (1.26 MN) capacity press.

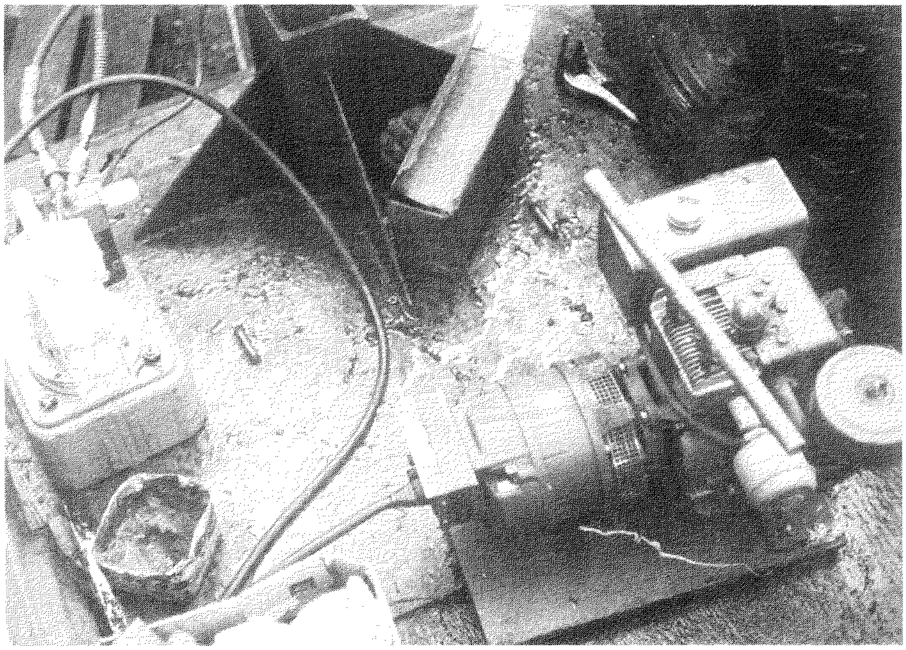


Figure 2. Gas generator and hydraulic pump.

Field Tests

Description of the Test Conditions

Three distinct transport conditions for log bundles were tested:

1. Self-loading and self-dumping log barge;
2. Raft-outside, rough water;
3. Raft-inside, calm water.

Each produces a different degree of strain on the securing bundle ropes. For the test, a representative sample for each environment was produced and the bundle rope survival noted. In the case of barge transport, survival comparisons were made with the steel banding and standard bundle ropes on each barge load.

Bundling Procedure

Lengths of wire rope were first laid at two places under the bundling cradle; perpendicular to the logs and approximately 10 feet (3 m) either side of the bundle centre.

A variety of lengths was cut to accommodate the fluctuations in bundle size.

After the bundle racks were filled with logs, the two ropes were placed around the bundle. When possible, the ropes were thrown over by hand. The large 20-cunit (57 m^3) bundles assembled at the water's edge required the use of a heaving line. The line was thrown over the bundle and retrieved from underneath with a pike pole. The attached wire rope was then pulled over. This eliminated the need for the employee to climb onto the bundle.

The truck carrying the press was then positioned (Figure 3), the rope ends were fed through the aluminium sleeve and pulled hand tight (Figure 4). The sleeve was then pressed (Figure 5). This procedure was duplicated on the second rope. It was possible, when properly organized, for one person to secure a 6-cunit (16.9 m^3) bundle in 4 minutes (including the time to position the truck). Debris and mud accumulation in front of the bundling racks made truck positioning difficult at times.

The 5/8-inch (15.9 mm) wire rope required two sleeves per bundle rope; otherwise the procedure was identical.

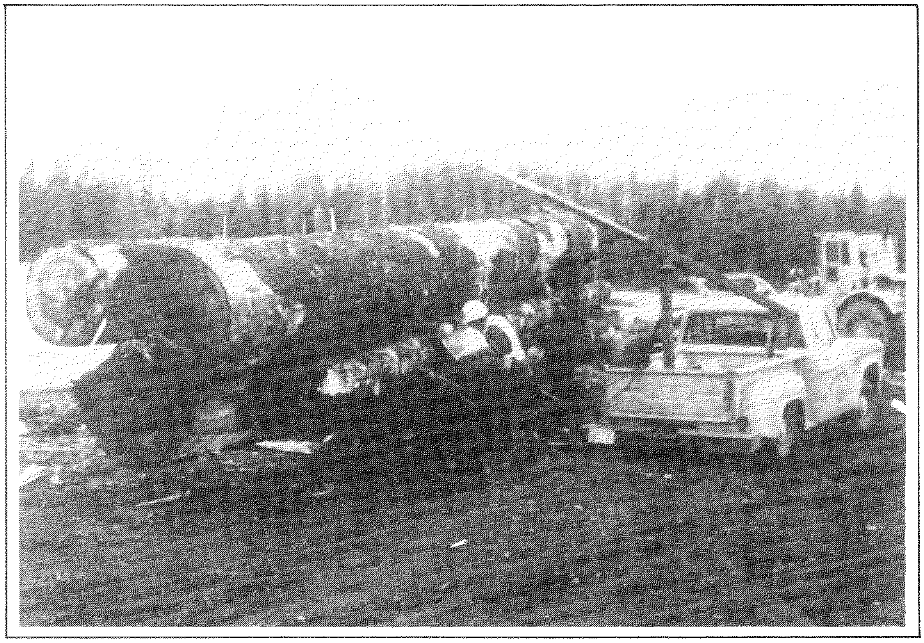


Figure 3.
Truck positioned beside bundle.

When the bundles arrived at the processing plant the bundle ropes were cut with a thin grinding disc, powered either by a chainsaw engine or air motor. At one operation, the ropes were tied to a cable suspended over the area where the bundles were cut. In other operations, the rope was pulled from under the bundle manually.

The ropes were coiled and returned in this form to the logging operations. There, returned ropes were laid out and inspected, and frayed ends cut off. If the rope had been cut in the middle and a tag end was present at the sleeve joint, it was removed and used as a joiner piece. Generally, the returned ropes required no lengthening, because of the variance in bundle sizes and the length of ropes available. When a rope was short, a joiner piece was added using another sleeve. Returned ropes that were damaged or that had deteriorated in service were cut up and used for extensions.

The returned ropes were as easy to use as new ropes. This is generally not the case with returned bundle ropes using hooks.

Discussion

The application of bundling ropes must be as efficient an operation as possible and the actual system used must be developed to suit individual conditions. Only at operations processing a large volume of wood can the expense of a two-man crew be justified. Individual operator adaptations of the system must make the press as convenient as possible to use or delays will result. If a vehicle (truck, tractor, etc.) is used to transport the press, a suspending rail or other method should be used so both straps can be pressed from one vehicle position.

The use of a vehicle introduces yet another moving machine into the dryland sort yard. It must keep out of the stackers' and loaders' way at all times, otherwise delays will occur and the "rhythm" of the sorting operation is disrupted. It is best to have the vehicle moving around the perimeter of the sort, behind the bundling racks as much as possible.

The suspension of the press from a gantry, high swinging crane or skyline would remove the need for a vehicle. This would speed up the operation but may not be applicable to all operations.

Figure 4. Sleeve before pressing.

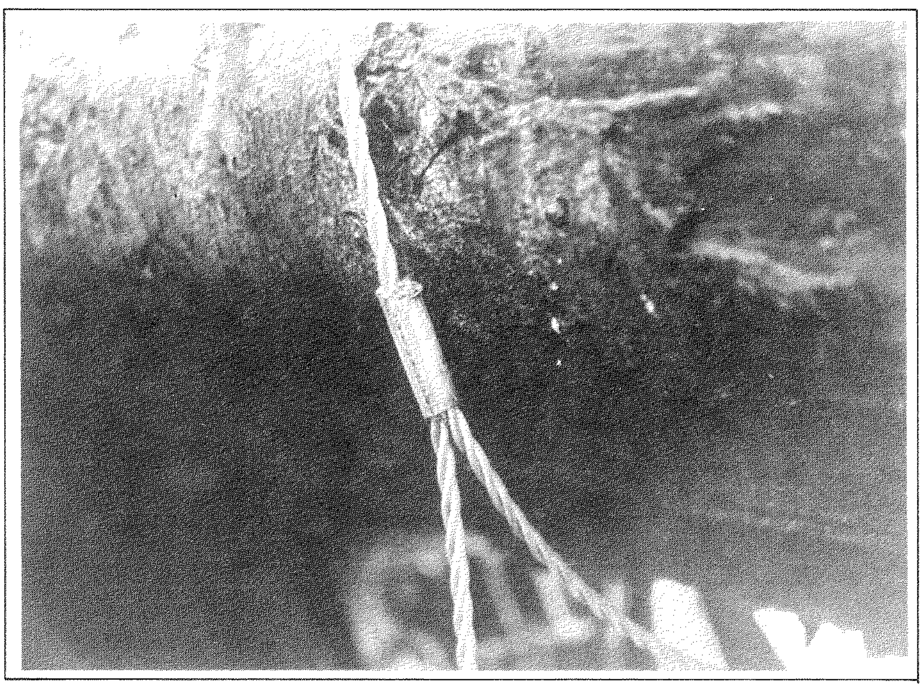


Figure 5. Sleeve after pressing.

Test Results

Barge Bundle Test

The first experiment with barge bundles was inconclusive because the barge failed to dump and the bundles were off-loaded by the barge cranes. This procedure damages the bundling ropes because it is difficult to encircle the complete bundle with the grapples and the logs hang in the bundle ropes. The grapples also cut the ropes and severe abrasion occurs as the bundles are thrown off before completely clearing the barge. The latter could explain the better success of the standard 5/8-inch (15.4mm) wire and hook, since survival is more dependent on the strength of the wire rope rather than the strength of the joint. Recovered ½-inch (12.7mm) ropes that had failed were broken in the wire, not at the joint.

Approximately 20 of the intact straps with wedge hooks were either stranded or kinked at the hook and would have to be cut at the mill.

The second barge test bundles were transported on the Straits Traveller, the best local barge for bundle handling. This barge has a single crane equipped with a 14-foot (4.3m) grapple. The crane travels the length of the barge on two steel rails. This results in smooth handling of the bundles and reduces breakage of bundling ropes.

TEST 1

RESULTS —	No. Bundles	No. Ropes	No. Failures	No. Survivals
½-inch dia. 6 × 26	42	84	21	63
½-inch dia. 3 × 19	37	74	28	46
Total:	79	158	49	109*
Percent Failure = 31%				
5/8-inch dia. & hooks	120	240	26	214**
Percent Failure = 11%				
2-inch × .050 Steel Banding	151	302	169	133
Percent Failure = 56%				

*Seventeen bundles were secured with only one rope giving 63 secured bundles (80% bundle security).

**Twelve bundles were secured with only one rope giving 113 secured bundes (94% bundle security).

TEST 2

RESULTS —	No. Bundles	No. Ropes	No. Failures	No. Survivals
½-inch dia. (re-used 3 × 19, 6 × 26)	47	94	14	80
Percent Failure = 15%				
½-inch dia. (1 × 19)	175	350	9	341*
Percent Failure = 3%				
5/8-inch dia. (sleeve)	49½	99	9	90**
Percent Failure = 9%				
5/8-inch dia. (hook)	70	140	24	116
Percent Failure = 17%				

*Five bundles were secured with only one rope giving 173 secured bundles (99% bundle security).

**Four bundles were secured with only one rope giving 47 secured bundles (95% bundle security).

Open Water Test

One section of a boom subject to outside "West Coast" towing conditions was bundled using ½-inch (12.7 mm) 6 × 26 and 3 × 19 wire rope.

RESULTS —	No. Bundles	No. Ropes	No. Failures	No. Survivals
½-inch dia. 6 × 26	20	40	0	40
½-inch dia. 3 × 19	23	46	0	46
Total:	43	86	0	86
Percent Failure = 0				

Inside Water Test

One section of a boom subject to inside, protected, and calm water towing conditions was bundled.

RESULTS —	No. Bundles	No. Ropes	No. Failures	No. Survivals
½-inch dia. 6 × 26	13	26	0	26
½-inch dia. 3 × 19	13	26	0	26
Total:	26	52	0	52
Percent Failure = 0				

Discussion of Test Results

In the second barge test the ½-inch (12.7 mm) diameter 1 × 19 galvanized strand showed very good results. The reason for its better performance compared to the 5/8-inch (15.9 mm) diameter rope is not obvious. The strand has a slightly lower tensile strength (29,000 pounds, 129 kN) but its smoother surface may allow it to slide over objects that would snag the four-strand 5/8-inch (15.9 mm) diameter rope.

The small sample size may have biased the results for the 5/8-inch (15.9 mm) diameter wire rope and ½-inch (12.7 mm) diameter strand. Future barge loads should give a better indication of the behaviour of both the rope and the strand. It would seem, from these results, that both performed satisfactorily. The choice of rope size will depend on the application and operation. The 5/8-inch (15.9 mm) diameter rope has good re-cycling characteristics, whereas the lower price of the strand makes it applicable when logs are sold outside of the company.

There is also no apparent reason for the higher than average (17 percent) failure rate of the standard hook and rope.

The poorer behaviour of the reused ½-inch (12.7 mm) diameter ropes and steel banding seems to indicate that their tensile strength is not sufficient for barge transported bundles.

Inspection of one barge showed that plates were welded to the deck. The edges of these plates could possibly snag and cut any type of rope. Future practice should include grinding of the edges of these plates to reduce this possibility.

It must be noted that the self-loading, self-dumping barges now in use were designed to handle loose logs, not bundles. With the increase in bundle transport, the present barges must be converted and new barges designed for this purpose. In general, the loading cranes will need the strength and power to place bundles accurately in one motion. Any re-positioning of the bundles after the initial placement may cause rope failure.

In the other two tests, the ½-inch (12.7 mm) diameter wire rope gave excellent results. It may be possible to employ 3/8-inch (9.25 mm) diameter wire rope for the inside water tows. Most of the breakage in this case occurs at the bundle dump. Slight modification to the dump structure could produce easier entry of the bundles into the water. This would reduce the rope strain which would make the 3/8-inch (9.25 mm) diameter wire rope highly serviceable.

Advantages and Disadvantages of the Pressed Connection

Advantages

1. When compared to the standard bundling rope with hook, the capital cost of ropes can be reduced by approximately 50 percent. The lower cost is made possible by:
   (a) Use of smaller diameter rope (where applicable).
   (b) No expense for: hook, cutting ropes to length, twisting ends and attachment of hook.
   (c) Reduction in length of rope used since rope is cut to suit bundle sizes.
2. The pressed sleeve is a safer and more efficient connection than the wedge-type hook. A decrease in the number of broken bundles will reduce log losses and result in fewer deadheads (loose, partially submerged logs).
3. The bundle rope can be cut anywhere in its circumference (although it is preferable to cut the rope as close to a sleeve as possible). Bundles do not have to be rolled and persons cutting the rope do not have to stand on the bundle.
4. Kinked or frayed ends can be trimmed, ropes can be repaired, and short lengths added at the bundling site to produce the desired length.
5. The ½-inch (12.7 mm) diameter wire rope is less bulky than the standard bundle rope. This makes it easier to handle and reduces return freight charges.

Disadvantages

1. The process requires specialized equipment which must be powered; and cannot be done by hand.
2. The weight of the press requires some type of vehicle or installation for transport and support.
3. The wire rope should be pre-formed, otherwise ends will unravel, making the rope hard to handle and non-returnable. If non-returnable, disposal problems and higher operating costs may result.

Discussion

Closing time for the press was 30 seconds. This time can be shortened by using a larger pump. The slow speed gives the operator ample time to correct misalignment or remove objects from the jaws. When compared to the time for tensioning and crimping steel banding, the pressing time was a few seconds longer.

With the "primitive" experimental test equipment of gantry and truck, a Millstream employee was able to complete 35 bundles in one 8-hour shift. The speed of the press was not considered to be a major disadvantage of the system. The Workers' Compensation Board advised against any speeding up of the press cycle.

The sleeve stuck in the dies after pressing. This problem was reduced by greasing the dies prior to pressing, but it remained a nuisance. A second set of dies was designed and tested but lubrication was still necessary. The manufacturer has since produced a new design of die and the problem has been eliminated.

Concern was raised about the presence of old sleeves on the rope, which could catch on the logs and make it difficult to pull the rope over the bundle. If too many sleeves are present in one section of the rope, that section can be cut out and replaced. It is estimated that 40 percent of the bundle is above water. There is a good probability that after the second trip one of the sleeves will be accessible and the rope can be cut there. Companies that make a variety of bundle sizes can plan to re-use ropes on progressively smaller bundles, thus reducing the number of sleeves used.

Costs

Comparative estimated costs for a variety of conditions are given in Appendix II. There is no labour cost included since the same crew would be used in all systems. There is also no cost given for log and rope losses when bundle ropes fail. It is estimated, for hemlock logs, that 5 percent of the volume will be lost if a bundle breaks. A bundle failure rate of 10 percent represents a cost of 30 cents per transported cunit (11 cents per m^3), based on $60.00 per cunit ($21.00 per m^3) market value, plus the cost of the lost bundling rope.

From the appendix examples, a potential saving for material and equipment of 11 to 55 cents per cunit (4 to 19 cents per m^3) is estimated. If the dollar value associated with reduced log and rope loss is considered, the potential savings are even greater with the new system.

Conclusion

With the increase in the water transportation of bundled logs, both by raft and barge, the method of securing them is most important. The system outlined in this report fulfils the purpose of containing the logs efficiently and at a competitive cost throughout transport and storage.

When considered individually, bundle ropes appear to be a low cost, operating supply item; yet, in total they represent a substantial expense. Consider, for example, the invested capital in bundling rope on a barge handling 450 six-cunit (16.9 m^3) bundles. This is an investment of $15,417 for the standard wedge hook and rope or $7,245 for the pressed sleeve and rope. The longer the recycle time for the bundle ropes, the greater the total investment becomes.

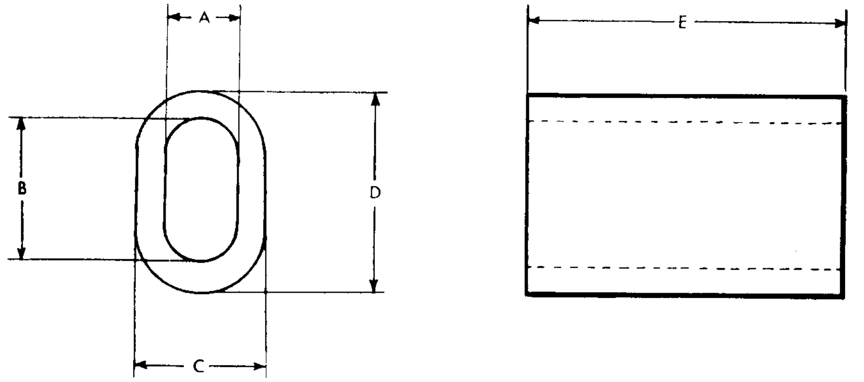
The cost of lost logs and bundle ropes would seem to justify the cost of adaptation of present equipment to reduce bundle rope breakage. Operators and manufacturers of equipment used to handle bundles must realize the importance of keeping bundles intact. Future designs must reduce equipment interference with bundling ropes. It is futile to incur the additional expense of producing log bundles without guaranteeing that a high percentage of the bundles arrive at their destination intact.

APPENDIX I

Specifications of Bundling Material

	Tensile Strength
Wire Rope	
½-inch (12.7 mm) diameter 3 × 19 galvanized	20,000 lbs. (89 kN)
½-inch (12.7 mm) diameter 6 × 26 black	23,600 lbs. (105 kN)
5/8-inch (15.9 mm) diameter 4 × 8 galvanized	33,000 lbs (147 kN)
Wire Strand	
½-inch (12.7 mm) diameter 1 × 19 galvanized	29,000 lbs (129 kN)
Steel Banding	
2-inch (50.8 mm) × .050 inch (1.27 mm)	16,000 lbs. (71 kN)

SPECIFICATIONS OF THE ALUMINIUM SLEEVE



	SIZE	WIRE ROPE DIA.	A	B	C	D	E
IN.	1/2	1/2	19/32	1 3/16	1 1/32	1 5/8	2 1/2
MM.	12.7	12.7	15.1	30.2	26.2	41.3	63.5

APPENDIX II

Comparative Costs of Securing Log Bundles with Pressed Sleeve Connection and Presently Used Methods

Equipment Cost

Marketing and servicing of the bundling system will be handled by Wire Rope Industries Limited, Vancouver. Initially, one model of press (200 short ton; 1.77 MN) will be available capable of securing wire rope from 3/8-inch (9.25 mm) to 5/8-inch (15.9 mm) diameter. The production of a smaller press (142 short ton; 1.26 MN) for ½-inch (12.7 mm) and 3/8-inch (9.25 mm) wire rope may be undertaken at a future date if a demand exists. The price of the hydraulic press and pump will be approximately $5,800. With an increased demand for sleeves and the smaller sizes of wire rope a reduction in their cost is expected.

Estimated costs are based on quoted current (spring 1976) catalogue prices.

Estimated Cost

1. Barge Loaded Bundles

1.1 ½-INCH DIAMETER 1 × 19 GALVANIZED STRAND AND PRESSED SLEEVES:	
Assumptions: 6 cunits (16.9 m^3)/bundle 450 bundles/barge Strand is not pre-formed, used only one trip	
Wire Strand: Two 21-foot ½-inch 1 × 19 strand per bundle 42 ft. @ 10¢/ft. = $\frac{\$4.20}{6}$ =	.70/cunit (.25/m^3)
Sleeves: ½-inch × 1¾-inch Alumaloc; 2 per connection 4 @ 50¢ each = $\frac{\$2.00}{6}$ =	.33/cunit (.12/m^3)
Depreciation on press equipment and truck: $10,000/(5 years × 70,000 cunits/yr) =	.03/cunit (01/m^3)
Total Cost: $1.06/cunit (.38/m^3)	

1.2 5/8-INCH DIAMETER 4 × 8 GALVANIZED WIRE ROPE AND PRESSED SLEEVES:	
Assumptions: Same as 1.1, but rope makes 6 trips before being lost or discarded; 6 cunits/bundle × 6 trips = 36 cunits/rope life	
Wire Rope: Two 21-foot 5/8-inch diameter 4 × 8 ropes per bundle plus a total of 4 feet per rope in additions for subsequent trips 50 ft. @ 35¢/ft. = $\frac{\$17.50}{36}$ =	.49/cunit (.17/m^3)
Sleeves: 5/8-inch × 2½-inch Alumaloc 22 @ 70¢ each = $\frac{\$15.40}{36}$ =	.43/cunit (.15/m^3)
Return Freight Charges: Return freight @ $150/trip = ($150/trip × 5 return trips) ÷ (450 bundles × 6 cunits/ bundle × 6 barge trips) =	.05/cunit (.02/m^3)
Depreciation:	.03/cunit (.01/m^3)
Total Cost: $1.00/cunit (.35/m^3)	

1.3 5/8-INCH DIAMETER 4 × 8 GALVANIZED WIRE ROPE AND WEDGE-TYPE HOOK:	
Assumptions: Same as 1.2	
Ropes: 2 standard bundle ropes with hooks 2 ropes @ \$17.13 $= \frac{\$34.26}{36}$ =	.95/cunit (.33/m³)
Repair Cost: Based on previous experience	.12/cunit (.04/m³)
Cost to roll bundles: Based on previous experience	.22/cunit (.07/m³)
Return freight charges:	.05/cunit (.02/m³)
Total Cost: \$1.34/cunit (.46/m³)	

2. Large Water-Rafted Bundles

2.1 ½-INCH DIAMETER 3 × 19 GALVANIZED WIRE ROPE AND PRESSED SLEEVES:	
Assumptions: 21 cunits (59.5 m³)/bundle 7 trips made by each rope 21 cunits/bundle × 7 trips = 147 cunits/rope life	
Wire Rope: Two 42-foot ½-inch diameter 3 × 19 ropes per bundle plus a total of 9 feet per rope in additions for subsequent trips 102 ft. @ 25¢/ft. = $\frac{\$25.50}{147}$ =	.17/cunit (.06/m³)
Sleeves: 26 @ 50¢ each = $\frac{\$13.00}{147}$ =	.09/cunit (.03/m³)
Return freight charges: est.	.02/cunit (.01/m³)
Depreciation:	.02/cunit (.01/m³)
Total Cost: \$0.30/cunit (.11/m³)	

2.2 5/8-INCH DIAMETER 4 × 8 GALVANIZED WIRE ROPE AND WEDGE-TYPE HOOK:	
Assumptions: Same as 2.1	
Ropes: 2 standard 45-ft. Bundle Ropes with hooks 2 @ \$24.00 = $\frac{\$48.00}{147}$ =	.33/cunit (.12/m³)
Repairs: Cut and damaged ropes, est.	.04/cunit (.01/m³)
Return freight charges, est.	.04/cunit (.01/m³)
Total Cost: \$0.41/cunit (.14/m³)	

2.3 2-INCH × .050 STEEL BANDING (where applicable):	
Assumptions: Same as 2.1 but banding only used once.	
Banding: 84 ft. @ 11¢/ft. plus Seals and Freight = $\frac{\$9.56}{21}$ =	.46/cunit (.16/m³)
Total Cost: \$0.46/cunit (.16/m³)	

3. Rafted Pulp-log Bundles

3.1 ½-INCH DIAMETER 3 × 19 GALVANIZED WIRE ROPE AND PRESSED SLEEVE:	
Assumptions: 3.5 cunits (9.9 m³)/bundle (short logs) 7 trips made by each rope 3.5 cunits/bundle × 7 trips = 24.5 cunits/rope life	
Wire Rope: Two 21-foot ½-inch diameter 3 × 19 ropes per bundle plus a total of 9 feet per rope for subsequent trips 60 ft. @ 25¢/ft. = $\frac{\$15.00}{24.5}$ =	.61/cunit (.21/m³)
Sleeves: 26 @ 50¢ each = $\frac{\$13.00}{24.5}$ =	.53/cunit (.19/m³)
Return freight charges, est.	.10/cunit (.03/m³)
Depreciation:	.02/cunit (.01/m³)
Total Cost: $1.26/cunit (.44/m³)	

3.2 2-INCH × .050 STEEL BANDING:	
Assumptions: Same as 3.1 but banding only used once	
Banding: 42 ft. @ 11¢/ft. plus Seals and Freight = $\frac{\$4.90}{3.5}$ =	1.40/cunit (.49/m³)
Total Cost: $1.40/cunit (.49/m³)	

3.3 3/8-INCH DIAMETER GALVANIZED WIRE ROPE AND PRESSED SLEEVES:	
Assumptions: Same as 3.1	
Wire Rope: Two 21-foot 3/8-inch diameter ropes/bundle plus a total of 9 feet per strap for subsequent trips 60 ft. @ 15¢/ft. = $\frac{\$9.00}{24.5}$ =	.37/cunit (.13/m³)
Sleeves: 26 @ 23¢ each = $\frac{\$5.98}{24.5}$ =	.24/cunit (.08/m³)
Return freight charges, est.	.10/cunit (.03/m³)
Depreciation:	.02/cunit (.01/m³)
Total Cost: $0.73/cunit (.25/m³)	