TECHNICAL STUDY TOUR OF STRUCTURAL LUMBER FINGER-JOINTING IN NORDIC COUNTRIES

Government of Canada
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TECHNICAL STUDY TOUR

OF

STRUCTURAL LUMBER FINGER-JOINTING

IN

NORDIC COUNTRIES

Primary Wood Products Division
Resource Industries Branch (52)
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TECHNICAL STUDY TOUR OF STRUCTURAL LUMBER FINGER-JOINTING IN NORDIC COUNTRIES

PART I

A. Introduction

As a result of the growing percentage of short lengths being produced in Canada's lumber industry and recognizing that this percentage will undoubtedly increase in the future as the northern forests and second growth forests are developed and the smaller timber is utilized; and in keeping with the Department's policy to assist Canadian industry to up-grade and improve the value-added of their products, an invitation was extended by the Department to lumber producing companies across Canada to participate in a technical study of structural lumber finger-jointing in Finland, Sweden and Norway in October 1976. A list of the companies and organizations visited is shown in Appendix 1.

Nine senior officers from lumber firms in B.C., Ontario, Quebec and New Brunswick took part in the mission which was led by Mr. T.A. Charles of the Primary Wood Products Division, Resource Industries Branch, Department of Industry, Trade and Commerce. The mission membership is given in Appendix 2.

As a follow-up to the mission, three members from B.C. and the writer visited the structural lumber finger-jointing operation of the St. Regis Paper Company at Libby, Montana at the end of January, 1977 and also met with experts

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at the Western Forest Products Laboratory of the Department of Fisheries and the Environment in Vancouver who have done extensive research work on the finger-jointing of structural lumber. The W.F.P.L. recently developed a technique for producing structural-quality finger joints in unseasoned lumber using exterior-type adhesives.

B. Purpose

The principal objective of the mission was to undertake a comprehensive investigation of the technological and commerical viability of installing finger-jointing equipment in Canadian lumber manufacturing operations for the purpose of producing longer, more valuable construction lumber from the growing volume of shorter lengths. The report that follows summarizes the findings of the mission members.

C. Overview of Nordic Forest Industries and Resources

1. Finland

Of Finland's total land area of 305,000 km^2, 61 percent is classified as forest land containing a growing stock of some 1,448 million solid cubic meters, including bark. 44 percent of this growing stock is pine (Pinus silvestris), 37 percent is spruce (Picea abies), 17 percent is birch, and the balance poplar and alder.

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In terms of forest ownership in Finland, private interests hold 65 percent of the area accounting for 71 percent of the growing stock. The State owns 24 percent of the area (20 percent of the growing stock), companies hold about 7½ percent of the area (6 percent of the growing stock) and the remainder is owned by communes, parishes and other interests.

It is reported that the Finnish forest industry today, both in extent and structure, is largely a result of the development that took place in the 1960's, the most intensive period of development in its history. Not only did the productive capacity of the industry increase sharply but also the structure of the industry underwent considerable changes which reflected the development of demand for various forest products in world markets. The volume of wood used by the Finnish forest industries increased by some 50 percent between 1960 and 1975 but, during the same period, the total drain from Finnish forests decreased by almost 10 percent. Between 1960 and 1970, the production of virtually all forest products except lumber rose dramatically in Finland. Closer and improved utilization of the forest resource coupled with other intensive forest management policies have been initiated in the past decade or more and have been largely instrumental in reducing the overall forest depletion.

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The forest industry's share of the gross production of Finnish industry is about 20 percent and the 80,000 or more workers directly employed by the forest industry account for approximately one-fifth of the country's total industrial labour force. Moreover, a similar number of workers are required for logging and hauling of wood to the processing plants.

More than 80 percent of the production of Finland's lumber and woodbased panel industries and nearly 90 percent of the pulp and paper production is marketed abroad. In terms of world exports Finland accounts for about 16 percent of total exports of pulp, paper, paperboard and plywood and 8 percent of sawn timber exports.

In 1975 Finland's total exports had a value of just over $5.5 billion (U.S.) and of this sum exports of forest products accounted for nearly $2.5 billion. 55 percent of the latter went to E.E.C. countries, 7.3 percent to E.F.T.A. members, 24.2 percent to the U.S.S.R. and other European countries, and the balance to Asia, Africa, Latin America, North America and Oceania.

Refer to Table 1 for a comparison of Finland's forest industry statistics with those of Canada.

2. Sweden

The total land area of Sweden is 450,000 km^2 of which 51 percent or 230,000 km^2 is forest land having a

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growing stock estimated at 2,290 million cubic meters (stem volume from the stump to the top, including bark). Of the growing stock about 47 percent is spruce (Picia Abies), 37 percent Scots pine (Pinus silvestris), 10 percent birch (Betula verrucosa and B. pubescens) and the balance in other hardwoods.

Approximately 50 percent of Sweden's 23 million hectares of forest land belongs to private owners, mostly farmers; 25 percent is owned by the Crown and church, and the remaining 25 percent by companies. Some 69 percent of the private forests consist of woodlots smaller than 100 hectares whereas 85 percent of the company forests belong to companies with holdings larger than 100,000 hectares.

It is reported that Sweden is currently in rather serious difficulty with respect to the age class distribution of its forests and the consequent allowable annual cut levels that could be applied for the next twenty years or more to bring the growing stock into a more normal condition. The findings of a Swedish Forestry Commission appointed in 1973 to examine the country's future timber requirements and resources indicated that the forest industry's raw material requirements have now reached such a level that the timber supply is a definitely limiting factor. Based upon 1973 figures, the Commission reported

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the Swedish forest industry's timber consumption was already at a point where, if continued at the 1973 level, after 1980 there would be an annual raw material deficit of some 15-20 million cubic meters.

Reports suggest that the present unfavourable age class distribution in Sweden's forests is the result of different silvicultural methods applied during various periods in the past. While today's silvicultural method is principally that of clear cutting of mature timber followed by planting of fast-growing seedlings, this was not the case earlier in the century when it was believed that cost-free reforestation could be accomplished by making small group fellings and relying on the surrounding trees to reforest the cut-over areas. It was ultimately discovered that this method was seldom successful and planting which should have been carried out in the 1920's and 1930's was not undertaken. As a consequence many of these areas will not be capable of supplying mature stands of timber ready for felling until well into the next century. Recognizing the problem facing them, Swedish forest authorities have embarked on a program of intensive forest management in order to force the development of young and middle-aged stands and eventually balance out the age class distribution of their forests which currently is heavy to mature timber. A program of better utilization of the existing merchantable timber has also been initiated which includes utilizing stumps

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and tops for pulp and panel products production.

In 1973 Sweden's forest industry accounted for 4 percent of the country's gross national product and nearly one-quarter of the value of total exports. Approximately 150,000 workers are directly employed by the forest industry. The total production of Swedish forest products in 1973 was comprised of 13.4 million cubic meters of sawn and planed timber,1.2 million metric tons of pulp and 5.2 million metric tons of paper and paperboard. Sweden is a major world exporter of forest products accounting for 26 percent of the world's pulp exports, 15 percent of coniferous sawn wood sales and 14 percent of paper exports.

Of the 13.4 million cubic meters of lumber produced in 1973, 9.4 million was exported. The principal markets were the United Kingdom (34 percent), West Germany and the Netherlands (14 percent), Denmark (13 percent), the rest of Europe (23 percent), and non-European countries (2 percent).

Refer to Table 1 for a comparison of Sweden's forest industry statistics with those of Canada.

The mission identified that Sweden has an interesting government scheme for companies to build up a reserve for future investment requirements. It is believed that the abundance of new, expensive conversion plant buildings and new sophisticated handling, sorting and production equipment in the Swedish wood industry is in large measure due to this program.

An article in "Some Data about Sweden 1975-76" published by the Skandinaviska Enskeidla Banken of Stockholm described this scheme as follows:

Reserves for future investment

Corporations reporting income from business may set aside up to 40 percent of pre-tax income as a reserve for future investment. The amount allocated is deductible from income for purposes of both national and local income tax. 46 percent of the allocation must be deposited in the Riksbank; the balance remains in the corporation's hands as part of its working capital. Whether an allocation to reserve shall be made, and the amount of the allocation (up to the 40 percent annual ceiling) is entirely at the discretion of the corporation.

Control over the use of the reserve is in the hands of the government, however. The government may authorize a corporation to use all or part of its reserve for a purpose allowed by law, such as construction of buildings, acquisition of new machinery and equipment, production of inventory, development of mines, or promotion of Swedish goods abroad.

When an investment reserve is used for one of these purposes with government permission, the amount

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so used is not restored to taxable income. But to the extent an asset or expense is charged to an investment reserve, it is not also subject to depreciation or deduction. A corporation using its reserve with government approval gets an additional special "investment deduction" equal to 10 percent of the amount so used. On the other hand, if a reserve is used without such approval, the amount involved plus a penalty equal to 10 percent of that amount, must be added to taxable income.

After five years from the time an amount is allocated to a reserve, 30 percent of that amount may be used without government permission for one of the purposes authorized by law. In that case, however, the corporation does not enjoy the extra ten percent "investment deduction".

For an expanding corporation able to make use of the rules governing inventory valuation, depreciation and reserves for futures investment, the effective rate of Sweden's national and local income taxes will often be less than the nominal rate of about 55 percent.

3. Norway

Of Norway's 8.33 million hectares of forest land, 6.45 million hectares are classified as productive containing about 480 million cubic meters of standing timber with an annual increment of 13 million cubic meters. Norway spruce (Picea abies) accounts for 250 million cubic meters of

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of the total standing timber, Scots pine (Pinus silvestris) for 150 million, and hardwood species, mainly birch, for 80 million cubic meters. With regard to the annual forest increment of some 13 million cubic meters, about 7.5 million is in spruce, 3.4 million in pine and 2.1 million in hardwoods. The target of Norway's current forest policy in terms of annual cut is to have it increase from the present level of 8 million cubic meters to 10 or 11 million by 1990. This objective is dependent upon reasonable market conditions prevailing throughout this period and timber prices following the general price trends. In order to help attain this goal the government has suggested a number of measures, including increased grants for forest road construction, grants for logging in difficult terrain in remote areas and for the transport of logs from such areas. It also proposes to increase the grants for silviculture so that they apply to all forest owners and to extend them to include the tending of the forest up to the time of the first thinning. The main principle of the Forest Act of 1965 is freedom for the owner to manage the forest without intervention from the authorities, provided his forest is managed in accordance with the principles of good silviculture. In order to ensure sufficient investment in reforestation,

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road-building, machinery, etc., a levy is made of usually 10 percent on the gross value of annual timber sales. This levy remains the property of the forest owner but is frozen in a bank account until he can prove the necessity for investments. As much as two-thirds of the investments in the forests are financed through this method.

Over 80 percent of Norway's forest land is owned by farmers and other individuals and 17 percent is public. The average size of the private forest holding is between 30 and 40 hectares.

For many years the annual cut of 7 to 8 million cubic meters has not met the industry's requirement of 10 to 11 million cubic meters and the short-fall has been imported, mainly from Sweden. About 50 percent of the annual cut is delivered as sawlogs and 45 percent as pulpwood.

The export value of forestry and forest industry products in 1974 was reported to be 2,890 million Norwegian kroner or about 13 percent of the country's total exports. The contribution from forestry and the forest industries to the Gross National Product in that year was approximately 8 percent and employment in these sectors amounted to 53,000 man years.

Refer to Table 1 for a comparison of Norway's forest industry statistics with those of Canada.

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Table 1

Comparison of Nordic and Canadian Forest Resources
and Industry Statistics (Quantities in,000m^3)

	Annual Forest Increment or Allowable Annual Cut	Total Annual Depletion	Industrial Roundwood Removals	Sawn Goods Production	Sawn Goods Exports
Finland	60,000				
1960		60,330	36,930	7,740	5,335
1965		55,950	36,810	6,920	4,125
1970		58,740	42,490	7,310	4,700
1973		-	-	8,140	5,255
1974		52,550	38,630	7,800	4,323
1975		40,660	28,210	5,020	2,855
1976 (E)		-	-	5,400	3,500
Sweden	70,000 - 77,000				
1971			70,000	12,450	7,455
1973			77,000	13,440	9,375
1974			75,000	14,300	7,420
1975 (E)			-	11,000	-
Norway	13,000				
1960			-	1,570	130
1970			-	2,000	100
1974			8,000	2,350	440
Canada	243,000				
Annual Average 1963-72		122,770	112,200		
1971			119,720	30,240	20,155
1973			143,800	36,275	23,560
1974			137,950	31,985	19,575
1975			113,300	26,930	15,470

Notes: 1. The figures indicated in the first three columns for Finland and Sweden include bark whereas those for Norway and Canada exclude bark.

2. (E) indicates estimated.

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D. Summary

The study tour was undertaken to explore the technical and commercial viability of installing in Canadian operations the structural lumber finger-jointing equipment and systems currently employed in Finland, Sweden and Norway. Visits were made to several finger-jointing operations in each country, meetings were held with officials of the respective national wood research institutes and industry associations, and calls were made on finger-jointing machinery manufacturers.

There are about 92 producers of finger-jointed lumber in the three countries of the study, all operating under official control. While the volume produced and the number of installations have increased steadily since the beginning of finger-jointing in Scandinavia around the middle of the 1960's, current production accounts for only two percent of the total volume of lumber produced. A high percentage of the production of finger-jointed lumber is consumed domestically.

The two softwood species of the three countries are Norway spruce (Picea abies) and Scots pine (Pinus sylvestris) with the predominant species being pine in Finland and spruce in Sweden and Norway. Both species are being finger-jointed in the countries visited but in each case the species are kept separate. This was different to the procedure observed at the St. Regis

Company finger-jointing operation at Libby, Montana where Douglas fir and larch were separated for end-jointing purposes but it appeared that no attempt was made to separate the wide variety of other species used, including several pines, true firs, Engelmann spruce and hemlock.

The main reasons for finger-jointing in Scandinavia are to supply the growing requirement for long length lumber from the relatively short logs that are available and to provide specific lengths called for by the consumer. The practice of finger-jointing is widespread and technically successful although productivity is low and costs are very high. The estimated average cost of around 70 dollars per thousand board feet seems to be readily recoverable from the buyer or, as is the case with many producers, the cost is simply considered a corporate expense in providing suitable raw material to their secondary manufacturing facilities producing such products as laminated beams, joinery, roof trusses, pallets and even factory-built housing. The trend of Scandinavian lumber producers toward establishing secondary manufacturing plants adjacent to their sawmill operations is growing rapidly. Because of the fact that most Scandinavian lumber is utilized or exported in the rough dry state, no finger-jointing of surfaced lumber was observed throughout the tour. Here again this was

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different to the St. Regis operation where the raw material for their finger-jointing plant consisted of seven foot and shorter surfaced and kiln dried trim lengths from the normal production of their stud mill.

In view of the high cost and low productivity of finger-jointing equipment and systems in Scandinavia coupled with the fact that longer length structural lumber is still reasonably available in Canada at premiums well below the indicated cost of finger-jointing and also that the Scandinavian technology does not appear to lend itself to the use of short lengths of surfaced lumber, the mission concluded that the feasibility of installing such equipment in Canada is doubtful at the present.

However, the short visit to the St. Regis Company finger-jointing plant at Libby, Montana by three mission members and the writer at the end of January, 1977 indicated that the equipment and technology for the manufacture of good quality finger-jointed structural lumber at a high level of productivity using surfaced short length lumber is available in the United States.

It was the consensus of the mission that considerably more study and evaluation is required before more definitive conclusions can be reached

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with respect to the feasibility of Canadian lumber producers manufacturing finger-jointed structural lumber. Answers are required to such questions as market acceptance, product standards and building codes, overall economic viability, and to conflicting opinions on glue types and glue curing considerations including maximum allowable moisture content, heat requirement and long-term joint stability.

Part II

A. Development of Finger-jointing in Nordic Countries

1. History

The practice of finger-jointing lumber was apparently first developed in Germany during the Second World War. Dr. Egner is generally recognized as the originator and most of the background research was done under his direction at Stuttgart.[2] The German standard, DIN 68140 published in 1960 and amended in October, 1971 is the basis for the standards generally adopted in most European countries.

Norway was one of the first Nordic countries to allow use of finger-jointing in structural lumber. After the first tests by the Norwegian Technical Institute proved successful, the government agreed to permit finger-jointing subject to organized control. Under this control program, finger-jointing of structural lumber started in 1966.

In Finland, there were only 5 producers of finger-jointed lumber in 1970 with a production of 19 million board feet. In the following six years the number of producers increased seven fold but finger-jointed lumber production only doubled in that period. The 1975 production of 35 million board feet represents only 1.6 percent of Finland's

(2) Otto-Graff Institut, Technische Hockschule, Stuttgart, Germany.

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total lumber production. Currently, about one-half of Finland's finger-jointed lumber is used internally by the producing sawmills in such products of secondary manufacturing as laminated beams and joinery products. Only about 5 percent of the country's finger-jointed production is exported as structural lumber and the remaining 45 percent is sold in the home market mostly for such purposes as industrialized housing components, roof truss members, pallets, doors, window frames and wall cladding.

The pattern of growth and current production for finger jointed lumber producers in Sweden is similar to Finland. Currently in Sweden, there are 37 producers and their finger jointed lumber production is about 2 percent of the total Swedish lumber production.

Finger-jointing started in Scandinavia mainly to provide long lumber components for the laminated beam industry. After successful laboratory testing of the jointed lumber and control of producers was established, production of finger-jointed lumber for structural purposes was started. However, the main use is still laminated beams and production for structural purposes is still less than 1 percent of total lumber production.

2. Reasons for Finger-jointing

The reasons for finger-jointing at sawmills in the Scandinavian countries are quite different from the reasons for interest in the process in Canada. To understand these differing reasons, it is necessary to discuss major background differences in wood supply characteristics, market requirements and sawmill design.

(a) <u>Differences in Wood Supply</u>

In Scandinavian countries, sawlogs appear to be of much higher quality than the average in Canada except for Coastal British Columbia. While this may be partly due to the fact that Canada's logging is mostly in natural stands while Scandinavian logging is principally in cultivated stands, high sawlog quality in Scandinavian countries is mainly attributable to the fact that the pulp industry acquires more than half of the round wood produced. As a consequence, the remaining sawlogs are the best quality and larger size logs and the lumber produced, therefore, contains a much smaller percentage of lower grades than is the case in typical Canadian sawmills. Thus, finger-jointing in Scandinavia is based more upon producing long lengths or the required volume of specified lengths rather than upon eliminating defects and upgrading, as would be the case in Canada.

67 percent of the forest in Finland, 80 percent in Norway, and 50 percent in Sweden is owned privately by independent owners who mostly bargain through co-operatives with the wood using industries. As a result of this ownership pattern, costs of sawlogs are nearly twice the

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average cost in Canada. Prices for delivered roundwood are currently 150 to 165 marks per cubic metre (or approximately $112 to $123 per cunit) in Finland. In Sweden, prices average approximately 20 percent higher than Finland with Norway's wood costs lower. Wood costs are now so high in Sweden that logs are being imported from as far distant as Maine,U.S.A. In Sweden, the problem of sawlog supply has been aggravated by an increasing pulp production from 4 million tons in 1955 to 8 million tons in 1975 and adding to the pressure of the saw timber shortage, is a drop in 1975 of 30 percent in the nation's allowable cut arising from a past over-estimation. These extremely high wood costs in Scandinavia create an urgent need for the conversion plants to maximize utilization and increase product recovery. As a result, finger-jointing and many forms of secondary manufacturing are introduced at the sawmills, developments which are not yet generally feasible in Canada.

The tradition in Scandinavia is to buck logs in the forest in fairly short lengths based upon log quality or grade. The lower grade logs are then delivered to pulp mills. Logs delivered to Scandinavian sawmills average 14 feet in length and only a small percentage goes up to 20 feet. In Sweden, for example, only one percent of the country's total log production is delivered

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in long log lengths compared with the relatively high percentage in many parts of Canada. It is difficult to understand why this practice is retained but some of the answers no doubt relate to transportation limitations had space restrictions in the old mills. It appears, however, that tradition is probably the overriding factor.

Based upon information obtained during the mission's visits in the three countries of the study, average delivered sawlog costs to the sawmills in terms of U.S. dollars per thousand board feet of lumber output would seem to be approximately $243 in Finland, over $300 in Sweden, and $173 in Norway. However, in view of the relatively few sawmills visited in each country and the many local variables to be considered, these costs should be taken only as a general indication of existing levels. These costs are considerably higher than those in Canada and in endeavouring to ascertain the reason for these high rates the mission was informed that the portion going to the private forest owner represents some 65 percent or more of the total cost. With 50-75 percent of the countries' forests in the hands of private owners who negotiate timber prices through their powerful co-operatives or associations, it became obvious that the present form of land tenure and the consequent price combine by farmer land owners were major contributors to the high log costs for sawmilling companies.

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(b) Differences in Market Requirements

In Scandinavian countries, grading and inspection of grades is not controlled as in North America by sawmill associations and grading agencies. Selling is done mostly by mill mark and there are differences in grades produced by each mill. Unlike the custom in Canada, where lumber conforming to a nationally approved grade is a commodity shipped to a variety of customers, Scandinavian mills have traditionally sold by mill mark to the same customers who understand the quality and grade shipped by the supplying mill. A high percentage of this lumber is sold in rough dry form ready for re-manufacturing by the customer into joinery and other finished or semi-finished items.

While Canadian mills often specialize in the products they make and confine the number of products (length, width, thickness, grades) from a handful in a studmill to perhaps 150 items in a more diversified operation, the average Scandinavian sawmill may produce as many as 1,000 items or more. Where the average Canadian sawmill sells in a volume market and the bulk of its products are supplied as a basic commodity in no less than rail car load lots, the average sawmill in Scandinavia is more orientated to custom sawing and processing, servicing in smaller order lots and less standardized items the whole European continent and the United Kingdom with its many tastes, building styles, codes and regulations.

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Sawmill companies who are large enough to be exporters usually have exclusive agreements with agents in each of the major importing countries. The agent negotiates sales in accordance with seller's instructions. Because the producing sawmill has little contact with the ultimate buyer, it has little knowledge about the end-uses of its products. Recently, however, larger Nordic sawmilling companies have set up their own sales companies in the principal European market areas, especially in Great Britain.

The tradition in Scandinavian countries is to sell packaged lumber sorted by grade, width and thickness but unsorted by length. Only recently sorting by length has started in a few mills with a trend developing for more deliveries of length-packaged lumber. Of course, in North America most lumber is sold in packages sorted to length in multiples of 2 feet or precision end trimmed to specific lengths. If it is sold in random lengths at lower prices, there is generally a clear understanding by both buyer and seller of what lengths are included based often on a minimum number of the preferred lengths and a maximum percentage of the less popular lengths.

(c) Sawmill Design Differences

Except for studmills, sawlogs in most Canadian mills are bucked in multiples of two feet plus an allowance for shrinkage and sawkerf. While the Canadian sawmills

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usually have a limitation on the maximum lumber length they can produce, most mills have facilities for sorting of lumber to certain specified lengths.

In Scandinavian sawmills, logs are sorted by species, grade and diameter to permit sawmills to operate for longer periods on one diameter size. This enables the predominant frame-saws to be set for maximum recovery during the whole period when the logs of one diameter are processed. There are usually no facilities for sorting to length so that the final product is ready for shipment in packages sorted for grade and all dimensions except length. The only way such a sawmill can accommodate specified length orders is to finger joint.

The Scandinavians have done a remarkable job in developing finger-jointing,and they have been successful in making end glued lumber a fully accepted product. By establishing standards and sound quality control methods, they have erased any stigma toward end jointed wood products. As a result, there are no price penalties for finger-jointing, nor are there premiums for finger-jointing, but there are premiums paid for supplying specified lengths. As a general rule, the cost of finger-jointing equals the premiums for specified lengths, and the basic justification for finger-jointing is the ability to stay and compete in a market that demands certain lengths which they could not otherwise supply,

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given the log length furnish mentioned earlier in this report.

B. Lumber to be Finger-jointed

1. Species

Both pine and spruce lumber are being finger-jointed in the three countries of the study with spruce being predominant, probably because of its greater availability and lower cost. In each country, however, the two species are manufactured separately.

2. Sizes

The main Scandinavian construction lumber sizes are standardized by international agreement with transverse dimensions in millimetres, lengths in metres and volumes in cubic metres. Standard sizes are as follows:

Thickness Widths

Thickness		Widths
mm		mm
19	x	75, 100, 125 and 150
22	x	100, 125, 150, 175, 200, 225
25	x	100, 125, 150, 175, 200, 225
32	x	100, 115, 125, 150, 175, 200, 225, 250, 275
38	x	100, 115, 125, 150, 175, 200, 225, 250, 275
44	x	100, 115, 125, 150, 175
50	x	100, 115, 125, 150, 175, 200, 225, 250, 275
63	x	100, 115, 125, 150, 175, 200, 225, 250, 275
75	x	100, 115, 125, 150, 175, 200, 225, 250, 275

The three major lumber sizes are:	50 mm x 100 mm (approx. 2" x 4")
	25 mm x 100 mm (approx. 1" x 4")
	25 mm x 125 mm (approx. 1" x 5")
Secondary common sizes are:	50 mm x 200 mm (approx. 2" x 8")
and:	50 mm x 75 mm (approx. 2" x 3")

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A study undertaken in Sweden in 1975-76 indicated over 45 percent of the lumber consumed annually by the Swedish building industry was in 25 mm x 100 mm and 50 mm x 100 mm sizes combined. Finger-jointing machines in the plants visited permitted jointing of stock to maximum of 4 inch thickness and 10 inch width. Minimum length capacity was 1 metre to 1.3 metres.

The common sizes being finger-jointed are 2" x 6" and 2" x 7". The minimum size finger-joint limitation is not due to physical machine capacity but economic considerations. Generally, the minimum size being jointed was 2" x 4" and it was said that the minimum economic length was approximately 8 feet. Figures provided by the Swedish Wood Research Institute show an average of 3 metre (9.8 feet) lengths being finger-jointed to provide an average of 6 metres (19.7 feet) length lumber. One Finnish sawmill operator told us that 40 percent of his mill's production now has to be sorted to length. He said there are wide differences in length requirements with Holland requiring lumber sorted to length and Denmark not wanting length-sorted lumber.

3. <u>Grades</u>

There is no common grading rule used as a standard for lumber in all the Scnadinavian countries. The only common grading rule is one for laminated wood.

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Grading lumber by appearance is generally adopted by sawmills in Sweden and Finland where the standards define permissible faults by grades. The three principal quality groups are "Unsorted" (Grades I-IV combined), "Fifths" and "Sixths" and these grades are recognized for both export and domestic sales. The standard was first published in Sweden in 1958 with a revised manual issued in May, 1976. It was developed by a Swedish Timber Grading Committee in close collaboration with a corresponding Finnish Committee. Typically, the lumber output by grades in Scandinavian sawmills is: "Unsorted" - 35%; "Fifths" - 50%; "Sixths" - 15%.

In all Scandinavian countries, each sawmill has the right to adapt lumber grading standards to suit its own conditions. Some of the large exporters in Sweden have started to use their own grading standards, particularly for Redwood and for adaptation to the specialized needs of the joinery and timber construction industries. However, the producer's own brand name takes precedence over grade in the European market place.

Scandinavian interest in stress grading received a boost from a British Government ruling that all lumber used in buildings should be stress-graded into classes specified in the B.S. Code of Practice 112. Special rules were drawn up in 1973 for both mechanical and visual stress grading in Britain (B.S. 4978:1973).

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Controversy exists regarding the merits of machine versus visual stress grading. Machine stress grading is now in use by lumber importers and other consumers in the United Kingdom to up-grade their imports. In Sweden, however, where the idea of machine stress grading seemed most popular among the countries visited there are 20 machines in use but these are utilized principally for grading lumber for such domestic uses as components for laminated beams and roof trusses.

Our impression was generally, and particularly in Norway, that visual stress grading is preferable to machine stress grading. The machines were only introduced in the late 1960's. They are expensive, their durability is in some question, and laboratory results in Finland show that there is only a 2 percent difference between machine and visual stress grading results.

Machine stress grading was being used to select lumber prior to finger-jointing for use in laminated beam plants. The justification for machine stress grading in these applications was a higher production of suitable material than was obtained with visual stress grading. However, it was observed to be a costly process with five people employed at the machine. Furthermore, there is still a necessity to grade visually for the various appearance defects that normally occur in producing lumber but are passed by the stress grading machine.

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It was observed that lumber used for finger-jointed load bearing application is either of "Unsorted" quality or is sorted by stress grade using either visual or machine methods.

In general, there are no specific standards for grades of lumber to be finger-jointed but rather a requirement for approval of the jointed structural lumber based on testing control. In Finland, the Association of Building Engineers has a Code of Building Practice which regulates use of finger-jointed construction lumber in domestic building. It allows use of finger-jointed lumber in compressive members but for members in tension it requires control by the Finger Joint Steering Committee for Stress Grades T20 and T30. It does not allow use of finger-jointed Stress Grade T40 unless by special permission of the Steering Committee.

Most of the mills visited had licences for jointing to a T20 Stress Grade. Stress Grade T30 production is rare in Scandinavia and there is little demand for it. Generally, architects specify heavier T20 members rather than the more costly T30 grade. However, it is anticipated that wider use of machine stress grading would increase the use of T30 grades.

Instructions on finger-jointing require that there be no defect in the area of the joint. For example, the rules in Finland and Norway require that the distance of any knot

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from the joint must be three times the smallest diameter of the knot. Also, there must be no wane, fibre derangements, sloping grain or other defects in the vicinity of the joint.

4. Moisture Content and Operating Temperatures

While the information received from the respective authorities concerning the moisture content requirements of lumber to be finger-jointed was more or less consistent, considerable variations as to the degree of tolerances was noted between producers. Since all operations we visited turn out acceptable products and, as a rule, exceed the test requirements, it is evident that finger-jointing is rather tolerant with regard to the level of moisture in lumber, provided each producer conducts the finger-jointing operation in a consistent and controlled manner.

In 1966, Norway applied the same maximum moisture content of 15% to finger-jointing as existed for components used in laminated beams. Industry found this to be too expensive, however, and after extensive testing, the maximum allowable moisture content was raised to 23%, with a proviso that the difference between two pieces to be jointed be no more than 5%. Operations visited in Norway operated well within these ranges and reported no problems. Most Norwegian operations pre-heat the lumber with high frequency equipment.

The State Research Institute of Finland recommends a maximum moisture content of 15% and the difference in moisture content between two pieces to be jointed not to

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exceed 7%. In visiting operations however, it was found there were a range of self-imposed standards ranging from 16% to 23%.

The Swedish industry operates pretty well within the ranges practised in Norway and Finland and the majority of systems we saw included high frequency pre-heating.

In the operations visited, and in meetings with scientists and technologists at the research institutes, very great importance was placed on the consistency of drying lumber to be finger-jointed. We heard several comments, such as "good kilns and careful drying are the key to a successful finger-jointing operation". Indeed, the Scandinavians take pains - as they do in all process stages - to dry slowly and evenly. Continuous low temperature kilns are common. Lumber is dried in the wet and dry cycle at temperatures of 35 - 40^{o}C (95 - 105^{o}F) with the objective to dry 66% of a kiln lot to 18% MC (+/- 2%). They claim to obtain very little lumber over 20% on such a cycle. Under these conditions, five to six days are required for 2" thick lumber, and six to seven days for 3".

The importance of evenly dried lumber in the finger-jointing process relates to the consistency of shrinkage and the absorption of glue. A drier end would tend to absorb more glue thus preventing proper bonding. The same applies if one end contains excessive pitch. In

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Finland it was reported that Lapland pine, which has a large area of heartwood and a small ring of sapwood, is not well suited for end glueing.

This is a subject many Canadian producers of Spruce-Pine-Fir lumber would have to investigate if they considered finger-jointing. The different density of these species may require separation for the purpose of drying and end-jointing.

Apart from the kiln drying, the Scandinavians employ a number of methods to properly condition lumber prior to finger-jointing. For example, storing lumber 12-36 hours in the heated (15-22^{o}C) finger-jointing plants was a common but costly practice.

More and more operations now employ high frequency (or radio frequency) equipment which heats in a continuous flow a minimum of 3" at the end of each piece of lumber to 80^{o}C, and in many cases to 100^{o}. This is sufficient, even in winter temperatures, to equalize the temperature in the ends to be joined, and the stored heat is considered sufficient for the glue curing process, even if the lumber is taken outside within 8 minutes of the glue application and pressing. The time span of 8 minutes is also sufficient to allow further processing, such as planing of the finger-jointed lumber.

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C. The Finger-jointing Process

The finger-jointing process incorporates seven or eight identifiable steps. In order of material flow through the plant these are:

1. Infeed
2. Defect trimming and squaring ends
3. Pre-heating
4. Cutting of finger profiles
5. Glue application
6. Pressing and curing
7. Cutting to length
8. Outfeed

A variety of equipment and systems including manhandling are utilized in the infeed stage which in each case brings the stock to be jointed to the first trim saw table where the lumber is inspected by the trimmerman. Any defects within four inches of the end of any piece are removed by trimming and the ends of each piece are trimmed absolutely square to ensure exact finger profiles and a good, tightfitting joint.

Preheating of the ends of the lumber to be finger-jointed did not seem to be considered an essential part of the finger-jointing process in Scandinavia. While it was fairly prevalent in Sweden and Norway, it was not so common

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in Finland where the usual practice was to place the stock to be joined in a warm building for some 24 hours before use and to keep it there for 12 to 18 hours after jointing.

Where preheating is done, about three inches of the end of each piece is passed through high frequency units for approximately 30 seconds. This brings the temperature of the ends up to 80° C or higher and greatly accelerates the curing of the glue when it is applied to the fingers and the profiled ends are pressed together. With preheating, the glue was said to be reasonable cured in 4 minutes and further processing such as planing, was possible after 8 minutes. This can be compared with one plant that did not employ preheating but did have a large storage area kept at a temperature of approximately 15°C or higher. Here the initial curing time was considered to be 5 hours and 12 hours was allowed before subjecting the jointed lumber to a stress test. This plant produces structural lumber and accounts for about one-half of Finland's exports of finger-jointed structural lumber.

The varying practices between plants with regard to preheating and curing seemed to result from the different conditions prevailing at each operation. Preheating is necessary, for example, in those plants which

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either finger-joint frozen wood or have the building in which the curing takes place subject to very low temperatures. Preheating is also usually performed when further processing follows closely behind the jointing process. Despite the wide variations in preheating and curing procedures between plants, however, the tests for quality of the joints apparently showed very good results.

The cutting, or profiling, of the ends of the lumber to make the fingers is done by circular cutting heads which operate at high speed. In some machines the cutter head will profile the two ends being joined in one pass. In others, two cutting heads are used, each one profiling only one end of the piece. Still other machines have a cutting head that will profile up to 10 ends in one pass.

The profile of the finger may be visible either in the wide face (Illustration 1), or narrow edge of the board (Illustration 2) where the fingers are machined parallel to two opposite lumber faces, as was generally the case in Scandinavia. Joints with diagonally cut fingers (Illustration 3) have been experimentally made but are not common at the present time.

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ILLUSTRATION 1

ILLUSTRATION 2

ILLUSTRATION 3

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Research and laboratory personnel in Helsinki and Oslo, who perform large numbers of destructive stress tests, attach no particular importance to the direction of fingers based on their test experience, but they point to the importance of sharp cutting tools, well maintained clamping devices, and good alignment.

Two factors were mentioned which, theoretically, would favour the pattern in Illustration 1. If an error is made, of if, for example, one tooth is poor, it will affect a smaller contact area than in Illustration 2. The outer fingers are, as a rule, not as strong as those in the centre of the end surface. Consequently, the configuration in Illustration 1 minimizes the percentage of outer joins relative to the total surface area.

There are certain ratios to be observed which concern the length, shape, tip width and pitch of teeth, and there are guides as to the minimum glue line relative to the cross-section of the lumber. Ratios of 1:10, and 1:7.5 of cross-section to area of glue line are common.

The finger length, for instance, relates to the end pressure required in the glue press. Shorter fingers require more thrust. Two individuals claimed that an increase in the finger length will increase the allowable differential in moisture content between pieces to be bonded.

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Slope of the finger and tip width affect the tensile strength of the joint, but the best conditions for strength pose practical problems in the machining and end press process.

Ideally, fingers should be machined immediately prior to the glue application. The maximum time lapse allowed between cutting and glueing is 24 hours under good storage conditions to avoid dust, dirt and distortion of the fingers, which would affect the fit of the joint and the quality of bonding.

While the British code requires a minimum distance of 1 metre (3.3 feet) between finger joints, the Scandinavian countries have no such code. However, they consider 3 joints in 16 feet is likely a practical and economic limit and suggest that this will become an international standard in the future.

There are three widely recognized glues used for finger-jointing in Scandinavia - urea formaldehyde, phenol resorcinol and polyvinyl acetate. Urea formaldehyde is generally suitable for interior conditions and some external joinery, such as window frames protected by paint. The polyvinyl acetate glues are only acceptable for non-structural applications and joinery where the end products are not exposed to moisture. Phenol resorcinol adhesives are suitable for both interior and exterior conditions. It

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was by far the most common glue observed during the study tour and was used almost exclusively where finger-jointed structural lumber was being manufactured.

Glues are usually prepared in a separate, cool room adjoining the finger-jointing operation. It was noted that the glue containers at the jointing machines were sometimes also cooled in order to prevent the glue viscosity from getting too high.

Three methods of <u>applying glue</u> to the fingers were observed - by hand, by mechanical rollers and by spraying. The first method, usually a simple brush, is wasteful and messy and was usually employed only when the mechanical glue application system was being cleaned or when a breakdown had occured. The mechanical rollers, shaped to the same configuration as the fingers, applies glue to the fingers of one or both of the pieces to be joined. It was generally accepted, however, that the relatively new system of spraying the glue onto the fingers was more effective and efficient than the other methods. In one typical plant using phenol resorcinol glue and mechanical rollers, glue consumption averaged on liter per cubic metre of finger-jointed lumber. This is approximately equivalent to one-half of one Imperial gallon per thousand board feet.

The finger-joint is completed when the two profiled, glue-covered ends are pressed together and the

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glue is cured. The amount of end thrust in the pressing stage depends on such factors as finger length and shape, clamping pressure, and the degree of accelerated curing of glue induced by heating. It was reported that in Scandinavian practice, end thrust pressure of around 450 pounds per square inch is usual.

With regard to the curing of the glue without preheating, lumber to be finger-jointed should be at a temperature of at least 18°C (64°F) when the glue is applied and should remain at that temperature until the glue is cured which, according to some Nordic operators, requires approximately 30 hours. If the jointed lumber can be exposed to 30°C (86°F) for 12 hours, however, the mission was advised that this should be sufficient to cure the adhesive.

The more common practice today is high frequency heating of the lumber ends to approximately 90°C (194°F) prior to glue application, with the effect that the stored heat will allow the glue to set. The curing takes place in 5 to 8 minutes. In installations where a planer follows the glue press, a time lag of 8 minutes is usally built in.

One of the experts at the Norsk Treteknisk Institutt, Oslo, gave this account of the development of glue curing methods. The expert explained that phenol resorcinol, being a two part adhesive, requires heat for the chemical process of glue-setting in order to become

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fully water resistant.

1st method

Heat plates were used at the joints, but they only warmed the lumber surface and set the glue at the surface.

2nd method

High frequency heating was used at the joints, which produced the required heat penetration and glue curing, but took up too much time and made the production flow too slow and costly.

3rd method

High frequency preheating was introduced, which is the most common method today and is described elsewhere in this report. Preheating serves two purposes: it equalizes the temperature in the lumber ends to be jointed and stores up heat at the joint for quick drying of the adhesive.

4th method

High frequency treatment is applied after the glue application.

The fourth method has only been used on a limited scale so far, but is considered to be the most advanced. Tests have shown that once water has evaporated and the glue is dry, it will provide strength but will not be as water resistant as glue cured under intense heat.

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Glue not exposed to high temperatures will "float" again when heat is applied a few days later, but since there are limits to this, the safe way is to apply heat (80^{o} - 100^{o} C) immediately after the glue application and end pressing.

Following the pressing and initial curing stages, the jointed lumber is trimmed to the desired length by a stationary or travelling cut-off saw. The cut-to-length, finger-jointed lumber is then stacked and packaged by manual or automatic means and piled ready for shipment.

D. Finger-jointing Equipment

1. Models

In Finland and Sweden alone there are over 80 controlled finger-jointing operations using equipment of about seven different manufacturers. The most common makes observed during the mission were the Swedish Sunfab (6), the West German Dimter (4), and the British Cook Bolinders (3). Other machines seen on the study tour were the Sauter and the Hombok, both made in West Germany.

The finger-jointing facilities which were observed on the study tour ranged in age from the late 1960's to 1976 and covered a wide range of makes and models. Where the mission had the opportunity to see the earlier and the latest models made by a particular manufacturer, it was evident that significant improvements had been made,

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especially with regard to compactness, speed and glue application.

Sunfabs manufactured by Sundinos Fabriker AB, have been available for many years and have brought out different models as time progressed. One of their newer systems was seen at AB Geiger & Soner in Langasjo, Sweden. This firm brought a package system from Sunfab which is comprised of a tilt hoist infeed, two preheaters, a profiler, separate roller-type glue applicators, a separate press, a trim saw, automatic overhead kickers and an elevator type stacker. This system required only two operators.

The British firm, Cook Bolinders Ltd., has just placed on the market a new finger-jointer (model FJ-AM) which, in one machine, does the joint cutting, gluing and assembly processes formerly carried out by three machines. The manufacturer claims that the new machine will produce 7½ joints per minute which is equivalent to an average throughput of 30 metres or 100 feet per minute. It was reported there were 45 of their earlier machines presently in use.

Two of the Dimter machines seen during the mission were similar in concept to the Sunfab, where the three main functions are separate and the pieces proceed one at a time through each stage. One installation, at Vierumaen Teollisuus Oy in Vierumaki, Finland, was

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different in conept. After defect trimming and squaring the ends, the pieces were tilted on edge and arranged five abreast. This batch was moved forward and then was backed into a cutter head that profiled five pieces on one end at once. The five pieces then moved forward to a second profiler which cut the other end. The glue was applied at the time the profiles were made. The pieces then were automatically turned on their flat side and moved conventionally through the press.

One of the most innovative finger-jointing plants was that of Moelven Limtre A.S., at Moelv, Norway, where they combined conventional equipment with that of their own design. The infeed is conventional, and once trimmed the pieces are placed on edge and accumulated into a batch of eight or nine pieces. This batch is then moved forward onto a turntable. The turntable is held stationary while the batch moves forward to intercept the profiler. Once one end of the pieces are cut, the turntable moves through 180° and the other ends are profiled. The batch is then released, the pieces fall onto their flat side and are fed into continuous press of their own design which differs radically from any others seen. The pressure is obtained by the difference in the direction and the speeds of the infeed rolls and the outfeed rolls. The force of the infeed rolls is offset by a lesser opposite force exerted by the outfeed rolls. The effect is to obtain the pressure required for a good joint while the pieces continue to move.

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This increases the lineal footage which can be processed in a given time period. The travelling cut-off saw is mounted on anoverhead trolley. It picks up the speed of the piece coming out of the press and cuts to length while moving. This again increases the lineal footage which can be processed.

Installation Requirements

Most of the machinery required for finger-jointing is easily installed on a concrete floor or on pads. The heaviest unit appears to be the Cook Bolinders FJ-AM finger-jointer which weighs around 10 tons. Only electric power supply is required. High frequency pre-heating units are water cooled by closed heat exchange systems. In certain models hydraulics control the clamping devices and move the cutter heads.

Maintenance

It would appear that the existing skills and precision required to operate and maintain a typical Canadian modern high-speed planer complex with a memory-controlled trimmer, would be sufficient to cover the operating and maintenance needs of a finger-jointing system. The Cook Bolinders and Dimter finger-jointers, which perform three functions in one operation, make for more difficult trouble-shooting than the more stretched out Sunfab system.

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E. Economics of Finger-jointing in Scandinavia

1. Capital and Operating Costs of Finger-jointing Plants

With the wide variety of finger-jointing machinery and equipment seen at the different plants during the study tour, the variations in lay-outs, and whether or not a new building was erected to house the system, it was difficult to arrive at a meaningful capital cost for a finger-jointing installation. In discussing this matter with the managing director of Cook Bolinders Ltd. in England, the mission was advised the cost of their new FJ-AM system, including high-frequency pre-heating, ventilation, coolers, testing equipment, infeed and outfeed facilities, but excluding the building, would be approximately $300,000 installed. A Swedish owner of a finger-jointing plant who had purchased a complete Sunfab system within the past two years with equipment comparable to the Cook Bolinders, estimated today's replacement cost at $200,000 or more.

Perhaps the most comprehensive data on capital and operating costs of a new finger-jointing operation is contained in a report published in 1976 by the Finger-jointing Committee of the Swedish Wood Exporters' Association. The following outline presents the pertinent information included in this report. Values are in Swedish crowns.

(a) Buildings & Land

Land, including preparation	100,000
Building	350,000
Electrical installations	50,000
	500,000

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(b) Machines

Finger-jointer complete with HF - heating, cutting equipment, conveyors, stackers, and including installation.	1,075,000
Testing equipment	25,000
Switching station and power mounting	100,000
Sawdust suction device	50,000
Consulting fees, etc.	50,000
	1,300,000

(c) Capital Costs

Depreciation time:

- buildings 15 years
- machines 7 years

Interest - 10%

Annuity factor at 10% interest:

- Building - 15 years @ 0.13147 x 500,000 - 66,000/year
- Machines - 7 years 0.20541 x 1,300,000 - 267,000/year

(d) Manpower and Administration

One feeder and one machine operator
@ 65,000/year = 130,000/year

Foreman and administration
75,000/year

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(e) Other Annual Fixed Operating Costs

Electricity	20,000
Tools, grinding	25,000
Maintenance and Service	20,000
Insurance	10,000
Heating	15,000
Quality control inspection	5,000
Miscellaneous	5,000
	100,000/year

(f) Variable Operating Costs

Cutting & Trimming = 18 crowns per m^3 jointed volume

Glue = 10 crowns per m^3 jointed volume

Handling & Transferring = 6 crowns per m^3 jointed volume

(g) Risk, Profit & Share in Central Administration & Management

15% of 1,800,000 crowns = 270,000 crowns

(h) Total Cost Per Joint

Based on costs in 1-7 above, a 200-day work year, an average length of 4 metres for the lumber prior to jointing, and 1100 joints per day, the total cost of finger-jointing 50 mm x 150 mm (2" x 6") lumber amounts to 5.09 Swedish crowns per joint.

(i) Cost for Finger-jointing Per Cubic Metre

Costs are based on an average length of 4.0 metres for incoming lumber, 6.0 metres for outgoing lumber, a size

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of 50 mm x 150 mm, 1100 joints per day, 3 cross-sectional size changes per day, and 5 length changes a day. Calculated costs for some of the sizes given in the report are outlined below.

Cross Section in mm	Cubic Metres per day	Glue, Cutting & Transferring	Fixed Costs, Risk, Profit	Total Costs per m^3
38 x 100	16.8	39	272	311
x 150	24.6	36	184	220
x 200	32.1	34	142	176
44 x 100	19.1	38	238	276
150	27.9	35	163	198
50 x 100	21.7	37	210	247
150	31.8	34	143	177
200	41.4	33	110	143
75 x 150	46.1	32	99	131
200	60.0	32	76	108

Another estimate of finger-jointing production costs was provided by Technicus Engineering AB, the consulting arm of Saab-tement AB which in turn is a part of Saab Scania of Sweden. This company calculated the cost of finger-jointing to be 1.14 Swedish crowns per joint exclusive of buildings and gave, for example, a jointing cost for 2" x 4" with a Cook Bolinder or equivalent machine as about 93 Swedish crowns per cubic metre or approximately $52 per thousand board feet.

Other companies quoted production costs ranging from 100 Skr per M^3 to over 150 Skr. with the average cost probably running about 125 Skr. per M^3 or $70.20 per thousand board feet based on an estimated actual operating performance of some 3 joints per minute.

2. Selling Price of Finger-jointed Lumber

From what the mission could learn from discussions during the study tour, many Nordic lumber producers who sell their products on the open domestic and export markets, treat finger-jointing as just another production step necessary to provide their customers with the growing requirement of longer length and specified length lumber that is not possible to produce with existing log lengths and sawmill equipment. Moreover, the ability of a mill to offer longer or specified length lumber often leads to the sale of a significant volume of random length lumber.

While the high cost of finger-jointing appears to be readily recoverable from the buyer, it did not seem that the premium obtained of some $57 to $85 per thousand board feet for finger-jointed lumber was much more than the cost of producing it.

It is estimated that over 90 percent of the finger-jointed lumber produced in Finland, Sweden and Norway is consumed within the country of manufacture. It was reported that the small volume of exports was shipped mainly to other Nordic countries and to Britain.

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F. Quality Control, Standards and Building Codes

1. Quality Control

The finger-jointing quality control organizations in the three Nordic countries visited must approve the finger-jointing process, equipment and product of any manufacturer or potential manufacturer of finger-jointed structural lumber before the company can apply the official control stamp to any of its products. These control organizations, or finger-jointing steering committees, are usually comprised of experts in the field from universities, technical research institutes, sawmill industry associations and finger-jointed lumber producers.

The control committee first require that the finger joint profiles comply with the German DIN Norm 68140. However, they will approve variations in the profiles providing that they meet special test requirements.

It would appear that there are two basic methods in Europe for determining joint qualification. The British standard, BS 5291:1976, assesses joint efficiency on the basis of a comparison of the strength of jointed lumber with the strength of unjointed defect-free lumber of the same species or species group. In Scandinavian countries, joint qualification is assessed by means of samples and machines strength testing but instead of rating joint efficiency by comparing jointed lumber with defect-free unjointed lumber, a certain minimum stress-before-failure rating must be achieved

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for each profile, measured in kilopascals per square centimetre. In the case of stress grade classes T20, T30 and T40, the jointed lumber must achieve at least the strength requirements of those classes. The T20 (approximately equivalent to 1200f) stress grade of finger-jointed lumber comprises by far the largest volume in terms of production and use. There is a small requirement for T30 grade, but virtually none for T40. In most cases special permission is necessary to produce and supply the latter two grades of finger-jointed lumber.

When an application for approval to supply finger-jointed lumber is received by the Finger-Jointing Steering Committee of a Nordic country, the Committee inspects the applicant's plant to ensure the equipment, procedures, operating conditions and other relevant factors comply with the necessary control regulations. Should the committee be satisfied with the inspection, samples are taken and thoroughly tested at the research institute laboratory. If these tests are satisfactory, approval is then granted to the applicant to produce and market finger-jointed lumber under the official control stamp.

The control agencies in each Nordic country require that a system of regular quality control be instituted by each producer to ensure that production of satisfactory joints is maintained. A minimum number of samples for testing are drawn from each production shift

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and the test results recorded. These results are forwarded to the research institute on a regular basis where they are evaluated. If the institute identifies any problem in the test results, the manufacturer is advised. If no improvement is evident in subsequent tests, the plant is usually inspected by members of the finger-jointing steering committee to ascertain what the problem is and a warning is given to the producer. Should this action still fail to bring the product up to required standards, the control organization may withdraw the company's right to use the control stamp until the problem has been rectified.

As a regular part of the control system, members of the steering committee make unannounced visits and inspections of each finger-jointing operation twice a year.

2. Building Codes and Product Standards

While each country visited had initially developed their own guides, standards and codes for the domestic use of finger-jointed lumber, based principally on its use in the manufacturing of laminated beams, over the years the close liaison that exists between the research institutes and industries of the countries coupled with mutual trade interests, led to the formation of a Nordic committee for building regulations. Under this committee the standards for finger-jointed lumber to be used for structural purposes

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are quite similar in Finland, Sweden, Norway, Denmark and Iceland and there is little difficulty in shipping this product between these countries.

As indicated earlier, Britain and West Germany have their own standard or norm for structural finger-jointed lumber for use in construction.

Under the auspices of the Economic Commission for Europe Timber Committee, however, a group of experts from Scandinavian, other European countries and Canada has been active over the past year or more in drafting a common European structural lumber finger-jointing standard that would replace those that now prevail in the various countries.

G. Visit to the St. Regis Paper Company Finger-jointing Operation at Libby, Montana.

Following up on reports of a high production structural lumber finger-jointing installation at the Libby, Montana sawmill operation of St. Regis Paper Co., the writer and three mission members visited this plant at the end of January, 1977. The tour of this facility provided an opportunity to compare what had been seen in Scandinavia with the equipment, system and raw material being utilized at a relatively new (December, 1972) plant in the United States.

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The raw material for finger-jointing at Libby consisted of 7-foot and shorter surfaced trim lengths from the normal production of the stud mill. Care is taken to ensure the stock is on-size and does not exceed 19 percent moisture content. A wide variety of coniferous species are utilized. The use of kiln dried short lengths of dimension lumber surfaced to standard ALS sizes as raw material is different to the Nordic operations where in every case rough dry lumber was jointed and in some plants then surfaced or otherwise further manufactured.

Finger-jointing equipment at the St. Regis Paper Co. operation was manufactured by the Industrial Woodworking Machine Co. Inc. of Garland, Texas and by Mann Russell Electronics Inc. of Tacoma, Washington.

After being strength tested the finger-jointed pieces go through a precision trimmer and then to a grader who pulls out any off-grade pieces, gradestamps the on-grade material and places stickers between appropriate rows when the lumber goes into the Moore automatic stacker. The units are then strapped for shipment by rail and truck.

At the conclusion of the visit it was obvious to the group that in terms of North American conditions and requirements, the equipment and system employed at Libby was far superior to anything seen in the earlier study tour of Nordic finger-jointing installations. Moreover, officials of St. Regis are extremely satisfied with their finger-jointing operation. It has

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upgraded a significant portion of their production, contributed to the income of their company, created new jobs and has proven to be economically viable.

H. Visit to Western Forest Products Laboratory (WFPL) Vancouver,B.C.

In order to learn more about the new technique of finger-jointing unseasoned lumber that has been researched and developed by the Western Forest Products Laboratory, the three mission members mentioned in the previous section and the writer visited the Laboratory on the morning of February 1, 1977.

The W.F.P.L. process, using exterior-type glues that are apparently much cheaper than those required in the radio frequency curing system, involves the rapid drying of the fingers of the pieces to be joined without drying the main body of the wood. In the short time required to dry the fingers, the moisture in the remainder of the piece acts as a heat sink to absorb excess heat from the fingers to speed the curing of the adhesive after the joint is made. It is also possible to apply a hot platen to the surfaces of the pieces being joined during the pressing stage to accelerate the curing of the glue near the surface thus permitting immediate safe handling of the product.

We were informed by the W.F.P.L. officers that the moisture content of lumber to be finger-jointed is of critical importance to the quality of the joints. It was stated that in lumber of high and varying moisture content, the heat applied to cure the adhesive is absorbed by the water instead, thus resulting in poor quality joints and innefficient use of power. High levels of moisture also tend to dilute the glue and result in joints of inconsistent quality. Moreover, when radio frequency curing is employed, moisture contents higher than around 14 percent can result in arcing and blistering or even burning of the lumber. As a consequence, the Laboratory experts are of the view that most finger-jointing systems in North America which utilize RF curing are not able to use green lumber and indeed face possible risks in using lumber which has been kiln dried to a maximum moisture content of 19 percent as permitted under the existing NLGA rules.

Laboratory tests have been carried out on several hundred pieces of lumber of various species having moisture contents up to 150 percent. Using the W.F.P.L. technique they have produced finger-jointed lumber with strength values in the Select Structural and Number 1 grade range even using Stud grade stock as raw material. It was reported that the joints produced have consistently been of a high quality.

The Western Forest Products Laboratory has obtained patents on their process in Canada and the United States through Canadian Patents and Development Ltd., the Crown Corporation in Ottawa responsible for obtaining patents for developments of Canadian government agencies.

During the meeting, Mr. James Dobie of the W.F.P.L. discussed his recently published "Economic Analysis of Finger-Jointing by W.F.P.L. Method" (Information Report VP-X-160). In his report Mr. Dobie indicates that by the W.F.P.L. system of finger-jointing unseasoned lumber, potential product prices were, at the time of his study, sufficiently high to render return on investments in excess of 50 percent for probable capital expenditure levels of from one-half to one million dollars.

It is suggested that any Canadian company that might be considering installing finger-jointing equipment should contact the Western Forest Products Laboratory for technical advice and guidance.

I. Conclusions and Recommendations

1. Finger-jointing of structural softwood lumber in Finland, Sweden and Norway began in the mid- 1960's and since that time it has increased steadily, both in volume produced and in the number of operations that have installed finger-jointing equipment. In spite of this growth, finger-jointed lumber is currently only 2 percent of total lumber production and the process is still in its infancy. By developing appropriate product standards and implementing sound quality control methods, however, the Scandinavians have been successful in making end-glued lumber a fully accepted product.

2. There is virtually no finger-jointing of surfaced lumber in Scandinavia due to the fact that most lumber is utilized domestically or exported in the rough dry state

and also to the apparent problem, with their current technology and equipment, of aligning the pieces correctly during jointing to avoid mismatch or "steps" at the joints.

3. In the Canadian sawmilling industry, a major application of finger-jointing would be the jointing of short lengths of surfaced lumber to produce premium value long lengths. While this does not appear to be possible with the systems observed during the mission, the visit to the St. Regis Paper Co. finger-jointing operation at Libby, Montana indicated that the technology and equipment are available in the United States to achieve a high production level of acceptable finger-jointed structural lumber from short length surfaced stock.

4. The main reason for finger-jointing in the three Nordic countries visited is to supply the growing requirement for long lumber from the relatively short logs that are available and to provide specified lengths called for by the consumer. This has only limited relevance in Canada where, within certain constraints, the desired lumber length is determined at the log bucking stage.

5. The practice of finger-jointing spruce and pine lumber in Scandinavian countries is widespread and technically successful. Despite wide variations in the

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moisture content of the lumber being jointed and despite the use of widely different equipment and techniques, finger joints were meeting the technical standards established by the control agencies in each country.

6. Though there are currently 92 controlled producers of finger-jointed lumber in Finland, Sweden and Norway, finger-jointed lumber represents only about two percent of total lumber production. At present a high percentage of finger-jointed lumber is utilized internally in such products of secondary manufacture as joinery, laminated beams, pallets and factory-built housing. A growing number of lumber producers are installing such plants adjacent to their sawmills.

7. The cost of producing finger-jointed lumber in Scandinavia is high and differs widely depending on the type of equipment used and the size of lumber being end-jointed. The average cost was estimated at an equivalent of around 70 dollars per thousand board feet and it appears this is readily recoverable from the buyer, or is considered as simply a corporate cost in providing suitable raw material for secondary manufacture by the company.

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8. With the current reasonable availability of long-length lumber in Canada, the high cost of finger-jointing identified in Scandinavia would not be recoverable by similar operations in Canada.

9. Cost of logs to the sawmills in Scandinavia are far higher than in Canada. In terms of lumber output it was estimated that these costs were between two and three times more expensive than in most Canadian provinces. In large measure this is due to the high degree of private forest ownership in the countries visited and to the powerful associations that negotiate prices on behalf of the private forest owners with the pulp, sawmill and plywood industries

10. The control organizations in the three countries of the study, in addition to granting approval of the finger-jointing process and processing equipment of manufacturers, also require appropriate testing and approval for each finger joint profile. It is also required that routine sampling and testing of the joints is implemented on a continuous basis for normal production of finger-jointed lumber.

11. The qualification codes and quality control requirements for producers of finger-jointed structural lumber in Finland, Sweden and Norway are considerably less rigid and demanding than those layed down in Canada's CSA Standard 0268-1974. The practical standards in Scandinavian countries, based mainly on maintaining satisfactory results of bending strength tests of jointed pieces, provide more incentive for finger-jointing

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plant investments than does more demanding Canadian standard.

12. It appears that further study of finger-jointing technology and marketing in the United States is warranted.

13. With respect to the feasibility of Canadian lumber producers installing finger-jointing operations at their plants, the mission concluded that further study and clarification is first required on the following points:

(a) Glue types and curing considerations, including maximum moisture content and heat requirements and long-term joint stability.

(b) Market acceptance of finger-jointed structural lumber in Canada and the U.S.A.

(c) Product standards and building codes, as relating to finger-jointed structural lumber.

(d) Economic viability.

14. It is suggested that Canadian companies interested in obtaining further data on the finger-jointing of structural lumber in Europe and the United States should write to the organizations listed below for relevant literature.

(a) Technical Research Centre of Finland
Timber Laboratory
02150 Otaniemi, Finland

- Mr. Urho Saarelainen, Research Engineer.

(b) Swedish Forest Products Research Laboratory
Wood Products Department
Drottning Kristinas Vag 65
Box 5604, 11486 Stockholm
Sweden

- Mr. Roland Palm

(c) Norsk Treteknist Institutt
Forskningsveien 3B
Blindern, Oslo
Norway

- Mr. Halvor Skjelmerud, Director

(d) The British Standards Institution
2 Park Street
London W1A 2B5, England

(e) The Otto-Graff Institut
Technische Hockschule
Stuttgart, Federal Republic of Germany

(f) American Institute of Timber Construction
333 West Hampden Avenue, Englewood
Colorado 80110, U.S.A.

(g) American Society for Testing & Materials
1916 Race Street
Philadelphia, Penn. 19103
U.S.A.

(h) University Forest Research Laboratory
Oregon State University
Corvallis, Oregon 97331
U.S.A.

(i) U.S. Department of Agriculture Forest
Products Laboratory
P.O. Box 5130
Madison, Wisconsin 53705
U.S.A.

With respect to Canadian literature on the subject of finger-jointing, companies may procure CSA Standard 0268-1974 and other relevant publications by writing to the Canadian Standards Association, 178 Rexdale Boulevard, Rexdale, Ont. M9W 1R3 or the Western Forest Products Laboratory, 6620 N.W. Marine Drive, Vancouver, B.C. V6T 1X2.

Appendix 1

List of Finger-jointing Operations Visited

1) Laivateollisuus Oy, Turku, Finland
2) Rauma-Repola Oy, Lahti Works, Lahti, Finland
3) Vierumaen Teollisuus Oy, Vierumaki, Finland
4) Oy Kaukas Ab, Lappeenranta, Finland
5) Oy Hackmann Ab, Joutseno, Finland
6) AB Johannebergs Ladfabrik, Upplands Vasby, Sweden
7) Valasens Sawmill, Karlskoga, Sweden
8) Boxholms AB, Boxholm, Sweden
9) AB Geijer & Soner, Langasjo, Sweden
10) AB Angsagen i Vislanda, Vislanda, Sweden
11) Mathiesen - Eidsvold Vaerk, Bøn, Norway
12) Berger Langmoen A/S, Brumunddal, Norway
13) Moelven Limtre A/S, Moelv, Norway
14) Moelven Brug, Moelv, Norway
15) St. Regis Paper Co., Libby, Montana, U.S.A.

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Appendix 2

List of Mission Members

Mr. Glen A. Patterson
Vice-President, Northern Operations
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505 Burrard Street
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Mr. Horst Sander
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Mr. Gilbert Tardif
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Longueil, P.Q. GOR 3K1

Mr. H.T. Boyles
Special Projects Manager
J.D. Irving Lumber Co.
284 Union Street
Saint John, N.B. E2L 1B7

Mr. George Richards
General Manager
Babine Forest Products Ltd.
Burns Lake, B.C. VOJ 1BO

Mr. T. A. Charles
Assistant Chief
Primary Wood Products Division
Resource Industries Branch (52)
Dept. of Industry, Trade & Commerce
240 Sparks Street
Ottawa, Ontario K1A OH5

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Appendix 3

List of Technical Research Institutes, Industry Associations & Finger-jointing Machinery Manufacturers Visited

1. The Finnish Sawmill Owners Association
   Fabianinkatu 29C
   00100 Helsinki 10, Finland

2. Technical Research Centre of Finland
   Timber Laboratory
   02150 Otaniemi, Finland

3. Swedish Forest Products Research Laboratory
   Wood Products Department
   Drottning Kristinas Vag 65
   Box 5604, 11486 Stockholm
   Sweden

4. Swedish Wood Exporters and Sawmill Association
   Villagaten
   S-11432 Stockholm
   Sweden

5. Teknicus Engineering AB
   Box 121
   S-123 al Farsta
   Sweden

6. Norwegina Institute of Wood Working & Wood Technology
   Forskningsveien 3B
   Blinder, Oslo
   Norway

7. Norwegian Timber Trade Federation
   Norges Trelastforbund
   Storgt. 14, Oslo 1
   Norway

8. Cook Bolinders Ltd.
   Commerce Way
   Leighton Buzzard
   Bedfordshire, England

9. Western Forest Products Laboratory
   Department of Fisheries & the Environment
   Vancouver, B.C.
   Canada

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APPENDIX 4

NORSK TRETEKNISK INSTITUTT

Rules
for
control system for companies which manufacture glued, end jointed materials for load bearing constructions

1. Definition and objective

1.1. Glued, end jointed materials are in this document defined as wood in constructional sizes which by means of glue is joined in the longitudional direction so that the jointed wood satisfies given strength criteria.

1.2. The objective of this control system is to ensure that the production at the manufacturers is conducted under safe control and in accordance with the technical demands necessary to obtain sterling joints.

2. Organization

2.1. The control is managed by the Norwegian Gluelam Control. The Norwegian Institute of Wood Working and Wood Technology is the secretariat of the committee.

2.2. The Norwegian Gluelam Control has decisive authority regarding authorization of companies manufacturing glued, end jointed materials for load bearing wood constructions.

2.3. Before making a decision on authorization or suspension, a technical evaluation should always be made by the Norwegian Institute of Wood Working and Wood Technology. The Norwegian Gluelam Control may also instruct the institute to make inspections of authorized companies.

2.4. The technical evaluation shall be carried out based on existing rules.

2.5. The Norwegian Gluelam Control itself cannot demand access to the manufacturing companies and cannot require from the Norwegian Institute of Wood Working and Wood Technology information regarding the production which the companies wish to keep confidential. The companies may demand from the inspector a declaration not to convey information on specified details.

2.6. Authorized companies shall pay a fixed annual fee covering the administration costs of the secretariat, meeting compensations and travelling expenses for the members of the committee etc.

3. Conditions for obtaining authorization

3.1. Any company manufacturing glued, end jointed materials for load bearing wood constructions in accordance with these rules may after application receive authorization from the Norwegian Gluelam Control.

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3.2. Authorized companies are permitted, in conjunction with its trade mark, to use the following quality marking:

"Authorized for finger jointing by the Norwegian Gluelam Control",

and the registered "F"-stamp.

3.3. When applying for authorization the company shall include an account of

a) buildings
b) production equipment
c) production routine
d) quality control

The applicant shall also enclose copies of the instructions mentioned in paragraph 6.5. All documents should be in triplicate.

3.4. The Norwegian Institute of Wood Working shall be permitted to carry out control at the manufacturers before authorization or renewal of authorization is given. The institute shall also be permitted to visit the companies when the Norwegian Gluelam Control finds it necessary. The costs of such inspection and control are to be paid by the company.

3.5. Approval must be obtained for each production line, even if parts of a production line consist of previously approved equipment. Approval for each production line will be given with specified limitation of maximum cross-section of the jointed wood. Limitations may also be specified regarding stress grades.

3.6. Authorization can be withdrawn with immediate effect if the Norwegian Gluelam Control finds that a company does not satisfy the demands which must be made to ensure a safe construction, regarding one or more of the items mentioned in paragraph 3.3. a-d.

3.7. Companies whose authorization has been withdrawn, shall immediately cease using the quality marking mentioned in paragraph 3,2.

4. Buildings

4.1. Production must be carried out in insulated rooms with heating facilities.

5. Production equipment

5.1. The company must have at its disposal the necessary equipment for the manufacture of accurate and even joint profiles, and also equipment to obtain satisfying pressure and temperature during curing. x)

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x) Adequate curing temperature can be obtained by:
a) preheating of the wood materials to about 90° C,
b) curing of the glue by high frequency in the press,
c) post curing of stacked materials at a minimum of 30° C for 12 hours

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5.2. Any change in production equipment shall be reported in writing to the Norwegian Gluelam Control.

5.3. The company shall possess the necessary equipment for regular control of the wood material's moisture contents.

6. Production routine

6.1. For the production only dried wood materials which have been conditioned prior to the jointing shall be used.

Maximum permitted moisture contents in the materials is 23% of the dry density.

6.2. The manufacture of the end joint profile must be done 24 hours at the earliest before glue is applied.

6.3. A production journal shall be kept which in addition to other data should contain information on quantity of materials, material dimensions, material quality, type of glue, moisture contents of the materials etc.

6.4. The production must be planned so that the limits that are set regarding the time from when the glue is applied until full pressure and also pot life for the ready mixed glue, are not exceeded.

6.5. The company shall prepare instructions for the procedure for storing, mixing and application of glue, and for the organization of the production according to paragraph 6.4., and also for pressure, curing time, quality control, storing of finished products and other details of importance to ensure a satisfying product, i.g. cutting of materials, replacement of milling cutter etc.

6.6. End jointed constructional wood shall be marked with a number giving the characteristic strength of the joint or the material strength, and always the lowest value of the two. In addition the materials shall be marked with the company's initials and the registered stamp for finger jointed wood.

7. Quality control

7.1. The company shall have at its disposal equipment for determination of the bending strength of end jointed materials.

7.2. A minimum of 1% or 3 specimen of the end jointed materials from each shift and production line shall be strength tested by the company. The Norwegian Gluelam Control may eventually demand more frequent sampling. The testing is made according to instructions by the Norwegian Gluelam Control.

7.3. Member companies which for extended periods manufacture non structural components shall nevertheless sample, test and report a minimum of 5 joints every two weeks.

7.4. A journal shall be kept of all tests and test results. The Norwegian Institute of Wood Working and Wood Technology will visit the companies at least twice a year.

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On these visits the journal shall be checked and if necessary, samples of the production will be taken for control at independent laboratories. The institute can demand that samples from the production are sent to the institute.

8. Special requirements

8.1. Glue of the resorcinal type or another glue of satisfying strength and ageing properties shall be used. Glue mixture and curing conditions must be according to the glue manufacturer's instructions.

The glue and hardener must be approved by the Norwegian Institute of Wood Working and Wood Technology.

8.2. Minimum distance between joint and knot shall be at least three times the knot diameter and also sufficient for the fibre derangement around the knot to fall outside the joint. The wood in or around the joint must not contain other fibre derangements or defects.

8.3. Wane must not be present in the joint to any appreciable extent.

8.4. The minimum nominal breaking strength calculated as the mean value minus K^x times the standard deviation of a certain number of test pieces shall at least have the following values for the various stress grades:

Grade F 20 - 20 MPa
" F 30 - 30 MPa
" F 40 - 40 MPa

No. of test pieces	4	5	6	7	8	9	10	11	25
K^x	2,7	2,5	2,4	2,3	2,2	2,1	2,1	2,0	1,9

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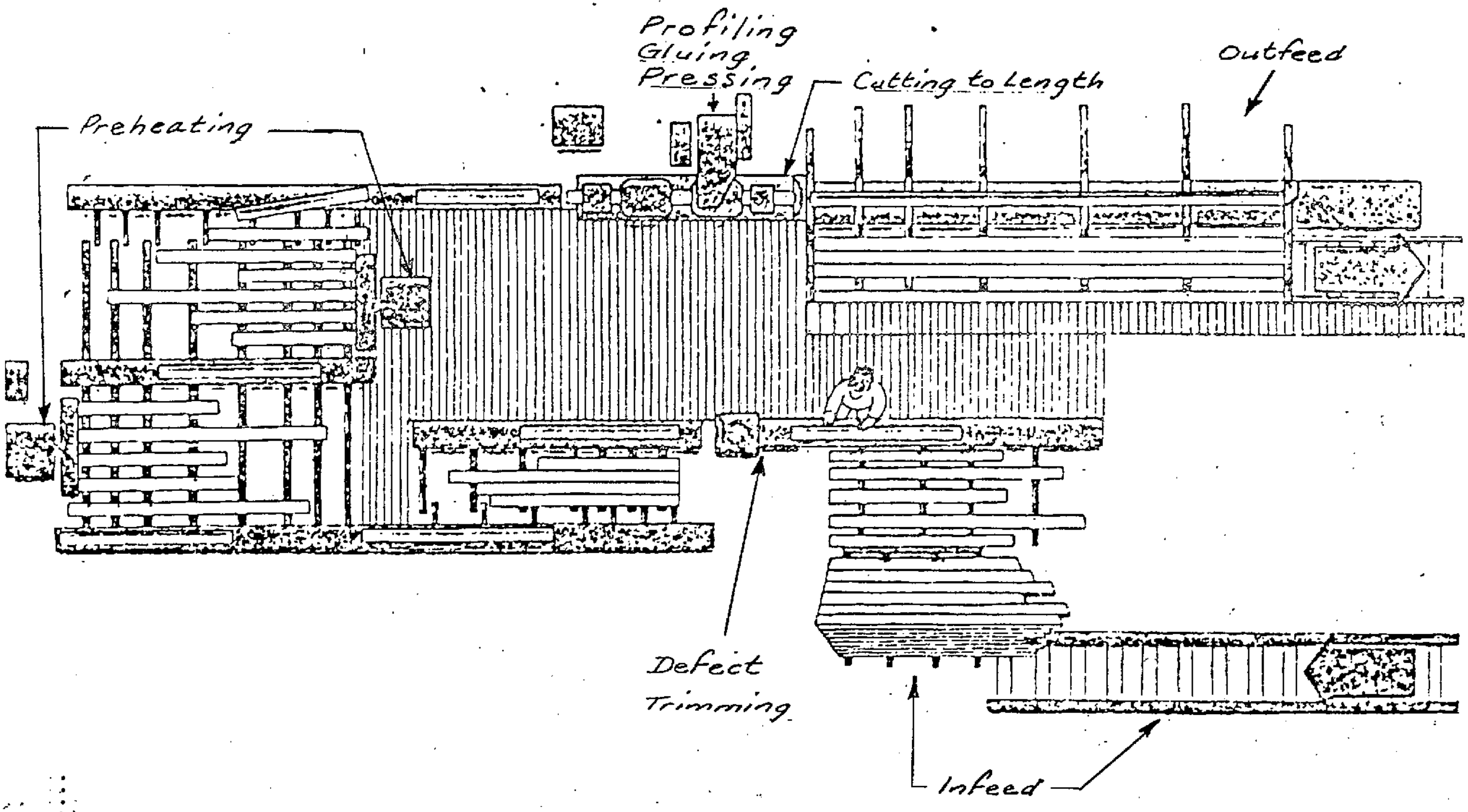
FINGER JOINTING - SCHEMATIC



APPENDIX 5

APPENDIX 6

INDICATED FINNISH SAWMILL PRICES FOR ROUND WOOD IN 1975
(Finnish marks per cubic metre)

	Spruce pulp wood	Pine pulp wood	Birch pulp wood	Spruce logs	Pine logs
Stumpage price	62.74	58.45	53.71	110.01	115.52
Logging	25.07	23.32	18.41	9.14	6.78
Timber haul	10.61	10.92	11.32	9.14	9.42
Storage, common and long haul costs	30.98	34.54	30.54	18.34	20.65
Indirect costs	13.50	13.50	13.50	13.50	13.50
Mill prices	148.90	140.73	217.48	160.13	165.87

Proportional share Percentage					
Stumpage price	42.1	41.5	42.1	68.7	69.6
Logging	16.9	16.6	14.4	5.7	4.1
Timber haul	7.1	7.8	8.9	5.7	4.1
Storage, common and long haul costs	24.8	24.5	24.0	11.5	12.5
Indirect costs	9.1	9.6	10.6	8.4	8.1
	100.0	100.0	100.0	100.0	100.0

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APPENDIX 7

CONVERSION FACTORS & CURRENCY EXCHANGE RATES PREVAILING DURING THE MISSION

1 cubic metre of sawn lumber	424 fbm
1,000 board feet	2.36 cubic metres
1 cubic metre of roundwood (under bark)	35.3 cubic feet
1 cunit of solid wood	2.83 cubic metres
1 cubic metre of chips (loose)	0.5 cubic metre solid wood
1 metre	3.28 feet or 39.37 inches
1 millimetre	0.039 inch.
1 hectare	2.5 acres
1 kilogram	2.205 pounds
1 litre	0.220 gallon
1 short ton	2,000 pounds
1 metric ton	2,204 pounds
1 long ton	2,240 pounds

Finland	$1.00 U.S.	=	3.8 Finnmarks (Fmk)
Sweden	$1.00 U.S.	=	4.2 Swedish Kroners (skr)
Norway	$1.00 U.S.	=	5.2 Norwegian kroners (Nkr)
England	$1.00 U.S.	=	£0.55 Sterling