Production, Approval and Quality Control of Structural Finger Joints in Sweden
Production, Approval and Quality Control of Structural Finger Joints in Sweden

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Nyckelord

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Stockholm 1988
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PREFACE

The major part of this report is based on work carried out at Statens provningsanstalt (the Swedish National Testing Institute).

Information about products, market and economy has been supplied by Stefan Wirtén at Träinformation (the Swedish Timbercouncil).

The project was initiated and financed by Träteknik-Centrum (the Swedish Institute for Wood Technology Research).

Carl-Johan Johansson
SUMMARY

Structural finger joints have been produced in Sweden since the 60's. In May 1986 there were 34 approved manufacturers. In 1985 the total production was 163 000 m³. Only 110 000 m³ (67 %) was structural timber i.e. stress graded timber.

Structural finger jointed timber is mainly used in roof trusses, floor structures and studs.

The most common joint configurations are:

<table>
<thead>
<tr>
<th>Finger length (mm)</th>
<th>Pitch (mm)</th>
<th>Tip width (mm)</th>
<th>Orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>3.7</td>
<td>0.6</td>
<td>Visible on the face</td>
</tr>
<tr>
<td>15</td>
<td>3.8</td>
<td>0.3</td>
<td>Visible on the face</td>
</tr>
<tr>
<td>20</td>
<td>6.2</td>
<td>1.0</td>
<td>Visible on the edge</td>
</tr>
<tr>
<td>32</td>
<td>6.2</td>
<td>0.5</td>
<td>Visible on the edge</td>
</tr>
</tbody>
</table>

Two finger joint machines dominate the market: Sunfab (19) and Cook-Bolinder (10). They may be characterized in the following way:

Sunfab: Produces 20 or 32 mm long fingers visible on the edge of the timber. Cutting, glue application and pressing take place in three different operations.

Cook-Bolinder: Produces 10 or 15 mm long fingers visible on the face. Cutting, glue application and pressing take place while the timber ends are held in the same position.

Different types of finger joints are used depending on the stress grade. The highest stress grade, T30, requires more efficient joint configurations than the lower grades T24, T18 and 8.

Only phenol-resorcinol glues are used. Glue is applied by means of two-components spraying or rollers.

The timber ends are almost always pre-heated by means of high frequency (HF) in order to speed up the curing of the glue and allow immediate handling of the timber.
Manufacture and control follow the guidelines in the Approval rules, Document 1975:7 issued by Statens planverk (The National Swedish Board of Physical Planning and Building) which also has the authority to approve manufacturers. Document 1975:7 is very similar to the ECE-recommended standards for stress grading and finger jointing of structural coniferous sawn timber.

Quality control is required and is carried out as routine control by the manufacturer and as supervisory control by Statens provningsanstalt (The Swedish National Testing Institute).

As part of the routine control three joints a day are tested in bending on the face. Statens provningsanstalt makes unannounced visits twice a year and on each occasion 15 finger joints are sampled and tested.

The basic requirement on finger joints is that the edge-wise bending strength should exceed the characteristic value of the strength class in question. In the case, for example, of T30 this value is 30 MPa.

For some joint configurations there is a difference between flatwise and edgewise bending strength. This is taken into consideration by means of the k-factor, which varies between 1 and 1.3. Multiplied by the characteristic strength value, k gives the required flatwise bending strength value.

It has also been studied whether or not the presently used k-values are correct. For the most common profiles - 10 mm with fingers visible on the face and 20 mm with fingers visible on the edge, the average k-values were found to be 1.1 and 1.0. These are also the values that are used at present to calculate the required flatwise bending strength.

Results from the routine and supervisory controls during a two year period have been evaluated, see figs 1 and 2 and table 1.

*) Economic Committee for Europe
Figure 1 Flatwise bending strength. Results from routine quality control at one manufacturer. July 1983–June 1985

Figure 2 Strength distributions based on all strength data from the 20 mm long joint with fingers visible on the edge. Results from the routine quality control (internal) and from tests carried out by Statens provningsanstalt (SP)
Table 1  Flatwise bending strength. Mean, standard deviation, etc. for each joint configuration based on results from all manufacturers

<table>
<thead>
<tr>
<th>Joint configuration</th>
<th>No of values</th>
<th>Mean value (MPa)</th>
<th>Standard deviation (MPa)</th>
<th>Lower 5 percentile (MPa)</th>
<th>Required value (MPa)</th>
<th>Proportion of values below requirement (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20x6,2x1,0 E*)</td>
<td>9479</td>
<td>34.2</td>
<td>5.4</td>
<td>25.2</td>
<td>24</td>
<td>0.9</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>1125</td>
<td>36.1</td>
<td>6.9</td>
<td>24.4</td>
<td>24</td>
<td>2.0</td>
</tr>
<tr>
<td>SP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10x3.7x0.6 F*)</td>
<td>2654</td>
<td>38.4</td>
<td>7.0</td>
<td>26.9</td>
<td>26</td>
<td>0.7</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>195</td>
<td>41.4</td>
<td>8.7</td>
<td>26.2</td>
<td>26</td>
<td>2.1</td>
</tr>
<tr>
<td>SP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*) E = visible on the edge  
  F = visible on the face

The following conclusions can be drawn from the evaluation.

- With very few exceptions the Swedish manufacturers meet the strength requirements.
- Generally the strength values achieved in the supervisory controls are higher than in the routine quality controls.

The tensile strength of the most common joint configuration - the 20 mm long profile with fingers visible on the edge - has been studied in a separate project. The average tensile strength is about 70% of the flatwise bending strength.
1 INTRODUCTION

1.1 Number of manufacturers and quantities produced

Structural finger joints have been produced in Sweden since the 60's. In the late 70's the number of manufacturers was 43. In May 1986 the number was only 34.

Finger joints are also produced by three glu-lam manufacturers but these are not dealt with in this report.

The production of finger jointed timber in 1985 was 163 000 m$^3$, which means a mean production volume of 5000 m$^3$ per manufacturer and year. Only 110 000 m$^3$ (67 %) is structural timber i.e. stress graded timber. The rest is non-structural, most being boards for external panels.

1.2 Market

Most of the finger jointed timber is distributed on the Swedish market. In 1985 123 000 m$^3$, i.e. 75 % of the total production, was sold in Sweden. About 25 000 m$^3$ was not put directly on the market but was used internally in the companies. This is, for example, the case with prefabricated housing manufacturers, who produce finger jointed timber as one step in the production of wooden houses.

The export was 40 000 m$^3$ (25 %). The most important markets are Norway and Great Britain. Norway is particularly important to the manufacturers in northern Sweden.

The German requirements for finger jointed timber makes exporting there difficult. In West Germany glue must be applied on both timber ends. The Swedish manufacturers have no equipment for that. Exports to West Germany are therefore limited to boards for external panels and to joinery.

1.3 Products

Structural finger jointed timber is mainly used in roof trusses, floor structures and as wall studs.

Finger jointed timber is normally produced in the following thicknesses: 38, 50, 63 and 75 mm and the following widths: 100, 125, 150, 175, 200 and 225 mm. These are the figures for sawn timber. Generally the timber is planed when it leaves the manufacturer. The most common sizes are 50x150, 50x175, 50x200 and 50x225. 38 mm thick timber is finger jointed in a relatively small scale. The demand for small sizes is weak.
1.4 Economy

Finger jointing is regarded by most manufacturers as a service to the customers and therefore it cannot be evaluated after the same economic criteria as other production in the company.

The price of finger jointed timber, as rule, lies at the same level or just above production costs, which means that the timber costs are about 200-250 SKR more per m³ than for normal sawn timber. The price includes delivery of timber cut as ordered by the customer. To the customer the joint in itself is not worth striving for. He merely wants lengths which are difficult or impossible to achieve without jointing.

Profits depend on the size of the timber. Large timber dimensions are more profitable to finger joint than small ones.

Most companies bought their equipment in the early or mid 70's. Companies that have bought finger jointing equipment in recent years have often been able to take over machinery from companies which have given up their business for various reasons. The capital costs are low, either because the machines are written off or because they were bought at a low price. Many manufacturers regard this to be of crucial importance to the economy of finger jointing. The market would not accept the higher price that would be the result of a new-investment.

1.5 Object of this report

This report is meant to provide a basis for evaluating the reliability of structural finger joints produced by Swedish manufacturers. The manufacture, the approval of joints and manufacturers and the quality control system are explained. To verify the reliability of the production test results from the manufacturers' internal quality controls are given. These are supported by further test results from Statens provningsanstalt (the Swedish National Testing Institute) which supervises the production of finger joints.
2 MANUFACTURE

2.1 General

There are mainly three types of manufacturing set-ups, named after the cutter and press used. The most common one is Sunfab, which is used by 19 manufacturers. The next one is Cook-Bolinder (10) and then Sunfab-Dimter (3). Figure 2.1 and 2.2 show typical layouts.

The following sections deal with the main steps in the production of finger joints, i.e.

- stress-grading
- cross-cutting
- pre-heating
- cutting of fingers
- glue application
- pressing
- curing and further handling

Detailed information about each one of the Swedish manufacturers is given in appendix 1.

2.2 Stress-grading

The timber is always stress-graded before finger jointing.

The following stress grades are used:

<table>
<thead>
<tr>
<th>Visual grading</th>
<th>Machine-stress-grading</th>
</tr>
</thead>
<tbody>
<tr>
<td>T30*)</td>
<td>T30M</td>
</tr>
<tr>
<td>T24</td>
<td>T24M</td>
</tr>
<tr>
<td>T18</td>
<td>T18M</td>
</tr>
<tr>
<td>Ö-virke</td>
<td></td>
</tr>
</tbody>
</table>

T30, T24, and T18 are graded by an authorized grader according to "Instructions for sorting and marking of T-timber" issued by the T-timber Association [1]. Grading of Ö-virke is carried out according to SBN 27:412 [2]. Machine-stress-grading is dealt with in special rules [3] issued by Statens planverk (the National Swedish Board of Physical Planning and Building).

Grading takes place after drying, when the moisture content is about 20 %.

*) The grade value denotes the characteristic bending strength which is defined as the 5-percentile value. The characteristic bending strength of Ö-timber is 15 MPa.
1 Timber infeed
2 Crosscut saw
3 HF-generator (preheating of timber ends)
4 Cutter
5 Glue application (rollers or spray guns)
6 Press
7 Saw
8 Timber outfeed

Figure 2.1 Typical Sunfab layout
1. Timber infeed
2. Crosscut saw
3. HF-generator (pre-heating of timber ends)
4. Cutter, glue application (roller) and press
5. Saw
6. Timber outfeed

Figure 2.2 Typical Cook-Bolinder layout
2.3 Cross-cutting

The purpose of cross-cutting is to avoid knots, grain disturbances and other defects near the finger joint.

Cross-cutting normally takes place at the time of jointing.

Details about how cross-cutting should be carried out are given in The Approval Rules 1975:7 [4].

2.4 Pre-heating

Theoretically it is possible to produce finger joints at temperatures from 15 °C upwards. At low temperatures, however, the jointed timber has to be handled very carefully and stored in a heated room for a long time before further processing. This is impractical. Therefore, the timber ends are normally pre-heated, to ensure sufficient and fast curing of the joints. The method used is based on the fact that wood containing moisture, placed in an alternating field of high frequency (above \(10^6\) Hz) is heated due to molecular friction caused by oscillations of the molecules. The thermal conductivity of wood is quite low, so that heat brought into the timber ends will stay there for a long time, and cure the (subsequently applied) glue.

To get a sufficient effect, the temperature in the timber should exceed 80 °C after heating.

As can be seen in appendix 1, high-frequency (HF)-heating is the dominant curing method in Sweden. It is used by 28 of 34 manufacturers. Both timber ends are heated.

In Sunfab machines hot plates are used despite preheating. These plates are used mainly to cure the glue in the outer finger, giving a certain immediate handling strength.
2.5 Cutting of fingers

2.5.1 Cutter profiles

The profiles used in Sweden are described in section 3.3. The 20 mm long profile with fingers visible on the edge of the timber is the most common one for T24, T18 and Ö timber. It is used in the Sunfab cutter and can be exchanged for the 32 mm long profile when T30 timber is to be jointed. In the same way the 10 mm long profile (visible on the face) is used together with the 15 mm profile in Cook-Bolinder machines.

Figure 2.5 shows how cutter profiles are usually described.
Figure 2.5 Cutter profile

The properties of a profile can be characterized by the **cross section reduction** \((R)\) and the **relative joint area** \((A)\).

\[
R = \left( \frac{t}{p} \right) 100
\]

\[
A = \sqrt{1 + \left( \frac{2l}{p} \right)^2}
\]

Experience shows that to meet the strength requirements of the high grades T30 the reduction \(R\) should be below 10%.

Experience also indicates that a relative joint area \(A\) of 8-9 is sufficient for the high grades.

Profiles used in Sweden are listed with values of \(R\) and \(A\) in table 2.1. The 10 and 20 mm long profiles are also standardized in the Federal Republic of Germany in DIN 68 140.

There are two different procedures. In the Cook-Bolinder machines cutting, glue application and pressing take place with the timber pieces held in the same position. In the Sunfab machine the timber ends are cut first, after which the timber is transported to the press.

2.6 **Glue and glue application**

2.6.1 **Type of glue**

Only resorcinol-phenol-formaldehyde adhesives are used. There are different formulations. More information can be found in section 3.2 and in appendix 1.
Table 2.1 Finger profiles for structural grades in Sweden and Federal Republic of Germany

<table>
<thead>
<tr>
<th>Length (mm)</th>
<th>Pitch (mm)</th>
<th>Tip width (mm)</th>
<th>Relative joint-section area (%)</th>
<th>Cross section reduction (%)</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.5</td>
<td>2.5</td>
<td>0.2</td>
<td>6.1</td>
<td>8.6</td>
<td>Ö,T18,T24,DIN 68140</td>
</tr>
<tr>
<td>10</td>
<td>3.7</td>
<td>0.6</td>
<td>5.5</td>
<td>16.2</td>
<td>Ö,T18,T24,DIN 68140</td>
</tr>
<tr>
<td>15</td>
<td>3.8</td>
<td>0.3</td>
<td>8.0</td>
<td>7.9</td>
<td>Ö,T18,T24,T30</td>
</tr>
<tr>
<td>20</td>
<td>6.2</td>
<td>1.0</td>
<td>6.5</td>
<td>16.1</td>
<td>Ö,T18,T24,DIN 68140</td>
</tr>
<tr>
<td>32</td>
<td>6.2</td>
<td>0.5</td>
<td>10.4</td>
<td>8.1</td>
<td>Ö,T18,T24,T30</td>
</tr>
<tr>
<td>50</td>
<td>12</td>
<td>1.7</td>
<td>8.4</td>
<td>14.2</td>
<td>Ö,T18,T24</td>
</tr>
</tbody>
</table>

Figure 2.6 Cook-Bolinder cutter with 10 mm cutting tools
Glue application methods

Glue is applied to one end only, either by means of rotating rollers or by 2-component spraying.

Reliability is a very important factor. The glue has to cover the whole cross section of each piece of timber and the glue/hardener ratio must be within certain limits.

In the Cook-Bolinder set-up one roller applies glue immediately after cutting. The method is safe because the timber is held in the same position during cutting and glue application, see figure 2.6.

In the Sunfab set-up two consecutive rollers are used, see figure 2.8. If one fails to apply glue the other one is likely to work properly. Extra safety is provided with an automatic switch-off which stops the whole machinery if the piece of timber misses both rollers. The glue is pre-mixed and, to prolong the pot life, the glue container is often cooled.
The 2-component spraying method is less common than rotating rollers. Usually two glue nozzles and one hardener nozzle are used, see figure 2.9. The hardener must be in liquid form, which may require special precautions in order to keep the formaldehyde concentration in the air below an acceptable level during application. One advantage of this method is that pot life is no problem. Quite fast glues may be used. The equipment has a warning system telling if the hardener or glue supply is cut off, or if the glue/hardener ratio goes beyond the permitted limits.

Figure 2.8 Glue application by means of rotating rollers

Figure 2.9 Glue application by means of 2-component spraying
2.7 Pressing

After glue has been applied the timber ends have to be pressed together as soon as possible. This is particularly important if, for instance, HF-heating and fast curing glues are used.

The end pressure brings the finger flanks together and gives a thin continuous glue line. Friction gives a locking, which enables immediate handling.

The higher the pressure the more efficient the locking effect. However, there are two important limiting factors. One is splitting at the finger roots and the other is compression failure of the wood, see fig 2.10.

The risk of splitting depends on the finger length, as is reflected in the German DIN 68 141 standard which prescribes 12 MPa end pressure for 10 mm fingers and 2 MPa for 60 mm fingers.

The compression strength of wood depends on density, temperature and moisture content. At room temperature compression strength is no problem, even if the moisture content exceeds 20%. If the temperature is raised to 90 °C, which is the case when HF-heating is used, compression failure will occur at pressures below 10 MPa.

Swedish manufacturers use end pressures in the range of 7-15 MPa, which very seldom gives compression failures unless the moisture content exceeds 20%.

Figure 2.10 Effects of overly high end pressure
2.8 Curing and further handling

Normally, the timber is stored after jointing for a certain period of time to allow the glue to cure enough to enable further handling i.e. normally planing to be carried out. When the timber ends are preheated with HF the timber can be planed about 10 minutes after leaving the press. Otherwise, it has to be stored for several hours.

2.9 Reasons for low quality

Despite all precautions, low quality is occasionally revealed. There are a number of reasons for this. The most common are:

1. Insufficient cross-cutting resulting in big knots and grain disturbances in the finger joint.

2. Lack of glue in a small part of the joint. The reason for this is that the gluing application equipment has not been properly adjusted.

3. Pre-cured glue caused by a stop in the machine after glue has been applied and before pressing.
3 APPROVAL AND QUALITY CONTROL SYSTEM

3.1 Swedish Building Code SBN 1980 and approval rules

Chapter 27 in SBN 1980 [2] covers timber construction including finger jointing. This document states:

- That external type glue must be used.
- How the timber must be marked.
- That manufacturers must be approved by Statens planverk.
- That the joint strength must be sufficient for the stress grade.


SBN 1980 is issued by Statens planverk. The regulations in SBN 1980 are, to a great extent, based on guidelines established by the Nordic Committee on Building Regulations (NKB). Chapter IX of NKB 13 on timber construction covers quality control aspects of finger jointing. Swedish Document 1975:7 is closely related to NKB 13.

3.2 Approval of adhesives

The glue must satisfy the requirements of gluing class U which is comparable to WBP according to BS 1204:1979 "Synthetic resin adhesives. Part 1. Gapfilling adhesives."

In practice, glue is chosen from a list issued by the Nordic Glulam Control Board, see appendix 3. In this list glues are divided into two gluing classes, 1 (interior) and U (exterior). Class U only contains resorcinol-formaldehyde and resorcinol-phenol-formaldehyde adhesives. In class 1 casein adhesives are also listed. Note that at present no urea-formaldehyde (UF) adhesives or modified UF adhesives have been approved.

The list of approved adhesives is based on tests carried out at Norsk Treteknisk Institutt (The Norwegian Institute of Wood Technology). The following tests are carried out:

- Shear strength according to ASTM D905-49
- Delamination test according to ASTM 1101-59
- Resistance to hot water according to BS 1204:Part 1:1979 (Specifications for gap-filling adhesives) and part 2:1979 (Specifications for close-contact adhesives)
If the requirements in BS 1204:Part 1 are fulfilled, bond-lines up to 1.3 mm in thickness will give satisfactory strength and durability.

The effect of deviation from the nominal ratio between hardener and glue is also considered. Tests are carried out at three different ratios: too much hardener, the correct amount and too little hardener.

The use of impregnated wood is considered. Most glues may be used together with different kinds of wood preservatives. The most common one is the CCA-type.

3.3 Approval of a finger joint configuration

Document 1975:7 gives directions about how a finger joint configuration can be approved. Testing in tension and bending is required. The number of tests must be at least 30 for each type of joint, timber size, disposition (fingers visible on the face or the edge of the timber) and type of stress. The finger joint is often only to be used for one disposition, requiring a total of 180 tests for each timber size. At least two timber sizes should be tested, for example the largest and the smallest cross-sections of timber for which the joint approval is to be valid.

The finger joint configurations presently used in Sweden are listed in table 3.1. In fact only the 10 and 15 mm long finger joints have been tested and approved as described above. The efficiency of the other joint configurations however, has been indicated by numerous tests in the quality control over a 10 year period.

Table 3.1 Structural finger joints presently used in Sweden

<table>
<thead>
<tr>
<th>No</th>
<th>Length (mm)</th>
<th>Pitch (mm)</th>
<th>Tip width (mm)</th>
<th>Disposition</th>
<th>Approved for timber stress grade</th>
<th>Number of manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7.5</td>
<td>2.5</td>
<td>0.2</td>
<td>F</td>
<td>Ö,T18,T24</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>3.7</td>
<td>0.6</td>
<td>F</td>
<td>Ö,T18,T24</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>3.8</td>
<td>0.3</td>
<td>F</td>
<td>Ö,T18,T24,T30</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>6.2</td>
<td>1.0</td>
<td>E</td>
<td>Ö,T18,T24</td>
<td>19</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>6.2</td>
<td>1.0</td>
<td>F</td>
<td>Ö,T18,T24</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>32</td>
<td>6.2</td>
<td>0.5</td>
<td>E</td>
<td>Ö,T18,T24,T30</td>
<td>9</td>
</tr>
<tr>
<td>7</td>
<td>50</td>
<td>12</td>
<td>1.7</td>
<td>F</td>
<td>Ö,T18,T24</td>
<td>1</td>
</tr>
</tbody>
</table>

*) F = fingers visible on the face  
   E = fingers visible on the edge
There are two joint strength levels. They can be characterized as follows:

1. Finger joints used for stress grades Ö, T18 and T24 must have a minimum strength of 24 MPa when tested on the strong axis in bending (edgewise bending).

II. Finger joints used for stress grades Ö, T18, T24 and T30 must have a minimum strength of 30 MPa when tested on the strong axis in bending.

Each type of finger joint is also characterized by a factor $k$ which is the ratio between the flatwise and edgewise bending strength. The $k$-values are listed in Table 3.2.

Table 3.2 $k$-values and required bending strength

<table>
<thead>
<tr>
<th>No</th>
<th>Joint configuration*</th>
<th>$k$</th>
<th>Required bending strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Edgewise</td>
</tr>
<tr>
<td>1</td>
<td>7.5x2.5x0.2</td>
<td>1.1</td>
<td>24</td>
</tr>
<tr>
<td>2</td>
<td>10x3.7x0.6</td>
<td>1.1</td>
<td>24</td>
</tr>
<tr>
<td>3</td>
<td>15x3.8x0.3</td>
<td>1.1</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>20x6.2x1.0</td>
<td>1.0</td>
<td>24</td>
</tr>
<tr>
<td>5</td>
<td>20x6.2x1.0</td>
<td>1.3</td>
<td>24</td>
</tr>
<tr>
<td>6</td>
<td>32x6.2x0.5</td>
<td>1.0</td>
<td>30</td>
</tr>
<tr>
<td>7</td>
<td>50x12x1.7</td>
<td>1.1</td>
<td>24</td>
</tr>
</tbody>
</table>

*) F = fingers visible on the face  
E = fingers visible on the edge

The finger joint is classified on the basis of its strength in edgewise bending. However, in the quality control (section 3.5), it is more practical to determine flatwise bending strength. The fact that some joint configurations have lower edgewise then flatwise bending strength also has to be considered in these cases. In order to ensure that the basic requirement with regard to edgewise bending strength is met, the required flatwise bending value has to be $k$ times the required edgewise bending strength.
3.4 Approval of manufacturers in Sweden

Production of finger jointed structural timber must be approved by Statens planverk. The manufacturer applies to Statens planverk, which gives an approval based on a recommendation from Statens provningsanstalt (the Swedish National Testing Institute).

The recommendation from Statens provningsanstalt is based on inspection and testing according to Document 1975:7.

The following points summarize the approval process:

- The company is inspected by Statens provningsanstalt (SP). Specimens of finger jointed timber are sampled. One small and the largest timber size to be jointed shall be represented.

- A total of 60 specimens are tested in flatwise and edge-wise bending.

- If the equipment, material, routine quality control and manufacture follow the requirements in Document 1975:4 an agreement for quality control is signed between SP and the manufacturer, see appendix 4.

- A copy of this agreement and a recommendation to approve the manufacturer is sent to Statens planverk, which issues an approval, see appendix 5.
3.5  **Quality control**

3.5.1 General

Quality control is extremely important in the case of finger jointing. It is not possible to get a visual impression of the strength in a joint. Another factor to consider is that finger joints show very brittle failures and therefore low strength finger joints are more dangerous than, for example, mechanical joints.

The quality control of finger joints follows the general principles of quality control. The details are given in the approval rules Document 1975:7. The basis is the routine control carried out by the manufacturer. Supervisory control is performed by Statens provningsanstalt, which also has the authority to advise the manufacturer to stop marking finger jointed timber if the requirements are not met.

3.5.2 Routine quality control

Document 1975:7 states that manufacture and quality control must be directed and supervised by a designated responsible supervisor.

The following points summarize the most important steps in the routine quality control:

- Check of moisture content
- Check of temperature in the timber ends (pre-heated ends is the dominating curing method)
- Testing of joint strength
- Record keeping

To check the joint strength at least three joints from each production line are selected during each working shift. The timber is tested in bending as described in fig 3.2 and a monthly summary of the results is sent to Statens provningsanstalt, see fig 3.3.
Figure 3.2 Routine testing of finger jointed timber

<table>
<thead>
<tr>
<th>Date</th>
<th>Produktionsnr.</th>
<th>Size</th>
<th>Grade</th>
<th>Test results</th>
<th>Type of failure</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>88/2</td>
<td>47x50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>5763</td>
<td>45x225</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>75x125</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>3818</td>
<td>47x220</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 3.3 Monthly summary of test results
Document 1975:7 stipulates two requirements:

a. No single test value $f_m$ may be less than the nominal strength $f_{m,nom}$ value for the appropriate timber stress grade multiplied by a factor $k$

$$f_m \geq k f_{m,nom}$$

b. The characteristic strength value (lower 5-percentile) $f_{m,\text{char}}$ must exceed $k f_{m,nom}$

$$f_{m,\text{char}} \geq k f_{m,nom}$$

If the stress grade is, for example, T24 then $f_{m,nom}$ is 24 MPa. The value of $k$ varies between 1.0 and 1.3 depending on joint configuration as was described in section 3.3.

When the characteristic strength value drops below the required value this could be an indication that, for example, the cutting tools need sharpening or the spray-guns need adjusting.

3.5.3 Supervising control

Statens provningsanstalt makes two unannounced visits each year. The main purpose of these visits is to make sure that the routine quality control is carried out according to Document 1975:7 and that the finger joint strength is at an acceptable level.

Records are checked and signed. The manufacturing unit and the marking of the timber is inspected.

Finally at least 15 finger jointed pieces of timber are selected at random to be tested at Statens provningsanstalt. This is done primarily to judge whether or not the results from the internal quality control are reliable.

3.6 Comparison with the ECE-standard

The ECE (Economic Committee for Europe) Timber Committee has issued recommended standards for stress grading and finger jointing of structural coniferous sawn timber [5]. These standards are meant to be implemented in most European countries.
The ECE recommended standard for finger jointing is based on NKB report No 13 from the Nordic Committee on Building Regulations. The Swedish approval rules Document 1975:7 is also based on this report, which explains the marked resemblance between the ECE-standard and Document 1975:7. The approval and quality control systems are basically the same. The test methods and methods of assessing strength are also very similar. There are some minor differences in the manufacturing requirements.

The most striking differences between the standards can be summarized in the following points.

**Manufacturing requirements**

- Only 6% difference in moisture content between pieces is accepted compared to 7% in the Swedish approval rules Document 1975:7.
- According to the ECE-standard the temperature of the timber at assembly should always be ≥ 15 °C. In Document 1975:7 there is a restriction on the climate in the premises only when pre-heating of the timber ends is not employed.
- The ECE-standard has somewhat more specific rules for cross-cutting.
- The ECE-standard gives intervals for the end pressure at assembly whereas Document 1975:7 only states that the pressure is to be adjusted so that close contact between fingers is reached with no splitting at the finger roots.

**Spacing of joints**

- According to the ECE-standard the distance between adjacent finger joints shall exceed 0.6 m. Document 1975:7 has no such restriction.

**Marking**

- The ECE-standard requires an F to be placed before the stress grade mark. This is not the case in Sweden where instead an approval mark is used to signify that the finger jointed timber comes from an approved manufacturer.
- In Sweden a time code is required in the marking. The ECE-standard does not contain this requirement.
Initial determination of joint strength

- In Document 1975:7 there are two steps:
  1. Approval of joint configuration
  2. Approval of manufacturer, which in turn requires an approved joint configuration.

In the ECE-standard, rules are only given for initial determination of joint strength in connection with approval of manufacturers.

- In Sweden the factor k which was mentioned in section 3.3 is determined in connection with the approval of joint configuration. According to the ECE-standard the factor k is determined in connection with the approval of a manufacturer.

- The ECE-standard allows use of a depth correction factor.

Routine quality control

- The ECE-standard states that test pieces shall be kept for 5 days in case an external inspection takes place.

- Document 1975:7 requires that the moisture content is measured in at least 2 % of the timber in each batch.

A detailed comparison between Document 1975:7 and the ECE-standard is given in appendix 6.
4 STRENGTH OF FINGER JOINTS

4.1 General

As was described in section 3.5 the strength of finger joints is tested regularly. The manufacturer tests at least three joints a day and as a part of the supervisory control, Statens provningsanstalt tests at least 30 joints per production line and year. These are "flatwise bending tests". Now and then joints are also tested in edgewise bending, and the tensile strength has been evaluated in a special project. The result from all these tests are summarized in the following sections.

4.2 Results from routine quality control

4.2.1 Type and amount of data

Data from a two-year period (July 1983-June 1985) have been evaluated. This, for instance, means a total of 17 208 bending strength values from 30 manufacturers. The following information has been collected from the monthly reports, see fig 3.3.

- Joint geometry and orientation
- Bending strength
- Timber size

Moisture content is not measured in connection with the bending test but the value would normally be in the range of 16-20 %.

Only results from specimens with failure in the joints are included in the evaluation.

4.2.2 Flatwise bending strength

The strength data have been evaluated in two ways.

1. Mean and standard deviation have been calculated for each month during the two year period. Three examples are presented in diagrams in fig 4.1. These make it possible to judge the ability to maintain a certain strength level from one period to another. In principle, the dotted line (the lower 5 percentile value) is always to lie above the straight horizontal line (the required value). Results from each manufacturer are presented in appendix 7.
2. The "total" mean value and standard deviations of all bending strength values from each manufacturer have also been calculated, see table 4.1. This makes it possible to compare results from different manufacturers.

As can be seen in appendix 7 there are months when a manufacturer has 5-percentile values below the required level. The total values "below the line" during the two year period, however, seldom exceeds 5%.

Manufacturers with a regular production of finger jointed timber show the most stable strength levels.
Figure 4.1 Flatwise bending strength. Results from routine quality control at three manufacturers July 1983 - June 1985
Table 4.1 Flatwise bending strength. Results from routine quality control. July 1983–June 1985. The lower 5 percentile has been calculated as the mean value -1.65 times the standard deviation

a. Joint configuration: 20x6.2x1.0 visible on the edge. Required value = 24 MPa

<table>
<thead>
<tr>
<th>Manufacturer No</th>
<th>No of values</th>
<th>Mean value (MPa)</th>
<th>Standard deviation (MPa)</th>
<th>Lower 5 percentile (MPa)</th>
<th>Proportion of values below 24 MPa (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>78</td>
<td>34.8</td>
<td>4.5</td>
<td>27.4</td>
<td>0</td>
</tr>
<tr>
<td>37</td>
<td>492</td>
<td>31.2</td>
<td>4.4</td>
<td>23.9</td>
<td>2</td>
</tr>
<tr>
<td>38</td>
<td>538</td>
<td>32.0</td>
<td>5.6</td>
<td>22.8</td>
<td>1</td>
</tr>
<tr>
<td>39</td>
<td>300</td>
<td>34.1</td>
<td>5.2</td>
<td>25.4</td>
<td>2</td>
</tr>
<tr>
<td>40</td>
<td>518</td>
<td>35.6</td>
<td>5.2</td>
<td>27.0</td>
<td>0</td>
</tr>
<tr>
<td>41</td>
<td>1494</td>
<td>34.7</td>
<td>4.6</td>
<td>27.1</td>
<td>0</td>
</tr>
<tr>
<td>42</td>
<td>315</td>
<td>34.1</td>
<td>5.6</td>
<td>24.9</td>
<td>3</td>
</tr>
<tr>
<td>43</td>
<td>488</td>
<td>32.3</td>
<td>4.4</td>
<td>25.0</td>
<td>3</td>
</tr>
<tr>
<td>44</td>
<td>693</td>
<td>38.7</td>
<td>4.1</td>
<td>31.9</td>
<td>0</td>
</tr>
<tr>
<td>45</td>
<td>2524</td>
<td>34.4</td>
<td>5.3</td>
<td>25.6</td>
<td>1</td>
</tr>
<tr>
<td>49</td>
<td>72</td>
<td>32.9</td>
<td>3.9</td>
<td>26.4</td>
<td>0</td>
</tr>
<tr>
<td>52</td>
<td>148</td>
<td>36.6</td>
<td>6.6</td>
<td>25.7</td>
<td>3</td>
</tr>
<tr>
<td>55</td>
<td>248</td>
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<td>4.5</td>
<td>27.0</td>
<td>0</td>
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<tr>
<td>65</td>
<td>649</td>
<td>35.4</td>
<td>5.7</td>
<td>26.0</td>
<td>1</td>
</tr>
<tr>
<td>68</td>
<td>281</td>
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<td>5.9</td>
<td>25.8</td>
<td>1</td>
</tr>
<tr>
<td>69</td>
<td>602</td>
<td>31.7</td>
<td>4.4</td>
<td>24.5</td>
<td>2</td>
</tr>
<tr>
<td>70</td>
<td>2043</td>
<td>34.9</td>
<td>6.2</td>
<td>24.7</td>
<td>1</td>
</tr>
<tr>
<td>72</td>
<td>799</td>
<td>33.7</td>
<td>4.2</td>
<td>26.8</td>
<td>0</td>
</tr>
<tr>
<td>193</td>
<td>94</td>
<td>31.6</td>
<td>4.3</td>
<td>24.4</td>
<td>0</td>
</tr>
</tbody>
</table>
b. Joint configuration: 10x3.7x0.6 visible on the face. Required value = 26 MPa

<table>
<thead>
<tr>
<th>Manufacturer No</th>
<th>No of values</th>
<th>Mean value (MPa)</th>
<th>Standard deviation (MPa)</th>
<th>Lower 5 percentile (MPa)</th>
<th>Proportion of values below 26 MPa (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>48</td>
<td>902</td>
<td>36.7</td>
<td>5.9</td>
<td>27.0</td>
<td>0</td>
</tr>
<tr>
<td>50</td>
<td>93</td>
<td>47.8</td>
<td>8.6</td>
<td>33.6</td>
<td>0</td>
</tr>
<tr>
<td>51</td>
<td>1021</td>
<td>41.3</td>
<td>7.5</td>
<td>29.0</td>
<td>0</td>
</tr>
<tr>
<td>58</td>
<td>731</td>
<td>36.5</td>
<td>6.2</td>
<td>26.2</td>
<td>2</td>
</tr>
</tbody>
</table>

c. Joint configuration: 20x6.2x1.0 visible on the face. Required value = 31 MPa

<table>
<thead>
<tr>
<th>Manufacturer No</th>
<th>No of values</th>
<th>Mean value (MPa)</th>
<th>Standard deviation (MPa)</th>
<th>Lower 5 percentile (MPa)</th>
<th>Proportion of values below 31 MPa (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>34</td>
<td>696</td>
<td>36.6</td>
<td>5.5</td>
<td>27.5</td>
<td>12</td>
</tr>
<tr>
<td>47</td>
<td>1065</td>
<td>40.2</td>
<td>6.4</td>
<td>29.7</td>
<td>3</td>
</tr>
</tbody>
</table>

d. Joint configuration: 32x6.2x0.5 visible on the edge. Required value = 30 MPa

<table>
<thead>
<tr>
<th>Manufacturer No</th>
<th>No of values</th>
<th>Mean value (MPa)</th>
<th>Standard deviation (MPa)</th>
<th>Lower 5 percentile (MPa)</th>
<th>Proportion of values below 30 MPa (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>37</td>
<td>100</td>
<td>33.7</td>
<td>5.5</td>
<td>24.7</td>
<td>16</td>
</tr>
<tr>
<td>38</td>
<td>24</td>
<td>38.5</td>
<td>5.2</td>
<td>30.0</td>
<td>0</td>
</tr>
<tr>
<td>39</td>
<td>103</td>
<td>38.9</td>
<td>5.1</td>
<td>30.6</td>
<td>1</td>
</tr>
<tr>
<td>41</td>
<td>21</td>
<td>39.1</td>
<td>3.6</td>
<td>33.2</td>
<td>0</td>
</tr>
<tr>
<td>65</td>
<td>83</td>
<td>42.4</td>
<td>4.9</td>
<td>34.4</td>
<td>1</td>
</tr>
<tr>
<td>70</td>
<td>7</td>
<td>38.4</td>
<td>8.7</td>
<td>24.1</td>
<td>0</td>
</tr>
<tr>
<td>72</td>
<td>48</td>
<td>39.3</td>
<td>4.5</td>
<td>31.9</td>
<td>0</td>
</tr>
</tbody>
</table>
e. Joint configuration: 15x3.8x0.3 visible on the face. Required value = 33 MPa

<table>
<thead>
<tr>
<th>Manufacturer No</th>
<th>No of values</th>
<th>Mean value (MPa)</th>
<th>Standard deviation (MPa)</th>
<th>Lower 5 percentile (MPa)</th>
<th>Proportion of values below 33 MPa (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>53</td>
<td>1224</td>
<td>48.1</td>
<td>6.9</td>
<td>36.7</td>
<td>1</td>
</tr>
<tr>
<td>57</td>
<td>549</td>
<td>44.9</td>
<td>8.0</td>
<td>31.7</td>
<td>6</td>
</tr>
<tr>
<td>67</td>
<td>458</td>
<td>49.9</td>
<td>9.2</td>
<td>34.7</td>
<td>3</td>
</tr>
</tbody>
</table>

f. Joint configuration: 7.5x2.5x0.2 and 50x12x1.7 visible on the face. Required value = 26 MPa

<table>
<thead>
<tr>
<th>Manufacturer No</th>
<th>No of values</th>
<th>Mean value (MPa)</th>
<th>Standard deviation (MPa)</th>
<th>Lower 5 percentile (MPa)</th>
<th>Proportion of values below 26 MPa (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.5x2.5x0.2</td>
<td>64</td>
<td>39.8</td>
<td>5.3</td>
<td>31.1</td>
<td>0</td>
</tr>
<tr>
<td>50x12x1.7</td>
<td>63</td>
<td>44.9</td>
<td>6.3</td>
<td>34.6</td>
<td>0</td>
</tr>
</tbody>
</table>
4.3 Results from tests at Statens provningsanstalt (SP)

4.3.1 Differences in testing methods between manufacturer and SP

The number of tests carried out by SP during the two-year period is normally 45–60, which in most cases is far less than what is achieved in the routine quality control. On the other hand the bending tests are carried out more accurately at SP. The major differences are:

- At the manufacturers, the joints are tested within 24 hours after production whereas the joints tested by SP are at least one week old. This means higher strength when tested at SP because the glue is better cured.

- When tested at SP the timber is somewhat drier than in the factory. The difference varies, depending on the time between manufacture and testing and on the weather conditions.

- The manufacturer normally tests the timber in sawn condition and the nominal dimensions are used in the calculations of bending strength. SP always tests planed timber. There is always a deviation from the nominal thickness value of sawn timber which gives a corresponding error in the calculation of strength.

- The manufacturer has simple testing equipment which, for instance, does not allow accurate reading of the ultimate load.

4.3.2 Bending strength – comparison with results from routine quality control

Table 4.2 gives results from each manufacturer. A comparison is also made with the manufacturers, results from table 4.1. Results are also summarized for each joint configuration in Table 4.3.

Only data from finger joints sampled at the regular unannounced visits have been taken into account. Quite often extra visits are carried out on the basis of weaknesses observed at the regular visits, but these results have not been considered as representative too normal production.

The moisture content is normally found to be about 18 % when tested at SP, which is slightly lower than at the manufacturers.
The following conclusions can be drawn from table 4.1.

- The bending strength represented by the lower 5 percentile value is generally close to or above the required value. In most of the cases where the 5 percentile value is too low the proportion of values below the required value is seldom higher than 5%. This indicates that the strength distribution is somewhat skewed, which can also be seen in figure 4.2.

- The results from tests carried out by the manufacturers may be regarded to be on the safe side and as fairly reliable despite the simple testing equipment and testing procedure. The mean strength recorded by SP is generally higher than what is found by the manufacturers, in some cases more than 20% higher. As was indicated in section 4.3.1 there are a number testing conditions and procedures that differ between SP and the manufacturers. The most important factor has not been determined, but whether the timber is sawn or planed when tested is probably an important one. When the finger jointed timber is tested in sawn condition there is a more pronounced indication of fracture caused by fingers at the surface that are not sufficiently glued. Parts of these fingers are removed when the timber is planed.

- According to the tests carried out by SP, manufacturers number 34, 39 (finger length = 32 mm) and 69 do not meet the strength requirements. In the case of no 34 the low strength level is confirmed by the results from the internal quality control, see table 4.1. Manufacturer number 39 and 69, however, appear to have sufficient strength according to their own results. This indicates that these manufacturers have to be thoroughly investigated with regard to production conditions and testing procedures.
Table 4.2 Flatwise bending strength. Results from supervisory control carried out by Statens provningsanstalt (SP). The 5 percentile has been determined at 75% confidence level.

a. Joint configuration: 20x6.2x1.0 visible on the edge
   Required value = 24 MPa

<table>
<thead>
<tr>
<th>Manufacturer No</th>
<th>No of values</th>
<th>Mean value (MPa)</th>
<th>Standard deviation (MPa)</th>
<th>Lower 5 percentile (MPa)</th>
<th>Proportion of values below 24 MPa (%)</th>
<th>Mean SP manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>60</td>
<td>42.0</td>
<td>8.3</td>
<td>27.1</td>
<td>0</td>
<td>1.21</td>
</tr>
<tr>
<td>37</td>
<td>30</td>
<td>35.8</td>
<td>8.3</td>
<td>20.3</td>
<td>0</td>
<td>1.15</td>
</tr>
<tr>
<td>38</td>
<td>60</td>
<td>33.6</td>
<td>5.0</td>
<td>24.5</td>
<td>2</td>
<td>1.05</td>
</tr>
<tr>
<td>39</td>
<td>45</td>
<td>35.1</td>
<td>4.9</td>
<td>26.2</td>
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<td>1.03</td>
</tr>
<tr>
<td>40</td>
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<td>35.4</td>
<td>4.0</td>
<td>28.0</td>
<td>0</td>
<td>1.00</td>
</tr>
<tr>
<td>41</td>
<td>60</td>
<td>39.3</td>
<td>4.6</td>
<td>30.9</td>
<td>0</td>
<td>1.13</td>
</tr>
<tr>
<td>42</td>
<td>45</td>
<td>39.7</td>
<td>8.1</td>
<td>25.0</td>
<td>2</td>
<td>1.16</td>
</tr>
<tr>
<td>43</td>
<td>60</td>
<td>35.8</td>
<td>4.6</td>
<td>27.6</td>
<td>0</td>
<td>1.11</td>
</tr>
<tr>
<td>44</td>
<td>60</td>
<td>40.5</td>
<td>5.7</td>
<td>30.1</td>
<td>2</td>
<td>1.05</td>
</tr>
<tr>
<td>45</td>
<td>60</td>
<td>35.8</td>
<td>4.7</td>
<td>27.3</td>
<td>0</td>
<td>1.04</td>
</tr>
<tr>
<td>49</td>
<td>60</td>
<td>35.5</td>
<td>5.2</td>
<td>26.1</td>
<td>0</td>
<td>1.08</td>
</tr>
<tr>
<td>52</td>
<td>60</td>
<td>36.3</td>
<td>7.9</td>
<td>22.1</td>
<td>5</td>
<td>0.99</td>
</tr>
<tr>
<td>55</td>
<td>45</td>
<td>37.0</td>
<td>6.5</td>
<td>25.1</td>
<td>4</td>
<td>1.07</td>
</tr>
<tr>
<td>65</td>
<td>45</td>
<td>34.8</td>
<td>6.0</td>
<td>23.8</td>
<td>0</td>
<td>0.98</td>
</tr>
<tr>
<td>68</td>
<td>45</td>
<td>43.1</td>
<td>7.0</td>
<td>30.4</td>
<td>2</td>
<td>1.21</td>
</tr>
<tr>
<td>69</td>
<td>60</td>
<td>30.6</td>
<td>5.8</td>
<td>20.1</td>
<td>10</td>
<td>0.96</td>
</tr>
<tr>
<td>70</td>
<td>60</td>
<td>37.3</td>
<td>8.2</td>
<td>22.5</td>
<td>0</td>
<td>1.07</td>
</tr>
<tr>
<td>72</td>
<td>60</td>
<td>31.3</td>
<td>4.8</td>
<td>22.7</td>
<td>3</td>
<td>0.93</td>
</tr>
<tr>
<td>193</td>
<td>30</td>
<td>31.3</td>
<td>3.6</td>
<td>24.8</td>
<td>0</td>
<td>0.99</td>
</tr>
</tbody>
</table>
b. Joint configuration: 10x3.7x0.6 visible on the face  
Required value = 26 MPa

<table>
<thead>
<tr>
<th>Manufacturer No</th>
<th>No of values</th>
<th>Mean value</th>
<th>Standard deviation</th>
<th>Lower 5 percentile</th>
<th>Proportion of values below 26 MPa</th>
<th>Mean SP Mean manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(MPa)</td>
<td>(MPa)</td>
<td>(MPa)</td>
<td>(%)</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>60</td>
<td>39.3</td>
<td>7.2</td>
<td>26.4</td>
<td>5</td>
<td>1.07</td>
</tr>
<tr>
<td>50</td>
<td>15</td>
<td>42.1</td>
<td>7.3</td>
<td>27.5</td>
<td>0</td>
<td>0.88</td>
</tr>
<tr>
<td>51</td>
<td>60</td>
<td>48.1</td>
<td>9.7</td>
<td>30.6</td>
<td>0</td>
<td>1.16</td>
</tr>
<tr>
<td>58</td>
<td>60</td>
<td>36.6</td>
<td>4.3</td>
<td>28.9</td>
<td>2</td>
<td>1.00</td>
</tr>
</tbody>
</table>

c. Joint configuration: 20x6.2x1.0 visible on the face  
Required value = 31 MPa

<table>
<thead>
<tr>
<th>Manufacturer No</th>
<th>No of values</th>
<th>Mean value</th>
<th>Standard deviation</th>
<th>Lower 5 percentile</th>
<th>Proportion of values below 31 MPa</th>
<th>Mean SP Mean manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(MPa)</td>
<td>(MPa)</td>
<td>(MPa)</td>
<td>(%)</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>60</td>
<td>42.6</td>
<td>7.3</td>
<td>29.4</td>
<td>8</td>
<td>1.16</td>
</tr>
<tr>
<td>47</td>
<td>60</td>
<td>42.4</td>
<td>6.1</td>
<td>31.3</td>
<td>3</td>
<td>1.05</td>
</tr>
</tbody>
</table>

d. Joint configuration: 32x6.2x0.5 visible on the edge  
Required value = 30 MPa

<table>
<thead>
<tr>
<th>Manufacturer No</th>
<th>No of values</th>
<th>Mean value</th>
<th>Standard deviation</th>
<th>Lower 5 percentile</th>
<th>Proportion of values below 30 MPa</th>
<th>Mean SP Mean manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(MPa)</td>
<td>(MPa)</td>
<td>(MPa)</td>
<td>(%)</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>15</td>
<td>41.5</td>
<td>4.9</td>
<td>31.8</td>
<td>0</td>
<td>1.23</td>
</tr>
<tr>
<td>39</td>
<td>15</td>
<td>31.8</td>
<td>5.2</td>
<td>21.4</td>
<td>40</td>
<td>0.82</td>
</tr>
<tr>
<td>65</td>
<td>30</td>
<td>45.0</td>
<td>6.3</td>
<td>33.1</td>
<td>0</td>
<td>1.06</td>
</tr>
</tbody>
</table>
### e. Joint configuration: 15x3.8x0.3 visible on the face
Required value = 33 MPa

<table>
<thead>
<tr>
<th>Manufacturer No</th>
<th>No of values</th>
<th>Mean value (MPa)</th>
<th>Standard deviation (MPa)</th>
<th>Lower 5 percentile (MPa)</th>
<th>Proportion of values below 33 MPa (%)</th>
<th>Mean SP manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>53</td>
<td>90</td>
<td>48.2</td>
<td>7.6</td>
<td>34.8</td>
<td>1</td>
<td>1.00</td>
</tr>
<tr>
<td>57</td>
<td>60</td>
<td>50.3</td>
<td>8.3</td>
<td>35.4</td>
<td>5</td>
<td>1.12</td>
</tr>
<tr>
<td>59</td>
<td>15</td>
<td>50.5</td>
<td>7.7</td>
<td>35.2</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>67</td>
<td>45</td>
<td>50.4</td>
<td>11.4</td>
<td>29.7</td>
<td>4</td>
<td>1.01</td>
</tr>
</tbody>
</table>

### f. Joint configuration: 7.5x2.5x0.2 and 50x12x1.7 visible on the face. Required value = 26 MPa

<table>
<thead>
<tr>
<th>Manufacturer No</th>
<th>No of values</th>
<th>Mean value (MPa)</th>
<th>Standard deviation (MPa)</th>
<th>Lower 5 percentile (MPa)</th>
<th>Proportion of values below 26 MPa (%)</th>
<th>Mean SP manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.5x2.5x0.2</td>
<td>64</td>
<td>42.4</td>
<td>5.3</td>
<td>32.8</td>
<td>0</td>
<td>1.07</td>
</tr>
<tr>
<td>50x12x1.7</td>
<td>63</td>
<td>45.9</td>
<td>6.8</td>
<td>33.6</td>
<td>0</td>
<td>1.02</td>
</tr>
</tbody>
</table>
In table 4.3 the strength values of the different joint configurations are compared more directly. All joint configurations intended for the T24, T18 and Ö grades (1, 2 and 3) have been found to have sufficient strength. It could be argued that the strength of the 20 mm profile with fingers visible on the face is too low. However, table 4.4 indicates that the k-value applied is too high and that the required value could perhaps be lowered from 31 MPa to 29 MPa.

It appears to be difficult for the T30 joints (4 and 5) to reach the required strength level. This is surprising in a way as the joint geometry is better than that of the other joints (1, 2 and 3). An important factor, however, is that the T30 joints are used very seldom. The normal situation for a Sunfab set-up is that T24, T18 and Ö timber is jointed with the 20 mm cutting tools. Now and then there is a demand for T30. The 20 mm tools are exchanged for the 32 mm long ones and T30 timber is jointed for a day or two. This is normally too short a time to make the equipment (cutting tools, glue application etc) operate properly.

The 15 mm and 32 mm profiles have previously been successfully used by a couple of Swedish glulam manufacturers. In this case the required bending strength was 39 MPa.
Table 4.3 Flatwise bending strength. Mean, standard deviation, etc. for each joint configuration based on results from all manufacturers

<table>
<thead>
<tr>
<th>No Joint configuration</th>
<th>No of values</th>
<th>Mean value (MPa)</th>
<th>Standard deviation (MPa)</th>
<th>Lower 5 percentile (MPa)</th>
<th>Required value (MPa)</th>
<th>Proportion of values below requirement (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 20x6.2x1.0 E *)</td>
<td>Manufacturer 9479</td>
<td>34.2</td>
<td>5.4</td>
<td>25.2</td>
<td>24</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td>SP           1125</td>
<td>36.1</td>
<td>6.9</td>
<td>24.4</td>
<td>24</td>
<td>2.0</td>
</tr>
<tr>
<td>2 10x3.7x0.6 F *)</td>
<td>Manufacturer 2654</td>
<td>38.4</td>
<td>7.0</td>
<td>26.9</td>
<td>26</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>SP           195</td>
<td>41.4</td>
<td>8.7</td>
<td>26.2</td>
<td>26</td>
<td>2.1</td>
</tr>
<tr>
<td>3 20x6.2x1.0 F</td>
<td>Manufacturer 1761</td>
<td>38.7</td>
<td>6.3</td>
<td>28.3</td>
<td>31</td>
<td>6.6</td>
</tr>
<tr>
<td></td>
<td>SP           105</td>
<td>43.7</td>
<td>6.6</td>
<td>32.1</td>
<td>31</td>
<td>2.9</td>
</tr>
<tr>
<td>4 32x6.2x0.5 E</td>
<td>Manufacturer 386</td>
<td>38.4</td>
<td>5.9</td>
<td>28.1</td>
<td>30</td>
<td>4.7</td>
</tr>
<tr>
<td></td>
<td>SP           60</td>
<td>40.8</td>
<td>7.8</td>
<td>26.7</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>5 15x3.8x0.3 F</td>
<td>Manufacturer 2651</td>
<td>46.2</td>
<td>8.6</td>
<td>32.0</td>
<td>33</td>
<td>5.8</td>
</tr>
<tr>
<td></td>
<td>SP           270</td>
<td>47.7</td>
<td>8.9</td>
<td>32.1</td>
<td>33</td>
<td>4.8</td>
</tr>
</tbody>
</table>

*) E = visible on the edge  
F = visible on the face
Figure 4.2 Strength distributions based on all strength data from the most common joint configurations. Results from the routine quality control (internal) and from tests carried out by Statens provningsanstalt (SP). Mean, standard deviation, etc. are given in table 4.3.
4.4 Edgewise and flatwise bending strength

As described in section 3.3, the basic requirement is applied on the edgewise bending strength. To transform this requirement so that it can be used on the flatwise bending strength a factor $k$ is defined and each of the finger joint configurations have been given a $k$-value which varies from 1-1.3.

In connection with approval of manufacturers, both edgewise and flatwise bending strength are determined. A large number of such comparisons have been made by SP over a 7 year period. These results are summarized in table 4.4.

The mean $k$-value of each joint configuration agrees quite well with the values that have been applied to calculate the required flatwise bending strength in the quality control. But the deviation from the mean is considerable. For the 20 mm long joint with fingers visible on the edge the $k$-values range from 0.79 to 1.21. In principle the $k$-value could also be calculated from the 5 percentile value. The values would then be 5-10 % higher and the range wider.

It is obvious that the $k$-value depends not only on the joint configuration but also on the manufacturers conditions. This could motivate $k$-values being determined individually for each manufacturer, which would, however, be very impractical. Not only does the $k$-value differ between manufacturers, but it also changes from one time to another.
Table 4.4 Flatwise bending strength compared to edgewise bending strength. Results gained in connection with approval of manufacturers. The number of specimens is 15 "flatwise" and 15 "edgewise". The k-value is the mean flatwise bending strength divided by edgewise bending strength.

<table>
<thead>
<tr>
<th>Timber size</th>
<th>k-value</th>
<th>Timber size</th>
<th>k-value</th>
<th>Timber size</th>
<th>k-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>10x3.7x0.6 F</td>
<td>38x100</td>
<td>0.98</td>
<td>34x90</td>
<td>0.93</td>
<td>39x100</td>
</tr>
<tr>
<td></td>
<td>38x120</td>
<td>1.11</td>
<td>38x100</td>
<td>0.98</td>
<td>45x95</td>
</tr>
<tr>
<td></td>
<td>44x120</td>
<td>1.13</td>
<td>40x100</td>
<td>0.79</td>
<td>45x95</td>
</tr>
<tr>
<td></td>
<td>45x120</td>
<td>0.82</td>
<td>45x170</td>
<td>1.02</td>
<td>63x200</td>
</tr>
<tr>
<td></td>
<td>60x195</td>
<td>1.08</td>
<td>47x150</td>
<td>1.00</td>
<td>70x195</td>
</tr>
<tr>
<td></td>
<td>60x198</td>
<td>1.17</td>
<td>47x225</td>
<td>1.12</td>
<td>70x195</td>
</tr>
<tr>
<td></td>
<td>60x220</td>
<td>1.04</td>
<td>50x225</td>
<td>1.21</td>
<td>75x225</td>
</tr>
<tr>
<td></td>
<td>60x220</td>
<td>0.98</td>
<td>75x225</td>
<td>1.07</td>
<td></td>
</tr>
<tr>
<td></td>
<td>63x200</td>
<td>1.08</td>
<td>70x195</td>
<td>Mean value</td>
<td>1.02</td>
</tr>
<tr>
<td></td>
<td>70x220</td>
<td>1.09</td>
<td>70x220</td>
<td>Applied value</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>75x200</td>
<td>1.17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean value 1.06</td>
<td>Applied</td>
<td>value 1.1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Timber size</th>
<th>k-value</th>
<th>Timber size</th>
<th>k-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>20x6.2x1.0 F</td>
<td>35x70</td>
<td>1.21</td>
<td>40x100</td>
</tr>
<tr>
<td></td>
<td>45x220</td>
<td>1.34</td>
<td>50x150</td>
</tr>
<tr>
<td></td>
<td>50x75</td>
<td>1.13</td>
<td>50x150</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean value 1.23</td>
<td>Applied</td>
</tr>
</tbody>
</table>

Mean value 0.95
Applied value 1.0

<table>
<thead>
<tr>
<th>Timber size</th>
<th>k-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>32x6.2x0.5 E</td>
<td>35x70</td>
</tr>
<tr>
<td></td>
<td>40x100</td>
</tr>
<tr>
<td></td>
<td>50x150</td>
</tr>
<tr>
<td></td>
<td>50x150</td>
</tr>
<tr>
<td></td>
<td>50x150</td>
</tr>
<tr>
<td></td>
<td>75x200</td>
</tr>
<tr>
<td></td>
<td>75x200</td>
</tr>
<tr>
<td></td>
<td>75x225</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

E = visible on the edge
F = visible on the face
4.5 Effect of timber size

The timber size has an effect on the bending strength of finger joints. This is common knowledge among manufacturers. It is harder to reach the required value for large timber sizes than for small ones.

The difference in strength due to timber size is shown in table 4.5. Values are given for the following sizes:

Small: Cross-section area < 5000 mm². The dominant size is 50x100 and the thickness is between 38 and 50.

Medium: Cross-section area 5000-7500 m². The dominant sizes are 50x125 and 50x150 and the thickness is normally 50 mm, but a small quantity of 63 mm is included.

Large: Cross-section are > 7500 mm². The dominant sizes are 50x175 and 50x200. Thickness is normally 50 mm, but small quantities of 63 and 75 mm are also included.

The difference in strength between medium and small timber is negligible whereas the large sizes for some joint configurations have more than 10% lower strength. This can naturally, to some extent, be explained by the statistical volume effect according to Weibull. But it is obvious that there is also some effect from the finger joint.
Table 4.5 Effect of timber size on the flatwise bending strength of finger joints. Mean bending strength based on data from routine quality control testing. The figures within parentheses give the relation to the "medium size" mean value.

<table>
<thead>
<tr>
<th>Joint configuration</th>
<th>Bending strength, mean value (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small size</td>
</tr>
<tr>
<td>7.5x2.5x0.2 F *)</td>
<td>42.1</td>
</tr>
<tr>
<td></td>
<td>(1.01)</td>
</tr>
<tr>
<td>10x3.7x0.6 F</td>
<td>44.6</td>
</tr>
<tr>
<td></td>
<td>(1.16)</td>
</tr>
<tr>
<td>15x3.8x0.3 F</td>
<td>49.0</td>
</tr>
<tr>
<td></td>
<td>(0.95)</td>
</tr>
<tr>
<td>20x6.2x1.0 E *)</td>
<td>35.6</td>
</tr>
<tr>
<td></td>
<td>(1.02)</td>
</tr>
<tr>
<td>20x6.2x1.0 F</td>
<td>41.4</td>
</tr>
<tr>
<td></td>
<td>(1.03)</td>
</tr>
<tr>
<td>32x6.2x0.5 E</td>
<td>39.4</td>
</tr>
<tr>
<td></td>
<td>(0.98)</td>
</tr>
<tr>
<td>50x12x1.7 F</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*) F = fingers visible on the face  
    E = fingers visible on the edge

4.6 **Tensile strength**

Determination of tensile strength is not a part of the quality control. However, in 1982 finger joints from all manufacturers were sampled by SP in order to determine the tensile strength level of the different joint configurations. Three joints were sampled from each manufacturer. The total number of specimens for most joint configurations was low. Only results from the most common joint are presented here.

The tensile strength is 70% of the bending strength based on the 5 percentile value, see table 4.6.
Table 4.6 Tensile strength of joint configuration 20x6.2x1.0 with fingers visible on the edge. Specimens sampled from 22 manufacturers. Moisture content = 17 %

<table>
<thead>
<tr>
<th>No of values</th>
<th>Mean value</th>
<th>Standard deviation</th>
<th>Lower 5 percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>65</td>
<td>28.0</td>
<td>6.1</td>
<td>17.0</td>
</tr>
</tbody>
</table>
REFERENCES


INFORMATION ABOUT JOINT CONFIGURATION, MAXIMUM TIMBER SIZE, APPROVAL, CUTTER AND PRESS ETC FROM EACH MANUFACTURER

The list is based on the conditions in May 1986.

The following points should be observed:

- "Approved in strength class" means the maximum stress grade for which the approval is valid.

- "Exp" is a special stress grade which is not standardized. It means that the stress grade should be at least 0 and the edgewise bending strength of the finger joints should be at least 24 MPa. The point of "Exp" is that the buyer can make his own grading.

- In the report, test results are given for most of the manufacturers'. Some manufacturers are missing because they had no production and therefore there are no or very few test results from the routine quality control to present. Results are also presented from manufacturers not listed here, because their approval was no longer valid in May 1986.
<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Profile (mm)</th>
<th>Orientation</th>
<th>Approved in strength class</th>
<th>Max dimension (mm)</th>
<th>Approval No</th>
<th>Cutter and press</th>
<th>Glue application</th>
<th>Glue</th>
<th>Curing</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>33</td>
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Appendix 1.6
SBN

Rules for Authorisation

1975:7

Statens Planverk

Finger-jointed Structural Timber

Manufacture and Control
Manufacture and Control of Swedish Finger-jointed Structural Timber

Before a Swedish manufacturing company is permitted to sell finger-jointed structural timber it must be authorised by Statens Planverk (The National Board of Physical Planning and Building). This authorisation is based on rules presented in SBN Godkännande Regler 1975:7 (Swedish Building Code. Approval Rules No. 1975:7 'Finger-jointed Structural Timber: Manufacture and Control').

This Technical Paper TP3 by the Swedish Timber Council is a translation of these rules which is a Swedish amplification of Nordic Document NKB13: Chapter IX:
0. Introduction
1. Conditions for joining the manufacturing control scheme
   1.1 General
   1.2 Supervisor and control instructions
   1.3 Premises and equipment
2. Manufacture
   2.1 General
   2.2 Material
   2.3 Cross-cutting
   2.4 Cutting the fingers
   2.5 Glue application
   2.6 End pressure
   2.7 Curing
   2.8 Delivery
3. Manufacturing Control
   3.1 Internal manufacturing control
   3.2 External supervising control

Appendix 1 Rules for initial testing of a finger joint configuration and for testing finger-jointed structural timber when authorising a finger-jointing production line.

Appendix 2 Guiding notes for drafting a description of the manufacturing process.

Appendix 3 Agreement for manufacturing and supervising control of finger-jointed structural timber.

Appendix 4 Bending tests of finger-jointed structural timber.

English summary as published in the Swedish Document.
INTRODUCTION

In SBN 27:4224 finger-jointed structural timber is described as timber joined lengthwise with finger joints glued with external quality glue (Swedish gluing Class U, British Class WBP).

Finger-jointed structural timber can be used in constructions where the fracture of a joint would not lead to considerable damage and risk of a continuous collapse.

SBN 27:2772 permits the use of finger-jointed structural timber in the following cases:

I  Buildings of not more than two storeys or a height of 10m:
   a) in compression members
   b) in members taking bending or tension where the members or frames are spaced at not more than 1.3m centres and where at least three components are acting together so that a failure of one member would not cause collapse of the complete construction.

II Buildings of more than two storeys:
   a) Roof structures propped from a floor structure.
   b) Infill panels taking only wind loading and their own weight, and complying generally with Case Ib) above.

Finger-jointed timber is not permitted in scaffolding or other constructions subject to impact.

Finger-jointed structural timber may be used in cases not covered above where 'type approval' has been granted by Statens Planverk after testing.

The following rules state the conditions for manufacturers being approved by Statens Planverk in the scheme for the control of finger-jointed structural timber to match SBN 12:12 and SBN 27:4114.

1. Conditions for joining the manufacturing control scheme

1.1 General

1.1.1 The finger joints must have strength appropriate to the stress grades for which they are intended. Finger jointing of structural timber is permitted if performed according to the following rules. Quality control is exercised as required by SBN 12:12, partly by the manufacturer's own quality control department (internal quality control), partly by random checks by an authorised quality control body (external supervising control).

1.1.2 The following requirements must be fulfilled for a manufacturer to be authorised.
a) The premises and the manufacturing equipment must satisfy Clause 1.3 below. The type of finger joint being used (profile and orientation) must be type tested according to Appendix 1 and be shown to have adequate strength for the intended stress grade.

b) The premises, equipment and manufacturing methods must be inspected by staff of the authorised quality control body, and during this inspection testing must be performed as Appendix 1.

c) The manufacturing company must prepare a formal description of the manufacturing procedure (see Appendix 2).

d) Agreement on the manufacturing quality control must be reached between the manufacturer and the control body (see Appendix 3).

e) The manufacturer must apply to Statens Planverk to obtain approval to produce finger-jointed structural timber and to mark with the control mark (see Clause 4.1) after obtaining inspection records and quality control agreement.

1.2 Supervisor and control instructions

1.2.1 There must be a supervisor responsible for the manufacture with an adequate knowledge of finger jointing, timber machinery, glue and gluing.

1.2.1 The supervisor must sign that he is responsible for the production and that quality control will be exercised by the agreed rules and that the internal quality control will be performed by persons qualified for the work.

1.2.3 Written instructions must be readily available regarding the conditioning and cutting of the timber, any pre-heating of the timber ends, and for the operation and maintenance of the jointing equipment. There must also be instructions for storing and mixing the glue, gluing (application and assembly pressures), and handling and storage of the timber after jointing. These must be adapted to the directions of the glue manufacturer. There must also be written instructions regarding routine quality control.

1.2.4 Any changes to the manufacturing instructions or change of supervisor must be reported by letter to the control body.

1.3 Premises and Equipment

1.3.1 A special room must be available for the mixing of the glue and hardener (the glue department). This room must have a water supply and a sink available for washing out utensils. Neither mixed glue nor the constituent parts may be drained into ordinary drains. If a glue spraying machine is being used on the production line then the requirement to have a glue department may be waived.

1.3.2 The glue department must be equipped with weighing scales or other reliable apparatus for measuring glue and hardener. There must also be a mixer.
1.3.3 The equipment for applying the glue must provide an even coating layer over the joint.

1.3.4 The glue spreading equipment should be designed so that it can contain the quantity of glue appropriate to the gluing time.

1.3.5 The press must be designed to give an evenly distributed compression which can be measured. It should be possible to set the equipment so that the deviation from nominal pressure does not exceed 20%. It must be possible to adjust the heating of the press table.

1.3.6 Equipment must be available for regular control and measuring of the moisture content of the timber. If the ends of timber to be joined are pre-heated or if initial curing is by high-frequency methods, equipment must be available to measure the temperature of the timber.

1.3.7 When pre-heating of timber ends is not to be employed, the timber storage and the manufacturing premises must have a temperature of at least 15°C and a relative humidity of not more than 30%. The air temperature and relative humidity should be measured regularly and should be controlled.

2. Manufacture

2.1 General

The timber must be dried to a moisture content appropriate to the type of glue and curing method being used. The temperature and moisture content requirements inside the manufacturing premises are dependant on the curing method being used.

2.2 Material

2.2.1 The timber must be stress graded before being joined or at the time of joining. Visual stress grading to T30 or T20 must be carried out by an authorised grader according to 'Instructions for sorting and marking of T-Timber' issued by the T-Timber Association (an English presentation is available from the Swedish Timber Council). Sorting to stress grade Ö-virke must be carried out according to SBN 27:4112. Machine stress grading must be carried out in the manner authorised by Statens Planverk.

(Note. Stress grading to the visual grades of BS4978 must be carried out by graders approved by 'The Swedish Management Committee for Stress Grading of Timber'. Stress grading to the machine grades of BS4978 must be carried out under the BSI Kitemark Scheme.)

2.2.2 Timber should normally be at a moisture content of between 8% and 18% although by using certain glues the upper limit can be extended to 23%. The difference in moisture content between two pieces to be joined together must not exceed 7%.
2.2.3 The glue must satisfy the requirements of gluing Class U (external, WBP). The glue used must be approved by the Swedish Forest Products Research Laboratory.

2.3 Cross-cutting

The timber must be cross cut to exclude grain disturbance within a zone of 130mm from the end of the timber. In this length knots must not occur closer to the fingers than a distance equal to three times the knot diameter, except that knots smaller than 6mm may occur in the 130mm length without restriction.

Pitch pockets may not occur within the finger length.

The timber should be cross-cut so that spring, cup or other deformation will not affect the final joint.

2.4 Cutting the fingers

The fingers should be cut sharp to ensure true fit on the sloping surfaces. The cutting should ensure that, when assembled, the two timber parts will not be off-set by more than the normal planing allowance. The top and side pressure at the time of gluing should be the same as that at the time of cutting the fingers. (This is particularly important if slightly cupped or twisted timber is being joined.)

2.5 Glue Application

Gluing should normally take place directly after the joints have been cut. When storage of cut timber is unavoidable the moisture content, the surface and finger profile must be checked for suitability immediately before gluing and joining. The glue application to one or both surfaces must ensure good 'wetting' of all surfaces to be joined.

2.6 End Pressure

The end pressure for assembly must be adjusted so that close contact of fingers is obtained without fissures being caused at the base of the fingers. When gluing finger joints visible on edges the time during which pressure is maintained should be extended so that the outermost fingers are still locked together when the pressure is released. The assembly pressure time depends on pre-heating (if any), the type of glue and the means of handling immediately after gluing.

2.7 Curing

The curing requirements must be suitable for the handling which the timber will receive after joint assembly. The minimum requirement is that the timber must be able to be handled, machined and stacked immediately after joint assembly without displacement of the joints.
When pre-heated ends or accelerated curing is used the timber can normally be planed about 10 minutes after the press has been released, otherwise a curing period of several hours at 20°C is necessary before the timber can be machined.

Before transporting the joints must be cured sufficiently to match the relevant stress grade. Normally a period of 1 - 2 hours is necessary if pre-heating or accelerated curing is used. When pre-heating or accelerated curing is not used a curing period of at least 12 - 15 hours at a temperature of 20°C is necessary.

2.8 Delivery

Delivery of finger-jointed timber may not be completed until satisfactory test results are obtained. The batch should be rejected if the quality is not up to the required standard.

3. Manufacturing Control

The manufacturing control must be carried out partly by internal manufacturing control according to Clause 3.1 and partly by an external supervising control authority according to Clause 3.2.

3.1 Internal Manufacturing control

3.1.1 The responsible supervisor

The manufacture and the continuous internal manufacturing control must be directed and supervised by the designated responsible supervisor.

3.1.2 Records

Records must be kept of all joints and include information about the date of manufacture, number of the timber pieces, dimensions, timber grade, glue type, the moisture content and temperature of the timber, curing time as well as the results of bending tests of the joints. The supervisor is responsible for the records. The results and associated manufacturing data must be dated and signed.

3.1.3 Operating the control

Before starting to join the timber the moisture content must be checked in at least 2% of the pieces of each batch being joined. The measurement should be taken near the end of the timber on the same day as the timber is to be joined. If the measurement is taken by an electronic device the influence of any impregnation fluid must be taken into account. When the timber ends are being pre-heated the temperature of the timber should be checked for each timber size being joined at least twice per shift to ensure that it has not dropped below 80°C. The measurement should be made 30-40mm from the end of the timber. After RF curing in a press the temperature in the joint should be checked to ensure that it is at least 75°C.
To check the joint strength at least three joints from each production line should be selected for bending tests from each working shift. The samples should be selected at uniform times during the production time. The test samples should be stored in the same way as the jointed timber. The batch should not be despatched before the result of the bending tests has proved that the joints fulfill the requirements of the desired stress grade.

Unless any other method has been specified the timber should be tested in bending as described in Appendix 3.

The test results must be entered in the company records and a monthly summary must be sent to the control institution.

The various timber batches should be kept apart until the result of their tests is at hand.

3.1.4 Assessing the joint strength
Judged from a few days' running production the joints can be considered to have obtained satisfactory strength if the test results from at least 15 running tests fulfill one of the following requirements a) and b). Results not associated with failure at a joint can be disregarded.

a) No single test value $\sigma$ may be less than the $\sigma_k$ value for the appropriate timber stress grade multiplied by a factor $k$.

$$\sigma \geq k \cdot \sigma_k$$

b) The value calculated from the test results ($\sigma_{bar} = \bar{\sigma} - 2s$) is greater than the value $\sigma_k$ for the appropriate stress grade multiplied by a factor $k$.

$$\sigma_{bar} \geq k \cdot \sigma_k$$

$\bar{\sigma}$ is the mean value

$s$ is the standard deviation for the test values ($\sigma$).

$k$ is a factor determined by type testing as described in Appendix 1 to ensure that the bending, tension and compression strength of the joint are satisfactory in accordance with Clauses 3.1.4a) and b). The value of $K$ (normally between 1.0 and 1.3) and $\sigma_k$ must be shown on the test records.

When assessing a production generating a large number of test specimens only Clause 3.1.4b) is applicable. The strength of the joints may be regarded as satisfactory if only one test out of fifty achieves a lower strength than the value of $\sigma_k$ above.

3.1.5 Rejection
Jointed timber which does not fulfill the requirements of Clause 3.1.4 or is found to be faulty during the manufacturer's continual internal control should be rejected as structural timber. Notification of such timber must be entered in the records. It is not permissible to reclassify such timber to a lower strength class.
3.2 External Supervising Control

3.2.1 External supervising control must be performed by a control institution authorised by Statens Planverk.

3.2.2 The control institution will make two unannounced visits each year to each production unit at times determined by the control institution. If required by the control institution, the manufacturer or by Statens Planverk an extra visit may take place within the framework of the control agreement.

3.2.3 The control inspection takes place in the factory where the manufacturing is undertaken. Samples of joints can however be taken from other places (for example a building site, a merchant's yard or a place of storage) at the discretion of the control institution or Statens Planverk.

3.2.4 On control visits the records since the last visit are checked and signed by the representative of the control institution. The manufacturing unit (machines, organisation and responsible supervisor), method of storing finger-jointed material and the marking methods must be checked thoroughly.

3.2.5 Random test samples (at least 15) of finger-jointed structural timber must be taken for testing at an approved test laboratory.

3.2.6 Following a control visit (normally within 4 weeks) the control institution makes its report, one copy direct to the responsible supervisor and one to the manufacturing company.

3.2.7 If a serious defect is detected in the manufacturing method or the internal manufacturing control the control institution must instruct the manufacturer to take immediate action. A control report is also sent to Statens Planverk informing them of the deficiency.

3.2.8 The cost of the control visits and control tests is paid by the manufacturer. The control institution must be allowed access to the premises at reasonable times. All necessary papers which directly concern the production being checked should be available at the time of the control visit.

4. Marking

4.1 Finger-jointed structural timber must be marked in a durable manner on one of the flat sides adjacent to each joint or by marking continuously with not more than 1.5m between each mark. The marking must contain the 'Trident' quality mark ₪ of Statens Planverk, identification of the manufacturer and place of manufacturer (when it is necessary to distinguish between two places of manufacture), date code indicating the production year and week of gluing, as well as information on the stress grading according to Clause 2.2.1 (T30, T20 or Ö for visual stress grading: T30M, T20M or ÖM for machine stress grading). When the timber is
machine stress graded by the manufacturer's machine the marking should contain the machine reference number of the authorisation certificate of Statens Planverk. Examples of marking are shown in Fig. 1 (Note that the markings illustrated are somewhat different from the marking directions given in Clause 27:4114 in SBN 1975 first edition.)

4.2 When the finger-jointed timber is to be used in the company's own production of structural components a simplified marking and/or less frequent marking may be used after special registration with Statens Planverk.

4.3 Finger jointed structural timber may not be marked as having a stress grade higher than that applicable to the approved strength of the finger joint.

A

(a) Stress grade T30, T20 or Ö-virke when visually stress graded (GS or SS also applicable for export to UK market). T30M, T20M, ÖM etc. as well as the machine registration number when machine stress graded.

(b) The control mark ('Trident') of Statens Planverk. (The design and proportion is as detailed below.)

(c) Identification of manufacturer and place of manufacturer. (Note: the S000 coding indicates the reference number of the stress-grading machine.)

(d) Time code for gluing, e.g. W for week, 6 for 1976 and 07 for the seventh week of the year (international standard).

B

Figure 1. Examples of Marking Finger-jointed Timber

A - visually stress graded.
B - machine stress graded.

The letters and figures must be at least 15mm high and 2mm thick.
APPENDIX 1

Rules for initial testing of a finger joint configuration and for testing finger-jointed structural timber when authorising a finger-jointing production line.

Conditions

The rules cover the testing of finger joints or joints of another type used in length jointing structural timber. The rules are to be regarded as a basis for general approval of a joint configuration which will be used in certain classes of structural timber or in components according to special type approval.

General Rules

Statens Planverk approving rules 1975:4 are applicable to certain parts of the test.

Definition

Finger joints should be defined by the profile details (Fig.1.1), the structural timber class for which the type testing results are applicable, any relevant limitation of the validity of the results with respect to the timber size, the position of the joint in the timber, climate class and stresses.

Timber

The timber used in the test must not be of a higher stress grade than the strongest grade for which the joint is to be used.

Manufacture of Specimens

The jointing must be performed according to the manufacturing rules of Statens Planverk approval rules 1975:7. The joints in the test specimens should be placed near to such knots or other defects which are close to the grade limit, however not closer than that permitted in the manufacturing rules.

At least two timber dimensions should be joined and tested, for example the largest and smallest cross-section of timber for which the joint approval is to be valid.

If the joint approval is to cover the case of fingers being visible on both the flat side and edge, both these conditions must be tested.
The Extent of Testing

The tests must include a tension and a bending test.

Timber of rectangular cross-section should be tested in bending both on the strong and the weak axis. The number of tests must be at least 30 for each type of joint, timber size, disposition (visible on face or edge) and type of stress. Testing of a joint profile visible either on face and edge will therefore entail at least 120 tension tests and 120 bending tests in each direction giving a total of 360 tests.

Note: The finger joint is often only to be used for one disposition (visible on the flat side or visible on edge) requiring a total of 180 tests.

Preparation of the Samples

The jointed samples should be conditioned to an equilibrium moisture content at a temperature of 20°C and a relative humidity of 80%. If the jointed timber is to be planed before delivery, the samples should be planed before being tested; otherwise they should be tested unplaned.

Bending Tests

The length of the sample should be 17h where h is the dimension of the timber in the direction of loading (the width when bending on the strong axis, the thickness when bending on the weak axis). The joint is to be positioned at the middle of the sample.

The sample should be tested in bending with the sample supported on two supports at 15h centres. The loading is through two point loads spaced at third points (ie 5h from each support). Where necessary it is permissible to restrain the samples from lateral buckling. The elongation speed must not exceed 0.003/min.

Tension Tests

The samples must be of full cross-section for at least a length of 9h where h is the larger dimension of the section. The clear distance between the clamps must be at least 9h. The joint is to be positioned at the centre of length plus or minus 1.5h.

The elongation speed must not exceed 0.003/min.

Evaluation of the Test Results

When evaluating the test results the rules in Statens Planverk Approving Rules 1975:4 must be applied. The strength of the test results should be such that the jointed construction timber can be expected to attain a characteristic strength at the lower 5% level corresponding to three times the permissible strength at normal duration loading according to SBN 1975.
Testing Finger-Jointed Timber for Approval of a Finger-Jointing Line

The testing related to inspection when approving a jointing line should be carried out as when testing finger-jointed structural timber. Tension tests are not necessary. Bending tests must be performed on both axes. As a rule two sizes should be tested with the joint positioned to comply with actual manufacture. At least 15 samples should be tested per timber size.

Figure 1:1 Details of the finger-joint profile and geometry

\[ l = \text{length of finger} \]
\[ p = \text{pitch} \]
\[ \theta = \text{angle} \]
\[ t = \text{tip width} \]
\[ c = \text{clearance} \]

Figure 1:1 Details of the finger-joint profile and geometry
APPENDIX 2

Guiding notes for drafting a description of the manufacturing process.

1. General
1.1 Place of manufacture

2. Professional experience and production management
2.1 The qualification of the responsible supervisor

3. Premises
3.1 Drawing of the layout of the premises
3.2 Required highest and lowest temperature in the premises
3.3 Humidification plant if applicable

4. Manufacturing equipment
4.1 Drawing of layout of the machinery
4.2 Equipment for controlling the moisture content of the timber
4.3 Equipment for cutting the timber
4.4 Equipment for pre-heating the timber if applicable
4.5 Cutters for cutting joint profile
4.6 Glue application and glue containers
4.7 Equipment for end pressure on the joints
4.8 Equipment for cutting the jointed timber
4.9 Equipment for handling the jointed timber
4.10 Arrangement for curing the glue
4.11 Equipment for mixing the glue and cleaning the glue equipment
4.12 Equipment for maintaining the cutters
4.13 Equipment for quality control tests of the joints

5. The basic timber
5.1 Stress grades relative to the joints
5.2 Drying the timber before jointing
5.3 Grading the timber before jointing
5.4 The moisture control of the timber at time of jointing
5.5 The largest and smallest sizes of timber to be joined
5.6 The longest and shortest length of timber to be joined
5.7 The longest length of timber after jointing

6. Glue
6.1 Types of glue to be used
6.2 Storage of the glues

7. Joint profiles
7.1 Profiles of joints to be used
7.2 Specification of the cutters

8. Description of the manufacturing process.
This section is to cover the procedure of the manufacturing process. The description should include details of the number of people employed in the jointing plant, their tasks, the temperature of the timber before joint, number of joints cut per minute, the time between cutting and gluing, the end pressure, curing requirements for the glue, the time between jointing and further handling and a description of further work on the jointed timber.

9. Instructions for manufacturing personnel
9.1 Method of measuring moisture content
9.2 Cutting equipment
9.3 High-frequency equipment
9.4 Measuring temperature
9.5 Pressure adjustment
9.6 Glue mixing
9.7 Cleaning equipment
9.8 Curing before planing. Curing after jointing
9.9 Quality control tests
9.10 Procedure at stoppages in production

Date
Name of company
Name of responsible supervisor
APPENDIX 3

Agreement for Manufacturing Control and Supervising of finger-jointed structural timber

The following agreement has been made between the control institution and the manufacturer related to manufacturing control in accordance with the Swedish Building Regulation 1975:12:12.

1. The product to be controlled.
The manufacturer produces finger-jointed structural timber in stress grades.

2. The object of the quality control.
The object is to ensure that finger-jointed structural timber is produced in accordance with Staten Planverk's rules for authorisation 1975:7 and in accordance with this agreement.

3. Operation of the control
The manufacturing control will be by means of continuous quality control carried out by the manufacturer and external supervising control carried out by the control institution.

3.1 The manufacturer is under an obligation:

1.1 to manufacture finger joints in accordance with Staten Planverk's rules for authorisation 1975:7 and Inspection Certificate No.

1.2 to carry out continuous control of manufacture in accordance with Clause 3.1 in Planverket's rules for authorisation 1975:7 and to assist the control institution with the external supervising control.

1.3 without receiving approval from the control institution or Planverket the manufacturer may not make changes related to the raw material, method of manufacture, type of joint or manufacturing control which would change the basis of Planverket's approval rules 1975:7.

1.4 to keep the control institution informed in writing of where the manufacturing is performed, where the manufacturer is storing the raw material and the manufactured products, and who has been selected as the responsible head of works (see Enclosure a) below).

1.5 to afford access to employees of the control institution to the manufacturing and storage premises as well as the records, certificates and available delivery notes for inspection: and also to give the required help and information to facilitate the control.

3.2 The control institution is obliged:

2.1 to carry out the external supervising control in accordance with Clause 3.2 of Planverket's rules for authorisation 1975:7.
22. to instruct the manufacturer to rectify immediately if any small defect is detected in the manufacture or manufacturing control, and to follow up the results of the changes to the procedure by the next control visit at the latest.

23. to instruct the manufacturer to rectify immediately (and to inform Planverket) if any major defect is detected in the manufacture or manufacturing control.

24. to send to Planverket at least once a year a summary of all the controls carried out during the previous year, and to inform if the recommendation is to retain the manufacturer on Planverket's approval list for the following year. If the recommendation is for the manufacturer not to be approved, the manufacturer must be informed.

4. Marking
Marking should be carried out according to Clause 4 of Planverket's rules for authorisation 1975:7. The marks must be applied to the timber after jointing.

5. Costs
The costs of the external manufacturing control including any testing carried out shall be paid for by the manufacturer.

6. Duration of validity of the agreement
This agreement comes into force on .......... and is valid until the 31st December 19..... Notice to terminate the agreement must be made in writing and at least ...... months before the end of the year and can be initiated either by the control institution or the manufacturer. The control institution will inform Planverket in writing if the agreement is terminated. If the agreement is not terminated it is automatically extended for a further year.

The agreement is drawn up and signed in two copies of which the control institution keeps one copy and the manufacturer the other. The control institution is to send a copy to Planverket.

..................date ..................date

..................

..................

..................

(Control institution)  (Manufacturer)

Enclosures  a) Place of manufacture and responsible head of works

b) Acceptance of responsibility
Enclosure a) to the agreement dated............

Place of manufacture and responsible head of works

Finger-jointed structural timber as approved by Planverket will be manufactured at:

Name of manufacturer:
Address:
Place of manufacture:
Factory marking:
Telephone No:

The head of works responsible for the production and internal quality control:

Occupation:
Name:
Address:
Telephone No:

This enclosure should be revised to take account of any change. If such a change is concerned with the place of manufacture one copy of the enclosure is sent by the control institution to Planverket.

.....................date

.....................

.....................

.....................

(Control institution)

.....................date

.....................

.....................

.....................

(Manufacturer)
Enclosure b) to the agreement dated...........

Acceptance of Responsibility

For manufacture of finger-jointed structural timber at:

Name of company .........................
Place of manufacture .....................

As the responsible head of works for the production of finger-jointed structural timber at (place of manufacture) ...........
........ I undertake the responsibility that the manufacturing and control of the jointed timber will be carried out according to 'Finger-jointed structural timber, Manufacture and Control', Statens Planverk rules for authorisation 1975:7, Inspection Certificate No. ........ and the signed agreement.

I also undertake to use only qualified staff on the control and manufacture.

In addition I accept the responsibility to inform the control institution of any change in the manufacturing procedure or of any important instruction documents.

Name ...................... Date ......................
APPENDIX 4

Bending tests of finger-jointed structural timber

1. Scope

The rules mainly cover bending tests on the weaker axis in conjunction with internal manufacturing quality control of finger-jointed timber.

2. Samples

The samples for bending test should have a length (L) equal to 17 times the thickness of the timber (dimension in the direction of bending). The joint should be positioned at the centre of the test sample. The moisture content of the timber should be 15% + 3%.

3. Testing

3.1 The samples are placed over two supports on a span of 15h where h is the thickness as illustrated in Fig.1. Load P is applied to the test samples by two equal point loads at third points (see Fig.4:1).

The sample should be placed with the face which appears to be the weaker underneath.

3.2 The speed of loading should correspond to a rate of deflection of approximately 0.15mm/min at the loading points. Note - Table 1 gives the accepted speed for various thickness of timber.

Fig.4:1 Method of applying load to sample. (The radius of the rollers should be at least 15mm.)
Table 1  Speed of loading for various thicknesses of test samples

<table>
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<tr>
<th>h</th>
<th>L=17h</th>
<th>l=15h</th>
<th>( \frac{L}{3} =5h )</th>
<th>Downward speed</th>
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<td></td>
<td></td>
<td>mm/min</td>
</tr>
<tr>
<td>25-31</td>
<td>425</td>
<td>375</td>
<td>125</td>
<td>5</td>
</tr>
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<td>1125</td>
<td>375</td>
<td>12</td>
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</table>

3.3 The test samples may be tested in two equally wide parts. The strength of the sample is then determined by combining the widths and failure loads.

3.4 The failure stress is given by \( \sigma = \frac{M}{W} \) which may be expressed as:

\[
\sigma = \frac{P}{bh^2} \quad \text{(see Fig. 4:1)}
\]

where \( P \) is the load at failure (or the sum of the failure loads - see 3.3).

\( l \) is the span \( (l = 15h) \) and \( h \) is the thickness of the timber.
Summary in English (as it appears in the original Swedish version).

The National Swedish Board of Physical Planning and Building Approval Rules No. 1975:7

Finger-jointed timber
The rules cover production, control and marking of finger-jointed timber.

The rules are used for approving finger-jointed timber.

In 'Rules for General Approvals', Rules No. 1975:1 information is given on the concept and the purpose of general approvals and also regarding the documents required when applying for a general approval.
Glues approved for production of glulam, January 1986

### Structures in Class I (interior)

- Casco Linulin 0102 (Casco)
- Dynalin 350 (Dyno Industries A/S)
- Norra Kasein Holdlin (Norra Kasein Trading)
- Mestari K (Mestari K)

### Structures in Class I and U (exterior)

- Aerodux 185 w/hard 150 (Casco)
- Aerodux 185 w/hard 155 (Casco)
- Aerodux 185 w/hard 155 (Casco)
- Dyncsin 350 (Dyno Industries A/S)
- Dynalin 350 (Dyno Industries A/S)
- Mestari K (Mestari K)

### Species

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### Impregnated with

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<th>Cyclate</th>
<th>Tanalith</th>
<th>Volusmiln</th>
<th>Tanalith</th>
<th>Cuprimol</th>
<th>Tryck</th>
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<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

1. For finger jointing of coniferous wood where the glue is applied with two component spray gun. (The equipment has to be approved separately).

2. Glues that are approved for materials impregnated with Rentokil K33 are also approved for materials impregnated with Kenita K33. Mitrol K33 and with Tanalith CCA oxide type B or C.

3. The glue is intended for separate string application. (The equipment has to be approved separately).
Agreement regarding production control in conjunction with type approval issued by the National Swedish Board of Physical Planning and Building (Statens planverk)

Between the Swedish National Testing Institute (Statens Provningsanstalt), herewith called the inspection agency, and herewith called the manufacturer, the following agreement regarding production control according to the Swedish Building Code (Svensk Byggnorm), section 12:12 has been made.

1 PRODUCT TO BE CONTROLLED

The product to be controlled is specified in control directions drawn up for each type approved product, see appendix 1. If the same conditions are prevailing, the instructions may cover several type approvals.

2 THE PURPOSE OF CONTROL

The purpose of the production control is to ensure that the type approved products conform to the existing type approval certificates and all pertaining documents.

3 PERFORMANCE OF CONTROL

The production control is based on a continuous in-plant control carried out by the manufacturer under competent direction (works control). In addition to the works control, impartial random inspections shall be performed through the inspection agency (supervisory control).

3.1 The manufacturer agrees to:

3.11 carry out and record works control as specified in section 4 and in the control directions appended to this agreement.

3.12 ensure that staff involved in manufacture and control has adequate and appropriate instructions conforming to the type approval certificate and the pertaining documents.

3.13 mark only type approved products according to the regulations of the type approval certificate. Products that do not meet the demands of the type approval certificate must not be marketed as type approved.

3.14 promptly stop marking products covered by this agreement according to 3.13 when ordered to do so by the inspection agency.
3.15 make no alterations in matters regulated by the control directions, the type approval certificate or the pertaining documents without first having obtained approval by Statens Planverk or the inspection agency. The date of application for an approved alteration shall be recorded. The inspection agency shall be notified in writing when a new person is assigned as contact.

3.16 give the agent of the inspection agency unrestricted access to the manufacturing premises and warehouses, make readily available for examination of all records, consignment notes, test reports regarding materials used in the production, and generally extend all the help needed and information required to carry out the inspection.

3.2 The inspection agency agrees to:

3.21 perform the supervisory control according to section 5 and the control directions pertaining to the agreement.

3.22 instruct the manufacturer to take appropriate measures in case of slight deficiencies in the production or works control, as well as to follow up on the results of such measures, at least by the time of the next inspection visit.

3.23 instruct the manufacturer to immediately stop referring to the type approval and production control in case of serious deficiencies in the production or works control.

3.24 send a report, at least once a year, to Statens Planverk regarding recommendations for continued approval of the product. If there are any objections according to 3.23, Statens Planverk and the manufacturer shall be informed as soon as possible.

4 WORKS CONTROL

4.1 DIRECTION AND SUPERVISION

Manufacture and continuous in-plant control shall be performed under supervision of a person with the competence needed, see appendix 1. This person is responsible for the keeping of records and shall, as the manufacturers contact with the inspection agency, give assistance during the inspection visits.
4.2 RECORDS

The results from control according to 4.3 and 4.5, as well as information on the quantity of production, are logged in a record which is kept as agreed upon with the inspection agency. Test reports shall be made available to the inspection agency. When recording results and procedures, they shall be dated and signed by the person doing the recording. 4.3 EXTENT OF WORKS CONTROL

Works control shall be carried out according to the control directions drawn up for each type approved product (appendix 1).

4.4 MARKING

Marking shall be done in accordance with the requirements of the type approval certificate.

4.5 DISCARDING

Components or material that are defective must not be used in the production of type approved products. Products that in the works control are found defective or deviate from the approval certificate and pertaining documents, shall be modified if possible or discarded. Marking on discarded products shall be obliterated.

5 SUPERVISORY CONTROL

5.1 INSPECTION VISITS

Supervisory control shall be performed by means of random inspections by a representative from the inspection agency at times determined by the inspection agency. The number of visits shall be specified in each control direction (appendix 1). If required by either the inspection agency, the manufacturer or Statens Planverk, additional sampling and inspections shall be made possible within the scope of this agreement.

The inspection is generally carried out at the place mentioned in appendix 1. However, at the request of the inspection agency the inspections can also be carried out elsewhere, e.g. at a building site or at a wholesaler's.

POSTADRESS
Box 857, S-501 15 BORÅS
Postal address
P.O. Box 857, S-501 15 BORÅS

BESÖKSADRESS
Brinellgatan 4
Office address
Brinellgatan 4

TELEFON
033-16 3000
Telephone
int. + 46 33-16 3000

TELEX
36252 testing S
BANKGIRO
715-1051
Postgiro
15882-8
5.2 EXTENT OF INSPECTION

Inspection visits shall include the following steps:

- Inspection of plant (machinery, organization and working management), raw materials, products and marking.

- Inspection of the marking of the products.

- Inspection of equipment used for measuring and testing according to 4.3 if needed.

- Inspection of records, test reports etc. according to 4.2, and signing of the records.

- Sampling and other checks and measures according to the control directions (appendix 1) for each type approved product.

If the inspection agency finds it necessary to perform particular tests and inspections in addition to what is required by appendix 1, additional samples can be selected and tested by the inspection agency.

5.3 RETESTING

If unsatisfactory test results are obtained, a retest shall be carried out as soon as possible. With permission from the inspection agency, the approved product may, in exceptional cases and for a limited time, be provided with marking in accordance with the type approval certificate while awaiting the results of the retest.

If unsatisfactory results are obtained from the retest, measures according to 3.23 and 3.24 shall be undertaken.

5.4 REPORTING OF THE INSPECTION RESULTS

Following each inspection visit, the inspection agency shall issue a report to be sent to the manufacturer. On demand, or if there are any serious objections according to 3.23, this report shall also be sent to Statens Planverk.
COSTS

All costs for the works control and supervisory control (including all the tests) according to this agreement shall be defrayed by the manufacturer.

PERIOD OF AGREEMENT'S VALIDITY

The agreement shall be in force beginning on 

Cancellation shall be done in writing at least four months before the end of the calendar year and can be done either by the inspection agency or by the manufacturer. If the agreement is not cancelled, it shall automatically be extended by one year at a time. The inspection agency shall inform Statens Planverk of the date when this agreement is terminated.

This agreement is automatically cancelled if the type approvals in question are withdrawn by Statens Planverk.

This agreement has been drawn up and signed in two copies, one for the inspection agency and the other for the manufacturer. It is the responsibility of the inspection agency to send one copy of the agreement and appendix 1 to Statens Planverk. It is the responsibility of the manufacturer to give one copy of the agreement and appendix 1 to the person appointed by the manufacturer to be responsible for their supervision and direction. This applies also to all revisions of the agreement or appendix 1.

Borås

STATENS PROVÑNINGSANSTALT
Building Technology

(When referring to this agreement, the date on which the inspection agency has signed this agreement shall be mentioned).
CONTROL INSTRUCTIONS

These control instructions complete the production control agreement.

Type of product Structural finger joints
Approval XXXX/XX
Company XXXXXXX XXXXXX XXXX
Contact person XXXXXX
Production set up XXXX
Joint orientation Finger visible on the edge (flatside).
Curing High frequency pre-heating
Pre-licence inspection report STFI or SP.
Production control According to SBN Approval rules 1975:7 (Finger-jointed timber used for construction - Production and control).

k-value according to part 3.1.4 in the Approval rules.

<table>
<thead>
<tr>
<th>Profile 1xpxt</th>
<th>Stress grade</th>
<th>k-value</th>
<th>Required bending strength (MPa)</th>
<th>Maximum size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20x6,2x1,0</td>
<td>T24,T18,Ö</td>
<td>1,0</td>
<td>24,0</td>
<td>75x225</td>
</tr>
<tr>
<td>32x6,2x0,5</td>
<td>T30</td>
<td>1,0</td>
<td>30,0</td>
<td>50x200</td>
</tr>
</tbody>
</table>

Supervision According to SBN Approval rules 1975:7

Borås XXXXXX

Swedish National Testing Institute XXXXXXXXXXXXXXXXXX
### Information is given by

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Marking</th>
<th>Comments</th>
<th>Validity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Derome Träteknik AB, 430 20 VEDDIGE</td>
<td>Finger jointed structural timber shall be marked with the name of the company, strength class, time code for the gluing (year and week) and the Statens planverk control mark.</td>
<td>Upon request this approval will be sent to the local building authority.</td>
<td>The approval is valid until 31 March 1991.</td>
</tr>
</tbody>
</table>
### Comparison Between the ECE-Standard and the Swedish Approval Rules No 1975:7

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scope</strong></td>
<td></td>
</tr>
<tr>
<td>Fingerjoints in structural coniferous sawn timber of the ECE visual stress grades S10, S8, and S6</td>
<td>Fingerjoints in structural coniferous sawn timber of the Swedish visual grades T30, T24, T18 and machine stress grades T50M, T24M and T18M.</td>
</tr>
<tr>
<td><strong>Manufacturing Requirements</strong></td>
<td><strong>Manufacturing Requirements</strong></td>
</tr>
<tr>
<td><strong>Timber</strong></td>
<td></td>
</tr>
<tr>
<td>Moisture content 8-18 %. For some adhesives the upper limit can be extended to 23 %. Difference between two pieces should not exceed 6 %.</td>
<td>Moisture content 8-18 %. For some adhesives the upper limit can be extended to 23 %. Difference between two pieces should not exceed 7 %.</td>
</tr>
<tr>
<td>At assembly temp of timber should be ≤ 15 °C.</td>
<td>The timber shall be graded prior, to or in connection with the finger-jointing procedure.</td>
</tr>
<tr>
<td><strong>Machinery and tools</strong></td>
<td><strong>Machinery and tools</strong></td>
</tr>
<tr>
<td>To be maintained in good condition and operated according to the manufacturers instructions.</td>
<td>Cutting tools shall have such sharpness and be adjusted in such a way that the fingers fit well allowing a gap between tips and apposing roots.</td>
</tr>
<tr>
<td>Cutting tools should be sharpened as necessary to ensure clean cutting of the required profile.</td>
<td>Glue application equipment must provide an evenly distributed and covering layer of glue.</td>
</tr>
<tr>
<td></td>
<td>The glue application equipment should be designed so that it can contain the quantity of glue appropriate to the gluing time.</td>
</tr>
<tr>
<td></td>
<td>The press must be in such a state that an evenly distributed and adjustable pressure can be achieved. The pressure must not deviate more than 20 % from the nominal value. The presstables must have adjustable heating.</td>
</tr>
</tbody>
</table>
Premises

When pre-heating of timber ends is not to be employed the timber storage and manufacturing premises shall normally have a temperature of at least 15 °C and a relative humidity greater than 30 %. In this case the temperature and humidity must be controlled regularly.

There must be a special room for the mixing of glue and hardener (the glue department).

Knots and fissures

Within the joint itself no knots or fissures are allowed.

Elsewhere, knots not greater than 5 mm may be disregarded.

Otherwise, the distance between the knot and the end of the cross-cut timber should not be less than 8 + 3d

The timber must be cross cut to exclude grain disturbance within a zone of 130 mm from the end of the timber. In this length knots must not occur closer to the finger roots than a distance equal to three times the knot diameter, except that knots smaller than 6 mm may occur without restriction.

Where a member is cross-cut to remove a knot, the cut shall be made at a distance from the knot at least equal to its dimension.
ECE-standard

Vane or edge damage

Note: Vane is restricted in the grading rules.

Glue

The glue used should be of a mutually accepted gap-filling and weather and boil proof type.

Assembly

Joints shall be glued as soon as possible and not later than 24 hours after cutting.

Sufficient glue shall be applied to the contact surfaces of the fingers to ensure "squeeze-out" at the joint on all four surfaces when the end pressure is applied.

End pressures of the order of 2 to 5 N/mm² will be sufficient for finger-joints over 25 mm in length whilst for shorter joints and pressures of 5 to 15 N/mm² are necessary. The full end pressure must act on the finger joint for at least two seconds.

The application of end pressure must be adequate to enable the jointed timber to be moved with reasonable care to the curing stage prior to any subsequent machining.

The end pressure should be adjusted within recommended limits to minimize the risk of splitting or compression failure on assembly of the fingers.

Swedish approval rules Document 1975:7

Vane or edge damage

Glue

The glue should fulfill the requirements for outdoor structures i.e. class U and should be approved by the controlling authority.

Assembly

Joints shall normally be glued directly after cutting.

Glue is applied on one - possibly both - ends.

The end pressure shall be adjusted so that close contact between fingers is reached without any splitting at the finger roots.

The hardening conditions shall be adjusted with respect the handling of the timber after pressing.

When pre-heated timber ends or HF-hardening is used the timber can normally be planed about 10 min after pressing in other cases hardening at about 20 ºC for several hours is required.
ECE-standard

SPACING OF JOINTS

The distance between the centres of any two adjacent finger-joints in a piece of timber shall be not less than 0,6 m.

MARKING

Each piece of finger-jointed stress graded timber shall have the following information clearly and indelibly marked on one face:

a) Information whereby the company and the person responsible for the finger-jointing and grading may be identified.

b) The grade of the piece as well as the species, the species group or the strength class where applicable.

c) The letter F placed before the grade mark.

d) The controlling authority where applicable.

INITIAL DETERMINATION OF JOINT STRENGTH

General

Specimens must be tested for bending strength in at least two representative cross-sections. One of the two cross-sections must be equal to the maximum for which the manufacturer is seeking approval.

Swedish approval rules Document 1975:7

SPACING OF JOINTS

MARKING

Finger-jointed stress-graded timber shall be marked in a durable manner on one of the faces near a joint or continuously with not more than 1,5 m between marks. The marking shall have the following information:

a) Name of the manufacturer.

b) Stress grade

c) The Swedish approval mark

d) Time code giving information about when the joints were assembled.

INITIAL DETERMINATION OF JOINT STRENGTH

General

At least two timber dimensions should be jointed and tested for example the largest and smallest cross-section of timber for which the joint approval is to be valid.
ECE-standard

Swedish approval rules Document 1975:7

Sampling

30 specimens in each cross-section 15 edgewise and 15 flatwise.

For European redwood and whitewood the density should not exceed 480 kg/m³ based on dry mass and volume.

The specimens shall be conditioned at 20-25 °C and 65-75 % relative humidity.

Method of test

Four point loading

Failure within 3-7 minutes.

Record for each specimen:

- maximum load
- type of failure
- time to failure
- moisture content
- density

Sampling

30 specimens in each cross-section 15 edgewise and 15 flatwise.

The specimens shall conditioned to equilibrium moisture content at 20 °C and 80 % relative humidity.

Method of test

Four point loading.

Increase in strain must not exceed 0,003/min.
Test results

The following data shall be calculated and presented in addition to the results above:

a) The mean, m (f_m), and standard deviation s (f_m) of the bending strength value (f).

b) The characteristic bending strength, f_k, defined as the lower 5% exclusion value estimated at the 75% confidence level

\[ f_k = m(f_m) - t \cdot s(f_m) \]

Joints are classified on the basis of the results of the edgewise bending tests.

If the characteristic strength is based on depth of 200 mm, then the adjustment is achieved if the test results are multiplied by the factor k_d in the table below.

![Diagram of a joint](image)

ROUTINE QUALITY CONTROL

General

Adequate quality control system including a qualified independent inspector, availability of testing devices and recording of vital production data is required.

Number of specimens

At least three joints per shift.

Swedish approval rules Document 1975:7

Test results

Evaluation of the test results shall be made according to Swedish approval rules 1975:4.

A characteristic strength value \( \sigma_k \) (lower 5% exclusion value at 75% confidence level) is to be calculated.

The requirement is that \( \sigma_k \) should be greater than or equal to 3 x the allowable stress according to the Swedish Building Code.

![Diagram of a joint](image)

ROUTINE QUALITY CONTROL

General

Quality control has to be carried out as internal quality control and as external supervision.

A special person has to be appointed as responsible for manufacture and internal quality control.

Number of specimens

Three joints per shift from each production line.
**Sampling and preparation of test specimens**

Draw specimens at random from the production batch.

Test specimens not covering the full cross-section of the jointed timber are allowed.

Testing shall take place within 24 hours of manufacture. The surface finish of the specimens at test shall generally be the same as that of the jointed timber normally supplied by the manufacturer.

**Method of test**

Flatwise or edgewise bending.

---

**Swedish approval rules Document 1975:7**

**Sampling and preparation of test specimens**

The specimens shall be stored together with the rest of the jointed timber until they are tested.

The test samples may be tested in two equally wide parts. The strength of the sample is then determined by combining the widths and failure loads.

**Method of test**

Flatwise bending.

---

**Test results**

Record maximum load and the type of failure.

Where the failure of a jointed specimen is associated with a defect in the timber, then the test value for this specimen can be included in the evaluation provided the stated performance requirements, are met, otherwise a further specimen from the same shift shall be tested.

The tested specimens shall be marked with the date of testing.

The test pieces shall be kept for 5 days in case an external inspection takes place.

**Test results**

Bending strength.

Values when failure did not occur in the joint, may be disregarded.
ECE-standard

Swedish approval rules Document 1975:7

Acceptance requirements

The shift's production is acceptable if one of the following conditions is met:

a) \( f_m \geq k_f f_k \)
b) \( f_k = m(f_m) - 2s(f_m) \geq k_f f_k \)

where

- \( f_k \) = characteristic strength of the relevant stress grade
- \( f_m \) = bending strength
- \( f_k \) = characteristic bending strength (lower 5% exclusion limit)
- \( m() \) = mean value
- \( s() \) = standard deviation
- \( k_f \) = largest between flatwise and edgewise characteristic bending strength obtained for different cross-sections tested.
- \( k_d \) = depth correction factor

Table 1 - Depth correction factors for coniferous timber

<table>
<thead>
<tr>
<th>Depth of specimen</th>
<th>Depth factor ( k_d )</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 75</td>
<td>0.87</td>
</tr>
<tr>
<td>100</td>
<td>0.69</td>
</tr>
<tr>
<td>125</td>
<td>0.92</td>
</tr>
<tr>
<td>150</td>
<td>0.94</td>
</tr>
<tr>
<td>175</td>
<td>0.98</td>
</tr>
<tr>
<td>200</td>
<td>1.00</td>
</tr>
<tr>
<td>225</td>
<td>1.02</td>
</tr>
<tr>
<td>250</td>
<td>1.05</td>
</tr>
<tr>
<td>300</td>
<td>1.10</td>
</tr>
</tbody>
</table>

Interpolate for intermediate sizes

Acceptance requirements

The joint strength can be regarded as acceptable if the test results from at least 15 subsequent tests fulfill one of the following requirements.

a) \( \sigma \geq k \sigma_k \)
b) \( \sigma_{ber} = \sigma_m - 2\sigma \geq k \sigma_k \)

where

- \( \sigma \) = \( f_m \)
- \( \sigma_k \) = \( f_k \)
- \( \sigma_{ber} \) = \( f_k \)
- \( \sigma_m \) = \( m(f_m) \)
- \( s \) = \( s(f_m) \)

\( k \) is a factor determined by testing so that the bending-, tensile- and compression strength are sufficient when the above requirement a and b are fulfilled. The value of \( k \) is normally 1.1.3.
Recording

The manufacture of the finger-joints must be exactly recorded (glue book, gluing day, glue formula, timber dimensions, timber quality, gluing supervisor). Manufacturing records shall be retained for inspection by the controlling authority for at least five years.

Other tests and measurements

Before jointing the moisture content of at least 2% of the timber in each batch shall be measured.

When preheating is used the temperature at a distance of 30 to 40 mm from the end of the timber shall be measured. The temperature must be greater than 80 °C.
MONTHLY STATISTICS 1983-07--1985-06

Joint configuration

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Details</th>
<th>Appendix</th>
</tr>
</thead>
<tbody>
<tr>
<td>20x6,2x1,0</td>
<td>visible on the edge</td>
<td>7.2</td>
</tr>
<tr>
<td>32x6,2x0,5</td>
<td>&quot;-&quot;</td>
<td>7.8</td>
</tr>
<tr>
<td>10x3,7x0,6</td>
<td>visible on the face</td>
<td>7.9</td>
</tr>
<tr>
<td>15x3,8x0,3</td>
<td>&quot;-&quot;</td>
<td>7.11</td>
</tr>
<tr>
<td>20x6,2x1,0</td>
<td>&quot;-&quot;</td>
<td>7.12</td>
</tr>
<tr>
<td>7,5x2,5x0,6</td>
<td>&quot;-&quot;</td>
<td>7.13</td>
</tr>
<tr>
<td>50x12x1,7</td>
<td>&quot;-&quot;</td>
<td>7.14</td>
</tr>
</tbody>
</table>
Joint configuration: 20x6,2x1,0 visible on the edge

MANUFACTURER 0035
MONTHLY STATISTICS 1983-07 - 1985-06

Mean value
..... 5-percentile value
- - - Required value
Joint configuration: 20x6,2x1.0 visible on the edge

Mean value
..... 5-percentile value
- - Required value
Joint configuration: 20x6, 2x1.0 visible on the edge

---

Mean value

. . . . 5-percentile value

- - - Required value
Joint configuration: 20x6, 2x1, 0 visible on the edge

MANUFACTURER 0045
MONTHLY STATISTICS 1983-07 - 1985-06

MANUFACTURER 0049
MONTHLY STATISTICS 1983-07 - 1985-06

MANUFACTURER 0052
MONTHLY STATISTICS 1983-07 - 1985-06

Mean value

5-percentile value

Required value
Joint configuration: 20x6.2x1.0 visible on the edge

**Mean value**

**5-percentile value**

**Required value**
Joint configuration: 20x6,2x1,0 visible on the edge

Mean value
....... 5-percentile value
- - - Required value
Joint configuration: 32x6,2x0,5 visible on the edge

Mean value
..... 5-percentile value
--- Required value
Joint configuration: 10x3.7x0.6 visible on the face

---

Mean value

--- 5-percentile value

- Required value
Joint configuration: 10x3.7x0.6 visible on the face

Mean value

5-percentile value

Required value
Joint configuration: 15x3,8x0,3 visible on the face

Mean value
.... 5-percentile value
--- Required value
Joint configuration: 20x6.2x1.0 visible on the face

---

Mean value
..... 5-percentile value
- - - Required value
Joint configuration: 7.5x2.5x0.6 visible on the face

Mean value

5-percentile value

Required value
Joint configuration: 50x12x1.7 visible on the edge

Mean value

..... 5-percentile value

- - - Required value