Client Report :

Desktop study for benchmarking experimental cladding designs

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Executive Summary

This Client Report presents the criteria necessary for encouraging the use of Sitka spruce within the UK timber cladding market. This has been undertaken within a project funded jointly by the Forestry Commission and Scottish Enterprise entitled “UK grown Sitka spruce for high-performance cladding”. It represents milestone 2 due 29th February 2004. The Forestry Commission funding was through agreement PPD17/02.

The aim of this report is to provide guidance on the optimal techniques for cladding construction using Sitka spruce, and is intended as a continuation of work within this project from the Scoping Study (BRE report 211-547) already submitted to the client. This will be used in conjunction with benchmarking performance work to be completed within this project. In addition, further consideration will be given to durability enhancement and suitable coating systems and reported at the given time.

Contents

1 Introduction

This project is part of a project being carried out for the Forestry Commission and Scottish Enterprises entitled “UK grown Sitka spruce for high-performance cladding.

Wood for cladding is seen as a promising market for timber that has yet to reach its full potential. This is due to such factors as timber currently available not being of the desired grade, inefficient treatments, in some cases incorrect design, and most importantly the desire within UK culture for brick facings on buildings. There is a tendency for designers and architects to ignore cladding designs used in Scandinavia and to use imported timbers such as Western red cedar for claddings at present due to their greater durability and desired weathering effects. Much home-grown timber has low durability. In addition, the higher grades of timber are generally used for purposes other than cladding.

Through this desktop evaluation, the current state of the art for cladding is reported, with an emphasis on how this can be applied to Sitka spruce, and the perceived performance in comparison with traditional cladding materials, such as redwood and whitewood (as in Scandinavia) and Western red cedar (as used for more prestigious buildings) . The observations within this report will then be applied and compared to experimental findings within the benchmarking studies to be run within this project

2 Desktop evaluation of Sitka spruce

Before determining the optimum processing requirements for Sitka spruce for use in cladding, it is necessary to ascertain the behaviour of Sitka spruce compared to other timber species more commonly associated with cladding. It is suggested this document is used in conjunction with ‘Timber Cladding in Scotland’ (Davies et al 2002) and the previously reported ‘Scoping Study Report’ (Jones 2003).

2.1 Assessment of alternative timber species

2.1.1 Introduction

Whilst there has been little work reported on the use of Sitka spruce for cladding, there is extensive use of whitewood and redwood in Scandinavia for cladding systems. A publication on claddings in Sweden (STC 1975) suggested that whitewood was currently the more favoured of the two materials. For cladding in Scandinavia, the lower quality of unsorted timber is often used (i.e. III or IV quality). However lower grades are also often used. The timber usually has a sawn surface finish, as this is better for coating adhesion. The use of planed surfaces are better suited to shedding water.

Whitewood is more resistant to pressure treatment with preservatives. As a result it is more common for redwood to have a higher price (due to the extra treatment). However, this resistance to treatment is due to reduced moisture uptake, which would suggest that whitewood is also more resistant to water uptake. Whitewood also has lower amounts of resin, so that resin exudation is less likely to be a problem.

Recently, BRE conducted a project, funded by DTI, to benchmark home-grown Douglas fir and larch against Western red cedar (Holland 2002), which is regarded as the traditional external cladding timber. The benchmarking was carried out by comparative testing of the major or important properties that make Western red cedar such a suitable timber for external cladding work.

The comparative testing generated data on the performance of the British grown timbers for direct comparison with Western red cedar. Such data will be important in overcoming the obstacles to the adoption of home-grown Douglas fir and larch for external cladding.

The findings in this work can be compared to the known properties of Sitka spruce, to provide a performance indication.

2.1.2 Dimensional stability / movement

The role of cladding, whilst superficially undemanding, will result in the extremes of environmental conditions being placed on the cladding material. During the summer months, south facing timber cladding would be expected to have a moisture content of around 10%. This may vary markedly throughout the cross-section from a surface moisture content of around 5% to 15% at the centre. This moisture variation sets up shrinkage stresses within the timber, opening surface checks and fixed joints. Whilst in the winter months with high rainfall the timber may on occasion be in excess of 20% moisture content, causing closing of joints and compressive stresses within the timber and fixings. Therefore, seasonal cyclic movement can over time have a long-term effect on the performance of the cladding.

Normally, timber species of known low movement are preferred for cladding due to these fluctuations in moisture content. The following represent findings from the DTI study, and how Sitka spruce may be compared to these.

From commencement of exposure of DTI project to week twenty-nine

At the start of the exposure the joints quickly opened although the initial moisture content of the wood was low. This situation remained unchanged throughout the summer and early autumn months even though there had been periods of heavy rain. At the onset of winter the Tongue and Groove (T&G) joints started to close and as the winter proceeded they closed fully as a result of rain and heavy seasonal morning and evening dew.

For the overlapped panels no visible signs of movement have been noted over the same time span for the T&G cladding; in fact movement had taken place but it was not noticeable.

Dimensional movement measurements were taken on three T&G panels and three overlapped panels, one of each species per cladding type. The measurements were taken at fixing positions across the abutment of the joints for T&G cladding, and at the point of overlap for the lapped cladding.

Figure 1 shows the dimensional movement for the T&G cladding plotted against the duration of exposure for the first twenty-nine weeks. The zero base line was the condition of the panels at installation. Through the early summer the joints opened and it is at this time when most of the water ingress may have taken place due to summer rain whilst the joints where open. As the weather changed the joints closed and the tight abutment of the two halves of the joint may have restricted the movement that resulted.

It can be seen from Figure 1 that all three timbers have a very similar performance, with no single timber appearing to be significantly better or worse than the others at this stage of the exposure.

The overlapped cladding has performed in a similar manner to the T&G cladding but it is less restricted in the total movement that can take place. Therefore, greater winter movement is shown (see figure 2). The timbers have followed a similar seasonal movement to that of the T&G panels, which is to be expected.

The movement that takes place within the overlapped panels is less obvious than with the T&G panels as the joints open and close with seasonal conditions. However, the use of a surface treatment such as paint or stain on overlapped cladding might draw attention to the movement by failures of the paint film at the joints.

Figure 1. Dimensional movement for the three timber species - T&G panels exposure from week) to week 29.

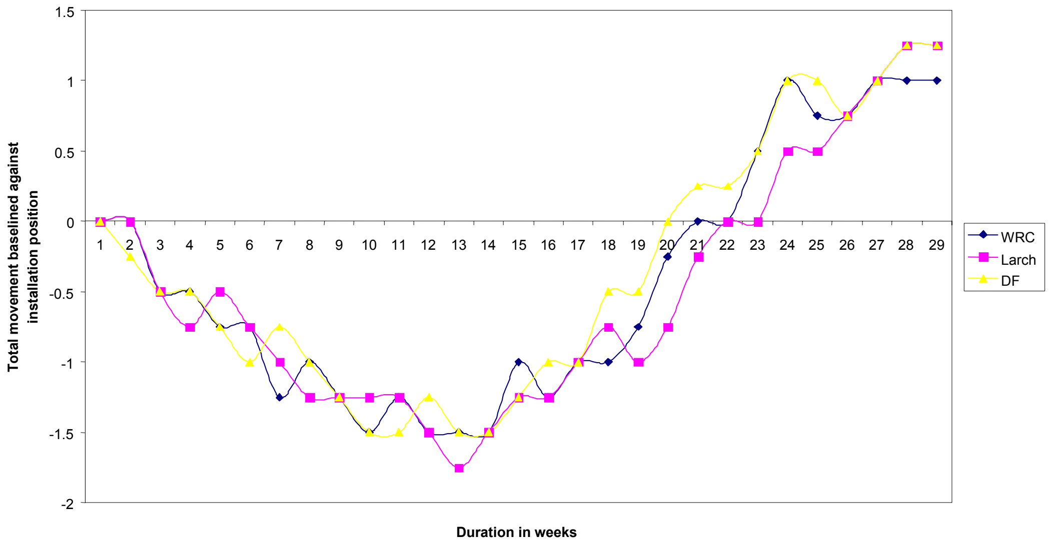
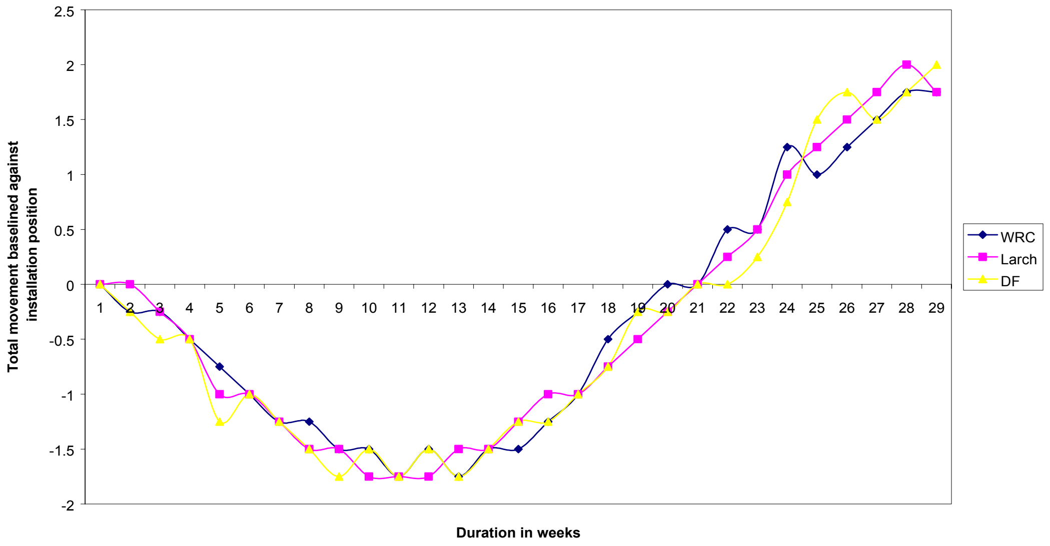


Figure 2. Dimensional movement for the three timber species - overlapped panels



7 Benchmarking cladding designs

From week twenty-nine to week fifty-two of the DTI project

Up to week twenty-nine, the performance of the three timber species had been remarkably similar, with no one species being better of worse than the others. The exposure since week twenty-nine has started to show a divergence of performance particularly between Western red cedar and the other two timbers. This divergence of performance has been noted for both types of cladding construction, T&G and overlapped and is shown in figures 3 and 4 respectively.

Western red cedar has shown an apparent smaller total movement characteristic and a slower response time to environmental changes than either Douglas fir or larch. This may not be entirely due to dimensional changes resulting in timber shrinkage as is being measured in these exposure trials. Both Douglas fir and larch T&G boards have started to show cupping that exaggerates the apparent shrinkage of the boards and emphasises the gap at the board joints. This effect has been compounded as the thin sections of timber that constitute the groves started to curl as they rapidly dried in the unusually dry spring. This curling makes the joints gape and look more distressed than the Western red cedar. The overlapped cladding panels have also started to cup but less obviously as one board rides above the other showing no apparent signs of the movement. These factors may explain why figures 3 (T&G panels) and 4 (overlapped panels) show a greater and faster response by Douglas fir and larch than western red cedar for the period from week twenty-nine until week fifty-two.

By week fifty-two there is a clear visual difference in performance between Western red cedar and Douglas fir and larch. However, this does not mean that the performance as a weather proofing material has been diminished.

Figure 3. Total dimensional movement to week 52 - T&G panels

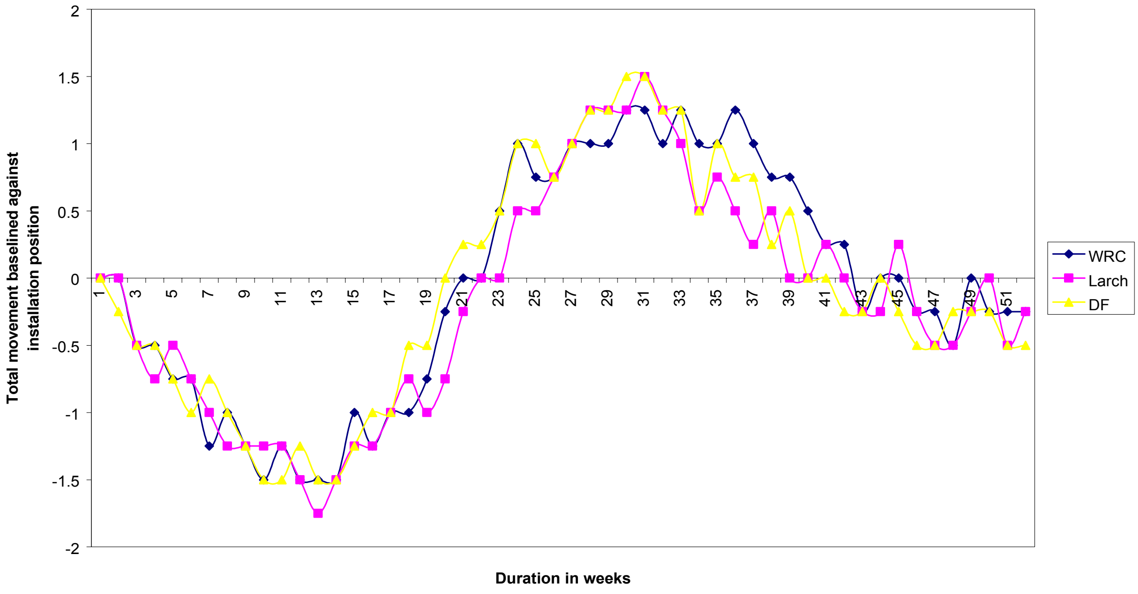
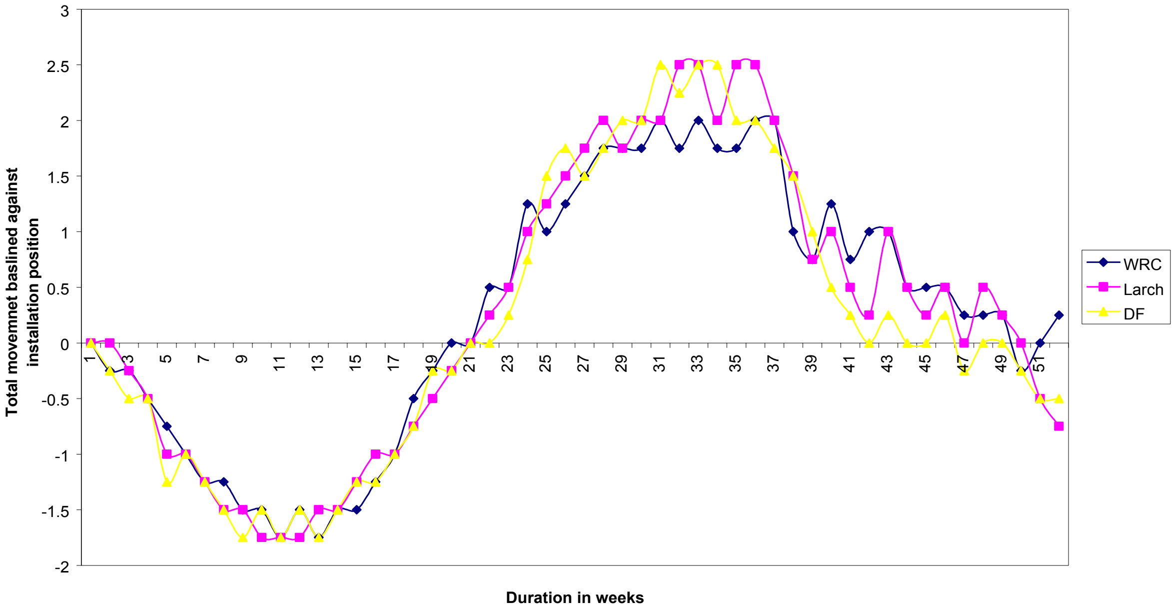


Figure 4. Total dimensional movement to 52 weeks - overlapped panels



From week fifty-two to week seventy-seven and completion of the DTI project

The major feature of the dimensional movement over the period from week fifty-two to week seventy-seven has been the slower response time, in general, for the Western red cedar compared to the Douglas fir and larch. Over this period the Douglas fir and larch have both shown a greater total dimensional movement than the western red cedar.

Figure 5 and figure 6 show the total dimensional movement for the whole exposure period for the T&G and overlapped panels respectively. The T&G panels showed a much slower response time as the winter period turned into the spring and summer compared to the overlapped panels that showed a steady and regular change with the change of the seasons.

What has become apparent as the exposure time increases is slightly lower total dimensional movement shown by the Western red cedar compared to that for the Douglas fir and larch. Douglas fir and larch have on the whole shown a similar degree of total movement.

Figure 5. Total dimensional movement to week 77 for the T&G panels

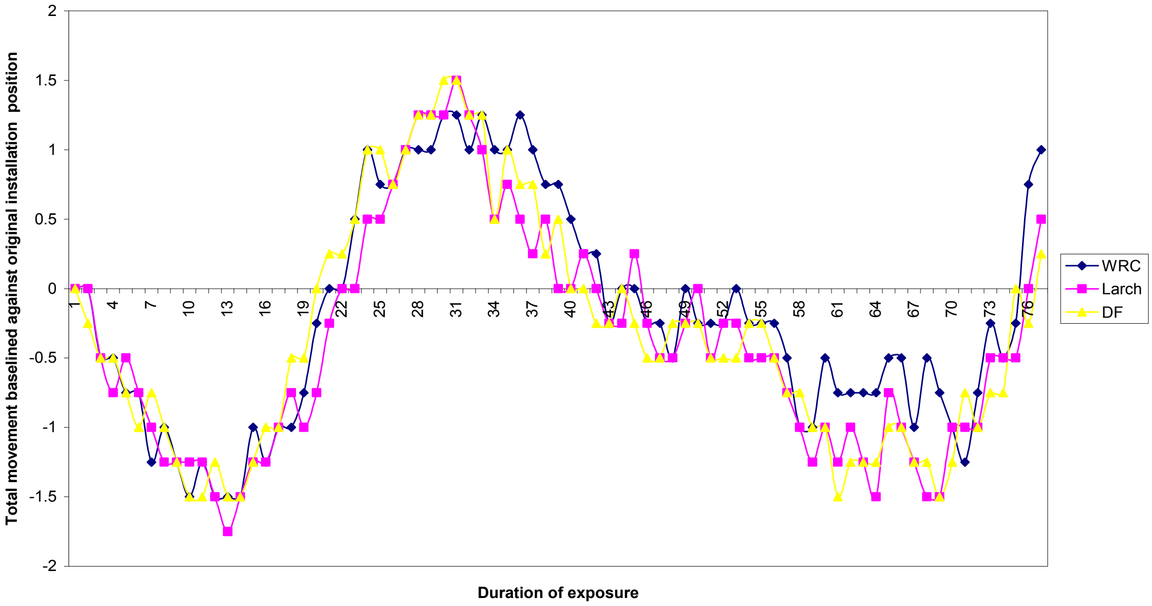
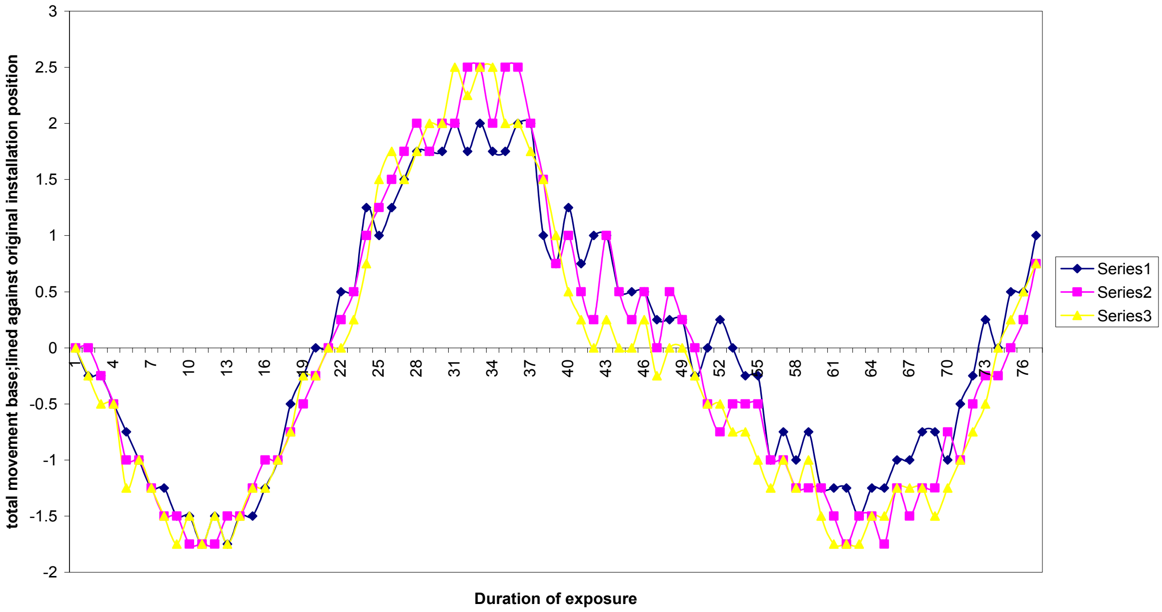


Figure 6. Total dimensional movement to week 77 for the overlapped panels



A key publication by BRE covers the movement of different timber species (Anon 1969). A specifically designed method was used to determine the movement of a given timber, which may be described as follows:

Not less than six, and generally considerably more, quarter-sawn and plain-sawn representative samples of good quality material are employed for determining the radial and tangential movements of each species. These are prepared from wood first seasoned to a moisture content of less than 15 per cent. Each sample is planed to a thickness of 6 mm and cut to a length of 50 mm. The width along or normal to the growth rings is of the order of 150 – 225 mm.

All samples are first conditioned in air at 25°C and 90% relative humidity until they attain constant weight. The width of each across the grain is then accurately measured, either on both faces by means of a flexible steel rule with vernier scale measuring to 0.1 mm, or by means of a jig and suitable dial gauge. Next they are conditioned in air at 25°C and 60% humidity and again measured as before. The difference between the two measurements is finally computed as a percentage of the width in the 60% humidity conditions. After the final measurement is made, each sample is oven-dried so that the moisture values attained in each environment may be estimated from the recorded weights.

The results from the DTI study reported earlier showed that whilst all three timber species considered (Western red cedar, Douglas fir and larch) had a similar dimensional movement for the first six months differences did start to develop and for both cladding types Western red cedar has an overall lower dimensional movement than Douglas fir or larch.

This was particularly obvious for the T&G panels where the dimensional movement could be seen over of the eighteen months exposure period. The Western red cedar panels looked less distressed during the summer months than either the Douglas fir or the larch as the joints in these two timbers tended to gape. While this may not have affected performance, the overall effect was unsightly compared to that of the Western red cedar.

Douglas fir and larch showed similar dimensional movements for the T&G panels and the overlapped panels over the course of the exposure and their overall performance was similar.

The overlapped panels did not show dimensional movement in as marked a manner as the T&G panels. Without careful measurement it was difficult to tell that the overlapped panels were responding to the changing climatic conditions. However, these were untreated panels with a natural finish; if they had been stained or painted then the movement may have been more obvious as discontinuities in the surface coating near the bottom of the overlap. There was far greater similarity in performance of all three timbers for the overlapped panels compared to the T&G panels. Unless suitable detailing can be introduced into T&G cladding that accommodates the movement of the Douglas fir and larch then the overlapped style of panel seems a preferable construction method for these two timbers.

The results quoted within this document provided movement as a percentage. For example a movement of 2.5% referred to a movement of 25mm per metre of timber.

Literature results that are of interest for this evaluation of Sitka spruce are given in Table 1 below.

Timber species (English)	Timber species (Latin)	Tangential movement (%)	Radial movement (%)
Western red cedar	*Thuja plicata*	0.9	0.45
Western red cedar (UK grown)	*Thuja plicata*	1.9	0.8
Douglas fir (UK grown)	*Pseudotsuga menziesii*	1.5	1.2
European larch	*Larix decidua*	1.7	0.8
Scots Pine	*Pinus sylvestris*	2.1	0.9
Sitka spruce (UK grown)	***Picea sitchensis***	**1.3**	**0.9**

Table 1: Overview of movement data for selected timber species (Anon 1969)

From Table 1, it may be seen that home-grown Sitka spruce has a movement between that of imported Western red cedar and Douglas fir / larch. However UK grown Sitka spruce has a better tangential movement compared to home-grown Western red cedar. This would suggest that Sitka spruce is more suitable for use in cladding designs than home-grown Western red cedar, though the actual profile of cladding selected will need to be considered, in order to minimise shrinkage gaps.

2.1.3 Natural durability

Western red cedar's main attraction for use as a cladding system is its natural durability resulting in a long service life without the need to add chemical preservatives, though this only applies to the heartwood. However, this high durability is related to ‘old-growth’ timber from virgin forests, and lower durability levels have been noted from younger trees and plantations. This has been linked to reduced levels of thujaplicins in the wood. Most timber species have a degree of natural durability, although not necessarily to the same extent as imported Western red cedar. Comparison of durability using field trials is a slow process, requiring (in some cases) several years to gain a meaningful result. However, accelerated testing can be carried out in the laboratory, these tests following protocol indicated within EN113 (1997).

The durability of timber species is covered within EN350 parts 1 and 2 (1994). Part One ('Guide to the principles of testing and classification of the natural durability of wood') provides the necessary information for setting up evaluation testing, with the classifications dependent on a mass loss ratio (when tested according to EN113). These classes are listed in Table 2.

Durability class	**Description**	**Results of laboratory tests following EN113 expressed as x ***
1	Very durable	x ≤ 0.15
2	Durable	x > 0.15 but ≤ 0.30
3	Moderately durable	x > 0.30 but ≤ 0.60
4	Slightly durable	x > 0.60 but ≤ 0.90
5	Not durable	x > 0.90
* Value x = average corrected mass loss of test specimens divided by the average lass loss of reference specimens		

Table 2: Classes of natural durability of wood to fungal attack using laboratory tests based on EN 113, as indicated within EN 350-1 (1994).

EN 350 Part Two ('Guide to natural durability and treatability of selected wood species for importance in Europe') gives a fairly comprehensive overview of the natural durability of timber species along with their ease of treatability. Table 3 lists the natural durability of timber species already mentioned within this report.

Timber species (English)	Timber species (Latin)	Natural durability
Western red cedar	*Thuja plicata*	2
Western red cedar (UK grown)	*Thuja plicata*	3
Douglas fir (UK grown)	*Pseudotsuga menziesii*	3-4
European larch	*Larix decidua*	3-4
Scots Pine	*Pinus sylvestris*	3-4
Sitka spruce (UK grown)	***Picea sitchensis***	**4-5**

Table 3: Natural durability as listed within EN 350 Part 2 data for selected timber species.

It can be seen from Table 3 that Sitka spruce has a relatively poor natural durability, though BRE report 211-547 (Jones 2003) indicated within section 4.5 that Sitka spruce was durability class 4, as indicated within the Handbook of Softwoods (Henderson 1956).

BRE report 211-547 also drew attention to the relationship between hazard class and durability class, as listed within EN460 (1994). This relationship is shown once again in Table 4.

Durability class Hazard class	**1** very durable	**2** durable	**3** moderately durable	**4** slightly durable	5 not durable
1 Above ground and covered (dry)	🟥	🟥	🟥	🟥	🟥
2 Above ground covered (risk of wetting)	🟥	🟥	🟥	🟪	🟪
3 Above ground, not covered (periods of wetting)	🟥	🟥	🟪	🟨	🟨
4 In contact with ground or fresh water	🟥	🟪	🟩	🟫	🟫
5 In salt water	🟥	🟩	🟩	🟫	🟫

Where:

🟥	In these conditions natural durability is always sufficient and there is no requirement for preservative treatment
🟪	Natural durability is normally sufficient in these conditions, but for certain uses where condensation may be severe, preservative treatment is advised
🟨	Natural durability may be sufficient in these conditions, but depending on the wood species, its permeability and end use, preservative may be needed
🟩	Preservative treatment is normally advised in these conditions but natural durability may be sufficient in some cases
🟫	Preservative treatment is always necessary in these conditions

Table 4: Relationship between hazard class and durability class, according to EN460 (1994).

Timber cladding is an example of a hazard class 3 use, so it would appear that Sitka spruce may not be suitable for such use, unless it has been preservative treated. The use of a durability class 4 material (untreated) within a hazard class 3 situation should provide a maximum of 15 years service life. This compares to Western red cedar imported from Canada, which with its higher natural durability, would have an expected service life of 60 years.

2.1.4 Treatability

Should it be desired to treat a timber prior to use, it would be necessary to ascertain the relative ease with which that species may be treated. EN350 Part 2 deals with this issue, providing treatability data for a variety of timber species. The treatability is determined as the relative ease that a given species may be penetrated by a liquid, such as a wood preservative. According to EN350 Part 2 (1994), there are four classifications for the treatability of timber, and these are listed in Table 5.

Treatability class	**Description ***	**Explanation**
1	Easy to treat	Easy to treat; sawn timber can be penetrated completely by pressure treatment without difficulty.
2	Moderately easy to treat	Fairly easy to treat; usually complete penetration is not possible, but after 2 h or 3 hr by pressure treatment, more than 6mm lateral penetration can be reached in softwoods and in hardwoods a large proportion of the vessels with be penetrated.
3	Difficult to treat	Difficult to treat; 3h to 4h by pressure treatment may not result in more than 3mm to 6mm lateral penetration.
4	Extremely difficult to treat	Virtually impervious to treatment; little preservative absorbed even after 3h to 4h by pressure treatment; both lateral and longitudinal penetration minimal.
* Historically treatability data may use other descriptive terms which approximate to the treatability classes as follows: class 1 permeable class 2 moderately resistant class 3 resistant class 4 extremely resistant		

Table 5: Classification of the treatability of wood, according to EN350 Part 2 (1994).

For the timber species that have been considered within this report, the treatability data are listed within Table 6.

Timber species (English)	Timber species (Latin)	Heartwood treatability	Sapwood treatability
Western red cedar	*Thuja plicata*	3-4	3
Western red cedar (UK grown)	*Thuja plicata*	3-4	3
Douglas fir (UK grown)	*Pseudotsuga menziesii*	4	2-3
European larch	*Larix decidua*	4	2
Scots Pine	*Pinus sylvestris*	3-4	1
Sitka spruce (UK grown)	***Picea sitchensis***	**3**	**2-3**

Table 6: Treatability data for various timber species, as listed within EN350 Part 2.

It can be seen from Table 6 that Sitka spruce is relatively difficult to treat due to its refractory nature. The reason for the refractory nature of such timber species is the irreversible aspiration of the pit membranes on drying the timber.

There are guidances within EN351-1 (1996) on the degree of penetration required for timber along with the retention of the preservative within the wood, depending on the type of preservative used. Thus there are different penetration classes for:

A. CCA type preservative treatments
B. Creosote type treatments
C. Organic solvent based preservatives
D. Boron based aqueous preservatives applied to dry timber
E. Boron based preservatives applied by diffusion to green timber
F. Preservatives that have recognised critical values according to EN599-1 (1997).

For Sitka spruce (an example of a resistant or difficult to treat timber species), there are different penetration classes, and these are listed in Table 7:

Treatment (as listed above)	**Penetration class req. for 15 years service life**	**Penetration class req. for 30 years service life**	**Penetration class req. for 60 years service life**
A	P2	P4	P5
B	P4	P6	P8
C	P2	P2	No rec.
D	P8	P8	No rec.
E	P2	P2	No rec.
F	P2	P2	P5

Where:

P2	Minimum 3mm lateral and 40mm axial penetration into sapwood
P4	Minimum 6mm lateral penetration into sapwood
P5	Minimum 6mm lateral and 50mm axial penetration into sapwood
P6	Minimum 12mm lateral penetration into sapwood
P8	Full sapwood penetration

Table 7: Some penetration classes for possible preservative treatments.

Thus, depending on the selected preservative treatment, different treatment regimes will be required to reach the desired service life for Sitka spruce when used as cladding.

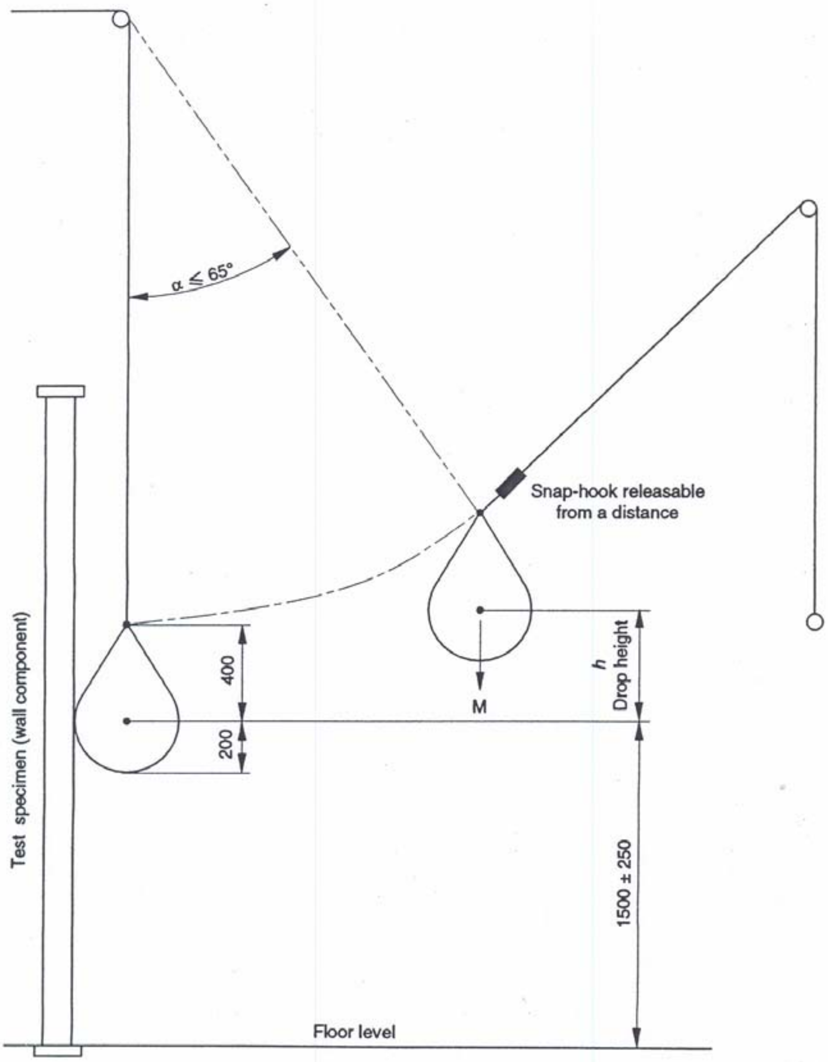
2.1.5 Mechanical properties

The mechanical properties of the timber can have a bearing on the long-term performance of the cladding. Cladding near ground level will need good mechanical properties to accommodate the wear and tear of daily life. Accidental collisions and impacts will require a high degree of toughness and resilience for the timber to remain in good service condition. Hence, the comparative testing of material properties to establish a benchmark standard for the material. The recognised method of testing for cladding is incorporated within EN596 (1995). This method involves the testing of a panel at its predicted weakest point, by the impact of a canvas bag from an angle not greater than 65°. The typical test configuration is shown in Figure 5.

There would be little variation between mechanical properties for Sitka spruce boards of differing strength grades used for cladding. This is due to the low performance requirement of cladding, where the greatest risk of damage is through the equivalent of a body impact as indicated above within EN596. BS4978 (1996) entitled “Visual strength grading of softwood” refers to the strength grades for various timber species, and the relevant classifications for timber to be classed as Special Structural Grade (SS) or General Structural Grade (GS). These are compared to visual grading within BS5268-2 (2002). A summary of timber species considered within this document is given within Table 8:

Timber species (English)	Timber species (Latin)	Strength class equivalent to GS	Strength class equivalent to SS
Western red cedar	*Thuja plicata*	C14	C18
Western red cedar (UK grown)	*Thuja plicata*	n/a	n/a
Douglas fir (UK grown)	*Pseudotsuga menziesii*	C14	C18
European larch	*Larix decidua*	C16	C24
Scots Pine	*Pinus sylvestris*	C14	C22
Sitka spruce (UK grown)	***Picea sitchensis***	**C14**	**C18**

Table 8: Strength classifications for various timber species fulfilling requirements listed within BS4978 (1996)



Sizes in millimetres

Figure 2 — Apparatus for testing soft body impact

Figure 5: Soft body impact test rig

3 Materials to be used

3.1 Sitka spruce

The quality of the Sitka spruce to be used is the most important fact to be considered. The high number of knots within Sitka spruce may present difficulty, though these are usually small. It is important that dead knots are excluded from use in cladding, as these will prove both unsightly and increase the risk of moisture build-up under the cladding rig.

Reference is made within the TRADA publication “External timber cladding” (Hislop 2000) to BS1186 “Timber for and workmanship in joinery” (1988) and more specifically Part 3 “Specification for wood trim”. This standard refers to four grades of timber, namely CSH and classes 1,2, and 3 respectively. These classifications relate to the knot size on the timber, with CSH having knots of sizes 6mm or smaller on its exposed surfaces, and these knots increasing in size with lowering classes. In BS1186-3, there is no specific mention of Sitka spruce as suitable for wood trim (i.e. cladding), though whitewood (Norway spruce) is considered. In order to make some assumptions for the requirements for Sitka spruce, the values quoted for whitewood will be assumed as being equivalent.

According to BS1186-3, whitewood is deemed as being easily worked, having medium dimensional movement, and should only be used as cladding when preservatively treated according to BS 5589 (1989). Knots that are on exposed surfaces that appear to be unsound or dead, but not loose, may be permitted.

Previously, cladding material would be manufactured from Class 3 material. Recent trends have seen improvements in the classes of timber used, as better quality cladding with a longer service life is required by end-users. Thus it is believed that a tendency towards Class 2 or probably Class 1 would be more advantageous.

A recent draft standard for further development entitled “Qualitative classification of softwood round timber – Part 1: Spruces and firs” (DD ENV1927-1 (1999)) attempts to grade timber within one of four classes:

Quality class A – this corresponds to first quality timber. It generally corresponds to a butt log with clear timber, without defects or with only minor defects and with few restrictions in its use.

Quality class B – this refers to timber of average to first quality, with no specific requirements for clear wood. Knots are permitted to such an extent as is considered to be average for each species.

Quality class C – this is timber of average to low quality, allowing all quality characteristics which do not seriously reduce the natural characteristics of the wood.

Quality class D – this is for timber that can be sawn into usable wood, which, because of its characteristics, does not fall into one of the above categories.

Comparison with strength grading rules within BS4978 would suggest that a strength grade of SS is comparable to timber classified between quality classes B and C within DD ENV1927-1. The SS classification is also equivalent to C18 graded timber when applied to Sitka spruce. A lower classification (GS) would be equivalent to Quality class C within DD ENV 1927-1, which would also correspond to C14 graded timber when considering Sitka spruce. These have already been described within Section 2.1.5 and Table 8 therein.

When considering the grading requirements used in Scandinavia as outlined in the Nordic Timber grading rules (1994), a similar system to that used within DD ENV1927-1 is employed, though the quality class A is subdivided into four sections under the Nordic grading rules. Among the classification rules within the Nordic grading rules are:

- Each side of the test piece shall be graded separately.
- The maximum values of wood features which in each grade are permitted in the worst one metre of length are given in the relevant tables.
- The grade is decided on the basis of the outside face and both edges.
- The inside face may be one grade lower.

Falling boards (referred to in the Nordic grading rules as ‘Schaalboards’) fall within the category C listing. Again this refers to conventional application, whereas current trends require higher grades to be used.

It is the viewpoint of BRE that higher than usual grades of Sitka spruce should be used for cladding. This will help eliminate any problems associated with knots and appearance, and to a lesser extent, mechanical properties. However, the preservative treatment of the Sitka spruce may need to be considered, in order to ensure the cladding product has a service life of 30 years (equivalent to a durability class 3 timber species in a hazard class 3 environment).

3.2 Fixings

With some species (for example Western red cedar), there are high levels of extractives that can result in corrosion of fittings. In the case of WRC, the high tannin content can lead to corrosion of ferrous fixings, which will produce a high level of staining in the wood. This is easily overcome through the use of corrosion resistant fixings, such as those manufactured using stainless steel.

Whilst there are far lower levels of extractives with WRC, it would be prudent to maintain the use of the highest quality fittings and fixings for cladding products. This can result in a slight increase in the overall cost of a cladding product, but is easily compensated by fixings that will last and maintain their appearance as long as the timber components used.

A further issue that arises with many timber species is the number of fixings per cladding board. Previously it was common practice to use a double fixing system across each board. Recent trends, especially from countries such as The Netherlands, has suggested that this practice can lead to increased splitting of the boards due to the resistance to shrinkage and swelling due to movement across the board. These problems may be overcome by applying a single fixing on each board width.

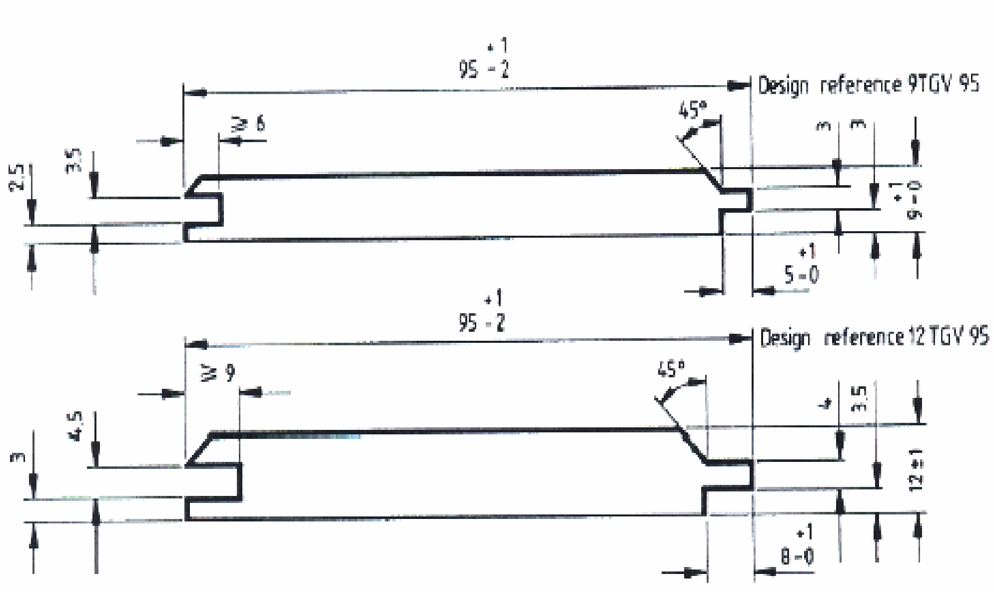
3.3 Design and profiling

There are a variety of cladding designs that may be applied. As reported in the Scoping study (Jones 2003), horizontal cladding is by far the most common, though there are many examples of vertical cladding. The use of diagonal cladding is fairly limited.

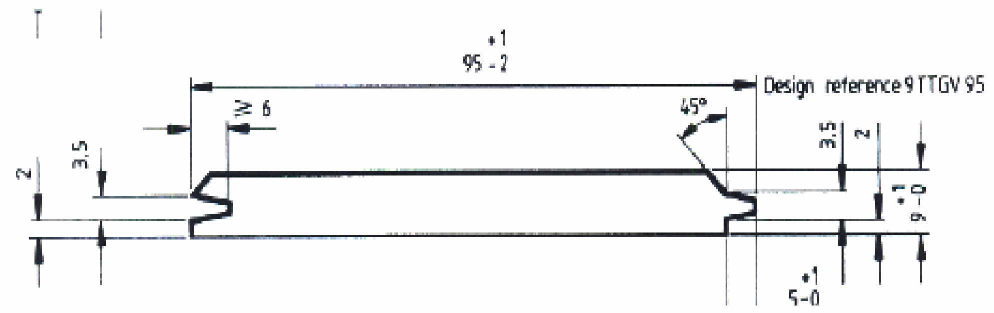
There are a range of cladding profiles listed within BS1186 Part 3 “Timber for and workmanship in joinery – Part 3: Specification for wood trim and its fixing” (1990). These profiles are listed in Figure 6.

It may be seen from Figure 6 that a variety of different profiles are recognised within BS1186-3 (1990). However, current thought and application tends towards the use of cladding with curved faces. This avoids the use of sharp and abrupt edges, which may be more prone to coating failure.

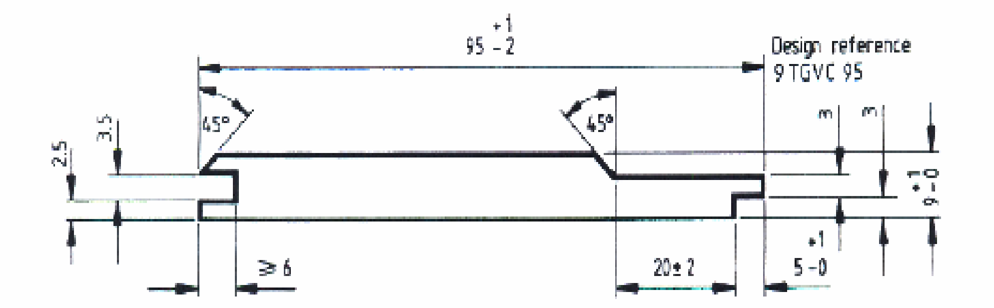
The design should also take into account a restriction in potential water traps. Again this is a feature that can be reduced with the use of cladding with rounded surfaces. The boards should be orientated in such a way that the outer exposed surface contains more heartwood. This will allow any warpage in the boards to cause a slight curvature away from the wall. This should help prevent any potential build-up of water behind the cladding should warpage occur.



(a) Tongued, grooved and vee joined

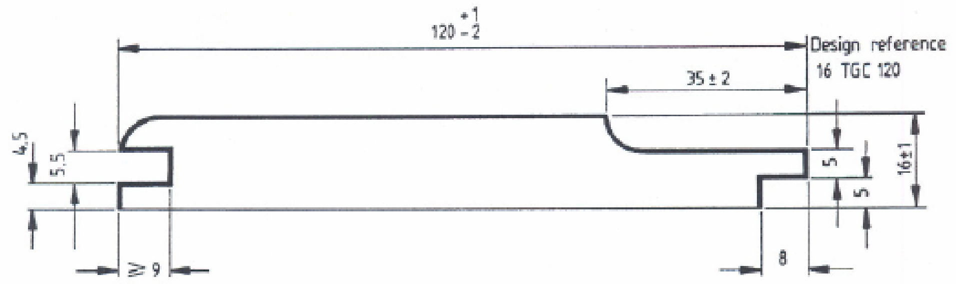


(b) Taper tongued, grooved and vee joined

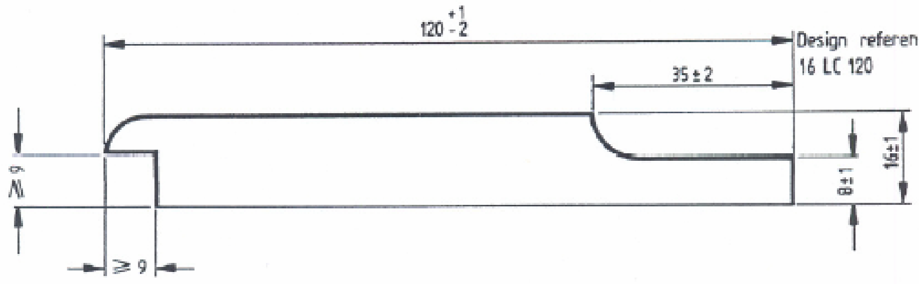


(c) Tongued, grooved, vee jointed and channelled

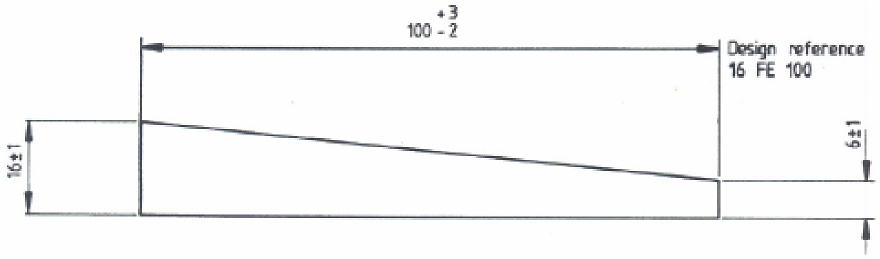
Figure 6: Possible cladding profiled as listed within BS1186-3 (1996).



(d) Tongued, grooved and channeled



(e) Lapped and channeled



NOTE All surfaces may be sawn or machined

(f) Feather edged

All sizes are in millimeters

NOTE 1 Thick lines denote a planed or machined surface.

NOTE 2 Board undersides can be fine sawn or hit/miss planed and the underside profile can be varied.

NOTE 3 It is good practice to machine stress relieving grooves into the back of the boards.

NOTE 4 It is advisable for boards to be machined so that the surface that faced the centre of the tree, when sawn, forms the exposed surface.

NOTE 5 If the back face is to be exposed, it is advisable for it to be machined as well as the front face.

Figure 6 (continued): Possible cladding profiled as listed within BS1186-3 (1996).

However, it should be noted that the use of thinner profiles can lead to greater risk of distortion. Also these thinner sections can result in greater moisture uptake, and due to these sections becoming saturated, result in increased dampness behind the cladding structure. The same is often true for tongue and grooved cladding, where it is possible to get capillary traction through the exposed section of the groove. The publication “Exterior cladding of redwood and whitewood” (Swedish Finnish Timber Council, SFTC 1982) draws attention to recommendations on cladding thicknesses. Timber cladding should be at least 16mm thick, though for tapered materials, boards should be at least 16mm at the widest part, and not less than 6mm at the thinnest.

There are recommendations from Europe (especially Netherlands) where the use of boards with diagonally cut edges can aid in the reduction of moisture ingress. Such designs are shown in Figure 7.

It can be seen from Figure 7 that the gaps between the boards will allow for drainage out of the cladding. This when combined with an adequate ventilation gap behind the boards should ensure satisfactory performance of the cladding. Figure 7 also shows that either a simple design or a dog-leg design may be applied, with both providing similar performances.

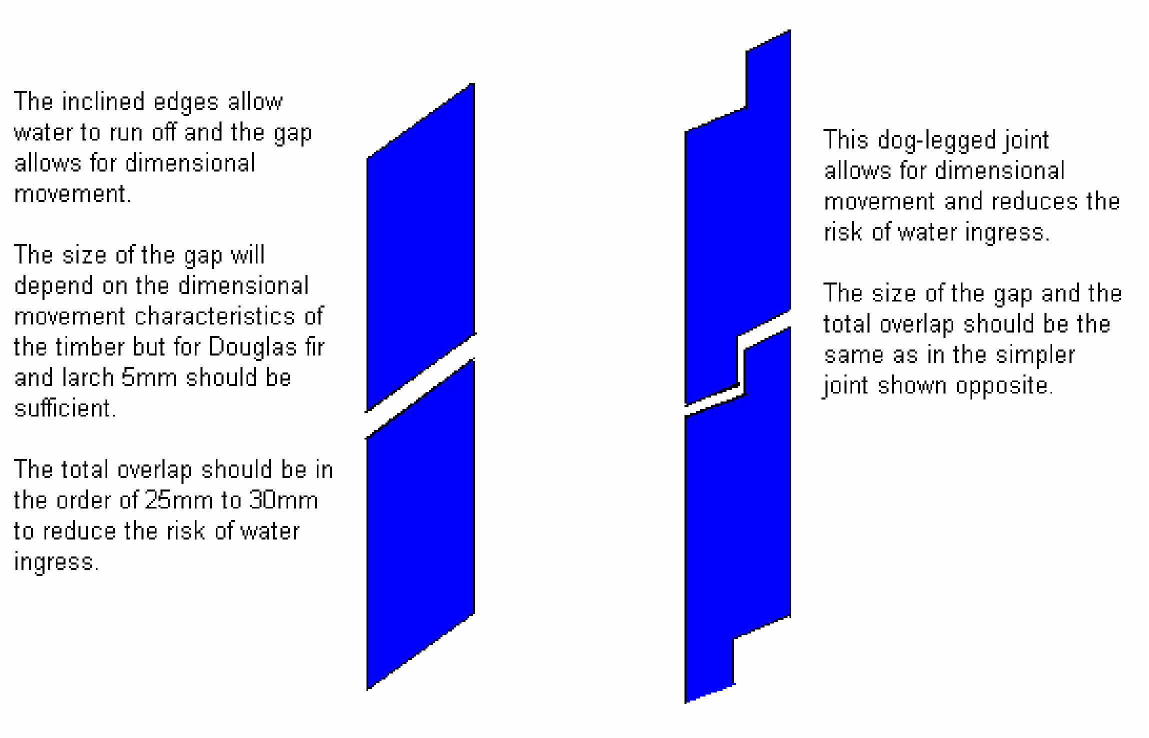


Figure 7: Possible designs of cladding joints that will allow dimensional movement whilst maintaining the visual appearance and weather tightness.

3.4 Coatings and finishes

Much of the cladding fitted today requires a coating-free surface. This is because the natural look of the timber is the aesthetical requirement of the product. The lack of a coating will reduce the service life of a cladding system. Thus the decision of natural looks against long term service life must be made by the user.

The natural durability of Sitka spruce, as with many other timber species more commonly used for cladding, suggests the need for timber protection. Whilst this may be done through the use of preservatives, the use of coatings will afford extra protection.

There are a variety of coatings options that may be considered:

1. conventional brush application of opaque or semi-transparent coatings
2. use of powder coatings in a factory finish
3. use of spray coatings, also in factory finishes.

Whilst (1) is regarded as the most common, there are currently moves within the cladding industry to consider the use of (2) or (3). However the use of powder coatings usually require curing (for example by UV or heat irradiation) often requires the use of dried timber (moisture content less than 6%). This can cause problems with the drying of the timber (high energy consumption and thus high processing costs), and the storage of the timber prior to coating (i.e. avoiding moisture uptake after drying). Thus it would be necessary to store the timber in an ultra-dry environment (again with high cost implications). Should there be a moisture build-up in the timber prior to coating, the high temperatures associated with the coating polymerisation processes could result in the evaporation of moisture from the timber. This will cause blistering and bubbling of the coating (as the moisture tries to escape from the substrate, but is sealed in by the coating). For this reason, it would be necessary to carefully appraise the potential of powder coating in terms of overall cost, and current thought suggests that powder coating technology is not suited to cladding designs.

The use of spray coating applications at the factory seem to provide the best quality coatings, as cladding with a known coating build can be generated. If this was considered, it would be necessary to ensure sufficient transfer efficiencies. If a complete factory finish is inappropriate, it may be wise to consider the application of a primer coat in the factory. This may be achieved either by the use of a roller coater or a curtain coater. Such techniques are already being used in other countries (e.g. New Zealand), and should offer potential way of application here in the U.K. However, these may be prone to coating damage in transit from the factory to the site of its use. Increased care in transportation of cladding may help reduce many of these problems, though the idea of ‘touching up’ coatings once fitted would appear to be the best option.

It is the viewpoint of BRE that the combination of factory finishing and brush applied coatings may offer the best scenario for cladding. The primer may be applied at the factory following the profiling of the cladding. These could then be shipped out to retail and trade sites in this condition. Once fitted, it would then be necessary to apply the relevant coating system by brush. For increased protection by the coating substrate, it is recommended that at least one primer coating and two top coats are applied to the cladding system.

The use of end-sealing will help to reduce any moisture uptake by the cladding. This is a major factor that should be done with any timber cladding system. Whilst Sitka spruce has a far lower tendency for moisture uptake than non-refractory species more commonly used in cladding, the use of end-sealing will provide an extra barrier and should be encouraged.

The use of a high quality coating system (multiple layers) on the higher grades of Sitka spruce recommended within this report, preferably with sawn surfaces (not planed) will result in cladding products that require little or no maintenance for at least 10 years.

4 Maintenance

In order to ensure the maximum service life of a cladding rig, it is recommended that regular inspections are carried out, after a period of about three years. However, any evidence of damage to the cladding before this time should be dealt with immediately.

As suggested in a publication by the Swedish Finnish Timber Council (SFTC 1982), a properly designed cladding system using uncoated material should require little maintenance. The use of coatings will reduce any risks of fissures developing on the boards.

The correct selection of coating should allow for a cladding system to be left free of maintenance for up to 10 years. This does not preclude the assessment of the cladding as mentioned earlier, as localised repair can help extend the life of the coating and thus the cladding.

All coatings and stains will eventually need to be replaced. This can be achieved by the removal of the original coatings and application of new systems.

By following coating manufacturer’s recommendations, it should be possible to have a cladding that is comparable to many of the materials referred to as ‘maintenance free’. Often this phrase should be replaced by ‘cannot be maintained’, as eventually they will need complete replacement. This is where timber cladding offers a benefit, in that correct use should allow a long service life, and should it prove necessary, relatively easy maintenance may be carried out.

Conclusion and recommendations

Sitka spruce may be used for cladding, provided the following criteria are met:

- **A moderate to high quality of timber is used.**
- **The cladding should be end-sealed.**
- **Should it be required, a preservative treatment is applied to the timber.**
- **A suitable cladding profile should be used, preferably avoiding the use of sharp edges.**
- **The surface of the cladding should be of a sawn finish to assist in the uptake of coatings. However for cladding systems being left uncoated, a planed surface may be beneficial.**
- **A coating system with a minimum of one primer and two top coats should be used. The primer coating should be applied at the factory, with top-coats applied by brush.**
- **Regular inspection and maintenance of the cladding should be carried out after being in service for about 5 years, i.e. inspection once a year.**
- **Where necessary, repair locally. This will extend the life of the coating and the cladding.**
- **Complete renewal of the coating system when required, estimated at about 10 years.**

By the implementation of these concepts, it should be possible to get cladding manufactured from Sitka spruce to have a reasonable service life, equivalent to those of conventional timber species.

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