ENGINEERED WOOD PRODUCTS IN IRELAND

Edited by Bill Robinson[1]

Contributing authors:
M. Bourke, J. Bregulla, M. Cornwell, V. Enjily,
C. Holland, K. Livesey, S. Moloney, E. Suttie

[1] For correspondence, email: robinsonbill@eircom.net

COFORD, National Council for Forest Research and Development
Arena House
Arena Road
Sandyford
Dublin 18
Ireland
Tel: + 353 1 2130725
Fax: + 353 1 2130611

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Foreword

Increased use of off-site construction methods, and ever-more demanding standards for insulation of residential buildings, are factors that are increasing the overall level of use of wood in construction. As a result of these trends, Engineered Wood Products (EWPs) are also growing in popularity as they lend themselves to increased speed of construction, have well characterised performance and are generally price competitive when the full construction cycle is taken into account.

With these developments in mind, COFORD funded the work on EWPs that this report outlines. Essentially the objective was to answer the question: is it feasible and economic to manufacture EWPs in Ireland? Hence the focus is very much at the manufacturing end of the spectrum. Factors such as the current level of demand, raw material suitability and manufacturing costs were examined in attempting to answer the question. For some products, particularly I joists, there is market potential, but the conclusion is that they need to be developed as part of a construction package, one that includes design advice and the provision of ancillary products such as joist hangers and rim boards.

Since the report was completed earlier this year, house construction has taken a sharp dip - from a high of 90-plus thousand units just last year, to a far lesser figure in the current year - with somewhere nearer 50,000 units forecast for completion in 2008. While this development will temper investment decisions in EWP manufacture, the medium term prognosis for the level of construction activity seems more favourable, given underlying demographics. Furthermore, the trends in building practice and energy performance of buildings already alluded to seem certain to remain in place, particularly given government policy on reducing the level of fossil fuel use and CO_2 emissions.

The publication will serve as a useful reference for those interested in the manufacture of EWPs and indeed their use in construction in Ireland. COFORD extends its appreciation to the authors, and in particular to the editor, for bringing a diverse series of project task reports into an accessible document.

Dr Eugene Hendrick	*Michael Lynn*
Director	*Chairman*

Brollach

Is fachtóirí iad úsáid mhéadaitheach na modhanna tógála seachtracha agus an t-éileamh ar amanna tógála níos tapúla atá ag méadú leibhéal úsáide foriomlán an adhmaid i dtógáil. Mar thoradh ar na treochtaí seo, tá Táirgí Adhmaid Innealtóireachta (EWP) ag dul i mhéid ar bhonn móréilimh d'fhonn go dtugann siad iad féin ar iasacht do thógáil gasta, le gníomhaíocht dea-thréithrithe agus go ginearálta tá siad iomaíoch ó thaobh praghais nuair a tógtar an roth tógála iomlán san áireamh.

Leis na forbairtí seo in aigne mhaoinigh COFORD an obair ar EWP a imlíninn an tuarascáil seo. Go heisintiúil an cuspóir a bhí ann ná chun an ceist a fhreagairt: an bhfuil sé féideartha agus eacnamaíoch chun EWP a tháirgeadh in Éirinn? D'fhonn sin tá an fócas go mór ar thaobh na déantúsaíochta den speictream. Rinneadh imscrúdú ar fachtóirí ar nós leibhéal reatha an éilimh, oiriúnacht na n-amhábhar agus costais déantúsaíochta mar iarracht ar an gceist a fhreagairt. Le haghaidh táirgí áirithe, go háirithe I ghiarsaí, tá poitéinseal margaidh, ach is é an conclúid ná go gcaithfear iad a fhorbairt mar chuid de phacáiste tógála, ceann a airíonn comhairle dearaidh agus an soláthar de tháirgí coimhdeacha ar nós crochadáin giarsaí agus clár imill.

Ón am gur cuireadh críoch leis an tuarascáil níos luaithe i mbliana, tá tógáil tí tar éis titim go géar – ó buaicphointe de 90-móide míle aonad anuraidh, chuig figiúr i bhfad níos ísle sa bhliain reatha – le rud níos cóngaraí do 50,000 aonad réamh-mheasta le haghaidh comhlíonadh i 2008. Cé go gcuirfidh an forbairt seo isteach ar chinntí infheistíochta i ndéantús EWP, féachann prognóis meán-téarmach do leibhéal na gníomhaíochta tógála níos fabhraí, d'fhonn déimeagrafacha tacaíochta. Anuas ar sin, tá na treochtaí i gcleachtadh tógála agus feidhmíocht fuinnimh na bhfoirgneamh ailléidithe cheana mar rud dóchúil chun fanacht i bhfeidhm, go háirithe nuair a áirítear polasaí an rialtais ar laghdú leibhéal úsáid na mbreoslaí iontaise.

Feidhmeoidh an foilseachán mar thagairt úsáideach dóibh siúd le suim acu i ndéantúsaíocht EWP agus gan dabht a n-úsáid i dtógáil in Éireann. Leathnaíonn COFORD a bhuíochas chuig na húdair agus go háirithe chuig an eagarthóir as ucht sraith éagsúil de thuarascálacha taisc tionscadail a thabhairt chun cinn i gcáipéis inrochtana.

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Michael Lynn
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Acknowledgements

Steering committee:

Ciaran Black, Coillte
Michael Bourke, University of Limerick
Julie Bregulla, BRE
Matthew Cornwell, BRE
Bob Davis, NSAI
Vahik Enjily, BRE
Eugene Hendrick, COFORD
Lou Hess, SmartPly
Jonathan Jennings, Kingspan Century
Lorna Kelly, Irish Timber Frame Manufacturers' Association
Ernest Kidney, Balcas
Bob Mang, Weyerhaeuer Europe
Aidan McMahon, A-Truss
Sean Moloney, University of Limerick
Joe O'Carroll, COFORD
Valez Picardo, Enterprise Ireland
Bill Robinson, Timber Design Services
James Sweet, Trus Joist
Ed Suttie, BRE
Sean Wiley, Enterprise Ireland

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Introduction

This study on Engineered Wood Products was commissioned by COFORD; the National Council for Forest Research and Development. The study was carried out by the Building Research Establishment (BRE) in the UK and the Wood Technology Centre (WTC), University of Limerick; the work was co-ordinated by Timber Design Services. The study was commissioned primarily because of the experiences of the UK market and the likely similar increase in usage of Engineered Wood Products (EWPs) in Ireland. The fundamental purpose of the study was to examine the opportunities for Irish timber in EWP usage and to examine the opportunities and threats facing Irish timber arising from the increased use of EWPs in the Irish construction market.

Engineered Wood Products (EWPs) come in various forms but only the more common ones were considered for this project and only those that represented the main share of the market were considered in any detail. For the purposes of this study EWPs were defined as:

- Re-engineered wood;
- I-joists;
- Glulam;
- Laminated Veneer Lumber (LVL);
- Parallel Strand Lumber (PSL);
- Steel web joists.

EWPs are widely used in North America and to a lesser extent in Europe. However recently they have been making inroads into the construction market in the UK, primarily in the use of timber I-joists and steel web joists in floor construction, and these products are now beginning to be seen more commonly in Ireland. The use of I-joists has reached around 50% of all floors in the UK; these include not only timber frame dwelling but also more significantly masonry dwellings.

The rise of timber frame construction in Ireland has seen a greater use of EWPs, mainly I-joists, steel web joists, glulam and parallel strand lumber, as these naturally fit in with the timber frame systems. The main EWPs used in Ireland and the UK are I-joists and more recently steel web joists; these account by far for the largest share of the market in terms of value and volume. While the market share of EWPs in Ireland is relatively low, I-joist manufacturers expect it to grow substantially in both timber frame and masonry construction over the next few years.

The study was divided into four separate tasks (produced in the report with the same chapter headings) described briefly below:

Task 1 - The Irish market (WTC): This considered the current and potential market in Ireland for EWPs.

Task 2 - Raw material (BRE): This considered the suitability of Irish timber as a feed stock for re-engineered timber and EWPs.

Task 3 - Cost benefit analysis (BRE): This considered the costs and benefits of producing re-engineered timber and EWPs for Ireland.

Task 4 - EWP - Opportunities and threats (WTC): This considered the opportunities and threats posed to Irish timber by the use of EWPs and the opportunities for producing EWPs in Ireland using Irish timber.

These tasks are reproduced in this report as separate, stand-alone sections. The individual tasks should be read for more detailed information and each task includes its own executive summary. In carrying out this study it was recognised that any company planning to manufacture a specific EWP would perform a much more detailed study of the costs involved. This report identifies some of the issues involved in relation to manufacturing and the use of EWPs but equipment, material availability and costs, labour skills and costs, construction processes and market size are clearly not static and will change, as will the volumes of timber available for use in EWP production. At present the Irish construction residential market is slowing down but the building rate (for housing and apartments) still remains relatively high.

In setting up an EWP manufacturing plant the question of market size is important and the UK and European markets would have to be studied in detail. A plant producing an EWP just for the Irish market would be relatively small, require a comparatively small amount of investment and would probably not have any problems with raw material supply. A plant producing for a wider market might have problems with raw material supply and would require higher levels of investment and would be entering a very competitive market, competing against well established products. In addition, the level of investment depends on the specific type of EWP; I-joist producion could be small-scale but LVL or strand-based products require significant through-put to be economically viable.

The question of timber availability and its suitability would have to be considered depending on the EWP to be manufactured. The most likely EWP plant to be set up in Ireland would be for the production of I-joists for use in floors, as all other EWPs represent a small volume in terms of construction (and material) use. However, while I-joists have achieved significant market share in the UK (particularly by breaking into the masonry house market), this market share will come under threat from steel web joists. Experience in Ireland, with the timber frame manufacturers, indicates that I-joists suit the manufacturing systems of some companies better than others; not all companies claimed significant time savings in floor production.

Widespread use of I-joists in masonry house building has not yet happened in Ireland; this may be due to the conservative nature of the building industry, that the I-joist manufacturers have not targeted the market as aggressively as the UK or that the nature of house building in Ireland is different to the UK. What Ireland has seen recently is a number of plants set up

▲ The use of I-joists in masonry housing is on the increase.

to manufacture steel web joists and these may very well be the EWP that will be commonly seen on Irish building sites. The engineered floor joist systems may well pose a threat to the use of Irish solid timber joists but they will never totally supplant the use of solid timber. Ease of use, skill levels on site, availability, familiarity and especially price will mean that there will always be a market for solid timber joists. The future size of this market may well change, but competition from cheaper and higher strength class imported timber may well pose a greater threat to Irish timber (as it always has) than that posed from EWP. What the emergence of EWPs onto the Irish market means is that there is another player seeking a section of that market; and some of that market share lost to EWPs will come from imported as well as Irish timber. If the same economics, in terms of time and labour savings on sites that have seen engineered joists break into the UK masonry house market apply to the Irish market, and are seen to apply by the Irish house builders, then engineered floor joists could very well take a substantial section of the floor joist market in Ireland.

Some of the technical issues of producing I-joists are outlined in the report. However, while it is true that the current I-joist manufacturers use high strength flanges; this does not mean that the flanges need to be made of such high strength material. The majority of domestic buildings are lightly loaded (a design imposed load ~ 1.5 kN/m^2 and a permanent design load typically 0.40 kN/m^2), and spans are often relatively short (~ 4.5 m). Strength and stiffness of I-joists depends mainly on the depth of the joist (i.e. the distance between the flanges) and the strength of the flange. A flange made from weaker material would require more material; but the increased costs of using more material (e.g. glue volumes, planing and handling) may be offset by cheaper material costs. If the domestic housing market were targeted, then because of the relatively lights loads and short spans the increases in flange size may be quite small.

▲ I-joist attached to masonry wall with a specialised hanger. Many EWPs are supplied as a package that includes fixings and other ancillary products.

In addition, companies considering I-joist manufacturing should examine the competing joist systems for the ancillary products and services that they will have to supply to compete in the market. Existing I-joist systems have Agrément certification, design software, provide engineering backup, site related information and a full range of ancillary products (steel joist hangers, partition supports, rim boards etc.). Any company intending to manufacture I-joists would have to supply a similar range of products and services. While companies may be able to charge for some services (e.g. engineering backup), much of the costs will fall directly to the manufacturer and will probably occur even before manufacture begins. Some of these costs could perhaps be offset by using external consultants and existing products (e.g. steel hangers) or perhaps by manufacturing under licence from an existing system. At the end of the day, price will largely govern the success of any manufactured I-joist in Ireland as elsewhere.

The supply of material to an EWP plant is reviewed in the report, but the question of adequate supplies cannot be addressed fully because it depends on the particular EWP and the scale of production. Forecasts indicate modest increases in sawlog sized roundwood over the coming decade, and the slowdown in the residential construction sector may also release more material for manufacturing. The scale of a plant for I-joists would depend on the market targeted. Technology and plant can readily be bought (i.e. under licence) from existing manufacturers and this would reduce some of the initial costs. If large timber volumes were to be required then a detailed assessment of timber resources would need to be undertaken. Information from Coillte and the private growers would have to be assessed, as well as future trends in Ireland and any overseas market.

The study looks at re-engineering Irish timber to upgrade its inherent properties and its use as a feedstock for the manufacture of EWPs. The extra costs involved in doing this means that re-engineering is almost certainly not feasible at the present, as imported timber, probably with the same strength properties that the re-engineered timber, would be cheaper.

The study (chapter 2) suggests a number of options available for Irish timber in dealing with the opportunities posed as the EWP market grows (mainly engineered joists). The study also considers impacts of possible changes in the setting of machine strength grading of imported timber and the effect that this might have on the trading bands in Ireland and Europe. One of the considerations that will obviously apply will be price, Irish timber prices have tended to follow and closely match imported timber prices.

Over the coming decade it is anticipated that the use of engineered wood products and off-site construction will experience considerable expansion in Britain, Ireland and throughout Europe. Opportunities exist for the forest products sector in Ireland to play a role in these developments. Companies considering investing in the sector will obviously conduct in-depth financial and technical appraisal to guide their decision. This report is intended to aid such appraisals by outlining important raw material and product development issues that need to be carefully considered as part of the decision-making process.

Engineered wood products offer considerable flexibility and scope in terms of their functionality and versatility, as well as aesthetics, and are becoming increasingly popular in Ireland. This building at the University of Limerick makes good use of the new EWP capabilities.

Chapter 1
THE IRISH MARKET

Summary

This section describes current and potential markets in Ireland for engineered wood products (EWPs). Market information was derived from a study of the main users of timber and EWPs in Ireland: timber frame manufacturers, builders and developers, merchants/distributors and sawmills. Experience in the use of EWPs in the UK market was also investigated, given their greater use in that market.

Key points

- The most commonly used EWPs are I-joists.
- Metal web joists are the only EWPs currently being manufactured in any quantity in Ireland.
- Market information indicated that in 2004 timber frame manufactures used about 0.7 million linear m of I-joists.
- Currently timber frame construction accounts for over 25% of total dwelling completions.
- Timber frame manufacturers are major users of EWPs.
- In 2006 over 90,000 dwellings were completed in Ireland; however, this level of construction has not continued and less than 50,000 dwellings are expected to be completed in 2008. Based on a floor joist use of 150 m per dwelling the potential for engineered joists is still high.
- I-joists have the potential to capture a significant share of the floor joist market and therefore may pose a threat to suppliers of traditional solid timber joists.
- Construction timber accounts for on average of 40% of the sales of Irish sawmills, with up to 65% in some cases.
- Engineered floor joists have approximately 50% of the UK masonry built housing market. Manufactures expect their market to grow and expect in the near future to see a significant growth in the market in Ireland including the masonry house sector.
- Sawmills have little experience of either manufacturing or trading in EWPs. They are aware, however, of the rapid growth in EWP sales which they expect to grow by 5-10% annually.

Introduction

The remarkable growth of EWPs in the last decade of the twentieth century constitutes one of the success stories of the wood products industry (De La Roche et al. 2005). Recent years have seen a move to off-site construction (and with it a move to EWPs); this is especially noticeable in the residential sector where timber frame has experienced rapid growth in the last five years. Building practice is changing from on site construction, to a greater use of prefabricated off-site construction techniques and subcontractors. The main benefits of the off-site approach, which include affordability, performance and flexibility in design, construction and renovation (Tissari 2002), are further outlined in Table 1.1.

The conversion of roundwood into strands, veneers and fibre, which are reassembled into new timber, panel and other construction products, has become more common. These products and EWPs have uniform physical properties and well-defined performance. Notable examples of these reconstituted products include finger-jointed timber, laminated veneer lumber (LVL), glue laminated timber lumber (glulam), parallel strand lumber (PSL), plywood, and oriented strand board (OSB). Some of these products are further processed to form EWPs such as I-joists.

While many factors have contributed to the evolution of EWPs it is those such as customer demand, fibre supply and quality, environmental concerns, and new technologies that have been the principal drivers (Guss 2003). The future for EWPs is positive as they provide the construction industry with solutions to problems arising from skilled labour shortages, the need to reduce construction site waste and reduce time spent on the construction site (Century Homes 2003).

Table 1.1: Benefits of off-site construction.

BENEFIT	DESCRIPTION
Faster construction	Work commences off-site, and is less affected by weather and by other trades.
Improved quality	Work in a controlled factory environment under quality control procedures results in a better finished product.
Reduced costs	Typically up to 20% savings over traditional onsite methods, including reduced waste and site storage.
Improved health and safety	High-risk site work replaced by a safer factory environment.
Improved co-ordination of effort	The whole structure is in place and is easy to access for tradesmen. Mechanical and electrical work proceeds in parallel, reducing clashes and re-work.
Labour saving	Off-site construction and the use of subcontractors reduces the number of site personnel directly employed by the man contractor/developer.

(Ching Ong 2003)

Timber demand

Total consumption of sawnwood in Ireland in 2003 was 1.6 million m^3. Local sawmills supplied about half, with the balance mainly coming from Sweden, Finland and the Baltic states. Of the total sawnwood consumed, it has been estimated (Coillte 2005) that 1.1 million m^3 was construction timber, of which 480,000 m^3 was supplied by Irish mills.

As the Irish construction market accounts for 72% of sawn timber and 25% of board sales it is a very important outlet.

Since the mid 1990s house construction in Ireland has been increasing steadily year-on-year (Wilson 2004); completions exceeded 76,000 units in 2004, and have peaked in 2006 at over 90,000 units. In 2003 it was forecast that an average of 55,000 new dwellings would be required annually to for the following 10-yesr period (Century Homes 2003). However, around 250,000 units have already been built in the last three years (2004-2006 inclusive).

The shift to off-site construction, mainly though timber frame construction, has further fed timber demand - timber frame has grown from 1% of housing units in 1990 to currently over 25%. Manufacturers predict that their market share may ultimately reach 50% (Kelly 2003).

The UK market for EWPs

UK experience in using EWPs is useful in evaluating possible future trends in Ireland. The market value of EWPs in the UK is currently about €680 m, of which just 15% is manufactured from home grown timber. Timber frame is the highest user of EWPs in the UK market and accounts for 40% of all new affordable housing (BRE 2004), with strong growth expected to continue.

The EWPs used in the UK market include glulam, LVL, I-joists and metal-web beams. I-joists and metal web joists are rapidly becoming the flooring product of choice for house builders (including masonry dwellings); they have a 40-50% market share, with some trade sources predicting that this will rise to 80% or even 90%.

Principal EWP manufacturers and suppliers to the UK market

In the UK, a small number of companies dominate the supply of EWPs and ancillary associated products and hardware:

- Boise Cascade supplies several EWPs including BCI JOISTS® (I-joists), VERSA-LAM® (LVL), and BOISE GLULAM™ (glulam).
- Finnforest (part of the Finnish Metsäliitto Group) are one of the main suppliers of I-joists, glulam and LVL (Kerto).
- Weyerhaeuser distribute their Trus Joist™ (I-joists), Parallam® (PSL), Timberstrand™ and Microlam® LVL.
- James Jones manufactures I-joists in the UK and distributes some LVL products (Kerto).
- Stora Enso supply mainly solid timber but also use EWP manufacturing techniques in their products.
- UPM is one of the main plywood suppliers in the UK. Their products are manufactured with EWP technology.
- BSW timber systems is one of the main distributors of engineered wood products (I-joists), flooring and roof systems.
- Benfield ATT manufacture, distribute and install engineered joists and also act as agents.

Hardware

- MiTEK, Gangnail and Wolf are leaders in pressed metal web joist systems. None of these companies manufacture joists but provide the metal webs, engineering backup and design software to fabricators and designers.
- Simpson Strongtie is one of the main suppliers of timber connectors.
- Cullen Building Products is a leading supplier of timber connectors and has a warehouse in Ireland.
- BAT Metalwork Limited is an Irish company supplying metal connectors.

UK view of EWPs

Opinions and perceptions of the UK forest industry and specifiers of EWPs were assessed as part of an earlier study by BRE (Table 1.2). Timber growers see EWPs as providing an outlet for timber that might otherwise enter the low price pulp and chip markets. Retailers and end-users voiced some concerns regarding the introduction of EWPs to the marketplace. Architects and engineers may need additional training in order to effectively specify, use and incorporate EWPs in their designs. Increasing the awareness of the benefits of EWPs has been key to their success in the UK.

Table 1.2: UK view of EWPs.

High price of EWPs was highlighted as a potential barrier to their use; however, manufacturers felt that if a product had improved performance then a premium could be charged.
Improved dimensional stability was considered a large benefit of some EWPs.
Concerns were raised regarding the strength, stiffness and durability of glued joints.
Clear, transparent adhesives are preferred for aesthetic reasons.
Visible finger-joints are acceptable for some applications such as external joinery and structural products, but in some products such as flooring require the joints to be hidden.

Source: BRE 2005.

The EWP market in Ireland

A study of the EWP and solid timber markets in Ireland was assessed using questionnaires, and follow-up visits to key companies with the following objectives:

1. to identify existing markets for home-grown solid timber products;
2. to identify existing EWP uses;
3. to examine the potential for the use of EWPs and the replacement of solid timber products (e.g. in roofs, floors and walls);
4. to identify markets where EWPs could be used (e.g. apartments, masonry dwellings);
5. to identify specific EWPs and other products that may affect solid timber usage.

EWPs assessed are listed in Table 1.3.

Table 1.3: EWPs examined in assessing the market size in Ireland.

PRODUCT	DESCRIPTION
Glulam	Comprises more than four timber laminates, glued together with no theoretical limit on overall section size. Glulam is ideally suited for use in structural systems, especially medium to large span roofs.
I-joist	I-joists consist of flanges typically made from solid timber or LVL and a web made from OSB or plywood. The flanges and web are bonded together to form an I cross-section.
LVL	Laminated veneer lumber comprises dried and graded veneers glued together to form panels from which structural sections of the desired dimensions are sawn
PSL	Parallel strand lumber consists of long thin strands of timber glued together.
Metal web joist	Metal web joists are similar to I-joists and are formed from timber top and bottom chords connected together with pressed metal V webs.

(Source: Tissari 2002).

Methodology

The first phase was a compilation of forest harvest and production data from available sources such as COFORD and Coillte.

The second phase involved four main surveying industry sectors:

1. timber frame manufacturers;
2. builders and developers;
3. timber merchants and distributors;
4. sawmills.

Timber frame manufacturers were contacted using the NSAI's National Register of Approved Timber Frame Manufacturers. The builder and developer database was extracted from a number of sources, including the top 1000 Irish companies and the Construction Industry Federation membership database. Timber merchants and distributors were contacted using a database developed from national commercial registers and other publicly-available sources. Sawmills were circulated using the Irish Timber Council's membership database.

Results

Timber frame manufacturers

Section A of the questionnaire determined the location of the business, the number of employees and the nature of the work as well as the type of business the company was involved in. Companies were also asked if they were involved in the manufacture of roof trusses. Some 32% operated solely as timber frame manufacturers, while the remainder operated in roof truss manufacturing as well. The turnover of each company was also ascertained in order to determine their scale of operation.

Table 1.4 shows the range of turnover in timber frame manufacturing companies. The majority had sales of less than €12 million per annum, a further 15% had sales of €12-24 million, while the top 15% had turnover of more than €24 million per year.

Table 1.4: Turnover of timber frame manufacturers in Ireland.

TURNOVER (MILLION EURO)	% COMPANIES
<= 12	70
12-24	15
>24	15

Solid timber sourcing

Section B of the questionnaire was designed to determine the source of solid timber usage by timber frame manufacturers. In addition, respondents were asked for specific reasons why they used imported, rather than home-grown timber.

Four out of five companies used only imported timber, while the remainder used some home-grown timber as well. Timber frame manufacturers' sourcing of imported timber is shown in Table 1.5.

One third of those using imported timber expressed an interest in using home-grown timber; the reasons why these companies did not use home-grown are implied in (Table 1.6).

The majority of respondents felt that quality, strength class availability and price were the most important factors; while appearance and finish were rated as important factors. Relatively speaking, the least important factor was the range of sizes available.

Table 1.5: Sourcing of imported timber by timber frame manufacturers in Ireland

SOURCING OF SOLID TIMBER	% COMPANIES
Direct imports	55
Through agent	45
Builders' merchants	36
Local supplier	9
Sawmill	9

(Sourcing categories are not mutually exclusive and hence the total exceeds 100.)

Table 1.6: Reasons for ordering imported timber.

REASON	%
Quality	78
Strength class availability	64
Range of sizes	29
Price	64
Appearance	42
Finish	57
Service	41

EWPs in current use

Section C of the questionnaire sought to ascertain EWPs in current use. The responses are shown in Table 1.7.

I-joists and glulam are the most commonly used EWPs, followed by LVL and PSL. While none of the respondents stated they were using metal webbed I-joists, it is known that some manufacturers are using these products.

Additional information from the responses is listed below for the particular EWP.

Table 1.7: EWPs used by timber frame manufacturers.

EWP	USAGE (%)
I-joists	78
Glulam	64
LVL	28
PSL	28

I-joists

- I-joists were the most commonly used EWP by timber frame manufacturers.
- The average amount of I-joists used by medium sized companies was 6500 linear m per month. Specific brands identified were JJI (James Jones), FJI (Finnforest) and TJI® (Trus Joist™, a Weyerhaeuser company).
- Distributors or agents included Cedarlan, Crown, Finnforest, Haldane and Fisher, and McMahons.
- The most common application was in two-storey housing, with some additional use in apartments.
- The approximate price was €5 per linear metre, which is about twice the price of a solid timber joist. However, when I-joists are used in floor cassettes there are considerable labour savings, which help to offset their higher cost. Although one timber frame manufacturer stated that EWP floor cassettes were 10% more expensive than solid timber cassettes, 10% of respondents stated that was no cost difference. Sterling exchange rates also affected price.
- I-joists are generally perceived as an excellent product by timber frame manufacturers.

Glulam

- Glulam use was widespread but volumes small - the average use by medium sized timber frame manufacturers was 40 m^3 per month.
- Germany, Holland or Sweden were the major sources of glulam.
- Roof purlins, lintels and beams were the main applications for glulam.
- Glulam can be up to three times more expensive than solid timber.

PSL and LVL

- Although not commonly in use some PSL was used for floor beams in two-storey detached and semi-detached housing. Some manufacturers stated it was being used as an alternative to glulam in I-joist floor systems.
- The main supplier of PSL was Crown.
- Some respondents used LVL and metal webbed beams.
- Finnforest was cited as a supplier of the LVL product Kerto.

Barriers to wider EWP use

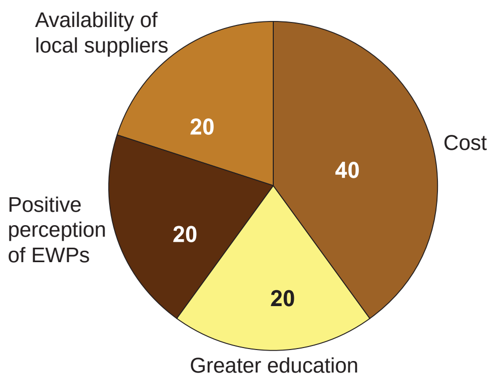
Four fifths of timber frame manufacturers were, or were beginning to use EWPs. Companies gave the following reasons for not using EWPs:

- EWPs are overpriced in relation to imported solid timber;
- some EWPs have not been approved for use in Ireland;
- more supervision is required when using EWPs;
- it is more difficult to do remedial work with EWPs;
- their current system is set up for solid timber and it would prove difficult to change to another system;
- the market is only becoming familiar with these products more education about EWPs is needed.

Cost was one of the main reasons companies had not used EWPs - in particular, one respondent stated that they had considered using glulam for structural beams in a particular project, but did not do so because of the cost. Timber frame manufacturers not using EWPs had considered using them in applications such as floor joists, structural beams, wall studs, lintels and roof structures Non-users were asked what would encourage them to start using EWPs (Figure 1.1).

Forty percent of non-users of EWPs felt that cost was one of the major deterrents in their use. Some stated that they were willing to pay up to 10% more for EWPs than for solid timber (on a linear metre basis) but the majority felt that pricing should be more competitive. In order to encourage the use of EWPs one fifth of the respondents felt that more education was needed on their use in construction. Some respondents felt that local availability and favourable public opinion on EWPs would encourage their use.

Figure 1.1: Factors that would encourage timber frame manufacturers to use EWPs.



Benefits of EWP usage

The main benefits of EWP usage to timber frame manufacturers and builders are summarised in Table 1.8.

The greatest benefit identified for I-joists was the ease of service runs, which is also a particular advantage for metal webbed joists. Improved functionality was an important benefit of EWPs, as well as speed of construction, ease of handling and low moisture content. Only one quarter of respondents believed that EWPs led to reduced wastage.

Table 1.8: Benefits of EWPs usage to timber frame manufacturers and builders.

	%
Ease of service runs	69
Improved functionality	53
Improved size tolerances	46
Strength	46
Low moisture content	38
Ease of handling	38
Speed of construction	38
Reduced waste	23

Disadvantages of using EWPs

The main disadvantages of using EWPs were identified by timber frame manufacturers as:

- expensive waste (particularly of I-joists);
- expensive hangers and connections;

- EWPs unforgiving if not used properly;
- party wall expensive to fireproof;
- traditional design details (for solid timber) may not be applicable to EWPs;
- high product cost.

Design information

A further objective of the survey was to elicit comment on design information available for EWPs: its source, its usefulness and its level of certification. The majority of users stated that good technical information and support was provided by the EWP manufactures.

Feedback from customers of timber frame manufacturers

Customer feedback is summarised as follows:

- there were no adverse comments on glulam;
- some Local Authorities will not allow the use of I-joists;
- customers requiring larger or one-off houses have questioned the cost effectiveness of EWPs;
- more site supervision required;
- difficult to do remedial work;
- I-joists: sometimes perceived as an inferior product;
- customers have questioned why use EWPs when solid joists can do the same job at a cheaper price;
- satisfied with I-joist installation and performance.

The future of EWPs

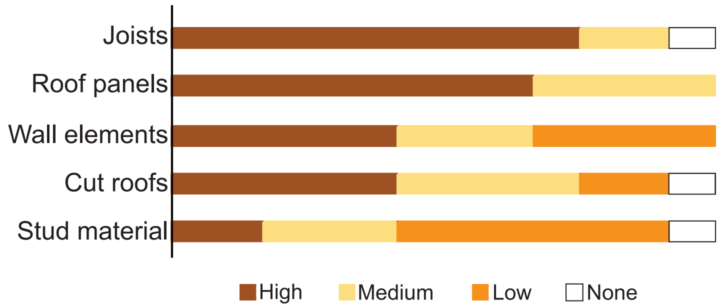
Section D of the questionnaire sought views on the potential for the replacement of solid wood by EWPs. The following applications were identified as having the largest potential:

- joists;
- roof elements;
- wall elements.

Respondents felt that stud material and cut roofs were less likely to be substituted by EWPs (Figure 1.2).

A general question was posed as to whether the growth in EWP use would continue. Again, the majority of respondents stated growth will continue, with most estimating a growth rate in excess of 10% per annum.

Figure 1.2: Applications with the highest potential for the replacement of solid wood by EWPs.



Builders and developers

This part of the study concentrated on the residential construction sector; seventy companies in all were surveyed. Responses were, however, difficult to obtain, with companies reluctant to disclose what they see as sensitive information.

The breakdown of respondents by housing sector is given in Table 1.9.

Table 1.9: Housing sectors of respondents.

HOUSING SECTOR	%
One-off housing	30
Housing schemes	40
Commercial/apartments	20
Social housing	10

Solid timber sourcing

The main source of solid timber for builders and developers were builders' merchants. Some 90% of companies stated that they used some quantity of home grown timber.

Builders and developers advanced the reasons listed in Table 1.10 for specifying imported timber.

Table 1.10: Reasons for ordering imported timber.

REASON	%
Quality	70
Strength class availability	70
Range of sizes	70
Price	60
Appearance	50
Finish	10
Service	10

Extent of use and advantages of EWPs

Over three quarters of builders and developers were using some form of EWP, while some four out of five believed that there is additional potential for use of EWPs in their business. Those who were not using EWPs stated that they would use them only if they are specified by the architects or client. Some builders stated that they do not use EWPs by choice. Other builders stated that EWPs were more expensive than solid timber.

I-joists are the most commonly used EWPs.

Builders and developers stated that ease of handling and strength performance were the most important advantages of using EWPs. A full list of the advantages quoted is given in Table 1.11.

None of the respondents quoted any problems with using EWPs.

Table 1.11: Advantages of using EWPs.

ADVANTAGE	%
Ease of handling	90
Strength performance	80
Improved functionality	60
Ease of service runs	60
Speed of construction	50
Improved size tolerances	50
Low moisture content	30
Reduced wastage	20

The future of EWPs

Builders and developers identified floor joists as the area with the biggest potential for EWP growth (Table 1.12).

The majority of builders and developers felt that the growth in EWPs would continue, at a rate of 5-10% per annum.

Table 1.12: Potential areas for EWP growth.

APPLICATION	% OF RESPONDENTS
Floor joists	90
Wall elements	70
Cut roofs	60
Studding	60
Roof panels	60

Merchants/distributors

Solid timber sourcing

The main sources of solid timber identified for merchants/distributors were European Suppliers, Sweden, and Baltic States, while Irish sawmills also featured. The main reasons for ordering imported timber were quality, strength class availability and appearance (Table 1.13).

Table 1.13: Reason for stocking imported timber.

REASON	%
Quality	67
Strength class availability	67
Appearance	67
Price	33
Range of sizes	0
Finish	0
Service	0

EWP stockists

One third of respondents selling solid timber and wood-based panel products were also stocking some form of EWP. A number of I-joist manufactures have been seeking agents in Ireland and see timber frame manufacturers as not only users of EWPs, but also as potential distributors to the wider construction industry.

The fact that user specifications can be obtained easily was rated the most important factor in the decision by merchants/distributors to stock/sell EWPs (Table 1.14).

The main disadvantages in stocking EWPs included significant staff training, the provision of customer technical support, high prices and a general lack of significant demand.

Table 1.14: Main advantages to merchants/distributors in stocking EWPs.

ADVANTAGE	RANK
Ready availability of user specifications	1
Less stock in yards	2
A simplified supply chain	3
Ease of handling	4
Availability of standard elements	5

The future of EWPs

All merchants/distributors thought that there was a potential for the replacement of solid wood by EWPs, particularly in floor joists and cut roofs (Table 1.15).

Merchants/distributors were of the same view as other sectors in seeing continued growth in EWP usage, at a rate of 5-10% per annum.

Table 1.15: Applications identified by timber merchants/distributors where EWPs can replace solid wood.

APPLICATION	POTENTIAL
Floor joists	High
Cut roofs	High
Studding	Medium
Wall elements	Low

Sawmills

The study sought to assess awareness among sawmills of the growing use of EWPs, their level of involvement in manufacturing or trading in EWPs, and their opinion on the future of sawn timber.

Questionnaires were circulated, follow up calls and contacts were made, and detailed responses were obtained from the major sawmills.

Roundwood processed

The respondents processed 2 million m^3 of roundwood, close to 80% of the total in 2005. Most of the roundwood processed was sourced in Ireland; with some mills importing from Scotland. Currently some 300,000 m^3 of roundwood is being imported per annum. Sawmills also imported sawn timber for re-sawing and distribution, alongside their own products. On average, the product breakdown was 38% construction timber, with the remainder comprising pallet (33%) and fencing/decking/other (27%).

Value-added processing

All of the respondents had kiln drying facilities, and the majority also had re-sawing, planning/moulding and preservative treatment facilities.

Involvement with EWPs

The majority of respondents had no experience in producing or trading in EWPs, although some had been involved in producing glued or finger-jointed products for non-structural applications. The reasons for not getting involved in EWPs included:

- lack of knowledge of the products and processes;
- not having time to investigate their potential;
- being focussed on other types of product development.

Outlook for EWPs

Almost all companies were aware of the growth in EWP sales and had considered becoming involved in the sector at some time in the future. All respondents believed that the growth in EWP sales will continue in the short to medium term, at 5-10% per annum. A majority also believed that EWPs have further potential to replace solid timber in some traditional markets, for example masonry house building. I-joists were the product seen almost universally as the one product that was going to gain significant market share. Only a few companies believed that metal-webbed joists and glulam sales would increase significantly. Some companies felt that EWPs pose a threat to the sawmilling industry in the longer term, with the greatest challenge from I-joists.

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Chapter 2
RAW MATERIAL

Summary

This section considers the suitability of Irish timber as a feedstock for Engineered Wood Products (EWPs) and assesses the Irish timber resource and its suitability for use in the manufacture of EWPs with the following points of emphasis:

- availability of timber supply
- material properties
- potential routes to market.

Sitka spruce is the main species grown in Ireland and is therefore the main focus in this study. The size of the Irish Sitka spruce resource is considered to be sufficient for EWP Re-engineering, in the form of finger-jointing and laminating timber to produce structural EWPs, can be used to upgrade the resource and establish market share. EWPs can be successfully manufactured from Irish Sitka spruce.

The routes to market for EWPs in today's structural products market have also been considered. The two main routes are:

- Designing the EWP within codes and standards – this puts limitations on the adhesives that can be used and the moisture content of the timber at the time of gluing.
- Designing the EWP outside of codes and standards – where the product or process used is not covered by current regulatory framework. The EWP will require third party approval which can be expensive.

Introduction

This section assesses the Irish timber resource and its suitability for use as a feed stock for various EWPs. Sitka spruce is the most common tree species grown in Ireland and is the only species considered in this study; however the principles set out in this report are applicable to other species.

The raw material review covers the following key areas:

- Supply of Irish timber.
- Issues for the Irish timber supply chain – why produce EWPs?
- Material properties of Irish Sitka spruce.
- Potential uses of Irish Sitka spruce in EWPs.
- Potential routes to market for EWPs.

Irish timber supply

The island of Ireland has a forest cover of 785,000 ha of which Coillte owns 440,000 ha, the Northern Ireland Forest Service (NIFS) 61,000 ha and a further 284,000 ha is in private ownership (Bacon and Associates 2003). Sitka spruce is the most common tree species and comprises approximately 60% of all forests – and accounted for 47,077 ha of the 83,252 ha of forest planted between 1997 and 2002. Sitka typically has a mean yield class of 16.5 m^3 ha^{-1} yr^{-1}; it a fast-growing species with average rotations of 30-40 years. However, it is characterised as a long fibre species and it is this property which makes it widely used in structural applications and makes it suitable for use in EWPs.

Irish forests produced 3.3 million m^3 of roundwood in 2003; Coillte is by far the largest supplier providing 78% of roundwood logs in Ireland. Sitka spruce makes up approximately 70% of its sales. Of the total roundwood sold by Coillte, almost 70% goes to sawmills with the remaining 30% is used as pulpwood or stakes (Coillte 2005) (Figure 2.1).

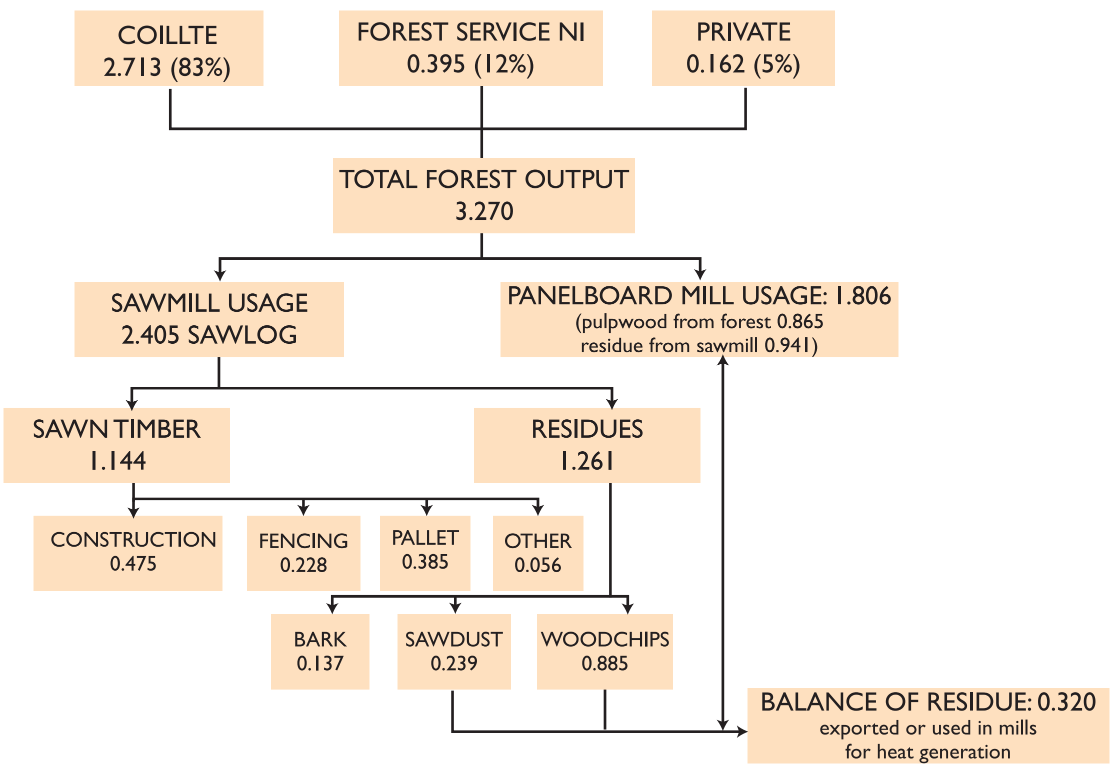

Figure 2.1: Flow of home-grown round wood (million m^3) in Ireland, 2003 (Coillte 2005).

Roundwood production in Ireland increased by over five and half times between 1979 and 2003. Roundwood supply from Coillte, NIFS and privately owned forests is forecast to increase annually with the potential to reach 5 million m^3 per annum by 2015 (Table 2.1).

Coillte will continue to be the largest supplier but its market share is expected to drop significantly. This will be largely due to a predicted increase in the roundwood production from private forests (Coillte 2005).

Table 2.1: Forecasted Irish roundwood supply 2006-2015.

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Production (000 m^3)	3,995	4,097	4,143	4,239	4,442	4,441	4,609	4,575	4,651	4,993

Source: COFORD and Coillte.

Issues for the Irish timber supply chain

The main issues affecting Irish timber supply are:

Price competitiveness against imported timber

Countries exporting to Ireland, such as Estonia, Latvia, Russia and Poland all have large reserves of timber and relatively low labour costs, which allows them to supply timber at a low cost. However, production costs are likely to increase as EU countries comply with labour, environmental and safety legislation. Prices for Irish timber tend to track those for imported material, demand in the UK, Europe and to some extent the USA also affects Irish timber and log prices.

Material properties

The timber industry in Ireland faces significant competition from Europe in the relation to timber quality and material properties. Most of the countries exporting to the Irish market produce timber with a higher density and higher stiffness than home-grown material with the timber also falling into a higher strength class. Currently there is little price difference between different strength classes which means that Irish timber achieves a similar price to imported timber. Other material properties such as knot area ratio and timber stability can be a problem affecting Irish timber accessing certain market segments.

Strength grading machine settings

The issue regarding the innate strength of Irish Sitka spruce and its position within the strength class system is highlighted by the current harmonisation of European structural timber codes and standards EN14081; parts 1 to 4. Part 4 sets out methods for the calculation of machine settings, with regard to the species and country of origin, for strength grading to the EN 338 strength classes. The main strength class and strength class combinations in relation to the current settings in EN 14081 - 4 for Northern and Eastern spruce and pine (commonly called European imported timber) are outlined in Table 2.2.

In addition to the combinations above, the following points will affect the process of machine grading imported timber:

- The single strength class settings are identical for C18 and C24 European for Cook Bolinder machines; therefore it would be logical to grade to C24
- The settings in all 3 machines are considered to favour the production of a single strength class, C24, rather than any strength class combination (e.g. C 16 and C24). Companies using the Dynagrade may use the C16 and C24 combination but at present it is unclear what the long term trend will be with the Dynagrade. It is likely that C24 will become

Table 2.2: Main strength class and strength class combinations for Northern and Eastern spruce and pine for the three most common strength grading machines.

Timber combinations	Cook Bolinder *1	Computermatic and Micromatic *1	Dynagrade *2
Single			
C16	No	No	No
C18	Yes	No	No
C24	Yes	Yes	Yes
C27	Yes	Yes	Yes
Combined			
	C24 and C35	C16 and C27	C16 and C24
	C18 and C30	C18 and C30	
			C24 and C30

*1 EN 14081-4 gives settings for single C16 and a combined C16 and C24 home-grown timber.
*2 EN 14081-4 does not give any settings for home-grown timber.

the main machine strength class rather than the current C16, although C16 will still be produced by visual grading.

- The cost of machine grading to the single strength class C24 is unlikely to be significant compared to grading to C16 or C16 and C24.

It is likely that in the future the main trading strength class for imported timber will be C24. In addition as the cost of grading machines comes down, there could be less visual grading taking place and therefore less C16 material on the market. This may mean that the price of C16 material (imported and home-grown) may become significantly less than C24 or at least the differential between the two strength classes may become greater than at present.

Competition from other materials and products in traditional applications

Globally solid timber has lost market share due to the emergence of new materials and products (including EWPs). A good example of this loss of market share is the emergence of I-joists in the UK masonry housing sector where they now have 50% market share. Another example is the replacement of solid timber architrave by MDF. The higher prices of these products is justified by their superior properties or and performance and savings in areas such as handling and finishing.

There are a number of options available to avoid or reduce market loss including:

- Tighter price competitiveness through innovation, investment and increased efficiency.
- Competition and efficiency in log supply (as identified in the COFORD-funded OPTlLOG report[1]),
- In the long term material properties can be improved through the use of higher quality genetic material and silvicultural practices such as thinning, pruning and rotation length.
- Develop new markets to replace market share lost to imported timbers and EWPs. Seeking out special markets, e.g. timber frame studding and providing products that fulfil the specific requirements of these markets.
- Improve timber quality through removal of defects such as knots, finger jointing and lamination. Re-engineered material properties can make the timber more suitable for a broader range of products that could be used in EWPs or could compete with higher strength class timber.
- Use the timber in an evaluated complete system irrespective of its components. However, this would be only appropriate to specific end uses and is unlikely to involve large timber volumes.

[1] *Summary available at www.coford.ie/iopen24/pub/defaultarticle.php?cArticlePath=196_265_256.*

- Compete against imported timber e.g. by reducing the cost of the material and improving client service.
- Develop new products, EWPs or new materials that use Irish timber.
- The use of Irish timber (improved or not) in an EWP - the most obvious example is in I-joists However, there are a number of issues that would need to be considered, not least production costs (see Chapter 3). Furthermore, EWPs that can be made from Irish Sitka spruce can also be made from higher strength class European whitewood, which is often sold at a similar price to Irish material.

The changes in the market described above have yet to fully materialise and may not happen as they depend to some extent on the greater use of machine grading. Cost and to some extent quality will always drive the market; Irish timber will always have a market if it is priced attractively and providing the standard of quality and packaging does not deteriorate.

Material properties of Irish Sitka spruce and EWPs

Sitka spruce properties

Irish Sitka spruce has similar properties to UK grown material. In Ireland it will be machine graded using (I.S.) EN 14081-4 machine settings (this also applies to timber exported to Ireland). The United Kingdom Timber Grading Committee (UKTGC) has accepted that Irish Sitka graded to (BS) EN 14081-4 may be used in the UK and NSAI has accepted a reciprocal arrangement. Timber strength graded to TR26 (effectively a UK grade) is accepted in Ireland and is used mainly in roof trusses and perhaps some I-joists and steel web beams.

Timber is a heterogeneous, natural material with properties that vary depending on species, geographical source, location in the tree stem, moisture content and so on. The strength class system groups together timbers with similar strength properties which simplifies timber selection and specification. Strength classes are the primary means of specifying structural timber throughout Europe. The same strength class system is used in I.S. EN 338, I.S. 444 and BS 5268 Part 2. This results in the design engineer not needing to consider issues such as species and the source of the timber.

EN 14081 provides a common method throughout most of Europe for strength grading timber and assigning the grades and species to a strength class. Table 2.3 shows strength requirements for C16 and C24, the most common strength classes used in Ireland and the UK. Irish Sitka Spruce falls mainly into C16 (machine graded or visually graded to RS - a unique grade specified only in I.S. 127 and applicable only in the Irish market), while the main strength classes for imported redwood or whitewood are C16 and C24.

There are two strength classes primarily used for timber truss rafters in the UK: TR26 and TR20 which are specified in BS 5268 Part 2 and not in any European Standard. Of these two grades TR26 is the only one imported into and used in Ireland.

While overall the characteristic values for Irish Sitka spruce fits with the C16 strength class[2] this does not rule out the possibility of attaining an acceptable yield of higher strength classes

Table 2.3: EN 338 main characteristic values for C16 and C24 (British Standards Institution 2003).

Strength class	5th percentile bending modulus, adjusted to 150 mm depth (N mm^{-2})	Mean modulus of elasticity (N mm^{-2})	Mean density (kg m^{-3})
C16	16 (5.3)	8000 (8800)	370 (370)
C24	24 (7.5)	11000 (10800)	420 (420)

Figures in parentheses refer to permissible values given in I.S.444 and BS 5268 Part 2.

[2] *as determined by the strength at the 5th percentile, mean stiffness and mean density*

such as C24. However, work by Picardo (2000) and at BRE has shown that above the C24 strength class yields are likely to be very low.

EWPs

Most EWPs are manufactured from high strength timber or composites such as LVL. Imported timber tends to be used in EWPs to maximise their high strength properties. If Irish timber is to be used as a direct substitute for imported timber there are two potential options

- the timber is graded to higher strength classes or
- the inherent properties of the material are improved (e.g. through re-engineering).

Assignment of Irish timber to higher strength classes realistically can only be done using machine grading. In the short to medium term the inherent properties of the material could be improved through processes such as lamination, re-engineering or total reconstitution of the timber in the manufacture of products such as parallel strand lumber (PSL). The process of re-engineering timber to produce EWPs is outlined in Chapter 3.

The common strength classes used in Ireland and their associated basic properties are listed in Table 2.4, as well as typical uses. The horizontal arrows show the up-grade potential of the timber and the likely level of re-engineering required to achieve that up-grade.

Upgrading timber should enable it to be used in a wider range of, and in higher value applications, but this needs to be balanced against the cost of upgrading.

Table 2.4: Typical applications for various grades of Sitka spruce and the estimated up-grade potential as a result of re-engineering.

Quality/Grade	Non Specific	Pallet wood (including sideboards from large logs)	Construction timbers		
			C16	C24	TR26
Uses	Chip, pulp, firewood. Bio-fuel.	Pallet, caressing.	Structural timber used mainly in domestic construction.	Higher quality structural timber used mainly in conventional floors, trusses or I-joists.	Very high quality structural timber used mainly in trusses.
Typical properties	Mixed quality containing a range of characteristics. A selection process is required.	Predominantly small knots and straight grained.	Average quality. Knotty, average slope of grain, tendency to distort.	High quality. Smaller knots and knot clusters. Low slope of grain and low tendency to distort.	Low slope of grain. Low tendency to distort. Highest strength, stiffness and density of the three strength classes shown.

Finger jointing short lengths. → → →

Laminating/finger jointing → → ⋯→ possible

Typical applications for various grades of Sitka spruce and the estimated up-grade potential as a result of re-engineering.

Manufacture of EWPs from Sitka spruce

The range of EWPs that can be made from Sitka spruce is determined by the general properties of the raw material as a structural timber. The precise added value achieved by manufacturing EWPs varies depends upon the product, dimensions, throughput, overheads, raw material price, raw material quality, transportation costs and the specific factory setup. These issues are further considered in the cost benefit analysis section in Chapter 3.

Long lengths of solid timber

Short lengths of timber generally have no potential for structural use. Defect cutting and finger-jointed can upgrade the timber to a higher strength class as well as producing long lengths; opening the door for their use in manufacture of EWPs. These products should command a premium price, which will help to offset the extra processing costs.

A BRE project sponsored by the GB Forestry Commission demonstrated that the yield of C24 was significantly increased by finger jointing Sitka spruce planks following the removal of major knot clusters (defect cutting) (Holland 2005b). An increase in strength beyond the C24 class seems less likely; the project clearly demonstrated that both stiffness and density limited the timber achieving higher strength classes.

Sideboards (approximately 25 mm thick) are cut from the outer portion of the log as it is squared for sawing and offer good potential for use in EWPs due to their good mechanical properties. Recent work at BRE on the use of sideboards for EWPs showed that around 80% of a sample of Irish Sitka spruce sideboards made the SS visual grade in I.S. 127/BS4978 (equivalent to C18 in I.S. 444/BS5268 and I.S. EN1912). Testing confirmed the graded material met the C18 strength class.

Work in the Partners in Innovation (PiI) project *Adding value to UK timber: Development and demonstration of glued laminated products* (Holland 2002) showed that randomly selected un-graded boards when laminated as pairs could meet the requirements of strength classes C18, C20 and C22 and fell just short of making the C24 strength class.

The study also examined the possibility of laminating pairs of boards that met I.S. 127/BS4978 SS (equivalent to C18 strength class) to meet the requirements for C24, but the majority of laminated planks failed to qualify. However, by selecting and laminating the stiffest and densest boards, a large proportion of the resulting planks exceeded the requirements for the C24 strength class and showed potential for achieving the TR26[3] strength class and perhaps entering the truss rafter market. If TR26 could be met there is every possibility that the C27 strength class would be met as well.

Therefore, sideboards have the potential to be used in EWPs and could form the basic assembly components for more complex EWPs, for example flanges for I-joists and pressed metal web beams. However, before using sideboards in EWPs the structural and mechanical properties of the resource would need to be determined, as well as the properties of the laminated boards. The cost effectiveness and the probable requirement for certification would need to be taken into account.

▲ Sitka spruce log pile.

Glulam and LVL

Glulam is usually produced by laminating long lengths of solid timber, commonly using finger or scarf joints. Sideboards have the potential to be used in glulam subject to grade limitations on the section size and the material properties being known. BRE has recently accumulated test data on deep glulam beams made with laminated boards 20 mm thick (Holland 2005a). The timber was Spanish chestnut but the underlying principle of thin laminate glulam remains the same and the

[3] *TR26 is exclusively a BS 5268 strength class which was aimed at directly replacing the M75 machine grade of CP112.*

principles should be applicable to Sitka spruce. The tension face (bottom) lamellae were required to have a low slope of grain and low micro-fibril angle for improved performance and this is where sideboards have an advantage over timber from the rest of the log, as they have a low slope of grain and micro-fibril angle[4].

Laminated Veneer Lumber (LVL) uses laminates are only a few millimetres in thickness and can be manufactured in the form of structural beams or as a board material. A project carried out by TRADA on behalf of the GB Forestry Commission demonstrated that LVL can be successfully produced from UK grown Sitka spruce logs. Selected logs were peeled and laminated and tested by TRADA with the LVL demonstrating good technical performance and performed particularly in water absorption tests where Sitka spruce's refractory nature resulted in low water take up.

LVL is an EWP in its own right and can be used for rim boards (header joists) and lintels for timber frame construction or as assembly components for other EWPs, such as I-joist flanges.

Complete products or systems

A possible use for Sitka spruce could be in a complete building or component system. For example, systems such as complete floors, roofs and walls could be developed and then evaluated by a Technical Approval Body; it may not be necessary for the individual components of that particular system to be evaluated separately, provided that they are listed as a part of the specification of the system.

Potential routes to market for EWPs

This section summarises the re-engineered timber process and how these products might achieve approval for use (Table 2.5). Appendix 1 describes quality control and certification issues specific to the Irish market.

The products above could be used in other EWPs such as I-joists and open web steel beams. However, the low cost of high strength class imported timber would make it difficult for such products to be used in these products. Open steel web beams are manufactured in Ireland and this would be an easer market to target than that for I-joists which are all currently made outside of Ireland.

Glue cost would be a significant factor and the selection of glue outside EN 301 might be an economic requirement. Green gluing might reduce waste and might be economical but would require further research.

Many of the above products and true EWPs are manufactured already on a scale which Ireland cannot probably match. Competition with established products can be difficult no least because established products can react to market competition by temporarily lowering prices and by aggressive marketing.

The routes to market for EWPs in today's structural products market are:

- designing the EWP within codes and standards

  The market may still demand third party certification. The future introduction of CE marking may also effectively result in the need for third party certification.

  Some testing may be required to confirm a products performance. Testing may be able to provide evidence of a products superior performance than that determined by design to existing codes and standards. This would involve third party certification and approval.

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[4] *Wood from the outside of the log is 'adult' compared with juvenile wood in the core – usually confined to the first 15 years or so of growth. Juvenile wood is prone to distortion on drying and is generally weaker than adult wood.*

- designing the EWP outside of codes and standards – where the product or process used is not covered by current regulatory framework will require third party approval.

  This is the Technically Approved Product route, a common method used to take new products, such as EWPs, to the market place. It can involve a process or use of adhesive not covered by current codes or standards. This is a less restrictive route than designing within codes and standards but is usually more expensive at the outset, but in the long-run could be cost effective when taking into account to the potential market size. Approval must be re-obtained if design changes, not taken into account at the outset, are made during the life of the product.

Table 2.5. Processes for approval of re-engineered wood products.

PROCESS	COMMENTS
Sideboards/solid timber	
Finger jointing short lengths	No increase in strength class. Existing grading rules apply. Maximum strength class C18 (visual grading) and C24 (machine grading, but small yield).
Defect cutting and finger jointing	Existing grading rules apply. Strength class may be able to be increased but only to a maximum of C24 with some increase in yield.
Defect cutting, finger jointing and lamination Lamination and gluing would have to comply with the relevant standards (e.g. EN 386 Glue laminated timber – Performance requirements and minimum production requirements). Third party approval (e.g. by the Irish Agrément Board) may be demanded by the market. Visual grading – limits on minimum of thickness of 20mm. Machine settings – minimum thickness dependent on machine, usually 30 or 35mm. The use of glues outside those in EN 301 would require third party approval.	2 boards (using the above methods) can be glued together and design based on the grade of the single laminate. Additional testing and product approval would be required if any increase in strength was to be derived from the 2 boards acting together – this would be a unique product and the increase in strength would have to be substantiated by extensive testing. Glulam requires a minimum of 4 laminates. The use of 4 single boards (or 2 double boards) glued together could be used in Glulam and design based on standards and the grade of the single boards. Scarf jointing might be possible in Glulam. The laminated boards should be more stable than solid timber which may help the boards in a wider range of uses e.g. joinery.
LVL	
Peeled logs A larger proportion of the log is used productively than in sawn timber. As there are a large number of thin laminates, the process uses large amounts of glue. The use of glues outside those in EN 301 would require third party approval. Production costs are high and LVL is expensive in the market place. Therefore only small amounts of LVL tend to be used; often in conjunction with floor systems such as I-Joists. The process can be used to produce boards (similar to plywood) or structural sections.	The laminate thicknesses are too small for normal grading rules to apply. Therefore, strength properties would have to be determined by extensive testing. Some pre-selection may improve the strength properties of the LVL, but these selection procedures would themselves involve testing and research to develop. High strength values would be expected, possibly equivalent to C24 or higher. The final product rather than the laminates would have to be tested. The result would be a unique product with its own strength properties defined in the certification.
Parallel strand lumber (PSL)	
Logs are sliced into strands and the strands re-constituted by gluing (under pressure) into boards and larger structural sections. Many of the comments on LVL apply.	The process is similar to that for OSB boards. The strands can be cut differently producing different products that use different amounts of glue. The material properties would have to be determined by extensive testing and third party certification would be required. The testing and certification process would be similar to that followed by Smart*Ply*.

Codes and standards

Adhesives are defined in EN301 by their chemistry, either phenolic or aminoplastic. Any EWP that is manufactured to the current codes should use one of these. However, the current trend is to use polyurethanes, popular on the Continent for the last 15 years. These fall outside of the current codes and standards, though currently an annex to prEN14080 (the main standard for glued laminated products) is being drafted that will permit the use of polyurethanes, provided that they meet performance criteria in the annexe. Before the annexe comes in to effect, the use of polyurethane adhesives should be as a Technically Approved Product, as is currently the case in Sweden, Germany and France, where the adhesive has been tested and found suitable for certain end use applications.

European Technical Approval Guidelines (ETAGs) and CE marking are also relevant to the operation of codes and standards. ETAGs apply to a product that currently have no European product standard and allow manufacturers to use innovative design. Their status is set out in each product specification document. They can, where appropriate, apply to EWPs or products made from EWPs, as in the case of ETAG 011 (Light composite wood-based beams and columns) which can apply to I-joists and similar products. Likewise, ETAG 019 (Prefabricated wood-based load bearing-stressed skin panels) can apply to EWPs containing products used in a manner covered by the ETAG.

CE marking applies to current product codes and standards and attests that the product has been produced in accordance with the relevant European codes (as referenced in the mark). For the timber industry this means that timber will or can carry a CE mark if its production complies with the appropriate European standards.

Technically Approved Products

Third party approval demonstrates the performance level of the product and provides information on the use of the product. This gives confidence and reassurance to end users and helps the introduction of a new product. To obtain certification the product must be defined in terms of its material, production and performance, and independently tested (depending on the attestation level required) by a third party body such as IAB, BRE Certification, BBA, BM-TRADA or BSI.

Where possible, working to the current codes and standards is recommended as it is the most cost effective route to market. However, when the product falls outside the usual design process a Technically Approved Product is the appropriate route to market. Experience has shown that without independent verification of performance, market placement will be difficult and the manufacturer is exposed to a higher risk in the event of difficulties arising from the use of the product.

The advantage in certification is that it demonstrates that the product will perform as specified, when used in accordance with the manufacturer’s instructions, giving confidence to end users. While this approach may seem costly at the outset, in the long-run it is cost effective provided there is a sufficient market to recoup costs. However, any changes in the manufacture, materials used or specification would require a further round of third party approval.

Conclusion and recommendations

This report outlines the following key points regarding re-engineered Irish timber as a feed stock for EWP manufacture (the LVL referred to is for structural sizes):

- Sitka spruce is the most common tree species in Ireland and accounts for 60% of all forests. Irish forests produced 3.3 million m^3 of round wood in 2003 and this is predicted to increase in future. Based on these figures it is considered that there is sufficient Sitka spruce available in Ireland to sustain a relatively large scale EWP factory. However, this would depend on the type of EWP as distinct from a re-engineered product.

- EWPs such as glulam and LVL can also be successfully produced from Irish Sitka spruce. There is potential for board materials to be made from Irish Sitka spruce and their technologies should be explored.
- Competition to Irish timber suppliers include: low prices of imported timber superior material properties of imported timber, changes to common strength grading machine settings in Europe that may result in a higher standard trading band and competition from other materials and new products.
- The innate characteristic properties of Irish Sitka spruce are equal to the C16 strength grade.
- Density and stiffness are the important properties when assigning Irish Sitka spruce to a strength class particularly when machine grading.
- There are two main routes to market for an EWP:
  - Designing the EWP within codes and standards,
  - Designing the EWP outside of codes and standards - the EWP will require third party approval.
- EWPs can be made successfully from Irish Sitka spruce. Structural products with up to C24 strength characteristics can be made by re-engineering. Both TR26 and TR20 strength grades could be attainable by Irish Sitka spruce if appropriate pre-selection criteria are used.
- Designing EWPs within codes and standards is advised in the long-run where possible. If this is not possible Third Party Approval is the alternative for a relatively quick method of getting the product on the market
- The environmental credentials of timber and timber products should not be overlooked as they are a major issue for any EWP producer.

In summary:

Considering the above conclusions and recommendations, a change in the perception of the use of Irish Sitka spruce is recommended. Four key options are available to the Irish industry:

- Look for new markets as specified in this report to replace markets lost to other species, products or materials
- Re-engineer the material's properties to make it more suitable for use in a broader range of products
- Use Sitka spruce in an evaluated and approved complete system irrespective of its components.
- Produce the more commonly used EWPs (e.g. I-Joists) using Irish timber to compete with imported products. The scale of the operation would depend on whether the export market (possibly Europe but certainly the UK) would be targeted. Considerable further research would have to be carried out to justify the investment that an EWP plant would require.

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Chapter 3
COST-BENEFIT ANALYSIS

Summary

This section considers the costs and benefits of producing Engineered Wood Products (EWPs) in Ireland, based on BRE's experience in the UK, with emphasis on:

- materials;
- equipment;
- skills;
- erection;
- whole life performance;
- costs related to the newness of the products.

Costs were estimated for the production of EWPs based on re-engineered timber, and manufacturing processing. Costs for EWPs are difficult to predict for a specific product type (e.g. I-joists) as the complexities of company confidentiality and market competitiveness limit the availability of robust data. Costs are dependent on factors such as product dimensions, raw material quality and price, processing methods, throughput, overheads, transportation costs and specific set-up details (e.g. production layout).

The cost of producing example products was estimated using a BRE cost model. Laminated products were the cheapest to manufacture, while EWPs with finger joints and laminations were the most expensive – the more processing required, the greater the cost.

Introduction

This section addresses the main issues which need to be considered when weighing up opportunities for EWPs using Irish Sitka spruce as the raw material.

In the analysis, a technical explanation of re-engineering is provided, as it is anticipated that re-engineering will be necessary for Irish timber to be used to produce EWPs. The further processing required to manufacture specific EWPs (I-joists, open metal web beams, glulam and SIPs) from re-engineered timber or traditional timber products is also outlined.

Production costs for finger-jointing and laminating operations can be estimated using a BRE cost model. Detailed costs for the manufacture of specific EWPs are difficult to estimate due to commercial sensitivity and a wide range of factors affecting production, such as:

- product type;
- product dimensions;
- raw material quality, source and price;
- throughput;
- level of automation in the process;
- overheads;
- plant layout;
- transportation of raw materials and finished products.

Production costs are estimated for manufacture EWP feedstock; the feedstock being based on re-engineered C24 structural planks derived using the following processes:

1. finger-jointing only;
2. laminating only;
3. finger-jointing and laminating.

These re-engineering processes were chosen due to the potential application of the feedstock produced in different EWPs. Cost predictions for the three processes were assessed to provide guidance on whether the feedstock could be manufactured cost-effectively.

The costs and benefits of EWPs were compared to traditional wood products by assessing:

- materials and equipment;
- handling;
- skills;
- erection;
- whole life;
- costs related to product newness.

All costs quoted in this report are indicative only; a generic exchange rate of €1.4 to 1 GB£ has been used. All prices quoted are exclusive of VAT.

Re-engineering timber products

Re-engineering is the process of improving a product's performance or to manufacture or use a product more efficiently. It mainly includes: defect cutting, finger-jointing and timber lamination; the number of potential end uses and manufacturing applications can be increased by these processes.

Processes such as chipping, peeling and slicing of roundwood have not been considered in detail as they are considered to be used mainly in composite board products such as ply and

OSB which can be used in conjunction with solid timber to produce EWPs, e.g. as webs in I-joists.

The re-engineering process can be undertaken in the stages shown below and vary depending on the product being manufactured. Kiln drying has not been included as its use in the production process will change depending on whether re-engineering uses dry or wet timber.

1. *Rip-cutting*: boards are sawn into strips, and can take place either early on in re-engineering or towards the end depending on raw material inputs and product requirements. Ripsaws can be used to remove waney edges or to cut boards to required widths. Strips may be cut before defect identification and crosscutting, or after lamination where pieces of timber have been glued together to produce large boards which then require cutting to size.
2. *Defect identification*: unwanted defects can be identified on the board surface either manually by trained strength graders or by an automatic scanning system.
3. *Crosscutting*: identified defects are removed using crosscutting either manually or mechanically (Figure 3.1).
4. *Finger-jointing*: after defects have been removed the resulting short lengths are finger jointed into longer lengths (Figure 3.2).
5. *Planing*: after drying boards can either be planed or left rough sawn. Planing will be required if the material is being face or edge laminated into thicker or wider sections.
6. *Edge or face laminating*: larger cross-sections can be produced by edge or face lamination (Figures 3.3 and 3.4).

These processes can be undertaken using either dry or wet (green) timber but laminating more than two wet sections can lead to drying difficulties and is not recommended.

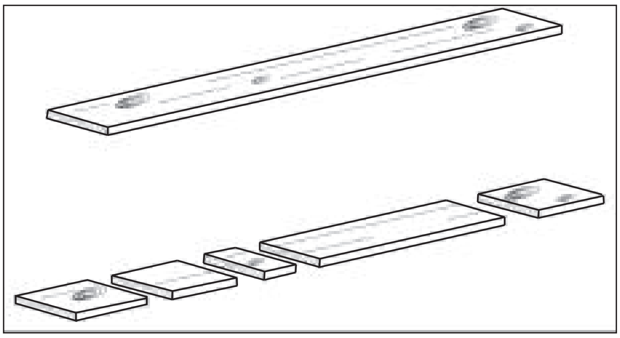

Figure 3.1: Defect cutting.

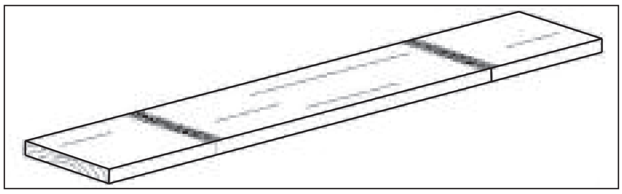

Figure 3.2: Finger-jointed board.

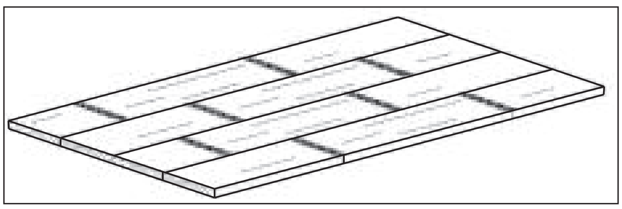

Figure 3.3: Edge laminated board.

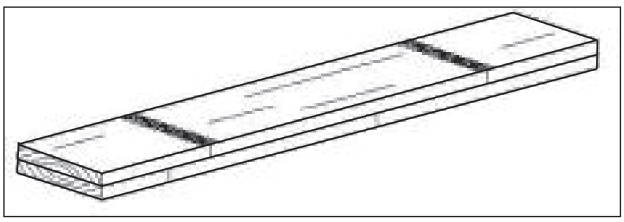

Figure 3.4: Face laminated product.

Production costs

The costs of producing a small range of re-engineered C24 structural timber products from sideboards (or falling boards) and planks, using defect cutting, finger-jointing and laminating technology on a large scale were predicted using a cost model developed by BRE. In the analysis, the re-engineering line is manned by five persons, working a highly automated re-engineering production line. Costs of administrative, managerial and sales staff are not included. The initial capital investment is estimated at €1.4 million (machinery only).

EWPs made from Sitka spruce for structural applications only are considered, although the process may be suitable for joinery blanks using other species such as lodgepole pine.

Material costs

The main factors influencing material costs are type, quality and source.

The type of raw material includes the timber component (e.g. Sitka spruce) and any other materials required to produce the finished product, particularly adhesives. Spread rate and joint type influence gluing costs, and these can differ greatly from one product to the next - for example face laminated boards require more glue than finger joints. Surface roughness also affects glue usage - rough sawn boards have a larger surface area than planed boards and take more glue although the bond may be stronger. Furthermore, the price of adhesives varies according to the level of usage, size of orders, and the type of adhesive. If the glue is not listed in EN301 then the adhesive (or product using it) may require third party certification which would be an additional cost.

The cost of timber depends on a number of factors including roundwood prices, transport and the level of processing. The level of processing is an important factor in the cost base in EWP manufacture. It can be part of a sawmilling operation or, for example, it can start from bought-in kiln-dried sideboards, proceeding to finger jointing and laminating to produce a C24 plank, which could then be sold on as flange material for I-joists. A sawmill producing feedstock could start with the unprocessed log while a company specifically manufacturing the feedstock may have to buy in processed material. This processed material could vary from kiln dried timber and or strength graded timber to boards which have already been re-engineered to some extent.

Finally, the source of raw material and security of supply need to be considered and may indirectly influence plant location and cost.

Equipment costs

The equipment outlined in Table 3.1 is required to manufacture the C24 structural planks and was used to model manufacturing costs. The machinery is available from a number of different manufacturers, with the choice depending on:

1. type and range of product;
2. processing speed;
3. degree of automation;
4. quality of finish;
5. machinery versatility;
6. capital cost;
7. maintenance costs.

Appendix 2 shows examples of suitable equipment for use in the different processes in the manufacture of C24 structural planks; the equipment can of course be used for other purposes. Table 3.1 shows an example of machinery selected top end of the range for the manufacture of C24 structural planks and was used in the BRE cost-benefit analysis.

Products in excess of 6 m can be manufactured using finger-jointing and laminating technology and are likely to provide the greatest return on investment. However, a more expensive bespoke system may be needed and for this reason the example products in Table 3.1 are all less than 6 m.

Handling costs

Handling costs related to the production of C24 planks include:

- Transportation – these include raw material supply (if the plant is not located in a sawmill) and transport to the customer. Locating close to a raw material supply will reduce transport costs.
- Storage – storage of raw materials and finished products can be a significant cost - this can be minimised by just-in-time delivery.
- Process handling – a good plant layout and automated transfer between machines can dramatically reduce handling costs.

Other handling costs are covered in the erection costs section.

Table 3.1: Machinery required to produce C24 structural planks.

Processing stage	Machine (manufacturer)	Performance specification/machine limitations	Costs
1. Rip saw	Profirip KM310M (Weinig)	• 90 to 105 mm max. thickness, depending on machine set up • 310 mm max. width	• €50,000
2. Cross-cut saw	Opticut 150 (Weinig)	• Automatic throughfeed saw • 150 m/min feed speed • 2.5 m infeed table (up to 6.3 m available) • 5 m outfeed conveyor • 150 mm min. infeed length • 30 x 12 mm to 230 x 130 mm cross-section	• €84,000
3. Finger-jointer	Ultra (Weinig)	• Horizontal or vertical finger joints • Shaper (2.5 packets/min) and press (4 cycles/min) • 600 mm package width • 20 to 80 mm thick, 40 to 205 mm wide sections • 150 mm to 1000 mm infeed length	• €210,000 +€28,000 (PU adhesive application system) =€238,000
4. Planer	Unimat 1000 (Weinig)	• 5 spindles (5 to 9 available) • variable feed speed (36 m/min) • 2.5 m straightening table • 20 to 230 mm width • 8 to 120 mm thickness	• €74,200
5. Laminating press	LS/L/CA (Orma)	• Automated • Face lamination • Glue system • 5300 mm max. length • 1300 mm max. thickness • 150 mm max. width (excludes delivery, commissioning and training)	• €252,000

Notes to Table 3.1:

1. All machinery has been checked to ensure that it is suitable for the manufacture of the C24 structural planks. However, in some cases the equipment may require larger support or straightening tables to rest long lengths as they pass through the machines.
2. Estimates using the BRE model for the finished C24 planks are provided in Tables 3.2-3.4.
3. Scanners and sorting equipment have been excluded as they are not essential for a re-engineering line. They may be incorporated in a production process at a later stage to improve productivity and quality.

Labour, training and QA/QC costs

These include:

- Administrative, marketing, sales and managerial staff and factory floor staff. In the cost model only five factory floor staff at €25/hour were used.
- Training for machinery is included in the equipment price for all machines produced by Weinig. Other machinery manufacturers may provide training either as part of the equipment price or as an additional cost.
- If manual defect identification is used then an experienced visual grader will be required.
- Quality assurance (QA) and quality control (QC)[5] are essential costs that must be borne in EWP manufacture.

Issues related to product newness

Introducing innovative products to the market can entail considerable effort as there may not be any established standards or regulatory guidance governing their design, manufacture and use. To demonstrate regulatory compliance, manufacturers may have to prove the suitability of the product by other means such as independent third party approval of the system or component. Certification and technical approvals offer third party confirmation and assurance that products meet and will continue to meet the requirements set out in the conditions of approval. Upon request, a third party notified body, such as the Irish Agrément Board (IAB), BRE and TRADA, develop approval criteria which set out the requirements based on the intended use of the products, taking into account Building Regulations, relevant standards, Highways Regulations and essential requirements listed in the Construction Products Directive (CPD) and other regulations.

Performance assessment for approval of construction products and/or systems typically includes:

- Structural behaviour and design, including the safety concept adopted, basis for design, strength values (this can be the most important part when only component certification is required).
- Fire resistance performance and reaction to fire.
- Acoustic performance.
- Thermal performance.
- Durability.

Achieving the approval criteria may require considerable testing which can be expensive and time consuming; in addition the criteria may identify a need to change aspects of the product or system or limit the application. The manufacturer may have to introduce a Quality System requiring considerable staff and resources and may have to change the manufacturing system even to the extent of changing or updating their premises.

There is an ongoing cost in maintaining the certification if the approval is to remain in force. This will involve surveillance assessment visits and satisfactory completion of agreed audit procedures. Certification can be suspended or withdrawn if the conditions of product certification are not maintained.

The cost for certification depends on the product, building system and the complexity of the assessment, as well as the technical information available. Clear, well laid out documentation can reduce costs and speed up certification.

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[5] *Quality control (QC) is a series of procedures to measure and control product quality. Quality assurance (QA) is a planned system of review procedures conducted in-house (normally by personnel not directly involved in the process) or by third parties to assure that the quality systems and controls in place are adequate and are being followed.*

For the re-engineered structural planks discussed in this section, certification costs are likely to be closer to the lower end of the range. Where components are used in building systems (for example finger jointed stud material used as part of a novel timber framing solution) the certification tends to be more extensive.

Secondary costs relating to the newness of products include the education of end users, building control, specifiers and site staff but are important to the success of the product or building system.

Appendix 1 describes quality control and certification issues specific to Irish markets.

Re-engineered structural plank cost predictions

The cost of producing the C24 structural planks was predicted using a cost model developed by BRE. The model has been used in previous BRE studies, such as a green-gluing feasibility study (Cornwell et al. 2005), to predict re-engineering costs for various timber products. Further processing requirements for the manufacture of a number of EWPs from these planks are also provided.

The plank dimensions chosen are typical product dimensions for those used in timber frame buildings and various floor constructions, while also being suitable for use in other EWPs, for example I-joist flanges. A range of processing options was covered by varying the use of finger joints or laminations. The three product types covered were:

- Finger-jointed products (Table 3.2 shows predicted costs).
  - 38 x 89 x 4800 mm planks produced by finger-jointing battens (no laminating)
  - 38 x 140 x 4800 mm planks produced by finger-jointing battens (no laminating)
  - 44 x 200 x 4800 mm planks produced by finger-jointing battens (no laminating)
- Laminated products (Table 3.3 shows predicted costs).
  - 38 x 89 x 4800mm planks produced by laminating sideboards (no finger joints)
  - 38 x 140 x 4800mm planks produced by laminating sideboards (no finger joints)
  - 44 x 200 x 4800mm planks produced by laminating sideboards (no finger joints)
- Finger-jointed and laminated products (Table 3.4 shows predicted costs).
  - 38 x 89 x 4800 mm planks produced by finger-jointing and laminating sideboards
  - 38 x 140 x 4800 mm planks produced by finger-jointing and laminating sideboards
  - 44 x 200 x 4800 mm planks produced by finger-jointing and laminating sideboards

The cost model takes the following factors into account:

- machinery capital costs (see Table 3.1),
- full machinery depreciation over a 5-year period,
- machinery utilisation factor (70%),
- machinery throughput (based on linear throughput of the slowest machine),
- power consumption (KWh – as specified by machinery manufacturer),
- fork lift truck use (€50.40/day),
- labour (€25/hour),
- machinery accommodation cost (based on floor area of machinery = €53.84/day),
- glue cost (€6.6/kg),
- product dimensions,
- product shrinkage during drying (4%),
- planing of finished product,

- number of finger joints per finished product length,
- number of laminations.

This model estimates the cost of re-engineering only. Therefore, the initial raw material costs, log-to-board conversion costs, handling/storage costs and administration/management costs must be added to the cost of re-engineering to find the overall cost of production. These costs are specific to each plant and largely depend on its set up and nature of the business. Manufacturing costs for the generic re-engineered planks are outlined below. Figures 3.5 to 3.8 show in a graphical format the results in Tables 3.2 to 3.4; Figure 3.9 summarises Figures 3.5 to 3.8.

The predictions above provide only indicative costs, calculated for a specific set of machinery, production, factory and energy costs.

The main trends to emerge were:

- The greater the throughput the lower the re-engineering cost.
- Laminated planks are cheaper to produce than finger jointed planks, while finger-jointed and laminated planks are the most expensive, as each processing step adds cost.

Table 3.2: Re-engineering costs for finger-jointed C24 structural products (with no laminating).

Product	Finished product dimensions (mm)			Infeed material dimensions (mm)			Finger joints (No.)	Laminations (No.)	Total glue costs (€/m³)	Production per day (m³)	Total cost (€/m³)
	Thickness	Width	Length	Thickness	Width	Length					
1	38	89	4800	44	95	1000	4	1	15.96	33.14	**84.67**
2						700	6		37.91	23.20	**130.09**
3		140			145	1000	4		10.14	52.14	**58.93**
4						700	6		24.09	36.50	**87.79**
5	44	200		50	205	1000	4		7.92	86.24	**42.95**
6						700	6		18.82	60.37	**62.86**

Table 3.3: Re-engineering costs for laminated C24 structural products (with no finger joints).

Product	Finished product dimensions (mm)			Infeed material dimensions (mm)			Finger joints (No.)	Laminations (No.)	Total glue costs (€/m³)	Production per day (m³)	Total cost (€/m³)
	Thickness	Width	Length	Thickness	Width	Length					
7	38	89	4800	21	95	4800	0	2	27.26	79.54	64.05
8	38	140			145				26.45	125.13	54.94
9	44	200		25	205				22.60	206.98	45.36

Table 3.4: Re-engineering costs for finger-jointed and laminated C24 products (contains finger joints and laminations).

Product	Finished product dimensions (mm)			Infeed material dimensions (mm)			Finger joints (No.)	Laminations (No.)	Total glue costs (€/m³)	Production per day (m³)	Total cost (€/m³)
	Thickness	Width	Length	Thickness	Width	Length					
10	38	89	4800	21	95	1000	4	2	34.52	16.57	157.96
11						700	6		44.52	11.60	214.87
12		140			145	1000	4		31.07	26.07	114.65
13						700	6		37.42	18.25	150.82
14	44	200		25	205	1000	4		26.56	43.12	82.63
15						700	6		32.00	30.18	106.09

Note to Tables 3.3- 3.5:

1 For a 4800 mm length product containing finger joints, the minimum number of joints is four, as the Ultra finger-jointing machine used has a maximum infeed material length of 1000 mm.

2 All products can be produced using the machinery outlined in Table 3.1.

3 Production is based on an 8-hour day.

4 Where finger joints are used defect cutting can be incorporated in the process to provide additional benefits through re-engineering.

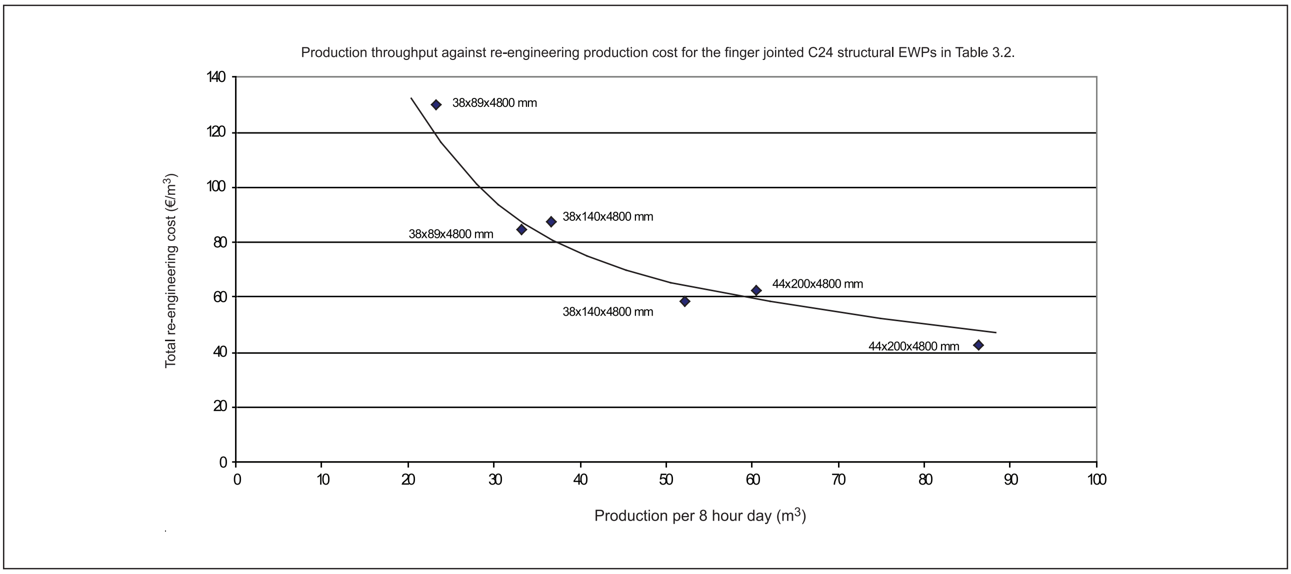

Figure 3.5: Re-engineering cost of finger-jointed EWPs as a function of daily production volume.

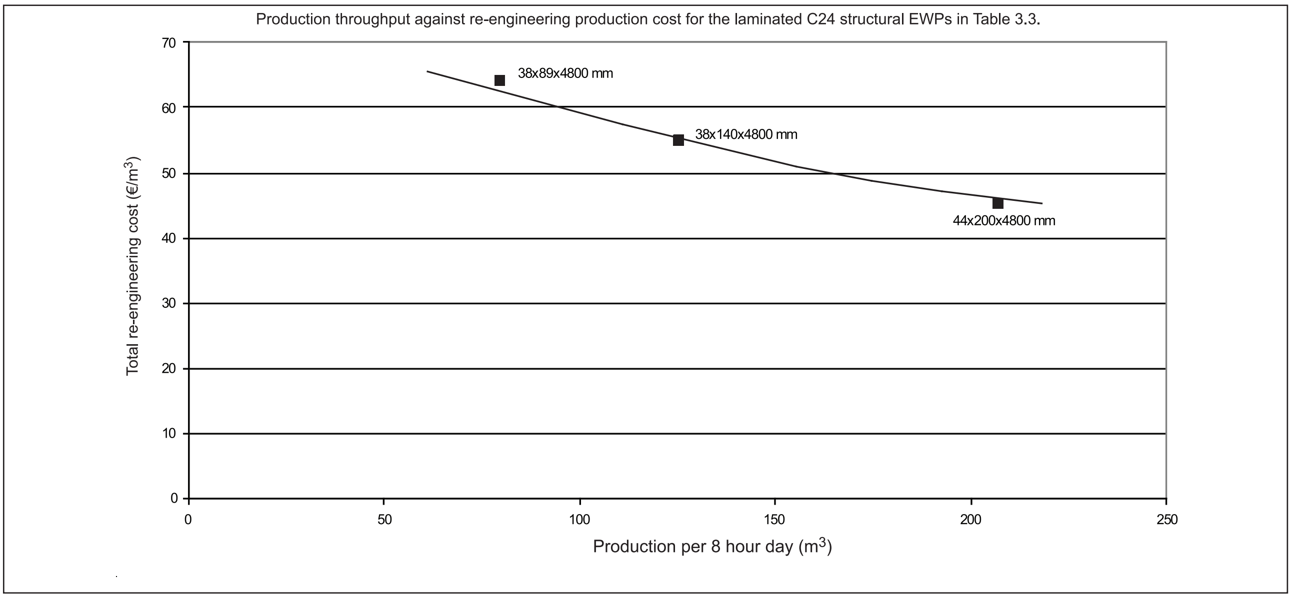

Figure 3.6: Re-engineering cost of laminated EWPs as a function of daily production volume.

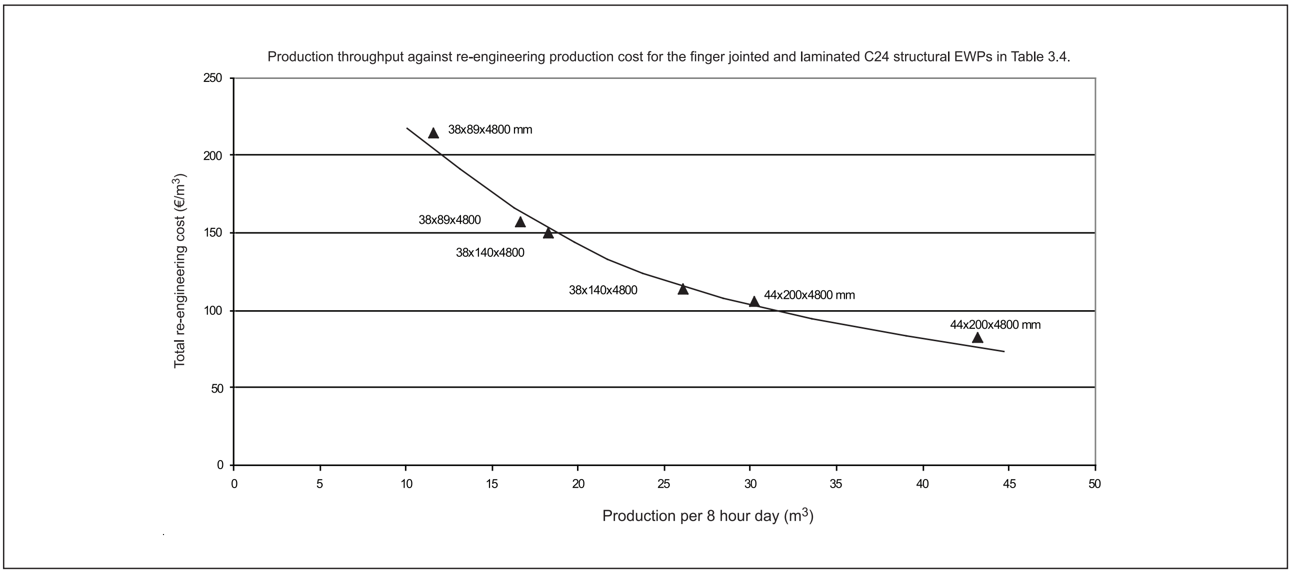

Figure 3.7: Re-engineering costs of finger-jointed, laminated EWPs as a function of daily production volume.

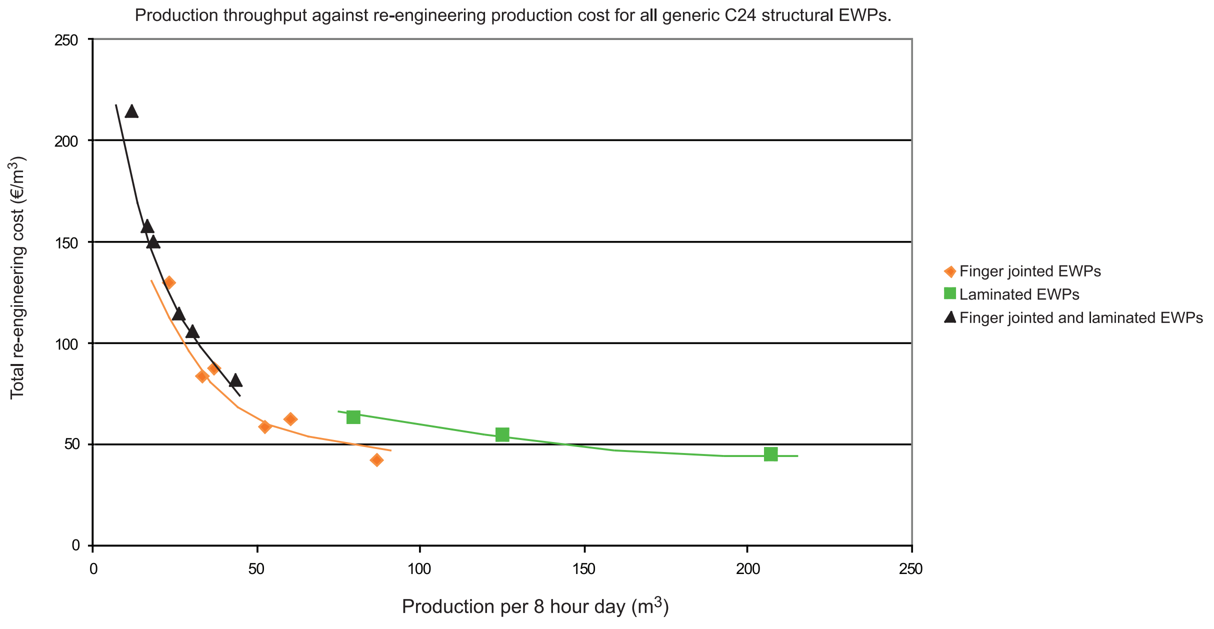

Figure 3.8: Re-engineering costs incurred in the production of EWPs as a function of daily volume production.

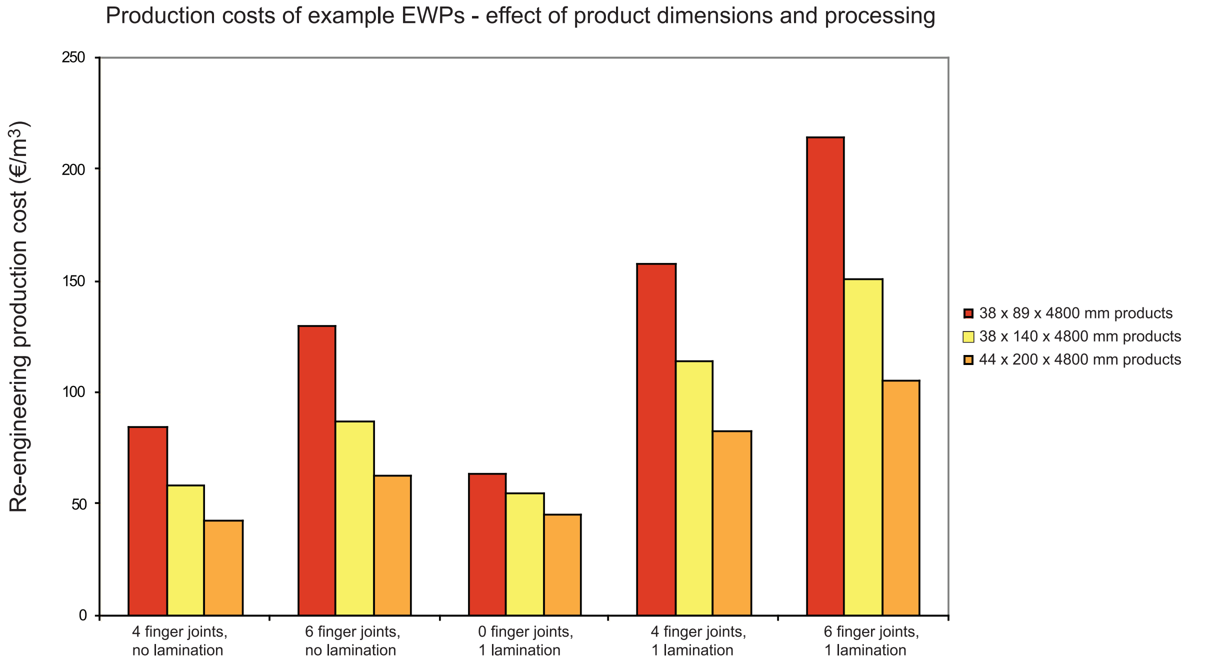

Figure 3.9: Effect of product dimensions and associated finger-jointing and lamination on re-engineering cost.

- Planks with a small cross-sectional area are the most expensive to produce.
- The larger the product cross-section the lower the production cost - a cubic metre of product with a large cross-section contains fewer finger joints and/or laminations than a cubic metre of product with a smaller cross-section.
- As the number of finger joints increases the product cost also increases. Low quality timber will require more defect cutting and subsequently more finger jointing than higher quality material – the higher the quality the lower the re-engineering cost. This suggests that there is a quality threshold for raw material below which re-engineering becomes too expensive and the process is not commercially viable.

EWPs in use

EWPs are high quality components which are well suited for use in offsite manufacturing systems and applications. In the UK, EWPs have been used in floor cassettes, pre-fabricated wall systems and extensively in roof applications. Off-site manufactured products and/or Modern Methods of Construction (MMC) have considerable benefits, the most common ones are:

- Predictability of cost, front-end planning minimises delays in the building schedule and reduces time wasted on site.
- Reduced contract period results in savings as buildings can be finished sooner resulting in quicker returns on investment. With savings of up to 35% on project duration (Kelly 2004), pre-fabricated components have had a considerable impact on the UK construction industry. MMC are now part of UK government policy and will probably be one of the main construction practices used in the future.
- Reduced construction waste on sites, fewer defects and associated disposal and remedial costs.
- Savings through reduced site activities and simplification of site activities. As engineered materials are designed for a particular end use, building systems using EWPs require fewer components, simplify on-site procedures, aid quality management and speed up delivery times. Higher quality can be achieved by having specialist erection crews that are trained and experienced in the erection of MMC.
- Less dependency on traditional craft skills with the potential to reduce labour costs.
- Less disruptions on site as products are tested and commissioned prior to delivery.
- EWPs are structurally strong and light components which are well suited for inclusion in lightweight construction solutions and may require lighter foundations. This has

▲ I-joists are light, easy to use and facilitate service runs.

several advantages: less excavation (soil can be used on-site, reducing disposal costs and disruption) and quicker build times.

- Health and Safety savings, with pre-manufacture there may be less work at height or in restricted areas, as systems can be assembled on ground and lifted into place. The use of fewer staff and less time spent on site should also result in savings.
- Fewer products on site can help minimise theft, loss and damage.

Potential EWPs using Irish Timber

Detailed production costs for specific EWPs (e.g. I-joists) are difficult to obtain due to the commercial sensitivity of the information in a highly competitive and emerging market. If Irish timber is to be used in the manufacture of EWPs it will probably need to be re-engineered; this section discusses the further processing required to produce EWPs from either the re-engineered planks described earlier or traditional timber products.

Types of EWP that can be made using Sitka spruce:

- Glulam beams consist of a minimum of 4 lamellas, face glued in order to build up the cross-section size. Finger-joints or scarf joints are often used to produce long lengths.
- I-joists consist of two flanges connected by a composite web (commonly OSB). Grooves are machined into the face on each flange to accommodate the web. (In an attempt to compete with I-joists a product called UltraJoist, a super-dry (approximately 14% moisture content) solid timber product, with preservative and water repellent treatment, has been launched recently).
- LVL consists of thin veneers face glued. They tend to be used in flanges of I-joists and steel web joists. Associated with LVL are rim joists which act as header joists in timber frame construction and are usually part of an I-joist floor system. LVL usually involves the rotary peeling of logs; the high knot content of Irish logs may affect the appearance and quality of finish. Rotary peeling results in a better recovery rate compared to sawn timber. High capital costs are a significant factor in considering investment in LVL manufacture.
- Metal webbed joists are similar to I-joists but with the two flanges connected by an open metal web.
- Parallel Strand Lumber (PSL) usually involves the slicing of the log into long strands which are then glued and reconstituted together. The process results in a better recovery rate compared to sawn timber. High capital costs are a significant factor in considering investment.

Different components, including the re-engineered planks can be incorporated into building systems such as timber frame construction. Long lengths of head and bottom plates can be produced, studs can be finger jointed to utilise short lengths and reduce waste. EWPs such as glulam and I-joists fit well into timber based building systems - better than steel or other high strength products.

Potential benefits of re-engineering

The benefits of re-engineering include:

- More efficient use of the Irish timber resource. Re-engineering allows shorter lengths and smaller cross-section planks to be used to produce longer and larger timber products.
- Increased value of the Irish timber resource. Re-engineering may add value to low value timber by up-grading the quality and strength of the timber section.

- Using sideboards in EWP manufacture makes good use of the sapwood of large logs, which tends to have good mechanical properties. Sideboards are traditionally used for pallet manufacture, a low value application.
- Upgrading from C16 to C24, and above, could enable Irish suppliers to compete better with European sawmills which may not grade whitewood below C24 in the future.
- Re-engineering enables lengths in excess of 6 m to be made from Irish timber. This could represent a market opportunity as it is now difficult and expensive to purchase long, traditionally sawn timber products.

If the timber is green glued additional benefits could be realised, including improved dimensional stability, reduced distortion (therefore reduced rejects) and reduced kiln drying costs (energy and space savings).

Conclusions

The following main costs associated with re-engineering are:

- Raw materials: type, quality and source affect cost.
- Equipment: typical machinery required includes rip saws, cross cut saws, finger-jointers, moulder/planers and laminating presses.
- Handling: transportation, storage and movement within the plant all affect cost.
- Labour, training and QA/QC: in addition to staff on the re-engineering line, staff requirements include administrative, marketing, sales, and managerial staff and related training costs.
- Glue: higher costs might accrue if glues outside accepted standards such as I.S. EN 301 are used.
- Production: Laminated products (with no finger joints) were the cheapest to produce, while finger-jointed/laminated products were the most expensive - the more processing the higher the production cost.

It is clear that manufacturing re-engineered planks is more expensive than traditional processing and they will be more expensive than traditional sawn timber products. Therefore in order to justify higher prices planks need a marketing strategy highlighting their advantages over traditional sawn products. For example, re-engineered timber planks can have reduced distortion, improved dimensional stability and improved strength.

Excluding timber, the main costs associated with EWPs are:

- Production: labour and insurance costs can be significant.
- Capital costs: these can be high depending on the type of EWP.
- QA/QC: a system will be required for manufacture.
- Certification: due to the newness of a product certification and testing will be required to prove the performance of the product.
- Technical guidance and documentation: aimed particularly at specifiers, end-users and site personnel generally.

Some key benefits of EWPs include:

- More efficient use of the Irish timber resource.
- Increased added value to the Irish timber resource.
- Irish timber products remain competitive with imported whitewood.
- The production of long length structural products.

- On site savings from the use of lightweight prefabricated components resulting in faster build times.
- I-joists can have improved acoustic performance and dimensional stability.
- Glulam can be made in large cross-section sizes and lengths which are not currently available from most sawmills.

In Ireland a number of companies have been looking at I-joist manufacture. Technical issues that need to be considered include:

- certification
- engineering backup
- design system including hardware and software
- construction details
- site documentation and guidance

The availability of the software package, along with technical back-up (as well as certification) will be vital to the products acceptance in the construction market.

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Chapter 4
OPPORTUNITIES AND THREATS

Summary

This section assesses the opportunities and threats associated with the increasing use of Engineered Wood Products (EWPs) in Ireland. To further the analysis, assessments were carried out of the technical benefits and weaknesses of the individual EWPs, the Irish timber resource and its inherent characteristics.

A brief review of the development of the EWPs is outlined, for glulam, laminated veneer lumber, parallel stranded lumber and I-joists. Factors that influence the adoption of EWPs are examined, particularly the use of off-site prefabricated components. The UK experiences with EWPs are reviewed and the attitude of insurers towards timber frame housing is considered.

An assessment is provided of the opportunities and threats on the use of Irish timber and EWPs.

The main opportunities include:

- The continuing strength of the construction industry;
- The increasing market share achieved by the timber frame sector;
- The potential for greater numbers of social and affordable housing units using timber frame;
- The increased emphasis on sustainability should lead to timber products obtaining increased market share from less sustainable materials;
- Changing living and working patterns leading to provision of options for re-configuring interior space in dwellings;
- Changes in construction practice (greater use of EWPs by masonry builders);
- Sawmills involvement in EWP manufacture and distribution.

The potential threats and constraints include:

- Availability of low cost imported sawn timber
- High costs of re-engineering timber for EWP use
- Greater use of EWPs replacing sawn solid wood components in construction
- The limited size of the Irish forest resource for large scale EWP manufacture

Introduction

Construction methods are increasingly moving towards off-site construction. Evidence of this shift is already strong in the United Kingdom with an increasing use of modular construction and pre-fabrication.

In Ireland a similar increase in off-site construction practice has occurred, with timber frame achieving 25% market share of the housing market. There has also been an increase in the use of steel frame and pre-cast concrete systems that have Irish Agrément Board certification, although these systems have not achieved the same market share as timber frame.

Approximately 60% of the Irish forest resource is Sitka spruce, which with its long strong fibres is suited for use in a number of EWPs. Private sector forests could, over time, become a source of raw material for EWP manufacture and ease concerns over timber supply.

EWPs are not exclusively used in modular or prefabricated construction systems, although this is a common end use. They are also used in masonry built housing challenging sawn solid timber use and EWPs such as I-joists and steel web joists are a clear threat to many traditional solid timber uses. The performance capabilities, environmental and sustainability benefits of wood and EWPs can be harnessed to effectively challenge competing materials such as steel and concrete.

Engineered wood products development

The emphasis in manufacturing wood products has changed in recent years, with the breakdown of roundwood into strands, veneers and fibre constituents, which are then reconstituted into new solid sections, boards, and other construction products. The use of adhesive is important to the performance of these products, which tend to have uniform and well-defined mechanical properties, good performance characteristics and have good environmental credentials. Notable examples of EWPs used in structural applications include: glue laminated lumber (glulam), laminated veneer lumber (LVL), parallel strand lumber (PSL), and board products, e.g. plywood and oriented strand board (OSB). The latter products can be further processed to form structural elements such as I-joists or steel web joists.

While many factors have contributed to the evolution of EWPs, customer demand, fibre supply and quality, environmental concerns, and new technologies have been the principal drivers (Guss, 2003). The future for EWPs appears to be positive, as they provide solutions to issues such as skilled labour shortages, the need to reduce construction site waste, and the possibility of reducing construction time on site (Century Homes 2003).

The strengths and weaknesses of the more commonly used EWPs are outlined below.

Glulam

Glulam is a strength graded engineered product comprised of wood laminations that are bonded together with strong, water-resistant adhesives. The laminations are scarf or finger jointed together to produce long lengths, which are then bonded together to create the required beam dimension (Engineered Wood Systems 2003). The grain of all laminations usually runs parallel to the length of the member. Glulam products typically range in net widths from 60 to 275 mm, although virtually any width can be custom produced (The Engineered Wood Association 2005).

Some of the advantages include savings in time and labour, the availability of a wide range of section sizes and long lengths. Glulam has greater strength and stiffness than comparable

Curved glulam can be used creatively and effectively to achieve aesthetically pleasing structures meeting many design requirements.

sized solid timber; thus glulam can span longer distances with minimal need for intermediate supports. Designers and builders have virtually unlimited design flexibility when using glulam, whether the application be for house construction, commercial warehouses or highway bridges.

Glulam components can be manufactured to meet a range of design requirements including curved, tapered beams and arches. Glulam can be manufactured more economically and efficiently by placing cheaper and weaker laminations in the centre of the section and the stronger laminations on the bottom and top edges of the section, where the maximum bending, tension and compression stresses tend to occur.

Glulam members are available in virtually any size and are often used for portal frames and for aesthetic reasons in open spaces. Typical uses range from simple purlins, ridge beams, floor beams and cantilevered beams, to complete commercial roof systems. In some instances, warehouse and distribution centres with roof areas exceeding 100,000 m^2 have been constructed using glulam framing.

Another positive attribute of glulam is its relatively good fire resistance. It performs in a predictable and uniform manner in fire (compared to steel members which may buckle and twist at high temperatures potentially causing early failure). Wood typically chars at a rate of around 0.6 mm per minute, thus, after 30 minutes of fire exposure, only the outer 18 mm or so would be damaged. The char insulates the underlying timber and protects it from further attack by the fire and enables the undamaged timber underneath to continue to carry load. Glulam sections can easily be designed to accommodate charring, so that the section will continue to function (i.e. in terms of supporting load and deflection) for the required period of fire exposure.

While glulam has benefits and advantages, it also has some weaknesses. Beams must be stored properly and handled with care to assure optimum performance. They should be protected with sealants, primers or weather resistant wraps when they leave the manufacturing plant. In addition, sunlight can discolour the timber, so additional precautions may need to be taken on site to protect the appearance of the timber.

Laminated Veneer Lumber - LVL

A relatively recent innovation is a group of products known as structural composite lumber. The main producers are based in the US and Finland, with the products generally branded and protected by patents or trademarks. Laminated veneer lumber (LVL) is in common use in Europe and is made from veneer sheets bonded together using water-resistant adhesives under high pressure with the grain direction of the plies parallel to the section or panel length.

Standard thicknesses of LVL range from 27 to 75 mm (for Kerto - a brand of Finnforest, from Finland) and 19 to 89 mm (typically for US producers). Widths typically range from 200 to 600 mm (although they can be supplied as full panels with a width of 1800 mm and more as specials). Lengths can range up to 25 m but are usually limited by transport considerations. LVL can be used as beams, truss members, as flange material in I-joists, and for various uses in prefabricated housing.

There are many advantages associated with LVL. It is a strong, uniform and consistent product, and the parallel laminated lumber out-performs conventional timber. LVL can be sawn to any specified size and is virtually free from warping and splitting. Another advantage associated with LVL is that the veneering and gluing processes enable large

▲ I-joists manufactured from LVL flanges and OSB webs.

timber sections to be made from relatively small trees, thereby providing for efficient utilisation of wood fibre resources.

Some of the disadvantages associated with LVL include its storage requirements. While all timber products should be stored off the ground, correctly stacked, ventilated and protected from the weather the low moisture content of LVL, resulting from the manufacturing process, means that it particularly susceptible to moisture pick up. Changes due to moisture uptake can include cupping, bowing or expansion to dimensions beyond the specified tolerance.

Producers usually have Agrément Board certification or similar and supply information on the product such as strength and stiffness values and guidelines on its use.

Some LVL producers may include a protective coating that retards moisture uptake during exposure.

Parallel Strand Lumber - PSL

Parallel Strand Lumber (PSL) consists of short, narrow strands of timber veneer. The main commercial brand in Europe is called Parallam® (manufactured by Weyerhaeuser). Species that have been used successfully in the manufacture of PSL, include Douglas fir, western hemlock, and yellow poplar. Parallam® is manufactured from strands cut to a thickness of 2.5 mm, a width of 19 mm and a length up to 2.4 m.

Water-resistant adhesive is used to bond the strands in a press using microwave curing, to produce large sections by a continuous process. The maximum depth and width of the finished product are 480 mm and 285 mm, while a wide range of lengths is available to suit customer requirements. Laminated strand lumber (LSL), is a variant on this process, using 300 mm long flakes and is produced in smaller section sizes.

An advantage of PSL is the fact that it uses wood resources more efficiently with more of the log volume being used compared to sawn timber and by allowing the manufacture of large beams from small logs. The quality requirements of the logs used for manufacture are not as high as for LVL production.

The disadvantages associated with PSL are similar to those with LVL (and LSL) as PSL is also manufactured with low a moisture content.

I-joists

I-joists are fabricated using flanges of sawn timber or LVL and wood panel webs (usually OSB) bonded together with adhesives. I-joists can be made in virtually any length (transport being the limiting factor) allowing long floor lengths to be made thus reducing cutting, overlapping and material waste on site. Compared with solid timber they can span longer distances and the joist spacing can be wider, resulting in a lighter section with fewer pieces to handle and install. Several of the main manufacturers supplying customers in Ireland are listed in Table 4.1.

Table 4.1: I-joist suppliers.

Brand	Manufacturer	Group	Base
BCI Joist®	Boise	Boise Cascade	United States
FJI	Finnforest	Metsäliitto Group	Finland
JJI	James Jones Timber Systems Division	James Jones and Sons Ltd	Scotland
TJI®	Trus Joist	Weyerhaeuser	United States

I-joists and timber strand.

Advantages of I-joists include good dimensional stability, lightness, ease of handling and the easy installation of pipes or cables through pre-formed openings. In particular, the lightness and ease of handling allow for faster installation both in site-made floors and in factory fabricated floor cassettes. I-joists allow the manufacturer to make efficient use of wood fibre resources while producing a product that performs to a consistent standard (APA 2005).

Potential disadvantages associated with I-joists are that they are unstable until they are completely installed and should not carry their design load until fully braced and the sheathing fixed. I-joist floors may have additional fire resistance requirements to floors using solid joists. Most I-joist floors need to be fire stopped and need a higher performing ceiling construction; if fire breaks into the floor void, rapid failure of the floor can occur.

Some timber frame companies use I-joists only in medium rise construction (effectively apartments), mainly because they are suitable for long spans, and are considered to provide better sound insulation than solid joists. A few of the companies surveyed claimed that I-joists did not result in time savings in floor cassette manufacture, whereas others claimed significant time savings. A number of companies have stopped using I-joists because of the difficulty in correcting any site errors.

Metal-webbed joists

This type of engineered product is classed as an ‘open webbed’ joist and is usually made from high strength class softwood flanges connected together by profiled thin V shaped steel webs. This results in a lattice type web that allows easy access for services to be installed on site. These joists share many of the advantages and drawbacks described for I-joists. They are beginning to be seen more commonly on sites in Ireland (in masonry and timber frame construction) and at present there are three or four manufacturers in Ireland.

Metal-webbed joists.

Factors that influence the adoption of EWPs

The remarkable growth of engineered wood products (in volume terms mainly I-joists) in the last few decades constitutes one of the success stories of the wood products industry (De La Roche, Dangerfield et al. 2005). However, timber has been used as a structural element in buildings for centuries and has proven to be an excellent material for such applications, mainly due to its superior strength/weight ratio (Guss 2003). As discussed earlier, from the manufacturing perspective many factors have led to the emergence of EWPs. However, the growing importance of pre-fabrication components or off-site has facilitated their rapid acceptance and use by the construction industry. Off-site construction is gaining market share world wide because of its affordability, superior quality, and flexibility in design, construction and renovation (Tissari 2002). The main factors influencing the growth of EWP and off site construction are outlined below:

1. Skills shortages

In recent years, there has been a skills shortage in the construction industry and high demand for labour has led to increased labour wages. As a result untrained personnel have been attracted into the building industry and this has had a detrimental effect on build quality. The use of prefabricated components reduces demand for skilled and unskilled site labour.

2. Insurance and staff costs

There has also been a general move to use sub-contractors due to insurance costs and the high cost of employment especially skilled staff.

3. Weather

The construction of masonry housing involves wet trades during the critical period of the building programme and these are affected by weather especially in the winter months. The use of EWPs and prefabricated components can help to overcome these difficulties and speed up construction. Timber frame is virtually a dry construction, and internal work can take place once the roof is battened and felted and the windows and door openings protected from the weather.

4. Speed

Prefabricated systems such as timber frame and steel frame are estimated to take 15-30% less build time than masonry block construction. This results in savings in labour costs, equipment hire and in better cash flow. EWPs (e.g. I-joist floor systems) can also speed up construction times on non-prefabricated buildings such masonry housing

5. The influence of government and EU policy

One of the factors influencing change in the construction industry is the desire of successive governments to encourage the improvement of and the adoption of new technologies within the industry. The introduction of the EU Directive on the Energy Performance of Buildings is also an incentive to use energy efficient building systems such as timber frame and steel frame.

Timber frame construction

Timber frame is a main user of EWPs due to the natural compatibility of the materials and ease of fixing, and is the main prefabricated construction method used in Ireland. As timber frame construction gains market share it is likely that EWPs will follow suit as more timber frame manufacturers use EWPs such as glulam, PSL and in particular engineered joists. However, EWPs (mainly engineered floor joists) have successfully penetrated the masonry housing market in the UK and it is expected that the Irish market will follow suit as well.

Like any building system there are advantages and disadvantages associated with timber frame construction. Table 4.2 illustrates the key features.

House construction in Ireland

Construction completions in Ireland exceeded 90,000 new units in 2006. In fact a record rate of building has been in place over the last decade, and is driven by several factors, including:

- A growing population strongly skewed towards the property buying age group; Ireland is the only EU country with a population bulge in the 25-34 age group.
- Immigrants from EU Member States have also stimulated the rental sector.
- Strong employment growth.
- Low interest rates.
- Tax incentives for investment in residential property (Bacon and Associates 2003).

Strong demand is predicted to continue into the foreseeable future; with sources indicating that more than 500,000 new dwellings will be required over the next 10 years.

Irish timber frame market

In 1990 timber frame accounted for 1% of total new houses in Ireland. Reliable national statistics on the number of timber frame dwellings constructed annually or the proportion of the total housing output represented by timber frame are not available. However, based on the Department of the Environment, Heritage and Local Government's Housing Statistics

Table 4.2: Advantages and disadvantages of timber frame construction.

Advantages	Disadvantages
Fast erection times.	Additional design and engineering time.
Reduced site labour.	Lack of experienced builders and erection crews; this is less so recently.
Reduced time in making the structure weather tight.	Following trades often lack experience of timber frame.
Earlier introduction of following trades such as plumbers and electricians.	Transportation costs and trailer access.
Low embodied energy.	Risks associated with exposure to weather before building is enclosed.
Greater recyclability.	Need for good organisation and site quality control.
Reduced construction waste through efficient controlled manufacturing.	Combustibility of timber requires vigilant quality control to achieve the required fire rating.
Low volume of waste on site.	Timber in external walls is preservative treated making disposal of waste material a little more expensive.
Energy efficient performance as thermal insulation is sheltered and protected from air movement.	Uptake and loss of moisture can distort timber and insulation should not be put in place until the framing moisture content is 18% or less.
Fast heating due to low thermal mass.	Additional scaffolding is required and to minimise scaffolding costs the site needs to be properly managed.
Fast construction time improves cash flow and reduces environmental nuisance and disruption to local residents.	

Bulletin and information from the Irish Timber Frame Manufacturers' Association, it is estimated that timber frame accounted for 25% of the housing market in 2005 and its market share is expected to continue to grow. Timber frame manufacturers predict that they will ultimately account half of all new dwellings on an annual basis (Kelly 2003).

The degree to which timber frame can increase its share within the housing sector depends on a number of factors. Recent changes in government policy now allow timber frame construction in Local Authority housing including affordable and social housing - a new opportunity to increase market share. As demand for EWPs derives largely from the timber frame sector, so this is also an opportunity for the use of EWPs. Section 4 develops this discussion in more detail.

Lessons from the UK timber frame market

System built timber frame housing was gradually introduced to the United Kingdom from the 1920s. Its use increased significantly in the period following the Second World War when housing demand rose sharply. By the early 1980s timber frame accounted for 20% of housing starts. However a television documentary broadcast in 1983 claimed that poor site practices were endemic throughout the timber frame sector, and predicted that large numbers of buildings would develop problems. As a result, timber frame construction in the UK (apart from Scotland) collapsed virtually overnight as customer confidence disappeared and speculative house-builders in England and Wales abandoned timber frame systems.

The predictions in the TV programme were not borne out. Work by the Building Research Establishment (BRE), including a detailed structural inspection of over 120 dwellings, representing over 40 timber frame systems, covering a wide range of site exposure throughout the UK, concluded that where 'worst case' situations were encountered they were the exception rather than the rule. The incidence of fungal decay found in timber dwellings built from 1930 to 1975 was slight and attributed to particular flaws in the design, construction or maintenance. Usually any fungal decay found was rare and localised and was relatively easy to correct. The BRE investigations concluded that the design and construction principles used in modern timber framed houses gave satisfactory long-term performance.

Timber frame construction in the UK is rapidly rising in popularity again as confidence within the construction industry increases. However, adverse media attention could easily undermine this rebuilt confidence. Consequently the timber frame industry in the UK has continued efforts to minimise and eradicate poor site practice and to continually improve standards; a similar process is underway in Ireland.

In the UK there was also a belief throughout the industry that timber frame houses incurred greater maintenance costs, that they did not perform as well as masonry built dwellings, were unsuitable for social housing and that tenant satisfaction levels were low. A report on the maintenance and performance of timber frame houses published by the Timber and Brick Information Council in 1994 concluded that any concerns about the long-term performance of timber frame dwellings and levels of occupier satisfaction were not based on fact. They also concluded that timber frame housing performs as well as masonry housing, and in a number of cases better. Thermal and acoustic insulation performances can be significantly higher in timber frame houses; in the UK the NHBC (National House Building Council, the UK equivalent of HomeBond) has found that they have had fewer call-backs with timber frame houses.

In summary, timber frame is a tried and tested form of construction and has become a recognised form of construction. Almost all of the two million houses built annually in Scandinavia, North America, and Australia utilise timber frame technology, while over 60% of all houses built in Scotland are timber frame.

Timber frame construction: Regulation and insurance

Timber frame manufacturers are regulated in Ireland by NSAI (National Standards Authority of Ireland) through their Timber Frame Manufacturers' Approval Scheme. HomeBond gives a 12-year structural guarantee on houses and apartments built by its members, and require that they use only approved manufacturers. HomeBond has also produced guidelines on timber frame construction in their House Building Manual. The timber frame industry is becoming more regulated with NSAI introducing a registration scheme for timber frame erectors and it has also commenced work on a standard for timber frame construction. FÁS (the body responsible for industry training) has also developed a training course for timber frame erectors. With the completion of the timber frame standard and NSAI regulating companies and erectors, confidence in the timber frame should increase and with it, its share of the residential building market.

Key industry sources from the timber frame sector have stated that insurance and financial institutions do not differentiate between timber frame and masonry construction; a number of major insurance companies confirmed that this is the case.

Opportunities and threats- the future of EWPs

This section looks at the strengths and weaknesses of the Irish forest resource and associated wood properties. Based on these considerations, opportunities to advance the use of locally grown timber and the threats presented by external influences were assessed.

Tables 4.3 (a and b) contain a SWOT analysis of the resource and the following section discusses the opportunities and threats presented.

SWOT commentary

Strong construction industry

Continuing buoyancy in the Irish economy and the factors detailed previously point to a strong construction industry in the short to medium term and presents significant market opportunities for all building materials.

Social and affordable housing

The opportunity for home ownership is related to property prices and interest rates. Recent trends have led to demands for greater state involvement in the provision of social and affordable housing and as a result the construction of several thousand units per year could be expected. However, Local Authorities have been slow to adopt timber frame as a building method for their social housing programmes; if the objections to this method of construction are overcome, there should be new outlets for both solid timber and EWPs.

Growth in timber frame housing

As stated earlier, the timber frame industry currently holds around 25% of the annual residential market, with predictions that this share will grow. Timber frame housing uses more timber than masonry construction and thus creates a higher demand for timber, including EWPs. The project survey suggested that timber frame companies are increasing their use of I-joists in their floor structures. It is estimated that currently I-joists are used in between 40% and 50% of all floor structures. More timber frame units should lead to a larger demand for EWPs such as I-joists and steel web joists (substituting for solid timber).

Table 4.3a: SWOT analysis of potential for manufacture of EWPs from home-grown timber - strengths and weaknesses.

STRENGTHS	WEAKNESSES
Some properties of Sitka spruce suit the production of a number of EWPs	Some properties of Sitka spruce make it unsuited for the production of some EWPs
The short rotation period of Irish forests means a greater volume of roundwood can be grown in a shorter time	Only low strength classes are available
A modern sawmill sector	Wood quality in privately owned forests is not well known
A strong board mill sector	Forecasted increases in roundwood supply may not be able to meet additional increased demand from EWP manufacturers
Strand based EWPs use a greater proportion of log volume	Production of strand-based EWPs may reduce the amount of co-products available to other sectors
A greater log volume goes into added value EWPs as distinct to lower value co-products	High costs of re-engineering or otherwise producing EWPs
	Imported timber can achieve high strength classes without the cost of re-engineering
	Transport costs to the UK and Europe

Table 4.3b: SWOT analysis of potential for manufacture of EWPs from home-grown timber – opportunities and threats.

OPPORTUNITIES	THREATS
Forecasted increases in roundwood supply may be able to meet additional increased demand from EWP manufacturers	Inexpensive high strength class imported timber readily available in Ireland
A strong construction industry	As I-joists gain market share, Irish timber may be more negatively impacted than imported material
EWP technology is readily available	Higher performance expectations, specifiers are demanding better products
Expansion of affordable and social housing	A move to a C24 trade band in solid timber could affect use of Irish timber in EWP manufacture
Growth in timber frame construction and off site building practices generally	Timber frame uses predominantly imported timber, it is difficult for Irish timber to satisfy timber frame quality requirements
The advent of the EU Directive on the Energy Performance of Buildings should encourage timber frame use	
Changes in living and working patterns	
Licences for the production of EWPs can be obtained without the need for expensive research, with possible tax breaks	
Trends towards sustainable construction suit timber products	

Changes in living patterns

Developments in technology and changing living and working patterns mean that more people are working from home or have the option to do so. It seems likely that these trends will continue, and with them the demand for more flexibility in the arrangement of living space in new houses. Thus, the use of large open spaces allowing for the re-configuration of room layouts may increase resulting in a demand for long floor spans will favour EWPs, especially engineered joists.

EWP production

One of the strengths of the indigenous sector identified in the SWOT analysis was that Ireland has an efficient modern sawmilling industry capable of high throughput. In addition, the technology to produce most engineered wood products is now readily available.

Plants of the scale necessary to produce re-engineered blanks for use in EWPs would be within the capability of the larger sawmills in Ireland. A dedicated line may be needed with timber being selected according to appropriate quality and grading requirements. These re-engineered blanks could be used in other EWP products such as glulam, steel web beams and possibly I-joists.

The scale and investment required for the production of flake or strand-based products, such as PSL or LSL would be far greater than that for producing re-engineered blanks and probably I-joists (but not steel web joists). However, the scale of investment in any process will depend on the product, raw material supply and the target market; addressing the European market would require a larger investment than just Ireland or Ireland and the UK.

Opportunity to obtain market share from less sustainable materials

Moves to evaluate construction products on the basis of their environmental impact will favour the increased use of timber products. Work undertaken by BRE points to the opportunities afforded to wood based products, as the energy involved in producing construction materials becomes a factor in decision-making.

Changes in construction practice

The results of the market survey clearly show that Irish timber frame companies have taken enthusiastically to using EWPs, and in particular I-joists. The same is not yet true of traditional builders, with relatively few using significant quantities of EWPs or engineered joists. Discussions with the UK industry show that EWPs have made major inroads in the masonry house building sector. This applies not only to large building firms where savings due to volume and uniformity of design might be expected, but also to small and medium sized companies. These firms have concluded that when all factors are analysed, engineered joists are the preferred choice to solid floor joists. It seems only a matter of time before similar reasoning will prevail in Ireland.

Higher housing density

High land prices accompanied the housing boom, which created ever-higher site costs per unit. This in turn influenced the design of residential structures with a recent trend to the use of apartments and duplex units. In timber frame apartment construction engineered joists are increasingly used in preference to solid floor joists for technical and performance reasons.

▲ Light-weight floor panels being lifted into position on a timber-frame construction site.

Size of the forest estate

The forest cover in Ireland has grown from very low levels at the start of the twentieth century to around 10% of the land mass, with significant investment in land acquisition and planting in the last few decades. However, this is a long way from the European average of over 30%. The annual output of roundwood from Irish forests currently stands at over 3 million m^3, compared to over 400 million m^3 from the main European suppliers. Close to 30% of the volume removed from Irish forests are thinnings with a substantial part going directly to the board mills for processing.

In the short-term additional volumes for the manufacture of significant volumes of EWPs is limited unless existing capacity is switched to their manufacture. Projections of output to the year 2015 show an increase in harvest volume of close to 4.5 million m^3. These figures are based on the Coillte output levelling off and a growth in private sector production to over 1.1 million m^3. An additional 560,000 m^3 is forecast from Northern Ireland's forests bringing the total potential harvest to over 5 million m^3. It is important to note that the output from private forests will be mainly in the small diameter classes, which will limit their direct use as construction timber. After 2015 the outlook depends on the rate of planting, which at the moment has fallen short of the targets set in the mid 1990s. Recently sawmills have begun to import logs from Scotland but this trend may not continue with rising log demand in the UK. Depending on availability and price, supplies from this source could supplement volumes required for an EWP manufacturing operation.

Availability of imported sawn timber

Irish timber has always had to compete with supplies from Europe and Canada. Recent entrants to the EU are adding additional volume to the timber supply. Estimates from Coillte and other sources put the annual consumption of sawnwood in Ireland at over 1.6 million m^3, with about 1.1 million m^3 being used in the construction sector. Of this total, the Irish Timber

Council (ITC) estimates that Irish sawmills produce 480,000 m^3 for the construction sector (representing over 40% of the market). The battle for market share is likely to intensify over the coming years with Irish producers being vulnerable to high log prices and production costs.

Costs involved in re-engineering

The ability to produce a viable engineered timber product is determined primarily by the ratio of extra costs to added value. Costs will include: losses from defect removal, machining (sawing, slicing peeling or flaking, depending on the process), adhesive, forming equipment (presses or clamping), re-sawing and planing/moulding, additional energy consumption and extra labour. It is therefore imperative that any re-engineered product be sold for at a higher price than the solid timber equivalent. However, the costs involved in re-engineering must be compared against the cost of buying imported timber, which may be at the same or even higher strength class of the re-engineered timber.

The Irish sawmilling sector

The results of the survey of the main sawmills revealed that they are fully aware of the growth in sales of EWPs (especially I-joists) and their belief that this growth will continue. Many sawmillers stated that they would like to know more about EWP products but were generally occupied to evaluate the EWP possibilities. While there is some experience in the sector with glued timber products, these have generally been made for non-structural applications. Sawmills do recognise that the key threat now and in the immediate future is from the engineered floor joists and 225 x 44 mm joists are seen as the most vulnerable.

Technical skills

Sawmillers recognise that additional in-house expertise and training will be required if they become involved in the production of EWPs. If EWPs are produced under licence it is likely that the licensor can provide some of this expertise and training.

Increasing strength of consumer lobbies

A potential plus point for the timber industry lies in the growing consumer awareness of the issues relating to the natural environment. If the environmental credentials of wood products can be demonstrated effectively in consumer markets, then benefits will follow. By moving quickly to higher standards of thermal insulation, some of the main Irish timber frame companies have kept ahead of the competition by emphasising their environmental credentials.

Conclusions

Having considered the principal opportunities and threats identified, the following conclusions were reached.

Re-engineered blanks and glulam

The principal re-engineering option described in this project is based on defect removal, machining and gluing to produce blanks for a range of engineered wood components. The scale of this type of investment is certainly within the capability of a number of the larger Irish sawmills. These products are effectively similar to glulam and can be further laminated together to produce large structural glulam cross-sections.

Metal-webbed joists

A number of companies are currently involved in producing metal-webbed joists and others are actively pursuing their manufacture. Although little evidence was found of widespread use of metal web joists, it is reasonable to assume that further potential exists for manufacturing in this segment. However, the volume of timber used in this form of joist is relatively low, being confined to the flanges.

LVL and strand or flake-based products

The current level of usage of products such as parallel strand lumber is low, but as builders and timber frame manufactures adopt the use of engineered floor joists the use of these products will increase, but not to any appreciable levels. PSL timber is expensive and tends to be used for lintels and beams as a substitute for steel and where solid timber is unable to carry the design loads.

If the option of manufacturing products such as strand or flake based materials were to be considered, an investment on a similar scale to a board mill would be required and timber supply dynamics would need to be carefully assessed.

LVL and strand based products such as parallel strand lumber require peeler grade logs, whereas flake based products can be manufactured from lower grade logs. A project carried out by TRADA on behalf of the Forestry Commission demonstrated that LVL could be successfully produced from UK-grown Sitka spruce logs (similar results have been obtained for Irish grown material). Selected logs were peeled and laminated on the continent and tested by TRADA. The LVL produced demonstrated good technical performance and performed particularly well in water absorption tests where Sitka spruce's refractory nature resulted in low water take-up.

I-joist options

It is clear from the survey that the key EWPs to consider are I-joists (and it increasingly appears also steel web joists). The level of investment required to produce the joists is not very large (especially for the steel web joists), but the key to success in this field is the ability to support the product in the marketplace with design information and software.

Most of the engineered joists systems have special ancillary products which typically include special depth rim boards (i.e. header joists), joist hangers, glulam beams, LVL beams, partition supports etc. Thus, while the main business is the manufacture and supply of joists, additional income can be derived from the supply of ancillary products.

Research requirements

The research requirements should focus on better knowledge of the quality and quantity of the Irish forest resource, allied to private and public investment in product and process innovation for the manufacture of EWPs.

Appendix 1

Quality control and certification

This section lists organisations involved in standards and certification of construction products, as well as some products that have been certified by the Irish Agrément Board (IAB).

Third party certification procedures have been instrumental in the introduction of EWPs in the construction industry. There are a number of institutions and certification bodies available to Irish companies, some of which are discussed below.

The National Standards Authority of Ireland (NSAI)

The National Standards Authority of Ireland (NSAI) develops and publishes standards to meet demands for quality, design, performance, safety and environmental impact of products and services. These standards are quoted extensively by architects, engineers and specifiers. NSAI comprises three sections: standards, certification and the Irish Agrément Board The certification section operates a number of voluntary timber certification schemes:

Visual Strength Grading and Machine Strength Grading Schemes

These schemes are offered to sawmills and timber merchants who wish to grade and stamp structural timber to the requirements of IS 127 (for the visual strength grading of softwood timber) and I.S. EN 14801-4 (for the machine strength grading of softwood timber). The scheme provides for the control and supervision of strength grading operations by trained and certified personnel. Only certified companies are permitted to use the NSAI registered mark on graded timber.

Roof Truss Manufacturers' Approval Scheme

The function of the scheme is to ensure that all roof trusses manufactured in Ireland comply with the requirements of I.S. 193 Timber Trussed Rafters for Roofs and I.S. EN 14250 'Timber structures - Product requirements for prefabricated structural members assembled with punched metal plate fasteners'. The scheme provides for the certification and on-going inspection of roof truss manufacturing plants and the inspection of manufactured trusses bearing the NSAI approved manufacturers mark.

Timber Frame Manufacturers' Approval Scheme

As with the other timber industry schemes, the NSAI requires companies to carry out certain procedures in order to achieve this standard. The NSAI's assessment and subsequent inspections verify compliance with the scheme requirements.

The Irish Agrément Board

Agrément certification is a process by which new products (which are not covered by a standard) are assessed by a technical review board and certified for particular use and under specific conditions. Agrément certificates provide an indication that a product is fit for purpose.

The Irish Agrément Board (IAB) reviews any submitted test data, drawings and samples and may visit the manufacturer's facilities. This technical evaluation assesses the products or methods and, if appropriate, certifies that the product is fit for purpose having considered

Irish construction practice, climatic conditions, Building Regulations, site installation and durability.

The level of demand for Agrément certification has accelerated since the introduction of the Building Regulations and in particular with the current building boom. The increased emphasis on environmental management, sustainability and greater focus on the need to achieve conformance with Building Regulations has also seen an increase in the number of products seeking certification.

The Irish Agrément Board has granted the following certificates, mainly associated with Timber Frame and EWPs:

Kingspan Tek Haus Building System

This relates to the manufacture and erection of buildings using structural insulated panels. The system can be used for domestic housing for up to two and a half storeys in height with a habitable space within the roof and can accommodate a wide range of custom designs covering detached, semi-detached or terraced house types (www.irishagrementboard.ie).

The Kingspan TEK Haus building system is based on structural insulated panels and is designed for use with brick, concrete block or other approved external finishes.

Ecojoist Beams

The Irish Agrément Board has granted a certificate to Ecojoist beams. The Ecojoist beam consists of strength graded parallel timber flanges, connected by engineered V-shaped galvanised steel webs. Ecojoist beams are suitable for use as structural members in floor construction in buildings up to and including four storeys high. The beams may be used in place of traditional solid timber joists.

Kingspan Century Homes Medium Rise Timber Frame Construction System

This certificate relates to the Kingspan Century Homes Medium Rise Timber Frame Construction System for the construction of buildings up to 4 storeys in height. The system can be used for domestic housing, including apartment blocks, and can accommodate a wide range of custom designs covering detached, semi-detached or terraced house types.

It should be noted that the British Board of Agrément has certified a greater number of similar products (especially engineered joists) and that many of the Agrément certificates can be downloaded from the IAB (www.irishagrementboard.com) and BBA (www.bbacerts.co.uk) web sites.

HomeBond

HomeBond is the main warranty company in Ireland and was first established in January 1978 to guarantee purchasers of new dwellings against major structural defects where they could not get satisfaction from the original builder. Currently HomeBond offers a warranty on structural defects for a period of 12 years and in some instances the warranty may extend to non-structural items. HomeBond inspects constructions to determine if “good practice” and/or HomeBond requirements are being met. HomeBond requires that new materials be independently certified that is effectively that they have an IAB or BBA certificate or similar. HomeBond also require that their builders use approved timber frame manufacturers.

Premier is a company has recently commenced operation in Ireland in competition to HomeBond and has an estimated 20% share of the market.

Architects and engineers

Architects and/or engineers can certify individual products and buildings systems. However, the Department of Environment, Heritage and Local Government does not readily accept this approach where grants or tax relief apply and HomeBond has concerns about this approach as well: both prefer products and systems to be independently assessed by a body such as the IAB.

Appendix 2

Rip-saws

- Flexirip (Raimann / Weinig)
- ProfiRip KM310 (Raimann / Weinig)
- ProfiRip KM310M (Raimann / Weinig)
- K34 V/1000 (Paul)
- C/GL (Paul)

Prices for ripping machines range from €28,000 to €56,000. In-feed section size limitations are: maximum thickness 90 to 170 mm; maximum width 310 to 1000 mm, some machines have a maximum length of 500 to 730 mm (but most have no length limit). Cheaper machines tend to have lower feed speed and throughput rates and usually have lower section size limits. Figure A1 shows a ProfiRip KM310 produced by Raimann / Weinig.

Figure A1: ProfiRip KM310 (Raimann / Weinig).

Scanning / sorting

- WoodEye cross cut (Innovativ Vision)
- WoodEye sorter (Innovativ Vision)
- WoodEye Parquet and Flooring (Innovativ Vision)
- EasyScan C90 (LuxScan Technologies)
- LaserScan C90/C180 (LuxScan Technologies)
- CombiScan C90/C180 (LuxScan Technologies)
- Xscan-Combi C180 (LuxScan Technologies)

Prices for scanners vary depending upon the processing requirements. Each production line has a different specification and as a result each scanner will have a specific set up. Scanners offer optimised cross-cutting, sorting and appearance grading capabilities, with a high degree of automation. Throughput varies but is likely to be limited by other machines in the processing line. Feed rates range from 30 to 300 m/min. In-feed sizes range from 4 to 125 mm thickness; 25 to 300 mm width and 250 mm to 10,000 m length. Scanning and sorting equipment has been excluded from the machinery in Table 3.1 as it is not essential for manufacturing EWPs. Instead, timber can be sorted and defects identified manually. It is more likely that scanners would be added at a later date to increase productivity. Figure A2 shows a WoodEye scanner produced by Innovativ Vision.

Figure A2: Basic WoodEye design (Innovativ Vision).

Cross-cut saws

- Maxicut 700 (Dimter / Weinig)
- Opticut S50 (Dimter / Weinig)
- Opticut S75 (Dimter / Weinig)
- Opticut 150 (Dimter / Weinig)
- 15AO (Paul)
- Push Cut CX203-C6 (Paul)
- Push Cut CX206-C7 (Paul)
- Series 11 (Paul)
- Series C14 (Paul)

Cross-cut saws range in price from about €15,000 to €84,000. Cheaper saws are manually operated while the more expensive are highly automated and can process material very quickly. In general the higher the price the larger the in-feed material that can be processed. Figure A3 shows an Opticut S50 cross-cut saw produced by Dimter / Weinig.

Figure A3: Opticut S50 (Dimter / Weinig).

Finger-jointing machines

- Profijoint (Grecon / Weinig) - additional capacity package and PU adhesive application system available
- Ultra (Grecon / Weinig) - PU adhesive application system available
- FJL 150 M or P (Omga)
- FJL 180SA (Omga)
- FJL 184 (Omga)
- FJL 183 (Omga)

Prices finger-jointing machines start at about €70,000 and go up to in excess of €350,000. All the makes outlined are capable of producing both horizontal and vertical finger joints. Feed speeds depend on the product being produced, the size of the shaper tray and the capacity of the press. Finger jointing is likely to be the bottleneck in most re-engineering production lines. Section sizes of in-feed material range from 15 to 150 mm in thickness, 15 to 205 mm in width and 150 to 1000 mm in length. Out-feed lengths range from 2 to 9.1 m. Figure A4 shows the Ultra finger-jointing machine produced by Grecon / Weinig.

Figure A4: Ultra (Grecon / Weinig).

Moulders / planers

- Unimat 300-002 (Weinig)
- Profimat P26 Fortec (Weinig)
- Unimat 1000 (Weinig)
- Robinson planer (Wadkin)
- Sintex XL (SCM Group)
- Compact P (SMC Group)
- Compact XL (SMC Group)
- Superset XL (SMC Group)

Moulders/planers cost from about €14,000 to €74,200. Feed speeds range from 5 to 36 m/min. In-feed material section sizes that can be processed range from 6 to 130 mm thickness, 13 to 230 mm width, and a minimum length of 300 to 600 mm. Figure A5 shows the Unimat 300 produced by Weinig.

Figure A5: Unimat 300 (Weinig).

Laminating machines

- Lamont Tregarne press (Lamont Tregarne)
- SP/L (Orma)
- LS/L and LS/L/CA (Orma)
- LS, LS/ECO and LS/CA/ECO (Orma)
- ProfiPress 2500 (Dimter / Weinig)
- ProfiPress 2500 RF (Dimter / Weinig)

Prices range from €18,000 to €252,000. Some machines do both edge and face laminating, while others are only capable of one or the other. Specialised laminating machines provide greater throughput and increased automation, but are significantly more expensive. The finished product size range is:

- Edge laminating: thickness up to 220 mm; width 2500 – 9000 mm; length 1000 – 1500 mm.
- Face laminating: thickness up to 220mm; width 2500 – 9000mm; length 1000 – 1500 mm.

Figure A6 shows the ProfiPress laminating machine produced by Weinig.

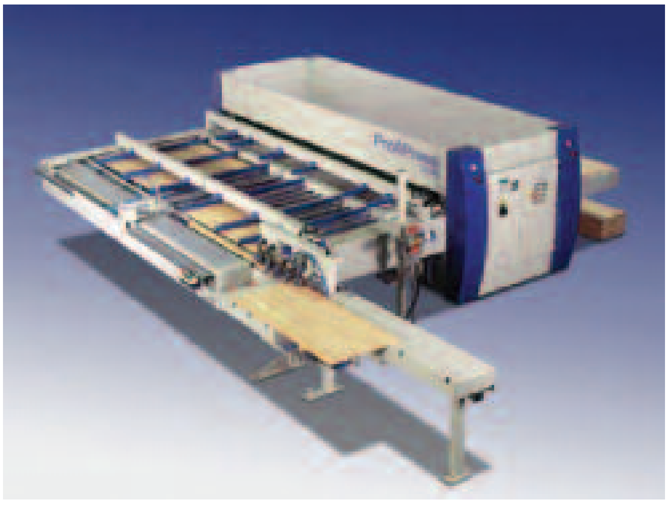
Figure A6: ProfiPress (Dimter / Weinig).