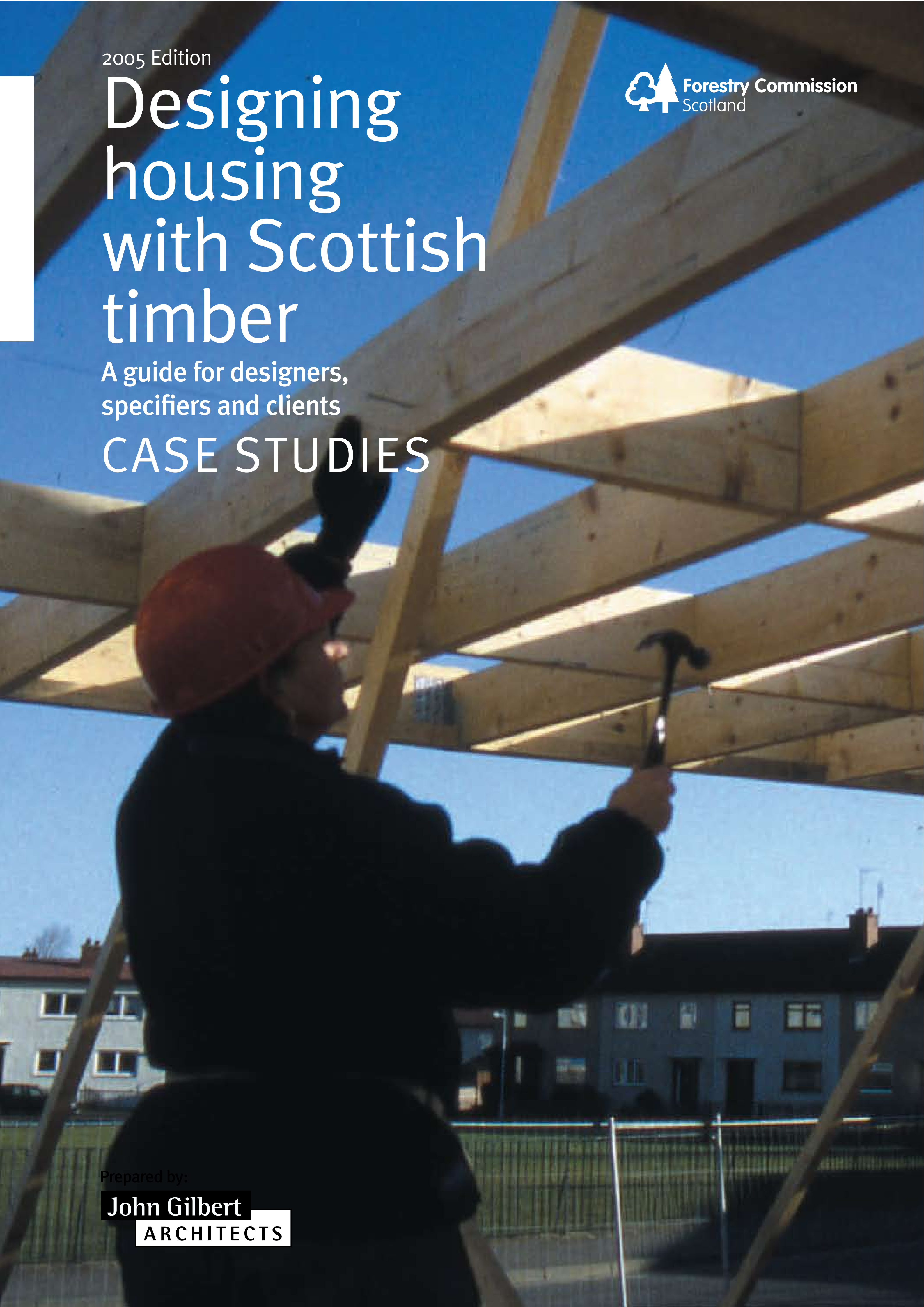
2005 Edition

Designing housing with Scottish timber

A guide for designers, specifiers and clients

CASE STUDIES

Forestry Commission Scotland



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Synopsis

This report by John Gilbert Architects was commissioned by Perthshire Housing Association and Forestry Commission Scotland, with support from Scottish Forest Industries Cluster, with the aim of reaching a wider audience that would include all those involved in providing social and private housing for rural locations.

The provision of locally sourced and produced construction materials is a key part of the sustainable design agenda. Rural Scotland is on the periphery of most transport networks and has vast timber resources; the potential to reduce transportation and increase local employment is huge. This report examines current sustainable housing and uses the lessons learnt to develop a new prototype, maximising the use of Scottish timber in rural, affordable, low energy housing provision. In addition it examines the practical implementation issues, such as costs, procurement issues and potential hurdles that need to be addressed.

The report is split into two sections, Section One outlines the development of a prototype, initial costs and the issues that would be important in construction. Drawings and supplementary information are within the appendices at the back.

Section 2 analyses four case studies of built social housing projects, in terms of their construction, timber usage and environmental credentials. It also considers the main reasons why Scottish timber is currently not commonly used in timber frame buildings.

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Section 2 - Case Studies
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1. Case Study Introduction

1.1.1 Previous studies into timber housing projects in Scotland have concluded that sawn Scottish timber is inconsistently used in the large scale manufacture of timber frame house kits, although it is used in post and beam structures. Large volume kit providers have their own supply chains which often source all their timber from Scandinavia and the Baltic, though some smaller scale producers do use Scottish timber. Timber frame construction is increasingly used in the social housing sector where it accounts for over half of the market share in the UK. Within Scotland the Scottish timber frame market has a 65% market share. Within many timber frame developments, considerable use is made of home grown board and engineered wood products such as orientated strand board (OSB), chipboard and I-joists.

1.1.2 The case studies that have been selected are thus aimed at examining the opportunities for the structural use of Scottish sawn timber in housing applications, and if it were not used, could it have been? A short list of projects was drawn up for further detailed investigation. The selection was made to cover the variety of timber construction types that would be applicable to social housing.

1.1.3 The projects chosen had to meet the following criteria:

- Be in the social housing field.
- Be based in Scotland as far as possible
- Demonstrate innovative practice in either construction or low energy design
- Demonstrate a variety of timber constructional techniques

1.1.4 The following projects were considered to merit further investigation from the point of view of both their possible structural variety and sustainable design credentials.

- **Inverurie:** A development of 22 houses and 12 flats in Inverurie near Aberdeen for Castlehill Housing Association
- **Leitch Street:** 87 houses and flats at Leitch Street, Greenock for Cloch Housing Association
- **Benarty**: 5 self- build houses in Fife for Link Housing Association.
- **Ruchazie:** 2 super insulated houses in Ruchazie near Glasgow

1.1.5 In order to show an example of cassette prefabrication, it was intended to include a project in Kilbirnie which used the Tradis system. However the project is already participating in another review, the results of which should be ready soon. Harlow Park, a terrace of 10 houses located in Liverpool was thus chosen to provide an example of Prefabrication.

2. Case Study Research Methodology

2.1.1 The case study research has involved discussions with the architects involved as well as some associated suppliers of the timber kits associated with the developments.

2.1.2 Basic constructional information has been obtained as well as house plan types, costs and any additional sustainable features.

2.1.3 We have then calculated the different U values of each construction type, the quantity of timber involved in the construction and the advantages and disadvantages of the different forms of construction.

2.1.4 We have examined various BRE and TRADA reports.

2.1.5 We have received plans and photographs of various projects including those featured in the case studies, for clarity this excess information has been omitted from the report and is available from John Gilbert Architects on request.

2.1.6 We refer to engineered timber I Joists as I Joists although they are also commonly referred to as I Beams and web beams. These I Joists have a thin web sometimes made of OSB (Orientated Strand board) and sometimes made from a compressed wood fibreboard. The flange is made from either solid softwood or laminated timber.

3. Description of the Case Study Projects

3.1 Inverurie

INVERURIE	BACKGROUND INFORMATION	1
Client	Castlehill Housing Association 4 Carlton Place Aberdeen AB1 1UT Tel 01224 625822	
Architects	MAST Architects 51 St Vincent Crescent Glasgow G3 8NQ Tel 0141 221 6834	Mike Jarvis
Main Contractor	Chap Construction Ltd	
Timber Frame	Stewart Milne Ltd Westhill business Park Westhill Aberdeen AB32 6JQ Tel 01224 747000	
Construction Period	14 months. (3-4 weeks for 4 terraced houses)	
Completion date	August 2004	
Contract Value	£2.5 million (Timber Frame £430, 000)	
No of Houses/Flats	22 Houses/12 Flats	




3.1.1 Aquhorthies Circle in Inverurie was the winner of the Chartered Institute of Housing ‘Envirobuild’ award 2004. This award recognizes innovation in the creation of energy efficient buildings and the use of sustainable construction materials. The project was built as a result of an architectural design competition and the desire for design quality to promote ‘pride of place’ was highlighted in the brief. Low energy design and the local sourcing of building materials was also required. The winners were chosen because they fulfilled all the criteria in the brief without resorting to complicated technologies and high-tech materials.

3.1.2 The development is laid out in short terraces following a circular road pattern that is placed around a central play area/ meeting space. The road is single lane, narrow and one-way to discourage on-road parking and slow drivers down. The location of the development is well placed to encourage public transport use.

3.1.3 Houses are orientated to take advantage of solar gains and natural light with large openings to the South and smaller openings to the North. Some houses have single glazed unheated sunspaces that act as solar heat collectors during the day.

3.1.4 A large proportion of the development is timber clad with some render for contrast. The houses are insulated above normal standards and an ‘intelligent’ heating system is in place that motivates the tenant to save electricity. This, in addition to the presence of a mechanical ventilation and heat recovery system, ensures that the houses will be very economical to run. The ‘breathing’ wall construction helps the control of humidity in the houses and will provide a healthy internal environment.

3.1.5 MAST originally requested that the roof and floor panels be prefabricated, but the kit manufacturer was unable to supply roof cassettes and was concerned about the size and weight of the 235mm wall panels.

3.1.6 The houses are all built using a 240 web beam in the walls. The flats used a 195 x 47 stud as this acts better in compression, taking the load of the higher storey flats.

3.1.7 Roofs used a 300 web beam and cellulose insulation was used throughout.

3.1.8 Inverurie is to be monitored in partnership with BRE commencing November 2004

3.1.9 Construction Information

INVERURIE	CONSTRUCTION	INFORMATION 1
Construction Type- Walls	I Joist	
Timber grade - walls	Structural grade	C24 (Imported) Web: OSB
Source of timber	Structure	I Joists made with European softwood Flange and Scottish timber OSB web
	Cladding	Untreated Scottish Larch Heartwood
	Quantities	Volume per M^2: 0.129
Structure	Roof	300x50mm I joists (OSB web)
	External Walls (houses)	240x50mm I joists one-sided prefabricated panels Largest panel size:1.5 storey
	External Walls (flats)	195 x 47mm sw studs C24
	Ground Floor	100 mm insitu concrete

	Foundations	100mm reinforced ground bearing slab with 75mm Kingspan TF70 insulation
Construction	Roof	Concrete tiles on 25x38 softwood battens &counter battens on: Daltex roofshield breather membrane on: 9mmOSB sarking board on 50x50 softwood battens (50mm ventilated cavity) on: 300x50 I Joists with 300mm warmcel 500 insulation. Ceiling12.5mm Duplex plasterboard
	External Wall	Cladding: Timber vertical and horizontal boarding, also rendered 8mm cement fibre board on 25x38 battens and counter battens on Daltox roofshield breather membrane
	Ext. sheathing	9mm Panelvent
	Timber frame	In houses 240x 50mm I joist from J Jones (In flats 195 x 47 sw studs)
	Insulation	240mm warmcel 500
	Internal sheathing	9mm OSB
	Service zone	25mm
	Internal lining	12.5mm Duplex plasterboard
	Party Wall	A mixture of standard 89mm kits with either 140mm or 235mm I Joists to opposite side depending on position and relationship to adjacent house type.
	Ground Floor	50x50 off-sawn timber battens @400mm c/cs with 18mm OSB flooring
	Intermediate Floor	235mm I Joists @400mm c/cs with 18mm OSB flooring
	Separating Floor	18mm OSB flooring on 19mm gyproc plank on acoustic floor battens on 15mm OSB decking on 235mm I joists 400 c/cs acoustic insulation (mineral wool) fitted between joist a floor/wall junction 100mm rockwool 23Kg/M③ placed on: 19mm gyproc resilient bars fixed to joists at 450mm centres Ceiling: 2 sheets of fire line plasterboard as SMTS deem to satisfy. Edge gaps filled with acoustic sealant.

	Glazing	double glazed.4mm float/16mm cavity filled with argon gas/6mm super-low E

3.2 Inverurie: Energy and Sustainable design

INVERURIE	ENERGY MATTERS	1
SAP rating	Average 118	
U values	Roof Wall to houses Floor	0.14 W/m2K 0.16 W/m2K 0.21 W/m2K
Thermal capacity	Ground floor slab	Concrete block/Fyfestone walls in Sunspaces
Draught lobbies	Draught Lobbies	Not included apart from sunspaces and closes
Solar	Sunspace	South facing single glazed sunspaces provided to 8 houses
	Solar hot water	No
Ventilation	Whole house positive mechanical ventilation with heat recovery by Nu-Aire, located in roof space above bathrooms	
Heating and hot water	Three centrally located gas fired boilers provide hot water/heating to all properties. The temperature is controlled in each house by the occupant via a room thermostat located in the hall. Hot water is primarily used to heat radiators for space heating to the thermostat setting. Once this temperature is achieved the hot water is diverted to heat the hot water cylinder. Tenants who use the heating system efficiently will have ‘free’ hot water most of the time, paid for in the rent, although a boost via the immerser may be required in times of high usage. Tenants who set the room thermostat to a high temperature will incur higher electricity costs because space heating will take precedence	

INVERURIE	ADDITIONAL	FEATURES 1
Local timber useage	Timber I Joists	Fabrication of the I joist (J Jones)
	Cladding	Scottish Larch Heartwood
VOCs	Minimised	
Transport	Car parking requirements	1 per 2 bed house. 2 per 3 bed house 4 Visitors
	Bike storage	No
Additional space	Home Office	A serviced study/computer area is provided on the fist floor landing of the 4P houses

3.2.1 Inverurie was the first time that Stewart Milne had used a web beam structure in a major project in Scotland. The I beam is slightly lighter than normal timber frame. The largest panel size was 4 m x 2.5m high (wall at monopitch)

3.2.2 3-4 terrace houses were built together in 4 weeks. This was comparable with normal timber frame so there was no impact on site programme. The only thing that was different was the manufacturing process required. It had to be more accurate.

3.2.3 However more haulage is required to transport the fairly bulky web beam frames (with a 250mm stud against a 140mm stud). Twice as many lorry journeys are required for a web beam structure compared to a normal timber frame although the thicker web beam allows for greater insulation values. This has a potential impact on cost although it was not much of a problem at Inverurie as the site was near the source of supply.

3.2.4 Only wall panels were prefabricated, roof and floor beams came loose on site.

3.3 Leitch Street

LEITCH STREET	BACKGROUND INFORMATION	2
Client	Cloch Housing Association 6 Regent Street Greenock PA15 4PL Tel 01224 625822	Andrew Cassells
Architects	John Gilbert Architects 4C1 Templeton Business Centre Glasgow G40 1DA Tel 0141 5518383	Paul Barham
Main Contractor	Kelvin Homes 87 Calder Street Coatbridge ML5 4EY	David Earlie
Timber Frame	K-Kit 87 Calder Street Coatbridge ML5 4EY	Steven Earlie
Construction Period	24 months	
Completion date	June 2004	
Contract Value	£6.2 million	
No of Houses/Flats	73 houses, 14 flats	


The crescent


Typical terrace


Flatted unit with solar close


Kit erection

3.3.1 Cloch Housing Association set a brief to provide social housing which addressed issues of sustainability. Initially they wanted to know what house construction types would be most appropriate and what standards could be achieved for their budget. A number of different construction options were considered at the outset, including: the Dutch system of building with prefabricated timber wall and roof panels and tunnel formed concrete shells; a timber kit supplier who made prefabricated breathing wall panels and a specialist in light metal framing systems.

3.3.2 The decision was made to adopt an enhanced timber kit frame for the houses and to clad this in a brick, board and render, or larch. The wall construction became a solid 145 x 44 softwood stud, using imported timber from Latvia. The external sheathing was ‘panelvent’ and the internal sheathing was oriented strand board and a service zone. The SAP ratings were all 100 and the U value of the walls is 0.22Wm2 deg C.

3.3.3 For the roof construction a traditional trussed rafter system was used in most houses, with attic trusses in some of the single storey roofs where extending into the roofspace was a possibility. The two bedroomed flats had cut-away roofs, using posijoist beams. The roof construction used a wood fibre board called Isolair 35mm as sarking with 300mm glass wool insulation in the attic space. The breathing nature of the roof void allowed omission of ventilation in the attic space and thus reduce heat loss through better airtightness. The U value of the roof is 0.114W/m2 degree C.

3.3.4 The floor is a concrete floor with battens and OSB flooring. Insulation is provided by 75mm of polystyrene insulation under the screed.

3.3.5 In order to increase future flexibility it was agreed to span first floor joists between cross walls, allowing internal partitions to be altered. Timber ‘posijoists’ were used. These provided good span distances for a limited depth, and services could be passed through the void between the metal stiffeners.

3.3.6 The houses are heated using a community heating scheme where the primary energy is supplied by a gas fired jet CHP unit. The ‘Minigen’ Unit is a generator, producing 60kW of electrical energy. As a by-product, the hot waste gasses are fed through a heat exchanger which then transfers the energy to a wet distribution system which supplies hot water to all the houses. When the flow temperature drops because of high demand at peak periods in cold weather, there are two gas boilers to provide additional heat input.

3.3.7 Electrical energy is supplied from the grid at a commercial rate and supplements the electrical energy supplied by the minigen engine.

3.3.8 The houses are not supplied with gas, thus saving on expensive yearly safety inspections in the social housing market. The electrical tariff is low, so this makes the use of electric cookers more competitive than gas.

3.3.9 Energy Efficiency is controlled in a similar way to the Inverurie project. If householders keep their heating up high and open windows to control temperature this will mean that hot water continues to flow through heating circuit rather than being diverted through HW cylinder by thermostatic controls. This will mean that householder will need to use their immerser more often for domestic hot water which will cost them more in electricity. Advice to this effect has been put in the tenant handbooks. The system is simple for tenants to use and leads to economies when using community heating schemes because heat metering is not used.

3.3.10 The boilers and generator are both low NOx. The boilers give off CO_2 and water vapour, much in the same way as a domestic boiler. The CHP unit gives off a pressurised stream of the same combustion products.

3.3.11 The estimated heating cost equals £6525/annum or £75/house per annum, maintenance £5220/annum or £60/house per annum (based on 87 houses).

Estimated electricity generated by CHP engine equals 219,000 kWh/annum, this equates to £17,520 per annum @ 8p per kWh (typical domestic prices). The CHP engine will generate 219,000 kWh/annum electricity and 438,000 kWh thermal energy at a cost of £8030 per annum. Therefore the cost for the CHP generated electricity equals £3650 per annum. This equates to an annual site saving of £13,870 or £160 per house, compared to a scheme with individual gas combination boilers.

3.3.12 The annual electricity CHP equals £3650/annum which equals £42/ house. Output of electricity is 60Kw. Annual grid electricity equals £9410 per annum or £108 per house per annum. Annual C02 emissions equals 277 tonnes $C0_2$ per annum, system saves approximately 123 tonnes of $C0_2$ per annum.

3.3.13 The estimate for an individual house electricity bill would be in the region of £150 per annum and that the CHP contribution amounts to 28 percent of the electrical energy load. The tariff is charged pro-rata on house areas.

3.3.14 The project includes a number of other features such as a SUDS (Sustainable Urban Drainage System); first floor sunspaces; homezone layout; use of recycled hardcore; acoustic fencing and timber criblock retaining walls.

3.3.15 A full technical report on the project is available from the architects website <www.johngilbert.co.uk>

LEITCH ST	CONSTRUCTION INFORMATION	2
Construction Type - walls	Enhanced Timber Frame	
Timber grade - walls	Structural grade	C16
Source of timber	Structure	FSC specified. 145 x 47 mm studs sourced from Latvia
	Cladding	Untreated Scottish Heartwood Larch
	Quantities	Volume per M^2: 0.238m3
Structure	Roof	254 deep posijoists and attic trusses
	External Walls (houses)	145 x 45 mm softwoods timber frame C16
	External Walls (flats)	145 x 45 mm softwood studs C24
	Ground Floor	100 mm insitu concrete
	Foundations	100mm reinforced ground bearing slab with 75mm EPS insulation
Construction	Roof	Concrete tiles on 25x38mm softwood battens & counter battens on: Proctors roofshield breather membrane on 25mm Isolair fibreboard sarking on roof structure. 300mm glass wool insulation Ceiling12.5mm plasterboard with vapour barrier

	External Wall	Cladding: Timber vertical and horizontal larch boarding, on 50 x 50 larch battens (and counter battens)
	External sheathing	9mm Panelvent
	Timber frame	145 x 45 sw studs
	Insulation	145mm warmcel 500
	Internal sheathing	9mm OSB
	Service zone	25mm
	Internal lining	12.5mm Duplex plasterboard
	Party Wall	Two leaves of 89 x 45 stud partitions, one leaf with glass wool. OSB sheathing and service zone.
	Ground Floor	50x50 off-saw timber battens @600mm c/cs with 18mm OSB flooring
	Intermediate Floor	254mm posijoist beams at centres varying between 600 and 300 with 18mm OSB flooring
	Separating Floor	18mm OSB flooring on 19mm gyproc plank on acoustic floor battens on 15mm OSB decking on 254mm Posijoists acoustic insulation (mineral wool) fitted between joist a floor/wall junction 100mm rockwool 23Kg/M③ placed on: 19mm gyproc resilient bars fixed to joists at 450mm centres Ceiling: 2 sheets of fire line plasterboard
	Glazing	Outer leaf: 4/16/4mm double glazed low E Ground Floor security 6.4/16/6.4mm Acoustic Barrier 4/18/4mm

3.4 Leitch Street: Energy and Sustainable design

LEITCH ST	ENERGY MATTERS	2
	SAP rating	Average 100
U values	Roof Wall to houses Floor	0.15 W/m2K & 0.14 W/m2K 0.23 W/m2K 0.21 W/m2K
Thermal capacity	Ground floor slab	Limited to cement screed under battened timber floor
Draught lobbies	Draught Lobbies	Throughout, front and back
Solar	Sunspace	South facing single glazed sunspaces provided to 12 houses on upper floors

	Solar hot water	No
Ventilation	Passive stack ventilation.	
Heating and hot water	The houses are heated using a community heating scheme where the primary energy is supplied by a gas fired jet CHP unit. The 'Minigen' Unit is a generator, producing 60kW of electrical energy. As a by-product, the hot waste gasses are fed through a heat exchanger which then transfers the energy to a wet distribution system which supplies hot water to all the houses. When the flow temperature drops because of high demand at peak periods in cold weather, there are two gas boilers to provide additional heat input. Electrical energy is supplied from the grid at a commercial rate and supplements the electrical energy supplied by the minigen engine.	

LEITCH ST	ADDITIONAL	FEATURES 2
Local timber useage	Cladding	Scottish European Larch Heartwood
	Minimised	Minimal use of concrete
VOCs	Car parking requirements	1 per house 7 Visitors
Transport	Bike storage	May be stored in porch spaces, otherwise no special storage
	Layout	Homezone shared surfaces
	Home Office	Some units capable of further expansion into roofspaces. Most two bed units have small study room
Additional space		SUDS system installed with containment zone under the road surfaces, water taken to deep soakaways.
Surface Drainage		Acoustic fence to perimeter of railway track
Acoustics		

3.4.1 The kit manufacturer felt that the major difference with a 147 x 45 kit is in the handling of the frame in manufacture and delivery. There are health and safety issues to be noted as the frame becomes heavier and K-Kit believed that further increases in stud size would lead to heavier frames which would make handling more difficult. The enhanced frame is referred to as ‘a good kit to put up,’ however a higher rate is paid for labour to erect it.

3.4.2 K-Kit appear to source their timber from Latvia.

3.5 Benarty

BENARTY	BACKGROUND INFORMATION	3
Client	Link Housing Association 45 Albany Street Edinburgh EH1 3QY Tel 01315570350	Craig Sanderson
Architects	Duncan Roberts Architect 13c High Street Belford NE70 7NG Tel 01668213146	Duncan Roberts
Main Contractor	Benarty Self Builders.	
Construction Period	25 months	
Completion date	April 2000	
Contract Value	£160,000 excluding sweat equity	
No of Houses	5 houses	

3.5.1

Douglas fir columns and softwood framing showing cross studding to increase insulation thickness

All of frame is site erected

Segal method uses Douglas fir frame to carry loads

Fibre board sarking and sheathing

3.5.2 An example of Post and Beam construction

3.5.3 Benarty is a self build project located on an inter-war housing estate a few miles outside Glenrothes. It comprises four 1 storey 3 bed houses and one 2 storey 'room in the roof' house.

3.5.4 The houses are constructed with a timber post and beam using the Segal Method of construction which minimises the use of concrete foundations and under building. This form of construction was particularly appropriate for the site which had a poor load bearing capacity.

3.5.5 The houses use softwood studs and cross battens with a breathing wall construction using warmcell at a depth of about 140mm. The houses are largely clad in Scottish larch except for the gable walls which needed to be finished with a cement fibreboard for fire protection between the gable ends.

3.5.6 A 25% share of the ownership of the houses was transferred to the self builders on completion in recognition of the labour they had put into the project.

BENARTY	CONSTRUCTION	INFORMATION 3
Construction Type	Post and Beam	
Timber grade	Structural grade	C16
Source of timber	Structure	100 x 50mm studs sourced from Scandinavia
	Cladding	Untreated Scottish heartwood larch
	Quantities	Volume per M^2: 0.238m3
Structure	Roof	225x50mm beams 175x50mm common rafters at 600 centres (all timbers are at 600mm centres)
	External Walls	100 x 50mm softwood timber studs between 100 x 100mm Douglas fir posts. Externally cross studded with 50 x 50mm softwood studs
	Ground Floor	225 x 50mm softwood joists at 600 crs set onto Douglas fir frame bolted to posts
	Foundations	Individual concrete pad footings for each post.
Construction	Roof	Clay tiles on 25x38 mm softwood battens & counter battens on: 25mm Bitvent fibreboard sarking on roof structure. 300mm glass wool insulation Ceiling12.5mm plasterboard with vapour barrier
	External Wall	Cladding: Timber vertical and horizontal larch boarding, on 50 x 50mm larch battens (and counter battens)
	External sheathing	9mm Panelvent
	Timber frame	100 x 50 sw studs
	Insulation	145mm warmcel 500
	Internal sheathing	9mm OSB
	Service zone	25mm
	Internal lining	12.5mm Duplex plasterboard
	Party Wall	N/A
	Ground Floor	50x50 off-saw timber battens @600mm centres with 18mm OSB flooring
	Intermediate Floor	254mm posijoist beams at centres varying between 600 and 300 with 18mm OSB flooring

	Separating Floor	18mm OSB flooring on 19mm gyproc plank on acoustic floor battens on 15mm OSB decking on 254mm Posijoists acoustic insulation (mineral wool) fitted between joist a floor/wall junction 100mm rockwool 23Kg/M^3 placed on: 19mm gyproc resilient bars fixed to joists at 450mm centres Ceiling: 2 sheets of fire line plasterboard
	Glazing	Outer leaf: 4/16/4mm double glazed low E Ground Floor security 6.4/16/6.4mm Acoustic Barrier 4/18/4mm

3.6 **Benarty: Energy and Sustainable design**

BENARTY	ENERGY MATTERS		3
	SAP rating	Average 96	
U values	Roof Wall to houses Floor	0.16 Wm2/K 0.22 Wm2/K 0.16 Wm2/K	
Thermal capacity	Walls	2 sheets 12.5mm plasterboard on one side of internal partitions	
Draught lobbies	Draught Lobbies	Throughout, front and back	
Solar	Sunspace	No	
	Solar hot water	No	
Ventilation	Mechanical ventilation from kitchen, bathrooms and WC.		
Heating and hot water	Gas central heating with Combi condensing boiler.		

BENARTY	ADDITIONAL FEATURES		3
Local timber useage	Battens	Scottish grown European Heartwood of Larch	
	Cladding	Scottish grown European larch heartwood	
VOCs	Minimised	Minimal use of concrete, practically none	
Transport	Car parking requirements	2 spaces per house	
	Bike storage	May be stored in porch spaces, otherwise no special storage	
	Layout	Off existing street	
Additional space		One unit capable of further expansion into roofspace.	

3.6.1 The houses have ‘breathing’walls and roof with cellulose insulation. Other features of an environmental specification include wood framed windows, natural clay drainage, no timber treatment inside dwellings (apart from exposed internal frame members) and solid wood skirtings, cill boards and linings.

3.6.2 The post and beam structure was imported Douglas Fir, however the architects would now specify Scottish grown Douglas fir in this situation.

3.7 Harlow Park (Phase 2): Liverpool

3.7.1 An example of TRADIS construction

HARLOW PARK	BACKGROUND INFORMATION	4
Client	CDS (Housing) Ltd Baltimore Buildings 13/15 Rodney Street Liverpool L1 9EF Tel 0151 708 0674	
Architects	Denovo Design 22-26 Clarendon Street Nottingham NG1 5HQ Tel 0115 841 5015	
Main Contractor	Warwick Construction	
Timber Frame	TRADIS	
Construction Period	8 months (superstructure 4 days)	
Completion date	March 2000	
Contract Value	£532,000	
No of Houses/Flats	10 houses	

3.7.2 Harlow Park is a development of ten 2& 3 bed family houses that were built on the site of a former block of council maisonettes near Liverpool city centre. They were constructed as the second phase of a development which was originally described as ‘environmentally friendly.’ The houses follow the slope of the site and are designed as a stepped terrace that surrounds a landscaped communal garden.

3.7.3 The superstructure was erected in 4 days due to the use of prefabricated load bearing panels. The construction period for the completion of all dwellings was 8 months which included demolition and clearance of the site.

3.7.4 The dwellings have achieved a BREAM award for environmental quality.

HARLOW PARK	CONSTRUCTION INFORMATION	4
Construction Type	TRADIS Trade name of a kit system that integrates masonite I joists, panelvent and paneline sheathing and warmcell insulation to provide prefabricated cassettes used in walls, floors and roof construction.	
Timber grade – walls and roof	Structural grade	C24 (Imported)
Source of timber	Structure	170 x 47mm I joists made by Masonite studs sourced from Scandinavia
	Cladding	
	Quantities	Volume per M^2:
Structure	Roof	TRADIS prefabricated roof cassettes comprising: 220 mm deep roof beams at 1200mm centres 9.2 mm Panelvent external sheathing 6mm hardboard inner lining

	External Walls	TRADIS prefabricated wall panels comprising: 170x47 Masonite stud 9.2mm Panelvent sheathing 6.0mm Paneline cladding
	Ground Floor	Pre-stressed concrete floor beam system on pre-cast ground beams
	Foundations	Pre-cast concrete short piles.
Construction	Roof	Concrete interlocking roof tiles on 50x25mm s/w battens on 50x50mm s/w counter battens on Breather membrane on Tradis roof cassettes Internal service void of 38x25mm s/w battens 12.5mm duplex plasterboard lining
	External Wall	Facing brick with 50mm cavity or Timber cladding on 25x50mm s/w battens, fixed to Tradis prefabricated wall panels 170 deep filled with Warmcel insulation. Internal service void 47x25mm s/w battens 15mm plasterboard lining
	External sheathing	9mm Panelvent
	Timber frame	170 x 47mm web studs
	Insulation	145mm warmcel 500
	Internal sheathing	9mm OSB
	Service zone	25mm
	Internal lining	12.5mm Duplex plasterboard
	Party Wall	2 No. 80 x 38mm timber frames with 50mm cavity Both frames lined internally with 2 layers plasterboard; 19mm thick fixed horizontally 12mm thick fixed vertically One leaf of timber frame infilled with Rockwool acoustic quilt retained by mesh
	Ground Floor	18mm spruce t & g flooring panels on DPM on Pre-cast beam system infilled with expanded polystyrene blocks on pre cast ground beams, ventilated under floor void

	Intermediate Floor	Masonite I Joists
	Separating Floor	N/A
	Glazing	4:12:4 mm

3.8 Harlow Park: Energy and Sustainable design

HARLOW PARK	ENERGY MATTERS		
	SAP rating	Average 100	
U values	Roof Wall to houses Floor	Not Available	
Thermal capacity	Walls		
Draught lobbies	Draught Lobbies	At front doors	
Solar	Sunspace	No	
	Solar hot water	No	
Ventilation			
Heating and hot water			

3.8.1

HARLOW PARK	ADDITIONAL FEATURES		
VOCs	Minimised		
Transport	Car parking requirements	spaces per house	
2 Additional space	Bike storage		
	Layout		

3.9 Ruchazie: Glasgow

3.9.1 An example of web beam construction with enhanced thermal mass

RUCHAZIE	BACKGROUND INFORMATION	5
Client	Communities Scotland	
Architects	Vernon Monaghan Architects	Vernon Monaghan
Main Contractor	Redrow Homes (Scotland) Ltd Redrow House 3 Central Park Avenue, Larbert Falkirk, FK5 4RX Telephone: 01324 555536	
Timber Frame	Donaldson & McConnell Grangemouth Road Bo'ness West Lothian EH51 0PU Tel: 01506 82889	
Completion date	March 2000	
Contract Value	£200,000	
No of Houses	2 houses	

South facing living room with skylights and solar panels

First floor deck

First floor deck


Balloon frame technique


I Joists for walls and roof

3.9.2 The Ruchazie project comprises 2 detached ‘Room in the Roof’ 3 bedroom houses. It was promoted with considerable foresight by Communities Scotland who were pursuing improvements in energy efficiency in house design.

3.9.3 The houses were constructed as part of phase 2 of a speculative development by Tay Homes and were supported by a ‘grow grant ‘ from Communities Scotland. Redrow Homes took over the construction of the development from Tay Homes after phase 1. The houses are now in private ownership.

3.9.4 The construction specifications, which were considered to be experimental, were originally agreed with the first developer, Tay homes. These specifications, together with a whole house ventilation with heat recovery system, would have provided a house that would only have required supplementary heating in cold spells.

3.9.5 When Redrow took over Tay Homes, they inherited the project and decided to install a gas central heating system. Windows were also changed to be PVC rather than all timber.

3.9.6 The house are designed to be orientated to the South to receive solar gains in the main reception room with the kitchen on the North side. The timber superstructure is super-insulated and the 150mm concrete ground floor provides excellent thermal mass.

3.9.7 Whilst the original ambition of a ‘Zero heat house’ was not realised, it is a very good example of what is possible using web beam construction and cellulose insulation.

3.9.8 The project took a bit longer than targeted due to the innovation in using web beams and balloon framing. It is essential to have trained labour to erect kit.

3.9.9 It was the intention that the houses would be monitored. Like many innovative projects this has not happened due to a lack of funding for such monitoring. In this case the residents would be willing to participate and energy monitoring would provide valuable data on the viability of Zero Heat Housing. Feedback from one of the residents would suggest they are very pleased with the house.

RUCHAZIE	CONSTRUCTION INFORMATION	5
Construction Type	Web beam + enhanced thermal mass	
Timber grade - walls	Structural grade	C24 (Imported)
Source of timber	Structure	300mm deep OSB I Joist for walls N.European softwood
	Cladding	Block and render
	Quantities	Volume per M^2: -
Structure	Roof	400mm OSB I Joist at 600crs
	External Walls	300mm OSB I Joists
	Ground Floor	150 mm insitu concrete
	Foundations	insitu concrete strip
Construction	Roof	Clay tiles on Isolair on 35x25 tiling battens on 38x25 counter battens. Tyvek membrane on 9.2mm panelvent on 400mm I Joist with full fill cellulose fibre insulation. 6.4mm Panelvent to underside. 38x38 service zone. 12mm TE plasterboard.
	External Wall	15mm render on 100mmblockwork. 50mm cavity. 9.5 mm Panelvent sheathing to 300mm Ibeam@ 600mm c/cs with full fill cellulose fibre insulation. 6.4mm Paneline lining. 38x38 service zone. 12.5mm plasterboard
	External sheathing	9mm Panelvent
	Timber frame	300 OSB I Joists
	Insulation	300mm warmcel 500
	Internal sheathing	6.5mm paneline
	Service zone	38mm
	Internal lining	12.5mm Duplex plasterboard
	Party Wall	N/A
	Ground Floor	150mm insitu concrete with thermal edge insulation on dpm on 200mm EPS on 50mm site concrete
	Intermediate Floor	300 OSB I Joists, particle board flooring
	Separating Floor	N/A
	Glazing	Double glazed. 4:12:4mm. Inner leaf Low E. Argon filled. PVC windows

3.9.10

3.10 Ruchazie: Energy and Sustainable design

RUCHAZIE	ENERGY MATTERS		5
	SAP rating	Average 110	
U values	Roof Wall Floor	0.11Wm^2/K 0.13Wm^2/K 0.13 Wm^2/K	
Thermal capacity	Walls	Concrete ground floor slab	
Draught lobbies	Draught Lobbies	No	
Solar	Sunspace	No, but large south facing window with enhanced height and open upper floor deck allowing heat to rise.	
	Solar hot water	Yes	
Ventilation			
Heating and hot water	Gas central heating		

RUCHAZIE	ADDITIONAL FEATURES		5
Transport	Car parking require-ments	1 space per house	
	Bike storage	No	
	Layout	Off existing street	
Additional space		Large upstairs open deck/hallway can be used by children	

4. Case Study Analysis

4.1 Case Study Variables

4.1.1 The same level of information was not present in each case study research material as the main focus of the research was the investigation of the potential use of Scottish timber in social housing, with sustainable design and prefabrication issues as an additional interest.

4.1.2 The variables that were analysed are listed on the following table with an indication of which case studies were relevant.

	Inverurie	Leitch St	Benarty	Harlow Park	Ruchazie
Structural Type	•	•	•	•	•
Structural Grade	•	•	•	•	•
Source of timber structure	•	•	•		
Source of timber cladding	•	•	•		
Timber Quantities	•	•	•		
Prefabrication	•	•		•	•
Sup/structure constr.period	•	•			
Foundations	•	•			•
SAP rating	•	•			•
UValues	•	•			•
Draught Lobbies		•			
Sunspace	•	•			
Solar h/water	•				•
Thermal Mass	•	•		•	•
Ventilation	•	•	•		•
Heating	•	•	•	•	•
Resource Use	•	•	•		
Transport Issues	•	•	•		•
Other Sustain		•			

Table 1. Information Available and Variables Within Each Case Study

4.1.3 The variety of information that exists in the case studies can be broken for clarity into 3 groups

- Structure and Construction
- Timber Quantities and the Use of Scottish Timber
- Design for Sustainability

4.2 Structure and Construction
Description and Discussion of the Structural Types

4.2.1 Three case studies chosen for an investigation into their structural use of timber because of their diverse methods of using timber structurally. They were Inverurie, Leitch street and Benarty.

4.2.2 The first two of these case studies exhibit the use of a load bearing timber frame in two different ways that can be compared and will be discussed together. The third (Benarty) is an example of post and beam construction beam and will be discussed separately.

Table 2: Structure and Construction

	Inverurie	Leitch Street	Benarty
Structural Type	I Beam	Enhanced Frame	Post and Beam
Wall Sizes	240x50	145x47	100x100 posts 100x50 studs
Structural Grade	C24	C16	C16
Source of timber structure	N.Europe	Spec:FSC Built: Latvia	N.Europe
Source of timber cladding	Scotland	Scotland	Scotland
Timber Quantities Volume per M^2 See Appendix 2	0.129	0.238	0.305
Prefabrication	One sided load bearing wall panels. I Joists for roof, all floors and roof	Timber frame Trussed rafters I Joists Posijoists. Roof and floors	Stick built
Insulation	Warmcel on site	Warmcel on site	Warmcel on site
Superstructure construction period	4 weeks	4 weeks	10 weeks NB Reduced time for foundations
Foundations	100mm insitu conc. ground bearing slab	Insitu conc.strip	1200mmsq. concrete pads under load bearing posts

4.3 Timber I Joists

4.3.1 Timber I Joists (also referred to as I beams or web beams or web joists) are factory fabricated structural timber elements created from 2 high grade soft wood flanges (C24- C28 is normal) separated by an engineered composite web (either Masonite or OSB). Where they are used in wall construction, the flanges take on a different section to provide greater load bearing capacity.

4.3.2 There are a number of different manufacturers. At Inverurie, the I Joists were manufactured by J Jones in Scotland. Their beam uses a C24 North European (imported) flange timber with a Scottish sourced OSB web.

4.3.3 At Inverurie the J Jones I Joists were prefabricated by Stewart Milne as load bearing wall panels with beams placed 600mm centres. One side only of the I beam frame is completed in the factory with cellulose insulation being turbofilled at a later stage.

4.3.4 Masonite makes another popular web beam. The Masonite beam is an I beam with a Masonite web. Masonite is a wood fibre board product, fabricated by a patented process from timber mulch. The Masonite Beam uses C18 minimum grade timber for the flange. A maximum of C40 grade can achieved for the beam as a whole. (See Appendix B for more detail). Tradis exclusively use Masonite I joists together with cellulose insulation and wood fibre board sheathing.

4.3.5 The advantages of the web beam are as follows:

- It is a lightweight beam, allowing large wall sections to be lighter than the equivalent kit in solid studs. This makes it more effective when prefabricated.

- The thin flange material prevents cold bridging through the wall structure
- Less material is used
- If an insulation material such as cellulose or wool is used, significantly lower U values can be obtained using 240mm and 300mm I Joists.

4.3.6 The disadvantages may be as follows:
- I Joists are less able to take compressive loading because of their limited cross sectional area.
- Junctions are not always straightforward because of the web section.

4.4 Post and Beam

4.4.1 This approach uses a solid post and beam frame to take the loads. Each post forming a pointload requiring small individual foundations rather than a strip foundation. Construction is usually stick built rather than prefabricated though the frame is often pre-cut off site, particularly on large projects. The post and beam frame is often made from douglas fir, although oak is another timber commonly used in post and beam structures. The floor joists and wall framing use spruce C16 timbers.

4.4.2 The construction method is well suited to individual houses which are built on site, rather than prefabricated. At Benarty it was selected because the construction method was self-build and the post and frame method also reduced the need for strip foundations.

4.4.3 Concrete strip foundations are not required as the load is transferred to the ground at fixed points and a simple shallow bored pile is all that is required. In the case of Benarty the foundations had to be increased in size due to the poor load bearing capacity of the ground but this was a cheaper option that a construction with normal foundations.

4.4.4 The advantage of post and beam construction is:
- Simplicity of structural frame
- Provides flexibility of walls as load is taken through post and beam structure
- It can accommodate a sloping site without the need for extensive underbuilding.
- All timber construction capable of using C16 timber and visually graded Douglas Fir
- Uses a mix of timber species

4.4.5 The disadvantages of post and beam construction
- Not suitable for prefabrication
- Longer to provide a wind and watertight structure
- Requires a ramp to reach internal floor level

4.5 Solid timber frame stud kits

4.5.1 The vast majority of houses manufactured in Scotland are made using timber frame kits. The kit manufacturers have traditionally used more standard 87 x 45mm studs, these are often imports, but 145 x 45mm studs are becoming more common due to the increase in insulation standards.

4.5.2 Inverurie used a 195 x 47mm stud in the construction of 3 storey flats and Leitch street used 145 x 47mm studs throughout. Lightweight roof trusses were manufactured using imported timber graded TR26 (close to C24).

4.5.3 The advantages of solid studs are as follows:
- The potential to use C16 homegrown timber
- Larger studs sizes tend to favour homegrown timber
- Preservative treated studs are widely available from UK sources
- One saw miller is planning to provide Boron treated studs
- Easy to work with

4.5.4 The disadvantages are:
- More likelihood of cold bridging unless insulated sheathing used
- Greater weight than I Joists for large sections

4.6 Prefabrication Issues

4.6.1 There are two main prefabricated systems. Timber kit is supplied open, without any insulation and closed panels that are brought to site with insulation installed. Timber kit construction has the advantage that the structural frame, walls, floor and roof can be made wind and watertight very quickly. The frames and the trusses are made off-site. At present the kits are rarely made to contain insulation or finishes.

4.6.2 A closed panel system such as that made by Tradis, was devised to provide a structural kit that would provide a wind and watertight structure, with insulation built in, using cellulose as an insulant and I Joists as framing.

4.6.3 House construction to water tight stage with closed panel system takes approx 5 days with a 3 man team and a crane. (This does not include foundations or ground floor slab. The site should be prepared to sole plate stage). 6-8 weeks is saved on the construction period over traditional 'wet' construction. 4 weeks is saved over a conventional timber framed house.

4.6.4 In a rural situation, prefabrication can help reduce site time which can be expensive if labour is not close. However it is essential to have skilled labour involved in the erection process, as tolerances can be quite fine. If errors occur rain can penetrate the roof element and damage floor cassettes, though standard timber frame and prefabricated kits should provide better quality control if the quality of the erection process is maintained.

4.6.5 The disadvantage of prefabricated wall panels in a rural setting is that more delivery trips may be required because of bulk and greater craneage is needed because of weight.

4.7 Solid Timber Quantities

4.7.1 The solid timber quantities (excludes wood based panels such as OSB and chipboard) were taken from a single house type from the following case studies. Drawings were measured and linear quantities were converted into cubic metres. Conversion to volume per M^2 enabled a valid comparison.

4.7.2 The difference in the amount of solid timber used in the different forms of construction is significant.

4.7.3 I Joists use 40-60% less material than a standard timber kit. As might be expected, the post and beam, the stick built structure at Benarty contains most timber. The summary table below is derived from a more detailed breakdown of timber quantities that is contained in appendix 2. The volumes are based on a 3 bedroomed house type taken from each of three of the case study schemes. Significantly more timber cladding was used at Inverurie and Benarty, than at Leitch Street.

Project	House floor area	Total volume of timber in m3	Volume per m2
Inverurie	77.8	10.01	0.129 m3
Leitch Street	91.8	21.84	0.238 m3
Benarty	110	27.11	0.305 m3

4.7.4 In general, timber studs at 600mm centres are designed for C16 timber, regardless of whether C24 is actually used. Whilst we cannot comment on particular details of each design, it would appear that they were all capable of using C16 home-grown timber in the wall studs.

5. The Use of Scottish Timber

5.1.1 Home-grown Scottish timber comes in many forms, but the larger sawmills and timber producers will provide visual and mechanical strength grading, regularisation of size, kiln drying to <20% moisture content and preservative treatment. This construction grade material is available from home-grown sources with Forest Stewardship Council (FSC) certification of sustainability. Whilst some of the timbers could reach relatively high strength grades, it makes commercial sense for most mills to provide such timber graded to C16. This grade is suitable for most domestic timber kit structures. It is assumed that where C24 timbers have to be specified, they will usually be obtained from overseas countries such as Scandinavia and the Baltic states.

5.1.2 Most prefabricated roof trusses are designed using C24 timbers. Some large timber kit producers use C24 timbers in order to keep timber volumes down and because they have set up kit design and supply chains incorporating this grade of timber.

5.1.3 Home-grown timber of strength class C16 is readily available. Provided it has a moisture content of 20% or less (stamped 'dry' or 'KD') it would be suitable for kit construction.

5.1.4 Despite technical evidence and examples of practical applications to the contrary, some reasons suggested for not specifying Scottish timber encountered in the course of the case study research, were:

- Structural grade (C16) Scottish timber is economically uncompetitive compared to imported (C24) timber, as less material is required when using higher strength timber.
- The supply chain for Scottish timber is inadequate and leads to delays on site.
- Scottish timber distorts and warps beyond acceptable limits
- Scottish timber is 'pappy' and full of knots

5.1.5 In housing clear spans to cross walls are favoured to provide plan flexibility, there will be limitations on the spans of plain C16 timbers. I joists (and other engineered joists) are more commonly used in this situation.

5.1.6 The first of the two perceived impediments, by timber frame manufacturers, to the use of Scottish timber, the cost of supply and the supply chain are out with the remit of this report. Timber kit manufacturers already source some timber from Scotland and at least one uses predominantly Scottish Timber. As the products are fit for purpose they are able to make competitive kits. Therefore we can see that the obstacles to preventing the take up of home-grown timber in kit construction are more likely a result of past prejudices (timber which was not properly dried or stress graded) as well as potentially some supply chain issues. Sustainable Scottish construction grade 'fit for purpose' timber is readily available at the main builders merchants chains.

5.1.7 Timber kits, with studs at 600mm centres, designed with standard sized timber, can be built from C16 timber and still meet the required structural criteria. In the majority of buildings there is no saving in quantity by using C24 over C16 grade timber. Obviously specific, exceptional project conditions may require closer spacing or higher-grade timber. This also implies no direct saving of weight and therefore no difference in foundations required for either kit.

5.1.8 Some concern over supply could be the result of late requests for non-standard sizes, these could be provided with sufficient lead in time

5.1.9 Scotland's forests currently produce over 500,000 tonnes of sawn timber per annum for the construction market, mostly FSC certified. A wide range of wood based panel board products are also produced in Scotland from sustainably produced and FSC certified timber, e.g. OSB, MDF and chipboard.

Logs arrive at the saw mill for milling, sorting and grading

Visual and mechanical stress grading is carried out to provide C16 timber

5.1.10 Some medium scale timber kit manufacturers have invested in their own supply chains allowing them to source homegrown timber that is suitably stress graded and fit for purpose.

5.1.11 The BRE and TRADA report (Multi-storey timber frame buildings BR454) on the subject of using homegrown timber is important as it shows how a 6 storey timber frame building could perform using C16 graded homegrown timber.

5.1.12 The issue of distortion in home grown timber is addressed by a research report from the BRE in march 2004 entitled "Comparison of Home-grown and Imported Softwood for Timber Frame Construction Market" Funded by the Forestry Commission and Scottish Enterprise and published on the Forestry Commission's website. Tests were carried out on unrestrained and partially restrained timbers both from a UK and a Swedish source. Distortion of both sources of material in the form of bow, spring and twist have been measured at varying levels of moisture content. The amount of compression wood has been analysed and put into categories and the proportion of knots has also been measured. The study concludes with the statement that 'UK grown timber is well suited to timber frame panel manufacture'.

5.1.13 However, current perceptions of the decision makers in the industry continue to prevail.

6. Design for Sustainability

6.1.1 All the case studies selected were above average in term of energy efficiency but some exhibited a more holistic understanding of sustainable design than others. These were Inverurie, Leitch street and Ruchazie.

6.1.2 Inverurie and Leitch Street were similar in design philosophy but were built with different constructional techniques. Ruchazie was originally designed as a zero emissions house but the built specification was altered slightly due to changes introduced by the new developer. Benarty exhibited an understanding of local resource use and was well insulated.

6.1.3 Three case studies, Inverurie, Leitch Street and Ruchazie, were chosen and a list of sustainable features was analysed with a view to setting down the key specifications and approach used in each project

6.1.4 The following observations were made during the case study investigation

6.1.5 The terms Zero Energy Design and Zero Emissions Design are in circulation. It should be noted that these terms are not interchangeable although there is an overlap of meaning. The latter term, Zero Emissions Design is concerned with the CO_2 emissions that are an output rather than the amount of energy that is an input. SAP calculations at present do not take this into account. It should be noted in this context that biomass fuel is assumed to be carbon neutral.

6.1.6 In order for solar heat gain to be effective at times of external temperature fluctuations, thermal mass is required to store excess heat that can be released later. This can be most effectively achieved as part of the fabric of a house, often in the form of a concrete floor. Whilst we recognise that houses built using solid mass timber will provide significantly more thermal mass than timber kit constructions, we would note that where houses are highly insulated and draught-proofed, thermal capacity is not so important.

6.1.7 The case studies performance was evaluated with the Eco-homes criteria. Whilst this is not yet a statutory requirement in Scotland, it provides a good base for performance standards. It should be noted that these standards contain 'lifestyle design' such as the provision of a home office, clothes drying and recycling facilities etc.

Project Title	**Inverurie**	**Leitch Street**	**Ruchazie**
SAP rating	118	100	110
UValues: W/m^2K	Roof: 0.11 Wall: 0.13 Floor: 0.24	Roof: 0.15 Wall: 0.22 Floor: 0.4	Roof: 0.12 Wall: 0.12 Floor: 0.14
Draught Lobbies	No	Back and Front	No
Sunspace	8 houses	Fst Floor/12 houses	
Solar h/w	Solar panels		Solar panels
Thermal Mass	100mm Concrete ground floor Sunspace: conc. wall	100mm Conc. ground floor	150 mm conc ground floor
Ventilation	Whole house MVHR Breathing Walls	Passive vent Breathing walls	Whole house MVHR Breathing walls
Heating	Gas/community heating	Gas/CHP	Gas central heating

Local Materials	Timber cladding	Timber cladding	
Non VOC	Paints/varnishes/sheet materials	Paints/varnishes/sheet materials	
Carparking	1/2B 2/3B	1/house	1/house
Bicycle storage	No provision	No provision	No provision
Other		SUDS	

Table 5. Indicator of Sustainable Features

7. Case Study Research: Summary

7.1 The Use of Scottish Timber

7.1.1 Scottish timber is beginning to be being widely used in the construction of social housing in the form of untreated larch heartwood cladding. However its potential for use as the structural and framing members has not been fully recognised amongst specifiers or kit manufacturers.

7.1.2 We can conclude from the investigations that have been carried out that sustainable Scottish spruce (whitewood) timber, graded C16, kiln dried, regularised and non-CCA preservative treated, is structurally adequate for domestic house frames, it is ‘fit for purpose’ and readily available. Thus a much higher quality of timber is now available from the Scottish timber supply.

7.1.3 However, there appears to be considerable resistance to the use of Scottish timber from the timber frame industry. The perceptions that are impeding the uptake of Scottish timber fall into 2 categories.

- Issues of the supply chain and the economic competitiveness.
- Evidence of structural strength and consistent quality

7.1.4 The first of these categories are out-with the current research remit but we can report that the issues raised during discussions appear to be of significant concern.

7.1.5 Under the second category we have concluded that the volume timber frame industry has a preference for using C24 grade imported timber. However some of the small to medium scale kit manufacturers do make use of C16 timber in their kits and some have been able to ensure their timber supply is sourced from homegrown forests. Despite this, some kit manufacturers remain reticent about changing to homegrown sources.

7.1.6 An understanding of standard sizes and lead in times is important to avoid delays.

7.1.7 Given the present reticence amongst timber kit suppliers there may be an advantage in proposing that small groups of rural housing are built by making the frames on site, rather than from a kit supplier, or by using the post and beam method as exemplified in the Benarty case study. Innovative pre- cut house kits, complete with necessary fixings could be supplied that would also have the advantage of using a higher volume per m^2 of solid timber.

7.2 Structural Types

7.2.1 The structural types that were investigated in the case studies have differing implications for the uptake of Scottish timber, most significantly in the quantity of timber required. The I beam requires the least solid timber and the post and beam method requires the most.

7.2.2 The I beam is becoming popular because of its ability to support an increased depth of insulation. At the moment the flange of the beam is fabricated from C24 grade timber although J Jones make a web beam for wall construction that uses C16 timber.

7.2.3 Scottish timber grade C16 is structurally adequate for the remaining structural types that were investigated. It is available as 89 x 44; 145 x 44; 194 x 44 and in lengths of 3m, 3.6m; 4.2m; 4.8m and 5.4m, in some mills 6.0m may be available.

7.2.4 The most significant difference in foundation design is provided by the post and beam structure that requires short bored piles rather than conventional strip foundations. Apart from less material being used there is a construction time advantage with this method and it can also be useful for a sloping site.

7.3 Prefabrication

7.3.1 The current debate about the necessity of prefabrication is largely driven by the conditions for house building in SE England in a built up urban conurbation. In Scotland, and in rural areas, the main value of using a prefabricated timber kit is in reducing the site time and providing a weatherproof skin to allow other work to progress in bad weather. The construction industry is quite fragmented and contractors often employ a range of skills, such as plumbers, electricians, carpenters and bricklayers. With greater prefabrication, the supply and sourcing of the materials should be simplified and erection of the kits can better be carried out using multi-skilled labour. In Scotland the tendency has been to only have the shell of the building prefabricated. However some European house kit suppliers provide the full kit, sourcing the windows, doors, electrics, roof tiles and cladding and using small multi-skilled teams, it would be good to see such a business operating in Scotland.

8. Appendix 1

8.1 Timber Volumes

8.1.1 These have been estimated by taking one typical 3 bed house type from each project. Leitch Street uses a solid timber studs, Benarty is Post and Beam with timber infills, the Inverurie scheme uses an I Joist, so the structural timber content appears lower, although this does not take into account the flatted properties which used solid studs.

		Inverurie	Leitch Street	Benarty
Floor - Ground	length	0.000	0.000	11.450
	Width	0.000	1.000	7.760
	Bracing	0.000	0.000	1.000
	Joist width	0.000	0.000	0.050
	Joist Depth	0.000	0.000	0.200
	Centres	1.000	1.000	0.600
	Total Volume	0.000	0.000	1.558
Floor - Upper	length	5.757	6.085	0.000
	Width	8.947	9.556	0.000
	Bracing	2.000	2.000	0.000
	Joist width	0.040	0.047	0.000
	Joist Depth	0.080	0.100	0.000
	Centres	0.400	0.600	1.000
	Total Volume	0.469	0.545	0.000
Floor Covering - Ground	length	5.575	6.085	11.450
	Width	8.947	9.556	7.760
	Thickness	0.022	0.022	0.025
	Batten Width	0.038	0.038	0.000
	Batten Depth	0.025	0.060	0.000
	Batten Centres	0.600	0.600	0.000
	Total Volume	1.176	1.316	2.221
Floor Covering - First	length	5.575	6.085	0.000
	Width	8.947	9.556	0.000
	Depth	0.022	0.022	0.000
	Total Volume	1.097	1.279	0.000
Wall - Posts	length	0.000	0.000	82.700
	Height	0.000	0.000	0.225
	Bracing	0.000	0.000	1.000
	Stud width	0.000	0.000	0.050
	Stud Depth	1.000	1.000	0.225
	Centres	0.000	0.000	1.000
Frames	length	48.600	18.255	26.670
	Height	2.900	2.560	2.700
	Bracing	5.000	5.000	1.000
	Stud width	0.040	0.045	0.050
	Stud Depth	0.080	0.145	0.100

	Centres	0.600	0.600	1.000
	Allowance for	10.00%	10.00%	10.00%
	Total Volume	0.873	0.643	5.527
Wall - Party	length	5.500	38.224	0.000
	Height	5.800	2.560	0.000
	Bracing	3.000	3.000	0.000
	Stud width	0.089	0.089	0.000
	Stud Depth	0.044	0.038	0.000
	Centres	0.600	0.600	1.000
	Total Volume	0.276	0.578	0.000
Wall - Internal	length	13.900	42.455	38.925
	Height	2.800	2.400	2.435
	Bracing	3.000	3.000	3.000
	Stud width	0.089	0.089	0.050
	Stud Depth	0.038	0.038	0.100
	Centres	0.600	0.600	0.600
	Total Volume	0.248	0.599	0.826
Wall Covering - Sheet Bracing	Length	48.600	18.255	45.600
	Height	2.900	2.560	2.900
	Thickness	0.010	0.010	0.015
	Total Volume	1.409	0.467	1.984
Wall Covering - Cladding	length	57.600	18.255	41.300
	Height	2.900	2.560	2.900
	Percentage coverage	90%	20.00%	75.00%
	Thickness	0.022	0.022	0.022
	Total Volume	3.675	0.206	2.635
Roof - Type 1	length	5.500	14.056	38.530
	Width	8.900	5.802	14.000
	Rafter Width	0.040	3.569	0.050
	Rafter Depth	0.080	0.040	0.175
	Centres	0.600	0.600	0.600
	Batten Centres	0.350	0.600	0.600
	Batten Width	0.028	0.028	0.050
	Batten Depth	0.028	0.028	0.025
	Ridge / Wallplate No.	0.000	6.000	3.000
	Total Volume	0.301	15.398	8.936
Roof Covering - Sarking	length	5.500	14.056	23.790
	Width	8.900	5.802	8.000
	Thickness	0.010	0.010	0.018
	Total Volume	0.490	0.816	3.426
Totals	Floor areas (m^2)	77.800	91.800	88.863
Structure	Type	I JOist	Enhanced	Post and Beam
	Source	N. Europe	FSC: Latvia	N. Europe

	Structural Grade	C24	C16	C16, SC3
	Volume (m^3 per Unit)	**1.920**	**17.163**	**16.021**
Cladding	Type	Larch	Larch	Larch
	Source	Scotland	Scotland	Scotland
	Quantity	3.675	0.206	2.635
	Total Volume	10.015	21.846	27.113
	Volume per m2	**0.129**	**0.238**	**0.305**

Note: Leitch Street Roof has different calculation based on rafter section area multiplied by depth.

9. Appendix 2

9.1 Standard Timber Sizes

47 x 50
47 x 75
47 x 100
47 x 125
47 x 150
47 x 175
47 x 200
47 x 225
47 x 250 (Available from Limited Mills)

75 x 75
75 x 95
75 x 100
75 x 150
75 x 175
75 x 200
75 x 225
75 x 300 (Available from Limited Mills)