Cross Laminated Timber Construction in Scotland

Stephen Miles and Jonathan McQuillan

Anderson Bell + Christie

Mass timber construction (specifically Cross Laminated Timber or CLT) is a relatively new system to the UK construction industry. It has been adopted on a large scale in southern England for use on projects from schools to 10 storey apartment blocks.

A CLT panel is formed from layered timber sections. The grain in each layer runs perpendicular to the next. The arrangement becomes a panel when it is treated with a resin and high pressure to bond it together. Effectively CLT is a very large sheet of plywood.

For Architects CLT is an exciting material, it presents a host of design opportunities. The large panel sizes and its inherent structural capacity allow large spans and cantilevers to be achieved if applied intelligently. The monolithic nature of the panel allows freeform shapes to be cut out of the panel without the need for lintels and secondary structural items. In essence it is like building an architectural model from card, it is a liberating and joyful experience.

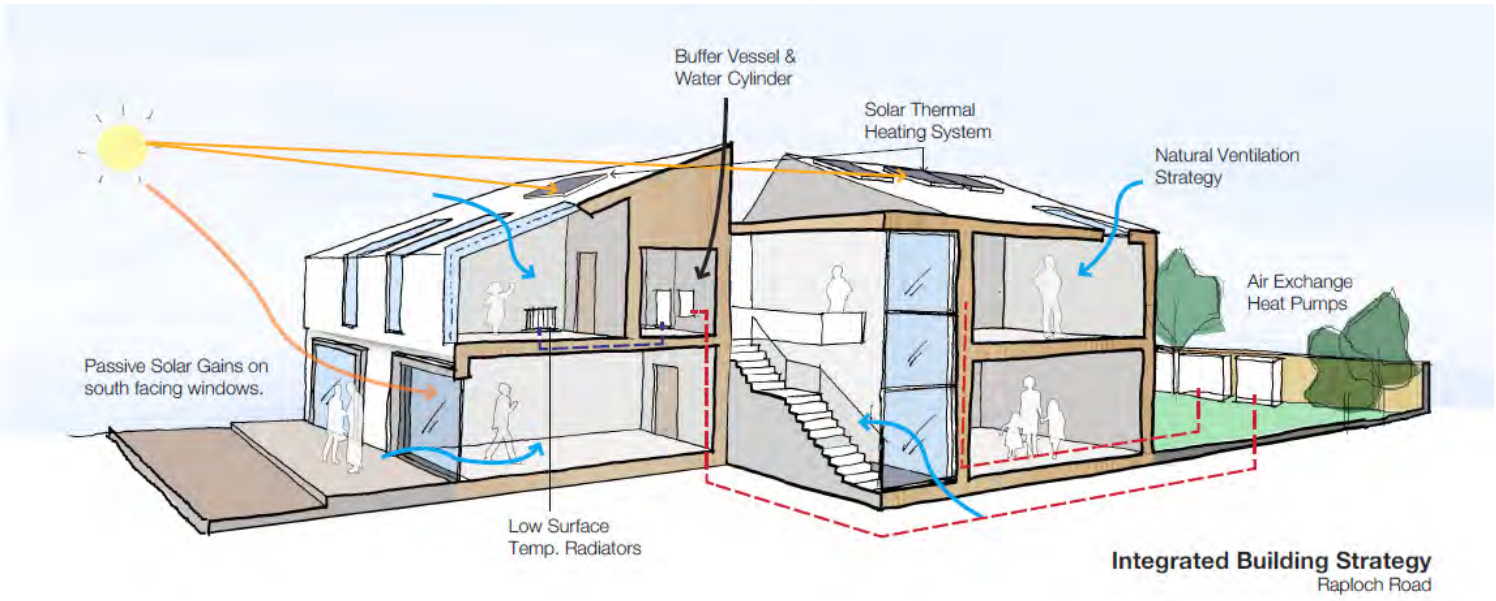
CLT also has a wide range of technical benefits. Its success in southern England is largely due to its potential to provide similar qualities to masonry construction. The main difference is time, as projects can be erected significantly faster than a comparable masonry build as there are no wet trades. The CLT panels provide excellent acoustic properties as well as inherent thermal mass and fire protection. The panels are fabricated off site to exact requirements and are delivered in sections optimised to road haulage efficiencies.

The uptake of the system in Scotland to date has been limited. This is perhaps due to two main factors. Firstly panels are produced in mainland Europe. So whilst southern England is relatively accessible to the European market the additional road mileage to Scotland adds cost to the product.

The other is our heritage of timber frame building. Mass timber will not be compared to masonry construction in Scotland, its direct comparator is lightweight frame technology.

This type of lightweight construction at present offers similar levels of speed and is fully compliant with current building standards.

There will be a cost increase on Scottish lightweight timber frame, so mass timber does not appear to be threatening its arrival in the Scottish market. So what makes it of interest to the Scottish construction industry and why are demonstration projects required?



Changing building standards legislation is a major driver for innovative construction systems. The Scottish Government has a target for all new buildings to achieve net zero carbon by 2016. This represents a massive step change for the industry and requires a new way of thinking about construction. Timber frame construction in its current guise has a limited shelf life and manufacturers are researching alternative solutions.

Adapting lightweight construction to suit upcoming legislation requires significant number of additional components and materials. This in turn increases the number of operations in a build and places greater reliance on the quality of workmanship.

The simplicity and accuracy of CLT detailing generates very airtight buildings with minimal effort. This omits the need for additional gaskets, membranes, tapes and mastic. In turn this simplifies the build and allows greater consistency in construction.

The depth of the CLT panels also creates a large amount of thermal mass within the building. When insulation is applied externally a 'tea cosy effect' is created that locks heat or coolth into the CLT panels. This assists in regulating the indoor temperature.

Finally CLT panels have a large quantity of embodied carbon that will become a significant factor in achieving net zero carbon. A typical CLT constructed dwelling contains 30-40m^3 of timber, equivalent to around 32 tonnes of CO_2.

CASE STUDY: Raploch Road

Raploch Road is currently on site, being constructed by Cruden Homes East, based in Edinburgh and is due for completion in February 2012.

Anderson bell + Christie Architects commissioned by Raploch URC – an urban regeneration company, were given a brief to design a new innovative mixed use development following the clients recent study trip to Freiburg. The project is being funded by the Town Centre Regeneration Fund.

A further case study is currently being prepared, alongside a microsite by **SUST**, for publication in Spring 2012. The key agenda is to look in detail at the specific challenges in designing and constructed low carbon developments with reference to current legislation, technology and local skillsets.

Raploch Road is a purpose-built "towards zero carbon" mixed use development, comprising of commercial shop units at the ground floor with residential accommodation above. This is intended as a "car free" development which takes advantage of its location at the heart of the new Raploch village centre. The new shop units sit at the back of an existing pavement, helping to frame and shape the adjacent public space.

The Sullivan report, which was commissioned by the Scottish Government to review the carbon efficiency of the building industry in Scotland suggested that the 2010 building regulation's Section 6 (energy performance and carbon dioxide emissions) requirements should demand a 30% reduction in Carbon as calculated against the 2007 regulations. Our proposals as currently designed are targeted towards 60% reduction which is towards the suggested 2013 standard.

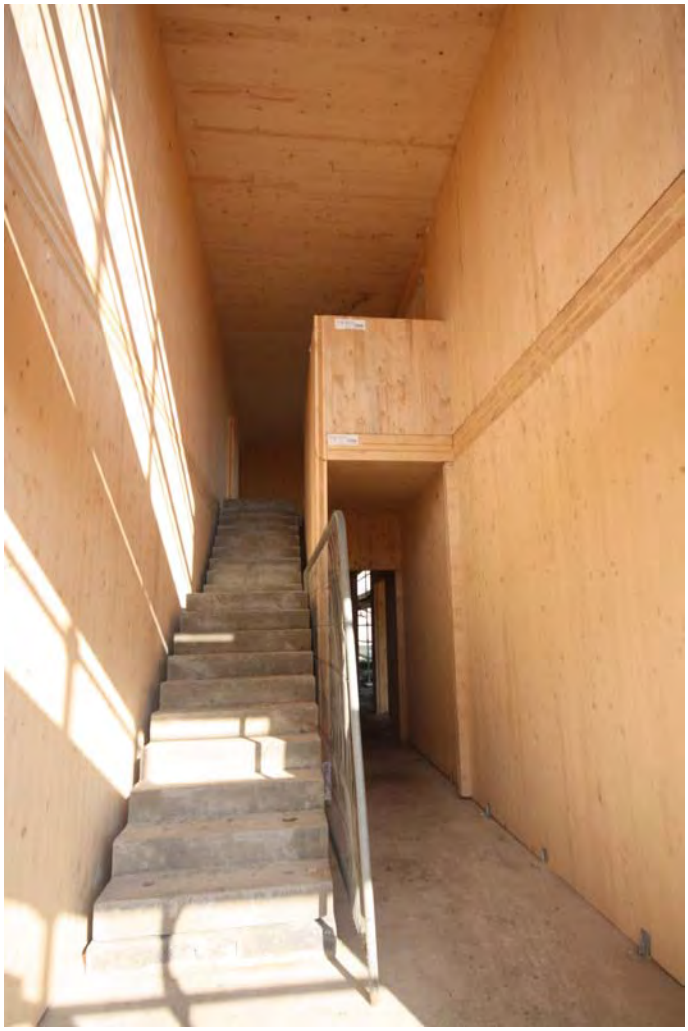
The proposals consist of commercial shop units at the ground floor with residential accommodation above. The development will be clad in Zinc at the upper level residential units, and will utilise rainscreen cladding to the lower levels. It is intended as a "car free" development which takes advantage of its location at the heart of the new Raploch village centre. The new shop units sit at the back of an existing pavement, helping to frame and shape the adjacent public space.

From the very outset, Anderson bell and Christie adopted a 'fabric-first' approach to the design. It was important that given the nature of the client and the tenant that the innovation of the project was simple and holistically integrated.

Our recent experience in massive timber design from the BRE proposals – particularly looking at CLT (Cross Laminated Timber) again informed the 'fabric first' proposals. The CLT that we have utilised was manufactured by **Storaenso** in a b espoke factory in Austria using European spruce. CLT has a huge number of inherent properties which are innovative yet simple. The CLT has been designed to be left exposed within the living areas of the three apartments. A higher quality fair-faced finish was applied.

Using CLT allowed us to resolve a number of challenges that arose during the design, statutory approvals and construction. A few of the key properties are:-

Air-tightness – Due to the 'massive' nature of the timber with cross-lattice lamellas, and simple construction jointing we expect the timber structure to achieve an air tightness value of around < 0.05 m3/h.m2 @ 50pa. This is hugely more efficient than currently required within the technical standards. This informed the SAP results and LZCT (Low or Zero Carbon Technologies) design.



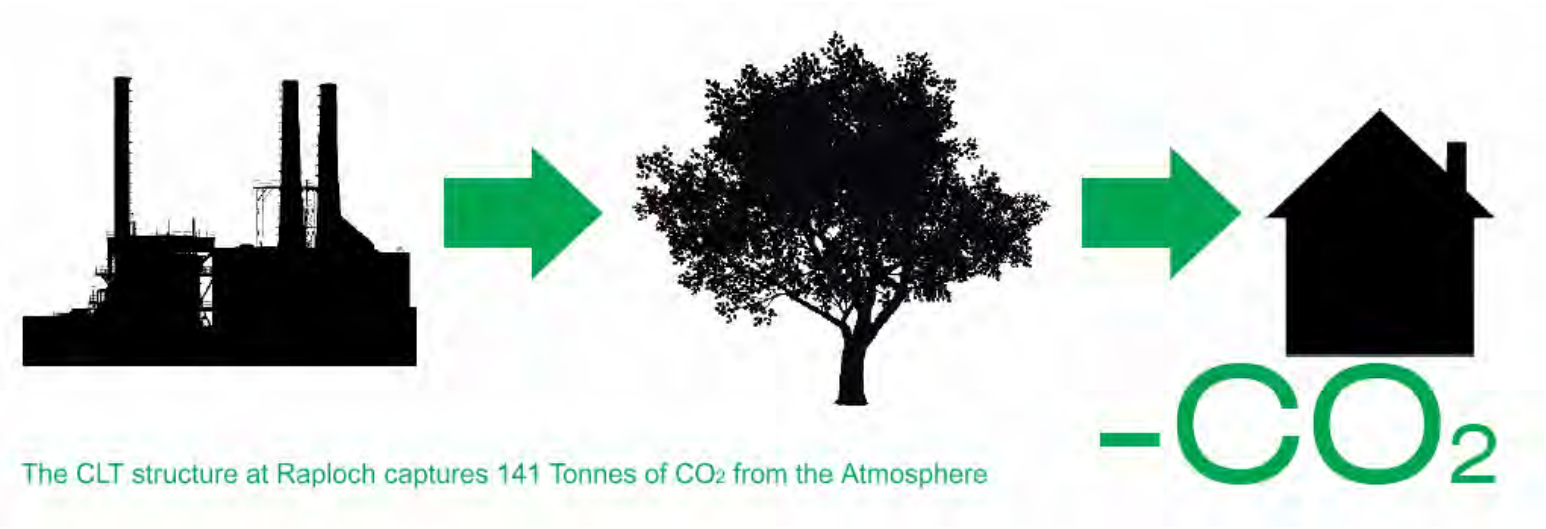
Structure - The CLT frame, has great ability to create large spans and free cut opening due to the nature of the cross lamination. Each panel acts compositely as both a column and a beam. The removal of other ancillary items such and lintels, trimming and any allowance for shrinkage simplifies the design, and partners with precision off-site manufacture for true lean construction. The building is easily erected with wall panels being built directly from a slab level, with floors being sat directly on top. This simple style of building could be compared to building a "cardboard model". This makes detailing interfaces much simpler, as the inherent structural capacity within the laminated panel allows freedom for creating openings.

Fire – The most onerous technical situation within the Scottish building standards is the conversation between non-domestic and domestic, and particularly relates to the specific term 'non-combustible'. Through partnership with Napier's Wood Studio we were able to demonstrate that CLT when designed properly through use of Eurocode 5: Scottish Market.

Design of timber structures to demonstrate charring rates and structural integrity in fire. Anderson Bell Christie successfully challenged the sub-clauses within the technical standards and gained ministerial consent to construct the whole structure in timber, most importantly including the protected enclosure which is a key challenge when looking at the future of timber construction within the Scottish Market.

Thermal Mass – By calculating the 'U-Values' dynamically, understanding the ability of the CLT to trap and retain heat – we were able to efficiently design the wall assembly for the best performance.

Insulation and assembly – By insulating externally we were able to completely remove repetitive thermal bridges through the wall assembly, which aided greatly the energy performance of the building. The ability of the CLT to also act internally as a moisture buffer is exploited by removing all ancillary 'plastic wraps' such as VCL (Vapour control layers) and Breather Membranes. CLT has the ability to aid regulation of seasonal variation of indoor humidity which was tested using Wu-fi dynamic calculation methods.



The CLT structure at Raploch captures 141 Tonnes of CO_2 from the Atmosphere

Carbon Capture – At 587m2 Raploch's CLT frame effectively captures approximately 141 tonnes of Carbon from the atmosphere. Whilst not yet recognised under the technical standards – SAP 'A' rated development will have an annual carbon footprint of approximately 2 tonnes. This effectively means that Raploch Road could be classified as a true 'Carbon Neutral' building for the first 70 years of its lifecycle when compared against non-timber construction methods.

Off Site Manufacturing – Due to the high level of precision design, undertaken by Eurban Timber engineers, the timber frame which was manufactured in Austria, the site construction time was massively reduced over more common building methods in Scotland such as traditional masonry or timber frame. The whole CLT structure was erected, air tight and water tight in 8 working shifts – with some panels as long as 15m being lifted directly from the lorry to an elevation. The ability to construct quickly greatly reduces site management fees and preliminaries, as well as reduces human error building key construction details. Where the CLT is being exposed internally, services routes and locations were factory routed into the structure before it arrived on site.

In essence, the CLT has been designed to perform a number of functions, it is a weathering line, a structure, and regulator and fire stop as well as being a natural carbon sink. Although typically more expensive than more common construction types in Scotland – when balanced against lifecycle energy performance, holistic performance and rapid construction it is much more readily comparable. The whole CLT structure is easily demountable and fully recyclable.

Services and LZCT's - In order to achieve the brief, a passive approach was taken when considering the building service strategy. Reducing consumption before trying to offset it with renewable energy was key. Natural ventilation and a hi gh daylight factor were a focus. Detailed comfort calculations were carried out to assess the viability of natural ventilation. The external walls were constructed to specifications which are recognised for their advantages in terms of sound absorption and transmission, air-tightness and thermal conductivity.

With the high levels of air-tightness and low u-values heating demand is minimised. When heating or hot water is required it will be supplied by solar thermal panels and an air source heat pump. The heat pumps extract latent heat from the air. This system has been designed to heat the apartments even on the coldest days of the year. The heat pumps can have an efficiency of 300%. This means that for every one unit of electrical energy 3 units of heat energy can be pr oduced. The result is less primary fuel consumption and reduced CO2 emissions. No chimneys, fuel tanks or gas connections are required. Its main components are a roof mounted solar panel, an outdoor unit and an indoor storage cylinder.

The indoor cylinder is then connected to low temperature radiators which are connected to sensors in the various spaces to control the room temperature to the occupants requirements. These controls allow for more flexible and responsive room heating so the desired amount of room heating can be delivered when and where it's wanted. This system therefore is low energy, low carbon and low cost.

The ventilation of spaces was provided by natural ventilation where possible. Natural ventilation provides a low cost, passive approach to fresh air supply. In the commercial units in the summer months the fresh air will leave through the high level grilles connected to the roof openings. These natural ventilation shafts can be opened and closed as required.

The bathrooms have heat recovery fans. These fans extract the air from the space. This air is passed over a heat exchanger then extracted to the outside air. This warm air heats the exchanger. The incoming air passes over this heat exchanger thus supplying warm fresh air into the bathrooms subsequently reducing the heat demand in the space.

A Building monitoring system was also specified to allow users the opportunity to control the heating system thereby giving occupants a c hance to understand their energy system and allow them the chance to fine tune it to their needs and requirements.

Value: £0.75m

Completion date: February 2012

Architect: Anderson Bell Christie Architects

Stephen Miles, Karen Anderson, Jonathan McQuillan

Client and CA: Raploch URC, Kevin Braidwood

Main Contractor: Cruden Homes East

Structural Engineer: Roy Easton Company

Timber Engineer: Eurban

M+E Engineer: ARUP

QS: Keegans Group

Conclusion

These case studies serve to highlight the benefits and introduce the Scottish construction industry to CLT. However this is only part of the story. To understand the true potential of CLT in Scotland it is important to understand why CLT was first made. On the continent CLT was first derived as an innovative way of using offcuts from the sawmilling industries. The layering and bonding process creates a panel whose collective strength is greater than that of its component parts. On the continent CLT is a very cost effective building material as it is close to source. It is widely used and there is a well established industry that is rapidly evolving the technology.

In Scotland a similar situation could exist. Scotland's forests are largely populated by trees which are fast growing and produce low structural grade timber. This timber is largely felled for use as paper pulp, fencing and transportation pallets.

In 2009 Scottish woods value share of the UK market was only 5.1% (FCS SFS Progress Indicators 2011). Scottish forestry is a substantially under exploited resource.

If Scottish timbers could be used to form a CLT panel then there is a potential competitor to lightweight frame construction as well as European imports. This would allow an industry to be created in Scotland which could generate jobs, infrastructure and additional revenue from our natural resources. We are excited by this prospect and are keen to see the Scottish construction industry realise CLT as a solution to the challenge of 2016 building standards.