The Art of Building

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Bruce Newlands studied at The Scott Sutherland School of Architecture and at the Illinois Institute of Technology, Chicago. His work also includes Phase F of the Crown Street Regeneration Project, small sustainable rural housing developments, a Primary School for Children with Moderate Learning Difficulties and a Turning Point Rehabilitation Unit in Glasgow. Bruce also teaches on a part-time basis at The Scott Sutherland School, Aberdeen and is a visiting critic at The Architecture Department, Northumbria University.

Kraft

Kraft was established a little over three years as an attempt to explore & practice within the space between academia, engineering, product development and architecture.

A wide & perhaps unusual brief for an architectural practice but one that we’ve found has thrown up many overlaps and exciting new trajectories into other fields.

The practice’s ethos aligns closely with Alvar Aalto’s sentiments on the art of building.

“…Building art is a synthesis of life in materialised form. We should try to bring it under the same hat, not a splintered way of thinking, but all in harmony together…..”

We aim to produce elegant practical design that occasionally delights. For the past three years our research & product development activities in conjunction with a wide range of collaborators has taken the office in a variety of directions, introducing new layers of understanding that are perhaps unusual to mainstream architectural practice.

In this article, we hope to give an overview of our modus operandi by briefly discussing a range of ‘projects’ that are currently live including sustainable product development, design for manufacture, designing for zero carbon and developing post occupancy evaluation are being tackled by Kraft through practice.

For the initial case study we’ve looked at a component that architects specify routinely in almost every project, namely insulation. It’s a generic component that is increasingly critical in achieving a ‘fabric first’ approach to building envelope design not just in terms of thermal insulation but also in terms of vapour diffusion, heat capacity and the embodied energy of the material itself which can account for up to a metric ton of material in every typical two up two down house.

Fig 1. Kraft Office
1. Thermobond

We wanted to develop an insulation product that maximises the ‘reduce, reuse and recycle’ agenda whilst competing on price with mineral fibre market leaders. We were targeting both new build off site timber frame manufacturers and public sector retrofit of older ‘breathable’ buildings.

The technical challenge we faced was how to ensure that insulation, a key component in all lightweight new-build building fabric and increasingly the first component of both public sector and private sector retrofit work can meet and surpass the performance requirements of emerging markets created by current & forthcoming carbon target legislation.

A nine month research programme was undertaken with the assistance of a Scottish Enterprise SMART Award, CIC Start Online Consultancy and Dr Paul Baker at Caledonian University we embarked on a programme of research and development of a natural fibre insulation that utilises waste fibre streams.

Waste fibres were identified as a key component as SEPA estimates the volume produced annually in Scotland is around 40,000 tonnes alone, utilising this for the purposes of insulation would not only close the waste loops but given that the fibres are largely natural wools, cottons etc, would also create a building insulation that was non-irritant and hydroscopic.

Initial work was undertaken to establish links with sources of waste fibre ranging from wool mills to social enterprises dealing with recycling. After finding reliable sources, a review of available processes and production was undertaken and two European partners identified who supply machinery capable of producing the quality of product required. There are two UK production lines but both have limited capacity, output formats and technical flexibility for trialling new products, we also went to Europe to avoid any commercial conflict with the existing UK producers of natural fibre insulation and because one of the commercialisation goals was and is to establish a production line for these products in Scotland, none currently exist.

We undertook some initial trials using Scottish waste wool at various densities and blends, thermal conductivity testing was then undertaken by Caledonian Universities Centre for Indoor Air Quality. This initial scoping identified that a thermal performance of between 0.030-0.035 W/mk was achievable and technically feasible.

This work informed a further small trial production run of 1 metric ton of material at a specific density and blend which was then submitted for thermal conductivity testing at the UKAS Accredited BBA Laboratories in Watford. The Heat Flow Method of ISO 8301 : 1991 and BS EN 12667 : 2001 using the BBA single specimen symmetric test facility designated K4 was used. An independently heated zone at the perimeter of each plate provided the edge guarding and apparatus wall temperatures were controlled to match the mean specimen temperature. The specimen thickness was measured in accordance with BS EN 883.

These results confirmed a thermal conductivity at the higher end of the range 0.034 W/mk.

The next key objective was to determine the performance of the waste textile insulation when tested utilising the principles detailed in with BS 5803: Part 4: 1985 Section 2, Flammability Test and Section 3, Smouldering Resistance Test. When tested the combustion zone was not observed to extend to within 25mm of any part of the timber surround. The product, as tested, therefore complies with the requirements.

When tested to BS 5803: Part 4: 1985 Section 3, Smouldering Resistance Test, smouldering or flaming was not observed to extend to more than 150mm from the centre line of the cylindrical ignition source. The product, as tested, therefore complies with the requirements.
Fig 3. Initial Thermal Conductivity Test Results

Fig 4. Fire Testing

Fig 5. Moisture / Vapour Testing
Further testing in accordance with CUAP Edition June 2003, endorsed at 46th TB meeting: Factory made thermal insulation materials and/or acoustic insulation materials made of vegetable or animal fibres. Section 4.1.1.2 and Annex E, the samples showed little onset of corrosion and no perforation with copper but some corrosion with zinc.

This data will be further reviewed and will inform COSHA and fixing advice. Water Vapour Diffusion testing was also undertaken which confirmed the properties of the natural fibre insulation.

The key outcome of the work has been to prove the technical feasibility of the waste fibre specification, blends and manufacturing process.

We are now in discussion with a Glasgow based investor about establishing a small manufacturing line capable of producing 600 tonnes of insulation annually.

The establishment of a Scottish production line also enables further optimisation of the product through further testing and development of other fibres such as cellulose, wood fibre and other waste fibre streams.

We have identified the need to enhance the following characteristics of the natural fibre insulation product to help achieve the advanced performance requirements:

1. Trial additional fibres including cellulose, wood, cotton, PLA, polyester, feathers and coconut fibre.
2. Enhanced Specific Heat Capacity which has an role in reducing heating / cooling loads in lightweight construction by enhancing the buildings thermal mass.
3. Enhanced Thermal Conductivity to significantly improve upon industry wide performance, current testing indicates a performance of between 0.031-0.034 W/mk. The aim of the feasibility work in this area is to make an approximate 10% improvement to below 0.029 W/mk.
4. Enhanced Bi-Polymer binder like PLA (Polylactide Fibres) can significantly improve the energy used in the manufacturing process, leading to lower embodied energy & potentially achieving a ‘100% Recycled’ or ‘100% Natural Fibre’ product.
5. Enhanced FR by establishing an ecologically benign method of achieving the FR performance through the material characteristics itself and/or by introducing trace components of non-toxic materials into the production process. The existing product achieves basic fire resistance performance for use in timber frame buildings but this may be enhanced to allow for it’s use in more demanding situations and as part of a ‘100% ecological specification’.

We are currently in discussion with Dr Mike Jarvis at Glasgow University and Dr John Liggat at Strathclyde University about a number of these issues going forward.
2. kII System

In tandem with the development of Thermobond, kraft embarked on the product development of structural components for a fully ‘homegrown’ timber superstructure system that could achieve a very low linear thermal bridging co-efficient whilst remaining suitable for closed panel off site manufacture.

Our key technical objective was to demonstrate through test data the use of C16 Homegrown Timber through Eurocode 5 testing. Whilst also undertaking Thermal, Structural, Fire, Vapour Diffusion Testing to establish feasibility of system

We were also very conscious of the need for any system to be manufactured offsite to help reduce wasteage and achieve higher standards of construction tolerance, we decided to include a review of the system for compatibility with a local OSM Production Line.

The resulting kII project is a collaboration with Napier Universities Institute for Sustainable Construction, principally Dr Robert Hairstans and Kenny Leitch working closely with staff at the Scottish Building Performance Centre at Glenrothes and CCG (Scotland) Ltd.
Our initial investigations focused on the performance of a low lambda soleplate connection for the kII closed panel wall system. A variety of details were quantified & tested with regard to strength and stiffness. This iterative process was extended to undertaking a series of racking tests using different sheathing including OSB, Woodfibre and Gypsum Fibreboard materials.

The behaviour of wall types under load was also determined and brittle failure mechanism identified. These results have been cross-correlated the draft method for racking design in Eurocode 5 and it has been identified that Engineers using this method would overestimate the racking capacity of these wall types. This is a fairly major finding which is invaluable for the specification of kII wall types in practice. Further racking tests on kII candidate wall types manufactured using ‘homegrown’ timber are now underway to further built the data set for live testing performance.

In tandem with this work we are also developing these approaches based on creating TEDDS software proforma in order to allow Structural Engineers to readily calculate racking resistance and soleplate capacity in accordance with the new Eurocode 5 method. Eurocode 5 had not yet been released and so the cross-correlation work being undertaken was ahead of the level at which the industry is typically currently operating at, effectively future proofing the system for 2013 onwards.
This work has resulted in a prototype product with patent pending on the key component named ‘thermostud’.

The thermal break incorporated in the stud uses no connecting components, resulting in zero repetitive thermal bridges in the wall assembly and contributes to very low linear thermal bridges when combined with the kII top and bottom rail components.

The kII system is being manufactured in one of the UKs largest and most sophisticated automated production lines for closed panel timber frame operated by CCG (OSM).

This will help eliminate the inherent inefficiencies and waste within standard construction practice but also deliver larger panels, quicker installation, higher tolerance with fewer follow-on trade interfaces leading to a potentially reduced construction period.

The first live demonstration of kII system will be on three terrace dwellings at the Fife Innovation Showcase project.

The system is currently being manufactured and erection is due to begin January 2012.

Find out more at www.futureaffordable.co.uk
3. Fife Innovation Showcase

Future Affordable is a collaborative project to deliver a sustainable & affordable housing system for the social rented & private market. The development of the system has involved Developers, Manufacturers, Architects, Academia & Material Suppliers working collaboratively to produce a housing system that supports these aims through the use of homegrown C16 timber, thermal mass, recycled materials, high thermal performance, excellent built quality and low to zero carbon emissions using appropriate innovative construction techniques that are readily adoptable by the house building sector.

The Fife Innovation Showcase will be the first demonstration of the future affordable concept.

Organised by Kingdom Housing Association the showcase aims to demonstrate off site manufacturing techniques and affordable house models that show incremental improvement in line with future regulations.

The design, orientation & layout of the housing itself is predetermined as part of the wider Oliver & Robb Architects masterplan for Dunelin Drive, Dunfermline but there is still a significant opportunity to demonstrate a number of technologies and building performance concepts.

Our terrace of three homes will demonstrate how to achieve 2013 Low Carbon & 2016 Zero Carbon whilst including a ‘control’ 2010 compliant house for comparison.

Our partnership is with Springfield Properties, Napier University, David Blaikie Architect, Living Solutions a local social enterprise sawmill and BSW Timber, supplier of the mainstay of home-grown timber.

C16 has been used for the kll external & internal walls but it has also been incorporated into the intermediate floor cassettes, which use a floor truss design and the 'room in the roof' attic roof trusses.

The use of home-grown timber, recycled materials & design for deconstruction ensures that the system is also very low in embodied carbon. David Blaikie Architect has designed prefabricated massive timber bathroom pods called e.Core, these lend thermal mass to the whole structure and provide a potential moisture buffer.

Together the systems should combine the best of both home-grown framing and massive timber construction.

Fig 15. Future Affordable 2010 / 2013 / 2016 Innovation Terrace
The Future Affordable concept is aligned with Scottish Building Standards Section 7.

The system generally surpasses the UK Zero Carbon Hub definition for zero carbon fabric standards (FEE) and therefore meets the Section 7 fabric standards. Section 7 demands percentage onsite renewables, which the future affordable concept aims to demonstrate in an integrated way through the use of efficient but affordable technologies.

We are particularly interested in measuring the real impact of fabric standard and renewables on running costs for tenants.

Our initial SAP 2009 analysis using NHER Plan Assessor, which includes a crucial allowance for, unregulated energy usage to give a ‘whole house’ assessment suggests that by carefully balancing fabric performance with investment into integrated renewables, there may be an affordable route towards the zero carbon 2016 target.

When modelling total energy usage it is important to consider unregulated energy. The NHER assessment includes cooking and electrical appliances, the degree-day region, displaying energy usage, fuel running costs and carbon dioxide emissions per year broken down by usage.

Our projections are based on actual market tariffs.

2010 ‘Bronze’
£400 Annual Cost

2013 ‘Silver Active’
£200 GBP Annual Cost + Feed in Tariff of £200 Annual

2016 ‘Gold Active’
£Zero GBP Annual Cost + Feed in Tariff of £600 Annual

All of the homes are destined for tenancy so there is a very real opportunity of getting some valuable post occupancy evaluation undertaken both on the occupants, the systems and the building fabric.

Fig 16. Scottish Stacked Plank Bathroom Pod Fabrication, designed by David Blaikie Architect

Fig 17. www.futureaffordable.co.uk
Our terrace of three homes offer a unique opportunity to test and better define the performance of 2013 Low Carbon & 2016 Zero Carbon designs against a 'control' 2010 compliant house using the same fabric but also against a more typical timber frame house built to the Scottish Building Standards accredited details, this will be completed by Kingdom Housing Association on a neighbouring site to provide a benchmark for all system exhibited in the showcase.

Further details of the other systems being exhibited can be found at the following website link:

www.housinginnovationshowcase.co.uk

A variety of post occupancy evaluation measures are proposed for the Future Affordable plots including the use of the Scottish designed Ewgeco Energy Monitor, one of the few affordable and consumer accessible real time monitoring systems for gas, electricity, water and renewables available.

Ewgeco can display energy consumption from up to three different sources including any combination of Electricity, Water, Gas and any micro-renewable source including Photovoltaic (PV) in our 2013 and 2016 dwellings.

The system also provides a means for off site monitoring of both the power generation and the different energy usage using a data analysis portal.

It allows occupants to store, monitor & share their energy usage, providing tools to make savings through identifying trends in behaviour - daily, monthly and across the year.

We will also be including temperature, humidity and co2 data loggers in the properties and carry out post construction airtightness testing and thermographic imaging.

We anticipate publishing results in 2013.
4. BRE Innovation Park Visitor Centre

The BRE are in the process of developing an Innovation Park on the site of the former steel works in Ravenscraig, Lanarkshire. The 1125-acre Ravenscraig site is being regenerated into a new town, featuring 10,000 houses, sports facility, town centre, community spaces and transport links.

There are plans to exhibit up to twelve demonstration buildings, which will showcase products, and technologies, which meet the future energy requirements for Scotland.

A small BRE Visitor Centre will also be situated on the site which it is hoped can also operate as a community meeting & educational space, engaging with local groups such as school children, young adults and FE colleges.

Kraft has been involved with the design & specification of the visitor centre of the project.

The off site building system specified surpasses the UK Zero Carbon Hub definition for zero carbon fabric standards (FEE) and therefore surpasses the Section 6 & 7 fabric standards.

The BRE have stipulated a challenging BREEAM Outstanding and Carbon Neutral Emission Target, these very high aspirations present interesting opportunities for a novel non-domestic post occupancy evaluation tool that can both monitor and manage a variety of renewables including Solar PV, Thermal & Heat Pump.

It is planned to use the building as the focus for a Building Performance Monitoring Demonstration Programme supported by European Research Funding and piloting the Energy Warden System.

Energy Warden is a European FP7 project, aiming at the development of tools for monitoring and control of energy resources, including renewables, deployed in the building domain. It’s inclusion in the BRE Visitor Centre will be it’s first implementation anywhere in the world and will provide a platform for optimisation.

Energy Warden will monitor and feedback into the various renewable energy sources propose don the building and control the usage of energy for immediate usage, export and storage in fuel cells.

We believe that this small non domestic building will be a very valuable test bed for Energy Warden which we hope if successful will lead to it’s adoption in larger more complex construction projects helping to manage energy conservation and usage in a smart, efficient and sustainable way.