

Placing low energy architecture in a low cost economy

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ABSTRACT: This paper examines a new low energy building located in Northern Ireland, designed by Alan Jones, an architect who practised in London for ten years with two "High Tech" architects – seven years with Michael Hopkins (RIBA Gold Medal 1994) and three years with David Morley (UK Young Practice of the Year 1998). Since 1998 Alan Jones has been adapting the knowledge and experience of London based projects to the low cost economy of his native Northern Ireland. The introduction considers the experience of the highly engineered London based projects, (Inland Revenue Centre Nottingham, the offices for the English Cricket Board and New Shop, Lord's Cricket Ground) and the impact of moving from a high cost high skilled economy to a low cost low skilled economy has upon low energy architectural design. The main body of text contains extensive consideration of a very large private house in the public centre of a town, adjacent to a protected historic church and graveyard and a conservation area, exploring the project as a model of how to address relationships between other buildings, matters of privacy, location of extensive glazing for solar heating, links between internal and external space, choice of colour, landscape, choice of technologies and construction.

Keywords: Energy, solar, house, urban, design, context, construction, practice

1. INTRODUCTION

1.1 The Author

The author is a chartered architect and studied at Queens University Belfast. The author spent the period 1989-1995 with architects Michael Hopkins & Partners, London – a practice renowned for their low energy architecture. During this time the author was assistant architect and then project architect on constructed projects – Phase 2 Schlumberger Cambridge Research, The New Inland Revenue Centre, Nottingham and the Saga Group headquarters. From 1995 – 1998 the author was an associate with David Morley Architects, London working on the acclaimed low energy New Cricket School, the new naturally ventilated England and Wales Cricket Board offices and New Shop - all located within the famous Lord's Cricket Ground in St John's Wood London. Projects named above were published extensively and received numerous awards. In 1998 the author returned this native Northern Ireland, lecturing in architecture at SPACE, Queen's University Belfast and practising as one of the directors of Alan Jones Architects Ltd, Belfast.

1.2 This Paper

It is not the intention to revisit the Hopkins and Morley projects listed above – as they have been extensively published in Architectural Review, Architects Journal and Building. The author returned to Northern Ireland in 1998, a region similar to others on the edge of central Europe, undergoing increased levels of development and investment.

1.3 Northern Ireland: Economic context

The region of Northern Ireland has a population of 1.6 million. Construction costs in this region are approximately 30% less than the south east of England. Simple housing is constructed for €750-850/sqm (April 2006) with the average house cost in the region reported [1] in March 2006 as €208,000. As a legacy of the economic severity of the period 1968-1998 (the thirty years of "The Troubles") government expectations for a full design team of professional consultants on a project remain at 10%, or less, of the construction budget. This level of professional fees is approximately half that of the south east of England. This low fee expectation of the major client in the region (commissioning over 50% of construction) and the low construction cost has negative implications for the quality of design, innovation, continuous professional development and the monitoring of construction quality - impacting on all levels of the construction industry in the region. Also as a result of location and the economic severity of the period 1968-1998, skills and innovation within the construction industry are relatively basic, with simple buildings of average quality being created.

1.4 Local materials and preferred construction

Local designers and contractors prefer traditional construction, materials and systems manufactured in Ireland for a number of reasons. Cost constraints, lack of familiarity due to unawareness or training and the relatively small-scale local economy mean that new techniques of design, construction and availability of new innovative products or materials is

slow to evolve. Preferred construction for housing is cavity wall construction with precast concrete floor units and tiled / slated roofs. There are relatively strong insitu concrete and precast concrete sectors to the building industry with many building contractors presenting themselves as both a building and civil engineering company – maximise the width of their potential market. There are recent government initiatives [2] to improve energy awareness of building design professionals but they are focusing the application of the new skills and knowledge on the business and public sectors. Building regulations and legislation is the local mechanism for improving better energy performance within all sectors including house design and development.

1.5 Consultants

In Northern Ireland less than 30% of all projects submitted for planning are designed by architects and the percentage of houses designed by architects is even less. On housing projects, structural engineering consultants are used sparingly and environmental, services, cost or landscape consultants are rarely used. Much advice is delivered through suppliers and contractors but, with few having professional indemnity insurance, the advice is often guarded and pragmatic, recommending familiar techniques and products. The team on this project comprises architect, structural engineer, cost consultant and landscape architect. Elemental u-value calculations were undertaken by the local insulation manufacturer and supplier [3] and overall building calculations by the mechanical services contractor [4] who undertook the complete heating and plumbing installation.

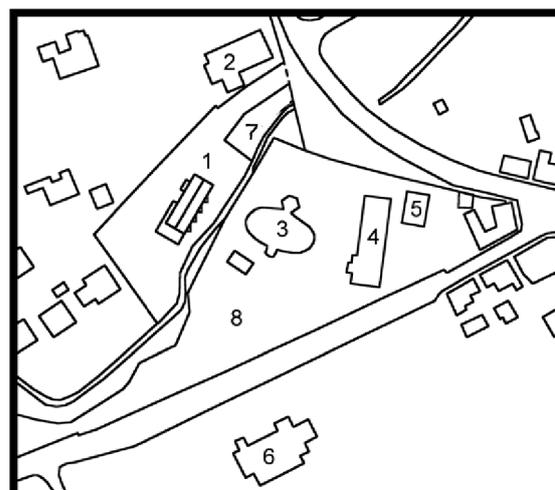
2.0 The project

2.1 Location

The project is in Northern Ireland, located in the centre of Randalstown (54°45' N, 6°19' W), a small town 32km north of Belfast and 50km inland from the Irish Sea. The town is on the southern end of a ridge that runs from the large central lake, called Lough Neagh, northwards to the coast. The site is elevated 46 metres above sea level.

2.2 Project brief and programme

The brief was for a family house with four bedrooms with half of the daytime living accommodation being able to be used for office/consultant use. The floor area including garage was to be approximately 375 sq m. The site was purchased in 2002 and the town-planning authority approved the designs in early 2003. Construction began in March 2004 and completed September 2005.



- 1 The House
- 2 Orange Hall
- 3 Presbyterian Church
- 4 Church Hall
- 5 Masonic Hall
- 6 Church of Ireland
- 7 British Legion Memorial Garden
- 8 Graveyard

Fig 1: Location plan confirming relationship with public buildings and spaces.

2.3 Site History and Context

The site is situated on a main public road, on the edge of the historical core of the town in the district where many of the public buildings are located. The site is within a row of public buildings, a Masonic hall, a church hall, a Presbyterian church with graveyard behind, the site and then an Orange hall. To the front of the site is the town war memorial and behind the site there is the Anglican Church of Ireland and beyond a primary school. The Presbyterian church next to the site is unusual, being one of only two oval churches in Ireland – and hence is listed Grade A, with extensive protection regarding new buildings being placed next to or in the vicinity of it. The church has three entrances, with one entrance facing towards the site. A small stream, owned and protected by a government agency, is to the eastern boundary between the site and the listed church. The conservation area boundary runs along the stream and then across the site close to the main road. There had never been a building on the site, which historically was used for holding livestock from the town market. During the 1960s and 1970s the site was used as the site compound for a builder constructing the numerous houses beyond the site to the southwest. Initial site investigations confirmed an initial two metre deep layer comprising soil, clay and construction debris, with soft rock below. Deciduous trees and bushes on the long site boundaries had never been managed and were overgrown, especially on the boundary next to the stream. A public sewer,

servicing the houses beyond, had a statutory six-metre zone within which no building could occur.



Fig 2: Listed church to left and house right – during a public parade. Single window placed in northeast elevation of house. Solid sides of bay windows to left side of house.

2.4 Low energy technology, grants and choice

The United Kingdom and Northern Ireland has a government agency grant scheme [5] to encourage homeowners and developers to integrate small-scale renewable energy technologies into the design and construction of housing. Grants are available for various technologies but with over hanging trees and an urban situation, solar hot water, wind power and wood pellet burning stoves were discounted as being potentially problematic and a ground source heat pump was chosen. The limit of grant, at the time of this project, was £1700, equating to 20% of the installation of the heat pump.

2.5 Simple design and simple construction

As with many developing regions of Europe the general trend for recently constructed architect designed buildings is to try and emulate the projects of elsewhere, as seen through journals. Considering the economic, professional fees and construction skills this often leads to frustration on the part of designers. An alternative is to embrace the culture in which the project is to be designed and constructed. Using a rowing analogy, one travels further rowing with the current rather than trying to row against it. This is the philosophy of the author's practice, looking to local older buildings that are normally simple forms, built in a simple way. This approach resonates with "The Plain Style" [6], where intellectual precursors to modernism advocated simple, plain construction and detailing without ornament, relying on local materials, natural light and ventilation. The design aesthetics of Amish, Shaker and other Calvinist inspired movements are relevant to the Presbyterian approach to design and construction. The listed Presbyterian church adjacent to the site is acknowledged as a good example of this approach.

2.6 Horizontal ground loop heat pump

Initial discussions with the chosen recognised heat pump installers [4] concluded that a single 11KW unit was suitable pending high insulation values, low air leakage, a significant contribution from solar gains, high levels of exposed thermal mass and a suitable

ground temperature. After the heat pump supplier measured the ground temperature a horizontal loop system within the 500sqm rear garden was deemed suitable – assuming the other factors could be delivered through the design and construction of the building.

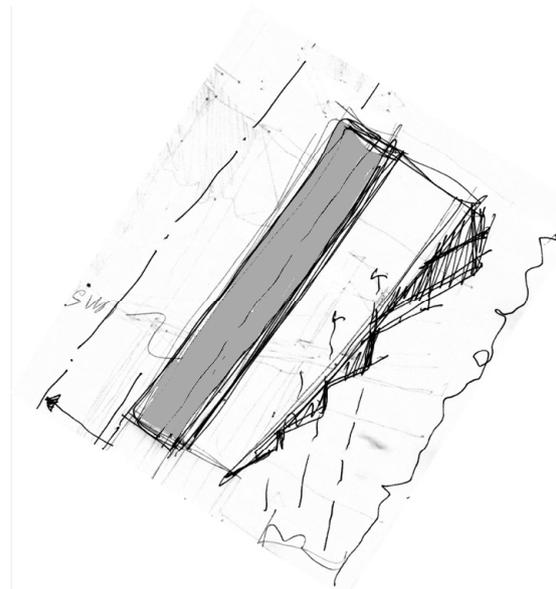


Fig 3: Initial design sketch, service core parallel to public sewer and façade faceted to respond to southerly orientation

2.7 Location of house within the site

The location and size of the maximum footprint of the house was determined by physical and legislative constraints. The listed status of the adjacent church implied a respect of the position of the church and so the building line of the church became a design constraint. The stream was a physical restraint and the building exclusion zone of the sewer and the distance required from the house behind were both legislative constraints. Keeping as far forward to maximise the area of the rear south-facing garden for maximum private area and maximum area for laying the horizontal ground loops for the geothermal heat pump. The actual footprint of the house was 73% of the maximum potential footprint area defined by the constraints. A basement level to house garage and services spaces was both appropriate in terms of site planning and easy to accommodate because of the gradual slope of the site.

2.8 Landscape

Fortunately, the largest and grandest tree on the site, a 250 year old oak tree was located to the north of where the house had to be located. Some management of this tree has ensured it could remain a feature on the site, marking the approach to the house without casting shadows over it. The rest of the trees and bushes along the boundaries were overgrown and a condition survey determined those that required removal and those requiring thinning and trimming. Even though the majority were deciduous and had evergreen ivy removed, much thinning occurred to maximise the effect of the low

sun in winter and general levels of daylight inside and around the house. Being advised that the large oak tree required a porous ground finish to allow rainwater to reach its roots, a local crushed white limestone was chosen for the drive, up to and along the side of the house, which allowed water to reach the tree roots and to reflect daylight in and around the house.



Fig 4: View from garden, with bay windows facing southwards and four windows on southwest gable onto terrace.

2.9 Glazing: Privacy and orientation

The size of the footprint determined by the constraints was such that the internal dimension of the envelope was 20.5 x 7.5m, with the long dimension set on a northeast - southwest axis. The northeast gable faced onto the war memorial garden and public road and the southwest onto the private rear garden. This fortuitous orientation meant that the public northeast elevation wanted to be relatively solid with few windows and relatively plain as it formed the backdrop to the war memorial. This duality of reason resulted in a simple single tall narrow window that also presented an ambiguity as to it being a public building (church or hall) or a house. In contrast, the southeast gable is much more glazed acknowledging the orientation, with a series of different sized domestic scale full height openings, leading out onto a large terrace that is set at the same level as the internal floor level. The northwest long side of the house is arranged with front (public) and rear (private) entrance screens and small windows to private small-scale rooms. The southeast elevation, running parallel and beside the stream has four tall openings with windows cantilevered to face south. At 4.5m high, these windows can let sunlight stream into the interior for six hours of each day, before the sun moves around onto the southwest elevation. Similar to the front elevation there is a purposeful ambiguity as the tall windows suggest the proportions of a public building, when seen from the public road leading to the Anglican Church and school, or when visiting the graveyard. From within the house, these windows give generous views of the sky and over the stream, and to the graveyard when the leaves are not on the trees. Those leaving the adjacent church see no windows, only solid wall construction, maintaining privacy for churchgoer and for occupant of the house.



Fig 5: From the adjacent graveyard - View of house from the southeast, with glazing in bay windows just visible. The exit from the church would be to the right of picture with no glazing of bay windows visible from that point.

2.10 Glazing: System and glass specification

The window and door systems are locally extruded and fabricated thermally broken extruded aluminium systems with enhanced thermal performance to match the new thermal regulations introduced in England but not yet applied to Northern Ireland. Many areas of the glazing came to floor level to maximise solar gain reaching the high mass floor construction, with the added benefit of a view – but with its urban context large areas of glazing implying potential security issues. To address this point laminated rather than toughened glass was used inside and out, improving security and meeting building regulation safety requirements. A hard low emmissivity coating and a 16mm air gap was specified to all double-glazed units.

2.11 Glazing: Air leakage and acoustic performance

The extruded aluminium window system chosen was also chosen for its good air leakage performance, assuming it was fabricated and installed correctly. A low air leakage performance was critical to the overall thermal performance of the building with added benefit of ensuring good acoustic performance in its urban context.



Fig 6: Internal view, 10am, January 2006. Bay windows to the left with view to stream. Exposed concrete walls and polished concrete screed are visible, as are the lightweight internal walls and ceilings.

During the initial occupation period of the house it became apparent that the system was not quite fabricated properly so traffic noise and air infiltration was increased. This problem was solved by the installation of a larger rear gasket on the opening element of the windows.

2.12 Daylight

The trees have been thinned and trimmed to ensure the tall side bays are exposed to the sky all year around. Internally sunlight moves across the floor plates in the predictable manner. Daylight entering these bay windows is reflected diffusely off white painted plaster surfaces into the main living spaces. High quality rooflights ensure the first floor accommodation has ample daylight. Some additional rooflights are placed above voids allowing skylight to reach the entrance halls and corners of the ground floor accommodation. The two central bedrooms have reduced ceiling heights creating more intimate scaled spaces – but also allowing daylight and morning and afternoon sunlight to enliven the circulation and stairwell. This is a response to one of the only potentially negative implications of the orientation of the building being imposed by constraints. The high levels of daylight found inside the house were intentional for energy reasons but also to address the suspicion that one of the clients suffered from Seasonal Adjustment Disorder.

2.13 Artificial lighting

Where possible discreet daylight balanced fluorescent sources mimic daylight and elsewhere low energy downlighters and uplighters are placed on numerous circuits to allow flexibility and control. The fluorescent sources in the main living spaces are fitted with dimmable ballasts giving a further degree of control.

2.14 Insulation standards: Solid walls, floor and roof

The local thermal performance requirements of main elements of dwellings are less stringent than the new regulations recently introduced to England. With no environmental consultant the development of the main elements of the construction was with a manufacturer of expanded polystyrene insulation systems. Working with the assumptions made in the overall thermal calculation of the building the U values to be achieved were higher than the local building regulation requirements. Table 1 compares the thermal performance requirements of local building regulations and the project.

Table 1: Comparison of regulations at the time and design performance

	<i>Regulations</i>	<i>Design</i>	<i>% enhancement</i>
Wall	0.45	0.30	33%
Roof	0.25	0.19	24%
Floor	0.45	0.30	33%

2.15 Primary structure

Considering the long footprint of the house, 20.5 x 7.5m, stability had to either be addressed through cellular construction wall construction or through rigidising the perimeter walls through a frame or

making the perimeter walls inherently rigid in themselves. There was a desire to leave the internal walls free of any structural role, allowing for flexibility and reconfiguration in the future. With large amounts of exposed high thermal mass necessary to reduce peak heating demands, a frame solution with high mass infill was considered as being difficult to achieve an acceptable visual quality in a domestic situation that would not deteriorate with cracking. The final choice was an insitu concrete wall perimeter construction with the internal face exposed to the internal rooms and insulation and rainscreen construction to the outside, maximising the extent of exposed thermal mass. RC35 strength concrete, using locally produced ordinary Portland cement and local black basalt stone aggregate was formed using Orientated Strand Board formwork manufactured in southern Ireland. This formwork gave an organic random pattern, very forgiving of constructional variations and defects, with visual echoes of the trees and bushes seen through the windows. The 20.5m long walls were constructed in 200mm and the shorter gable walls constructed in 250mm. The concrete was constructed up to eaves and apex of the gables, with steel beams spanning across the first floor restraining the sides. The ground floor was formed with locally manufactured precast concrete slabs.



Fig 7: Internal face of insitu concrete perimeter walls formed with Orientated Strand Board. This finish is left exposed internally and is unsealed.

2.16 Secondary structure

The roof was formed of simple timber joists running from eaves to ridge, with noggins between to give full structural stability. The first floor was formed with 15mm structural plywood, glued and screwed to timber joists set between the first floor steels. The tall bay windows next to the stream were constructed as a vertical version of the roof structure.

2.17 Internal arrangement of accommodation

Small-scale support accommodation, comprising toilets, bathrooms, study, library, entrance halls and stairs, was placed along the long northwest facing perimeter wall, forming a core of the heavily serviced area close to the public sewer adjacent. Collecting the small spaces into this single area allows the ceiling level to be reduced to 2.4m, for easy routing of pipework and drainage. The main living spaces and bedrooms are located along the steam side of the building, with a view and the morning and afternoon

sun. The basement has a large garage and plant room.

2.18 Externally insulated wall construction

This type of construction, quite normal for central Europe, is rarely used in housing in Ireland. The preference is for cavity wall construction, a form of construction common to the damp climate of The British Isles. However in the future, cavity wall construction may be found to be unable to meet enhancement thermal regulations. Already externally insulated systems are being considered due to the increasing costs of labour to lay two layers of blockwork or brickwork.

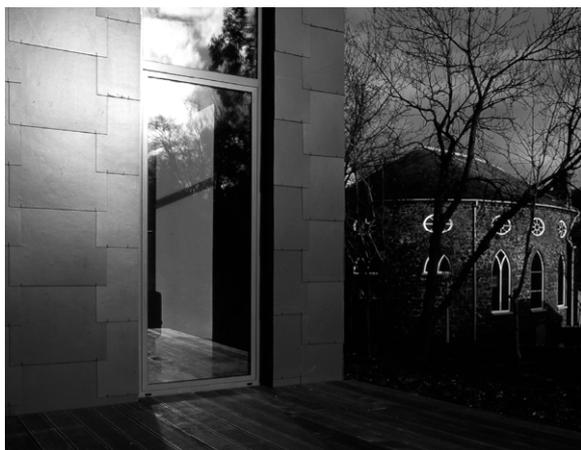


Fig 8: All walls have hung 600x600 tiles forming a ventilated rainscreen. Behind is 130mm insulation on the insitu concrete walls. No light colours have been used on the exterior – so as to not visually draw attention away from the listed church adjacent.

2.19 External finish

Considering the potential effect of the building upon the setting of the adjacent listed church the external rainscreen had to be suitably restrained and visually “quiet”. A low budget painted fibre cement tile, manufactured in southern Ireland, was chosen to hang on wall in a basket-weave pattern and laid the traditional lap pattern on the roof. The hanging tile system ensures a degree of ventilation, for drying out in winter and preventing excess heat build up in the summer and gives the town-planning authority the comfort to know the external finish is self coloured and will remain the approved colour. A warm dark grey finish to the tile and similar for the window and door systems ensured the house had no light colours so as to not visually draw attention away from the listed church adjacent.

2.10 Occupancy feedback

The project was completed September 2005 and occupied from October 2005 onwards. Poorly gasketed windows and a preference to run the heat pump purely on the low tariff electrical supply has meant that internal temperatures during the winter months have stayed around 16-20°C, with the lowest temperatures in the evening before the heating system recommences its heating cycle. An improper

trip fuse to the heating system meant that twice the heating system did not operate during the winter months. In those situations we found the house losing 1-2° C of internal temperature per day, a reflection of the extent of exposed high thermal mass in the walls and ground floor. In March 2006 the gaskets have been improved and with increasing daylight and sunlight the internal temperature at April 2006 was reaching 22-23°C in the main spaces during late afternoon and dropping off to 19-20°C by midnight. The extent of daylight within the house means that artificial light can remain off until low levels of daylight are reached. With regards to SAD of the one of the clients, it would appear that her wellbeing has improved – but with so many variables it would be difficult to justify the design of the building as being the main reason for her improvement.

3.0 Summary

3.1 Low energy building in an urban context

This project demonstrates that placing a low energy building within an urban context requires consideration of the following:

- a) The quality and legislative protection of adjacent buildings
- b) Conservation design guides relevant to the area
- c) Soil conditions can be more varied than greenfield
- d) Adjacent buildings and trees, in and outside of the control of the designer, determining shading, quality of natural light and sunlight penetration.
- e) Location of public sewers and utilities can affect location
- f) Smokeless zones and proximity of trees / buildings can affect choice of technologies
- g) Security implications
- h) Acoustic performance of external wall design
- i) The effect development will have on adjacent trees.
- j) Finish of external works to determine quality of light
- k) Position and design of glazing to maintain privacy for user and neighbour
- l) Position and design of glazing to maintain privacy for user and neighbour
- m) More reliance on roof-glazing to create good internal natural light levels
- n) The appropriateness of the design for its context.

[1] As reported by University Of Ulster Centre for Research on Property and Planning.

[2] The main initiative from the Carbon Trust. See www.carbontrust.co.uk

[3] Springvale Ltd. Their products, including the innovative *Warmsqueeze*, are designed and manufactured close to the site. www.springvale.com

[4] Powertech Ireland Ltd. See www.powertechireland.co.uk

[5] Blue Skies administered by The Building Research Establishment. See www.clear-skies.org. This programme was replaced with a DTI programme in April 2006.

[6] See Brett, David, “The Plain Style”, Cambridge, Lutterworth Press, 2005 for further information.