433: Construction methods which can achieve A3 rating at minimal extra cost

James Pike
O'Mahony Pike Architects

Abstract

Analysis of completed multiple housing schemes designed to achieve an A3 rating, using current standard construction methods, showing the additional cost of achieving the A3 rating, set against the potential advantages.

The study will then show how these additional costs can be reduced and other technical problems solved, using off-site construction methods and advanced technical solutions.

The first scheme is: A development of 67 dwellings consisting of 2 storey terraced houses and some 3 storey apartment buildings, built using a timber frame with brick or block rendered external walls.

- Windows and doors with lower u-value (1.4Wm2K)
- Increased insulation in the floors and lofts
- Airtightness level of 1.5 a/c per hour
- Heat Recovery Mechanical Ventilation
- Hot water solar panels and twin coil copper tank
- Energy efficient light fittings
- Energy efficient gas boiler and efficient heating controls

The study of alternatives will be based on the second stage of this development which is awaiting planning permission and will be on site before the autumn.

The second scheme consists of 280 apartments in 6 and 7 storey buildings on a "brownfield" site. The construction is traditional blockwork walls with brick faced cavity walls.

Energy Efficient Features:

- Insulation specification 60% more than required in the building regulations
- Heat Recovery Mechanical Ventilation to all units (individual air handling)
- A high level of airtightness was achieved
- Exposure was minimised by using natural shelter, woodlands and landscaping
- Draught lobbies were designed into main entrances to minimise heat loss
- District heating system utilises 10 gas-fired boilers in the basement to supply hot water and heat to units, gas bought at commercial rate therefore 30% saving to homeowners
- An individual metering system for each apartment allows the management company to issue heating bills every 2 months, a laptop is simply plugged into the system and each bill printed instantly
- Room thermostats allow individuals to control the level of heat they use, the 10 boilers operate on a 'when needed' basis, the greater the demand the more boilers fire up with the system falling back to 10 or 2 boilers at off-peak times just to supply hot water

The study of the alternatives will be related to a similar development of apartments which will entirely use off-site construction and is currently at planning stage.

Three other projects which are either on-site or pre-construction will also be analysed in conjunction with the 2 above.

Keywords: reduced energy consumption
airtightness
increased insulation
solar hot water
heat recovery ventialation
district heating
metering system
user friendly system

1. Introduction

As an architecture practice we have been involved in the design of low energy passive solar houses in Ireland since 1980. As one of the leading architectural practices in the country concentrating in recent years on the residential sector our main body of research is our built projects, two examples of which we are presenting in this paper. Or methodology has always been *research by design*. In addition to the two completed projects we will also look at three other projects, one currently near completion and two others which are at the pre-construction stage. These five projects utilise a variety of construction systems and energy technologies ranging from traditional block construction, timber frame, pre-cast off-site construction and right up to newer more innovative systems such as the steel frame fusion wall system and the new generation of timber frame construction. In this paper we will look at the appropriateness of these different systems for different types of development from low density detached to medium density low-rise developments right through to high density apartment schemes. We will also examine the energy efficiencies of the various technologies and give an overview of the practicalities of their on site application. The costs are not always entirely identifiable, but where possible we have made reference to this as it is an important factor nonetheless.

2. Built Projects

2.1 Preamble

Our first sustainable design project was back in 1980 when we were commissioned to design a scheme of passive solar houses by Clonmel Borough Council (Fig. 1). This scheme won an award in an EC Passive Solar Housing Competition and became the subject of an ERG research programme.

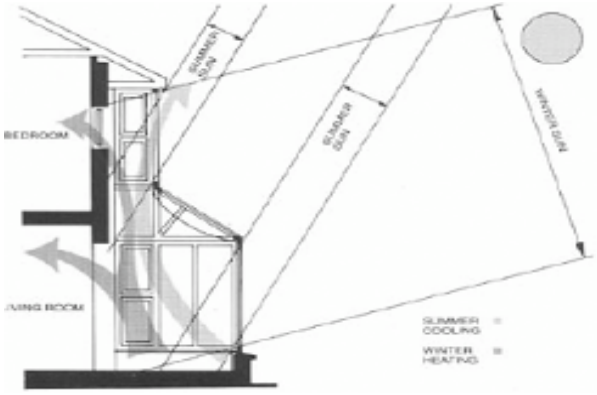

Fig 1. Passive Solar Houses in Carrigeen Park, Clonmel, 1980-1984

Passive solar gain remains a key aspect of our residential designs and we are currently undertaking an analysis in-house of houses built in 2004 in Northbrook Lane, Dublin 6 (Fig. 2). which aim to maximise passive solar gain and have achieved an energy saving of 40% over standard houses built to the regulations in force in 2004.

Fig 2. Passive Solar Houses in Northbrook Lane, Dublin

2.2 Cornerpark, Newcastle, County Dublin Phase 1

Our practice were involved in producing a Masterplan for the lands to the north of Main Street in Newcastle, a village in south county Dublin which has been the subject of rapid expansion in recent years. This Masterplan in itself identified many sustainable targets such as creating pedestrian and traffic links through the Masterplan lands, providing services such as a crèche, access to the village centre and shops all within a short walking distance, protection of the flora and fauna present on the site and increasing the density due to proximity to public transport. Phase 1 of this development is comprised of 67 dwellings, mostly terraced houses with a few duplex apartments and was completed in 2007. It achieved SEI House of Tomorrow standard and received funding in the form a capital grant from SEI under the House of Tomorrow programme.

From the outset the brief for this project was that they achieve the highest levels of energy efficiency feasible. With this in mind we started with the site layout plan (please see poster 01 on this project for drawings and images) and maximised the passive solar gain for all dwellings by ensuring every main living space was either south or west facing. Next we looked at the building envelope, choosing timber frame as it was the most efficient way to achieve high levels of thermal performance in the envelope as well as the main constituent material having low embodied energy. A local Irish supplier, Kingspan, was used thus also cutting down on the energy used to transport the timber frame elements to site. In addition, the levels of insulation were increased in the floors and loft spaces and the windows specified were low-e, argon-filled double glazed timber windows with a very low u-value of u-value to 1.4 W/m2/K.

The House of Tomorrow standard identifies a specific airthightness target for developments and so an airtight membrane was fitted internally to the timber frame prior to the first fix, with great care being taken during the subsequent fitting of the services to ensure the membrane wasn't compromised in any way (Fig. 3.). It must be noted that there were problems on-site with the installation of the airtight membrane and with the integration of the services.

Fig 3. Phase 1 Newcastle, Problems with Airtight Membrane

Having done all that was feasible with the envelope we then looked at the building services. In conjunction with the mechanical and electrical engineers on the project the following three items were specified:

- Proair 400 Heat Recovery Ventilation system
- A high-efficiency Viessmann Vitodens 100 gas combi-boiler
- 5m2 of Calpak Solar Collector and 210 litre twin coild copper tank solar hot water heating system

In addition the kitchens were all fitted with A-rated appliances.

The overall calculated energy saving for the units was in excess of 40% based on all of the above, with the solar panels accounting for 18% of that energy saving. The units achieve an A3 rating with an average mid-terrace 3 bedroom house using 54 KW/hr/m2 per year and producing 14.5 Kg of Co2 per m2 per year, based on the BER system and using Sustainable Energy Ireland's DEAP software to calculate these values. The average estimated additional construction costs in achieving this standard were in the region of €20,000 per unit.

2.3 Landsdowne Gate, Drimnagh

This is a development of 280 apartments in 6 and 7 storey buildings on a "brownfield" site and includes a crèche, shop and 400m2 office suite. It is within walking distance to the LUAS redline Bluebell stop and re-instates part of the Landsdowne Park/Camac walk along the river Camac. The blocks are arranged around a courtyard which is open to the southeast to maximise natural daylight and solar gain and all units are dual aspect or single aspect south-facing. The site layout minimises exposure by using natural shelter from nearby woodlands. (please see poster 02 for drawings and images).

In terms of the building envelope the following key elements were utilised: the insulation specification is 60% above that in the building regulations, the wall construction is traditional blockwork, dry-lined on the inside face with 100mm fibreglass insulation and having a brick outer leaf, thermal mass is used for passive heat storage, the orientation, glazing positions and detailing were resolved to maximise benefit from solar gain, draught lobbies at ground floor (to avoid heat loss by people coming and going) and extremely high levels of airtightness were achieved through rigorous site practices after the first fix.

The biggest innovation with this development is the use of a district heating system which distributes hot water to the individual apartments. A gas fired centralised boiler room contains 10 modular condensing boilers and the low energy pumps which control the flow and return pipes. The distribution pipes are highly insulated and supply both the hot water demand and the space heating requirement of all the entire development. Residents can enjoy instant hot water and the apartments each have an individual meter which monitors consumption, they are then billed bi-monthly per kilowatt/hour of energy for the hot water they have used. The gas is bought by the management company at the commercial rate, which allows savings to be passed onto the residents. The additional cost of the central boiler house and HRMV systems over normal individual heating and ventilation systems is approximately €2000 per dwelling.

In addition to this, each apartment is ventilated with an individual mechanical ventilation with heat recovery (HRMV) system. The heat recovery unit is a device that delivers a constant stream of fresh warm air to the apartment by recycling or *recovering* the heat from air being vented out of the apartment and transferring it to the fresh air being drawn in. About 60% of the heat is recovered, which reduces the need for residents to turn on their heating system. The benefits also include: a constant supply of filtered fresh air, reduced air moisture and reduced allergens in the air, reduced condensation and dust.

The individual controls for both the district heating and the ventilation system have been specifically

designed to be user-friendly. The HRMV control is factory-set so the 'off' mode corresponds to the background 'trickle' rate of air changes and the 'on' mode is a booster setting to be used for instance after a shower has been used or after cooking. The heating and hot water operate on simple timer clock timers

2.4 Residential Development at Waterfall, County Cork

This is a low density, landscape-based and energy-conscious scheme which fully integrates with its rural village context, whilst fulfilling a demand for larger detached houses in close proximity to Cork city. The 10.5 hectare site comprises three fields, with a gently sloping topography and triangular geometry. It is located in the village of Waterfall, about 1km from Cork City boundary and within the Metropolitan Greenbelt. The agricultural characteristics of the site, with its hedgerows, drainage channels and adjacent farmyard, suggested the use of traditional Irish field patterns as a model for subdivision of the lands. (please see poster 03 for drawings and images)

There are four main house types in the scheme, ranging from 250m2 to 345m2, with each having a separate garage. The design of the buildings draws on the scale, form, language and materials of vernacular rural architecture. The pitched-roof forms and occasional barrel-vaulted roof are familiar in the Cork landscape. Walls are of painted render and roofs are of natural slate and metal (zinc). Houses have been designed to benefit from passive solar gain, with living spaces opening onto south-facing gardens. In addition, active measures such as increased insulation and heat recovery systems have been used in order to achieve a high energy rating for the houses. The scheme is currently under construction, with the first phase due for completion in autumn 2008.

Currently construction has commenced on the first cluster of houses which includes one of each house type. The developer decided from the outset of the construction stage that the houses should be designed and constructed in order to achieve an A3 building energy rating, while maintaining the usual desirable specifications for the purchaser. Due to the size and nature of these houses, this was and still is a huge challenge.

The houses are built in Fusion steel frame, which consists of standard galvanised 92mm sections with 162mm fused insulation. This frame is resting on a concrete sub-floor. Concrete ist floors are poured and supported off the steel frames. Traditional sand/cement rendered concrete block outer leaf tied to the steel frame completes the external walls.

The ground floor insulation and screed is installed after the windows and doors are installed and first fix M+E is complete. This ensures a complete air tight membrane around the floor perimeter and services coming up from the floor area. This also facilitates some flexibility during construction on the service locations. Pre-fabricated truss timber roof with air tight ceiling completes the structure. Special care is taken around windows and doors, between panels and at junctions with first floor and roofs to ensure no gaps exist before plasterboard is installed. The complete building is then skimmed internally and sealed once again around windows and doors. Service openings in ceilings for ventilation systems and downlighters have been specifically dealt with by creating service voids.

The hot press was moved to the garage to facilitate minimum penetrations in the house itself, maintaining low noise levels (avoiding pumps in the house). Luxuries like underfloor heating on groundfloor areas were retained. It was found that close coordination between all design team members and M+E sub-contractors and site management staff is a must to achieve such a high level of detail on site.

The main heating system is to be a high efficiency oil condensing boiler with 6m2 of glazed flat panel system providing solar hot water heating as a secondary hot water system. There is also to be Photovoltaic panels to provide 1.55 kWh/m²/annum of electricity. At this time the developer does not intend to install a Heat Recovery Mechanical Ventilation system or replace the 4 standard open chimneys with fully sealed log burning/gas units with balanced flues. Therefore the energy rating that will be achieved is be B3. An A3 rating would have been possible if these items were installed.

3. Projects in Development

3.1 Preamble

Both projects discussed in this section are due to start construction very shortly and are currently being looked at in terms of using the lessons learned in the above built projects and developing the various construction systems so that even more efficient methods are applied. It is worth noting that both projects will most likely utilise fully pre-fabricated walling systems in order to achieve the airtightness targets. Another similarity is that an outer leaf of either blockwork or pre-cast elements is common to both.

3.2 Cornerpark, Newcastle, County Dublin Phase 2

Phase 2 of this development proposes 116 dwellings, mostly terraced houses, on a site of 2.92 hectares. Whilst this phase of the development is still currently in the planning system we have nonetheless carried out a large amount of research on the various options now available for both the building envelope and for the services provision for the units.

Specifically, we have used a sample unit type to analyse and compare three options for the building envelope in terms of performance, compliance with Part L 2007, energy rating and cost. The three systems we have looked at are: i) the traditional open panel timber frame system used for Phase 1 ii) Structural Insulated Panels (SIPs) and iii) a timber frame system that is still in development by the manufacturer but which, once launched, will be the new generation of timber frame system for mass housing in Ireland. (please see poster 04 for drawings and images)

We are nearing a decision on details and specification for Phase 2. More on this topic will be included in the final draft of this paper available in September 2008.

3.3 Greystones

The development proposed for Greystones Harbour, Wicklow was the winning submission in a design competition for the development of a new marina at Greystones. The brief clearly stated a need to create a new public park for Greystones The layout responds to two specific north / south movement axis.

There are three distinct blocks of buildings which make-up the heart of the new Marina Village and range in height from three storey over retail units to the boardwalk and overlooking the Marina Basins to two storey along the spine street. Each block includes a mix of apartments and duplex units ranged around a communal landscaped courtyard. Mixed commercial uses amounting to 6405m² nett are provided within the development including shops, pubs, restaurants and specialist uses. The community uses and storage areas are located in a low complex on the Harbour There are 375 residential units comprising 144 No. 3, 4 and 5 bedroom houses and 231 No. 1, 2 and 3 bedroom apartments. (please see poster 05 for drawings and images)

It is intended to use a fully pre-fabricated pre-cast construction for this development. We will apply the lessons learned in the Landsdowne Gate development in terms of the heating and ventilation systems.

4. Concluding Summary

We find that our clients are split 50:50 in terms of those who use traditional construction methods and those who prefer off-site fully pre-fabricated systems. Therefore we find ourselves constantly researching and re-assessing the way in which we design and construct projects. This *research by design* has allowed us to look at what we have already achieved and try to develop more efficient and cost-effective elements and methods of construction. We find that new products and new methods are constantly coming on the market and that in recent years the developing market of sustainable designs and technologies has spurred manufacturers on to produce better and more innovative systems.

In this paper we have given a pretty broad overview of a range of different construction technologies. The information presented has come ostensibly from project based research and analysis and also on investigations carried out during in-house workshops in our practice. We continue our search for and development of the optimum construction system for low, medium and high density applications. We are fully committed to researching the challenges of meeting the standards set out for the 2010 revision to Part L of the Building regulations and ultimately of designing zero energy housing.

5. Acknowledgements

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