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UCD 'Passive House' Student Residences – Roebuck Hall II

Tony Rigg

Kavanagh Tuite Architects, Dublin
tony.rigg@gmail.com & tonyr@kavanaghtuite.ie

Abstract
Roebuck Hall II is a new student residence project, on the UCD Belfield Campus, Dublin, for 650 to 700 student rooms & ancillary accommodation, to adjoin the recently completed 300 room Roebuck Hall I residence.
The accommodation will be in 5 high quality free-standing buildings within generously planned open space, in the vicinity of Roebuck Castle, to be built in 3 stages.
The project is to be constructed to a very high energy performance level – ''Passive House" standards are guiding the design, with the aim of achieving at least a Class A3 Building Energy Rating, and an "Excellent" BREEAM rating. The buildings will aim to have very low carbon footprints and are being designed to be an 'exemplary' statement of sustainable development.
This paper will present the final architectural & services design for the first of the 5 buildings, (due for completion by December 2009), explaining some aspects of the project context & design development, and the anticipated performance parameters.

Keywords: student residences, energy conservation, comfort, sustainability.

1. Introduction – Project Context

1.1 UCD Masterplan
The UCD Campus has around 20,000 students, and at present about 2,500 live on campus in a variety of accommodation types. The college is aiming to increase this number to a critical mass of about 5,000, which will be able to support an animated, diverse 24-hour, 7-day 'living' campus. The additional accommodation will be directed toward students who presently commute from outside the city, thus reducing traffic congestion and demand for on-campus student car parking.
In this context, UCD is developing "student villages", one of which is centred on the historic Roebuck Castle, dating from medieval times, but largely re-modelled in the early 19th century. The Castle and some later surrounding additions are currently home to the Law Faculty, which will move to other purpose-built accommodation elsewhere on campus.
The Castle will then be renovated for student ancillary use, and become the focus of the planned Roebuck Hall Village.
Roebuck Hall phase I, with 300 student rooms, was completed in 2006, & Roebuck Hall phase II will now be developed, and constructed in stages, as the existing Law Faculty buildings are vacated.

1.2 Irish Building Regulations 2007
Following the inclusion of the Green Party in the government coalition in 2007, the Building Regulations were revised, basically requiring a 40% reduction (compared to previous Regulations) of energy consumption for space conditioning and water heating, plus a requirement that 20% of residual energy demand be supplied from renewable sources. These requirements come into effect from 1/7/08, and a further 40% reduction is planned for 2009-2010. This will bring the Irish regulations more or less to the pan-European standards that are due to become mandatory by 2016 – basically "Passive House" standards.
The net impact of this is to bring the Irish regulations to the fore-front of European building energy standards, and to bring high-performance energy conscious development into main-stream usage.

1.3 UCD Project Sustainability Brief
In this scenario, the College decided to aim for an exemplary sustainability standard in the first phase of the Roebuck Hall expansion, setting a standard for future student residence development on Campus.

2. Design Concepts for 1st stage building

2.1 Project Brief
The overall requirement was for accommodation for about 700 students. This, together with the existing accommodation for 300 students in Roebuck Hall I, will create a Student Village of around 1,000 students, which will be supported by a variety of ancillary facilities in the later phases of the development.
UCD aim to develop a variety of student accommodation on campus, and with several shared apartment type residences already operational, it was determined that Roebuck Hall II should be 'Hall of Residence' type accommodation, with individual 'ensuite' student

rooms in groups of 12-18, with shared kitchenette, living and study facilities. This accommodation is to be supplemented in the first stage building by a coffee shop/ light meals outlet, common laundry, internet study, and fitness facilities, at ground level. Full hot meals service will be provided in the central campus restaurant.

Unlike many student residences, the UCD accommodation is used year round, occupied in the summer by mainly foreign students attending special summer courses.

In line with the UCD Development Plan, the College instructed the design team to achieve a high level of sustainability, to aim for a BER (Building Energy Rating) of at least A3, and an "Excellent" BREEAM rating.

However, the project had to keep within current UCD budget standards for student residences, with a cost-benefit justified uplift for energy and water conserving capital cost additions.

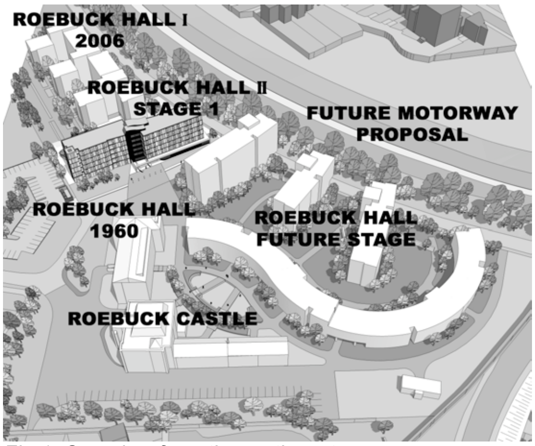

Fig 1. Overview from the northwest

2.2 Sustainability Concepts for Project

To achieve the level of energy efficiency required, it was decided to adopt the "Passive House" design approach, using very high standards of envelope insulation, high performance windows, and a high level of air-tightness together with heat-recovery ventilation.

The SEI recommended building U-values are:

Walls	0.175 W(m2K)
Roofs	0.150 W(m2K)
Windows	0.800 W(m2K)
Ground slab	0.150 W(m2K)

As there exists spare heating capacity from high efficiency condensing gas boilers in the existing adjacent Roebuck Hall I, it was decided to use this for the residual heating requirements for the new building. Evacuated tube solar collectors will be used for DHW heating.

Sensitivity studies, using the PHPP software, indicated that for this building form, with relatively small window area, high internal mass, and highly insulated envelope, building orientation had marginal impact on either winter heating energy requirements, or summer overheating potential.

For water conservation the project will use rainwater harvesting for WC flushing, and low-flow fittings on all water outlets to reduce hot & cold water consumption.

Low environmental impact materials will be used as far as possible, with eco-concrete for the main structure, sustainably sourced timber, water-based paints, etc.

2.3 Performance Analysis Systems

SEI (Sustainable Energy Ireland), as the official agency responsible for energy rating systems in Ireland, subsequently determined that this project should be classified as "Commercial" rather than "Residential". The BER rating system for non-residential buildings in Ireland has not yet been issued, we cannot assess the project under this system yet. The BER DEAP (Dwelling Energy Assessment Procedure)[1] was designed for assessment of single houses and apartments, and is not suitable for analysis of this (hotel) type of project.

However, SEI have issued a publication "Passive Homes – guidelines for the Design & Construction of Passive House Dwellings in Ireland"[2], and they distribute the "PHPP 2007" (Passive House Planning Package)[3], calculation software developed by the German Passiv Haus Insitut. This has been used in the analysis & development of the project design.

The results of these analyses are compared, & the impact of the results on the project design, are discussed below.

2.4 Project Design Concepts

The brief, for 'Hall of Residence' style accommodation, was best served by a 'hotel' arrangement, with study-bed rooms + shower rooms, and common rooms, on either side of a central access corridor. This long, narrow building form was thus basic to the overall master planning of the accommodation on the site.

The 700 student units are planned in 5 blocks of different plan sizes, from 4 to 8 stories high. The first stage building will accommodate 135 students on 6 floors. There are two groups of 12 student rooms on each floor, sharing a central lift and stair core, with additional escape stairs at each end, outside the thermal envelope.

In the immediate vicinity of the project, there are two buildings: one from the 1960's, a 4 storey grey rendered block building, the other (Roebuck Hall I) a 6 storey beige brick and painted render building, completed in 2006.

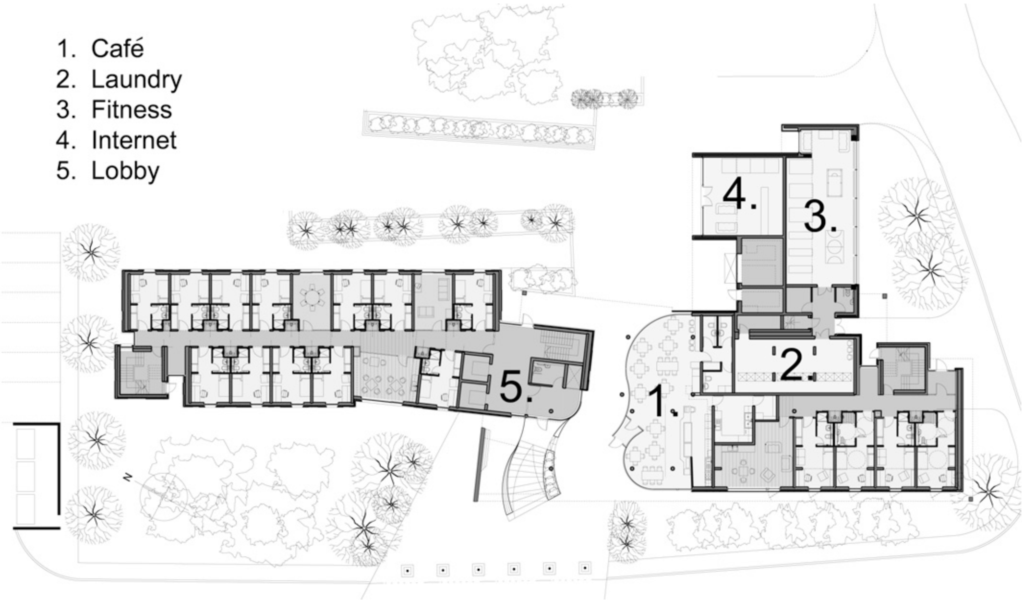

Fig 2. Overall Ground Floor Plan

Fig 3. Typical Upper Floor Level Plan

Fig 4. View of project from the north west

While these gave a context, it was the high level of insulation required in the project walls that to a large extent determined the facade design.

It is not really feasible to stabilise and support a brick facing skin through 200mm of insulation required to achieve the desired U-value: likewise, fixing and support of pre-cast cladding panels without cold bridging is also extremely problematic. GRC floor height panels were ruled out because of limited local supply options.

The above lead to a conclusion that light weight rain-screen cladding was the only real option, fixed to an insulated light steel framed, fully insulated wall panel.

This process of design through exploration of practical available options, to achieve a new and different standard of building construction and performance, very largely informed the aesthetic design of the whole project.

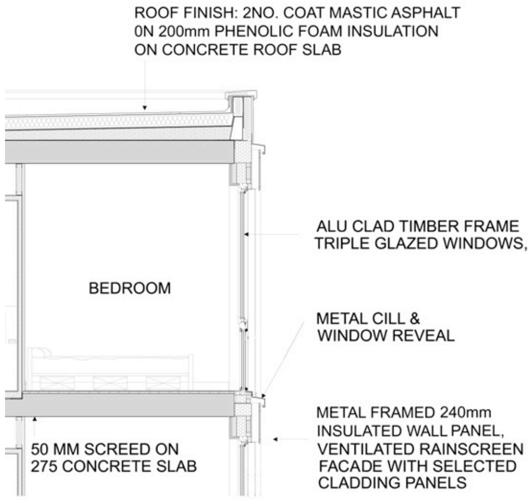

Fig 5. Typical Detail Section

3. Construction & Services Methodology

3.1 Construction Methodology

3.1.1 Building Structure

For cost and efficiency of construction, it was decided to use concrete cross-wall construction, with concrete floor slabs. These are to be formed with thin pre-cast concrete wall and ceiling panels as permanent formwork integral with the building structure. This gives a fast, clean and economical construction method, eliminating plaster, ready for internal paint finish. Eco-concrete, based on ground blast-furnace slag, will be used. This is a waste product, and concrete made from this source has a much lower carbon footprint, is stronger and higher quality than conventional concrete. The only drawback is a slightly longer curing period.

3.1.2 External Walls

With this high-mass internal structure giving good thermal stability, in order to achieve a reasonable thickness for the external walls, it was decided to use a 162mm thick system building panel, integrating a light-weight galvanised steel frame with full thickness, injection moulded insulation. This provides a fully insulated facade panel, simple to air-seal to the surrounding concrete floor slabs and cross-walls, and with minimal cold-bridging at floor slab level.

These panels are to be finished internally with an additional 50mm insulation and plasterboard lining, and externally with a protective magnesite board, and a proprietary rain screen cladding system, with storey-high panels of either resin-bonded wood fibre (Trespa) or compressed glass fibre reinforced cement (Rieder FibreC), or similar, on an aluminium support system fixed to the insulated wall panel.

It is possible that the wall panels will come to site with the windows already fixed and air-sealed into them.

3.1.3 Windows

The windows will be high-performance, with triple glazed, argon filled glass, and thermally insulated wood frames, with external aluminium cladding, with an overall U-value of 0.8 W/m2K. This standard of window is not manufactured in Ireland, and the most economical source at present appears to be Austria. The windows will have 'tilt and turn' operation, with the 'turn' option available only to maintenance and cleaning personnel, as part of UCD safety standards.

3.1.4 Air Tightness

The building envelope will be built to high level of air-tightness: the Passive House standard requires a (site tested) air tightness of <0.6 m3/m2/hr at 50 Pa, but we are aiming to achieve <3.0m3/m2/hr for this project. If we achieve the passive house standard we shall be very pleased, but we do not expect to do so on this first building.

Achieving such a high level of air-tightness with a relatively new building construction method, involving highly integrated site coordination of different skills and trades, requires special training, team understanding and commitment, with a lot of goodwill involved. On a first-time project of this scale, this will be exceedingly difficult to achieve.

Together with high standard of air-tightness, there will be a mechanical ventilation system with heat-recovery, serving all living spaces.

3.1.5 Envelope energy performance

At this stage, final energy simulation figures are not yet available, but the overall preliminary figures, which are well within the Passive House standards, coupled with current project budget estimates, show that the over-costs associated with higher insulation and window specifications will have a payback period of between 5 and 7 years.

3.2 Mechanical Services Methodology

3.2.1 Space Heating

The construction methodology created a demand reduction for space heating to less than the Passive House standard of 15 kWh/m2/yr.

A preliminary simulation of the building performance indicated 11 kWhr/m2/yr, and the PHPP 2007 programme indicates 10 kWhr/m2/yr. This represents a reduction in the space heating demand of about 80% compared to current Building Regulation standards.

This residual heating demand could very easily have been provided by heating the supply ventilation air at the central heat recovery air handling unit, but the client wanted some visible, in room source of back-up heating, from a student psychology point of view.

Although the residual heating demand is so low, it was decided to put in very small thermostatically limited hot water radiators at the supply air location, similar to those used at the OAD Student Residence, Molkereistrasse[4], in Vienna, which had been visited by a client and design team delegation. The radiator will have a shut-off valve, operated if the window is opened, similar to standard hotel operation. The heat source for this system will be spare capacity in the adjacent Roebuck Hall I plant room, which has high-efficiency condensing gas boilers.

For the next stages of the project, biomass fed boilers, or inter-seasonal geothermal storage, fed by solar collectors, are being considered, to meet the 20% renewable energy Building Regulation requirements.

3.2.2 Ventilation

The mechanical air extract and supply system will be serviced by a central, roof mounted AHU with counter current air flow heat exchanger for maximum heat transfer to the supply intake air, in the region of 80% to 85% efficiency.

High-efficiency electronically commutated (ECM) motors, will be employed in the units to reduce power consumption.

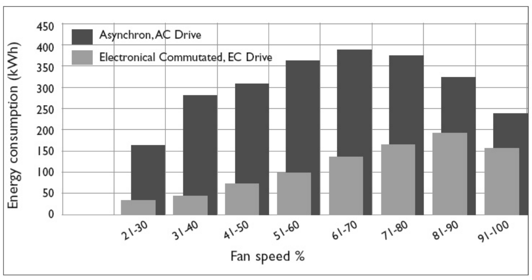

Fig.6 Graph Comparison of AC drive v's EC Drive

Extract will be continuous at 0.8 air changes per hour for each study-bedroom.

Initial studies show a payback period of approximately 3.5 years for this system.

3.2.3 Hot Water Supply

Hot water consumption is a major energy issue, and after adjusting expected demand for water-conserving fixtures, various energy conservation and supply options were considered.

Heat recovery on the waste water was examined, but this only works effectively if there is a separate waste pipe for shower and basin water, (without cold WC water, which reduces the temperature differential for heat exchange), and this proved uneconomical.

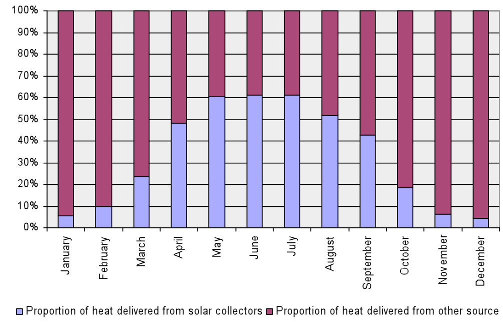

Fig 7. Hot water supplied by solar collectors.

The optimum system for the project was determined to be evacuated tube solar collectors to supply 33% of HW demand. While the payback on this is not good (27 years, including SEI subsidy), this will supply 20% of the combined heating and hot water demand from a renewable source, as required by the Building Regulations. Remaining load will be supplied from spare capacity in Roebuck Hall I condensing gas boilers.

3.2.4 Water Supply

Water consumption will be conserved through the use of dual-flush, low volume toilets, and low-flow shower and tap fittings.

Rainwater will be collected from the building roof will be collected and stored in a 15,000 L underground storage tank, and used for WC flushing. It is estimated that 575 m3 will be collected, as opposed to demand of about 760 m3. This will save €1,230 in water charges per year, and on estimated system costs of €8,480, gives a payback period of slightly under 7 years.

3.2.5 Electric Lighting

High-efficiency lighting will be used throughout, with regular and compact fluorescent lights for all functional lighting, and LED lights for any decorative fixtures.

In common circulation areas the lighting will be controlled by daylight sensors.

It is expected that these measures will give a 70% reduction in electricity used for lighting, compared to 'normal' practice.

4. Provisional PHPP Calculation Results

Provisional results from the PHPP calculations at the time of submitting this paper are as follows:

PHPP Category	Value	PH limit
Space heat demand	10 kWh/(m2a)	15 kWh/(m2a)
Air-tightness – project goal	3.0 h-1	0.6 h-1
Total primary energy demand	100 kWh/(m2a)	120 kWh/(m2a)
Frequency of summer over heating (over 24 deg C)	0%	

Following thorough analysis of all PHPP inputs and calculated results, further sensitivity studies will be carried out to determine whether some reduction in insulation standards could reduce construction costs, while remaining within the Passive House standards. It is anticipated that the air-tightness will be better than the stated goal of 3.0 h-1, but even with this figure the overall Space Heating Demand is within PH limits.

4. Conclusions

Through this design process, as described above, we have found that it is possible to design a project of this type and scale to "Passive House" standards within an economic framework. That is, with all extra costs required to reach PH standards over and above current building regulation standards, having a payback period of 7 years or less, according to detailed cost estimations made by the project Quantity Surveyors. On the basis of minimum expected project life of 20 years before major refurbishment, this means a major saving for UCD for the latter 13 years. With rising fuel costs, the actual benefit may well even greater.

5. Acknowledgements

Client:
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Building Services Department.
Project Design:
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Terminus Mills, Clonskeagh,
Dublin 6, Ireland.
Project Leader, Tony Rigg
Civil & Structural Engineering:
Hanley Pepper Consulting Engineers,
Blackrock,
Co. Dublin, Ireland.
M&E Consultants:
Delap & Waller Consulting Engineers,
Bloomfield Avenue,
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