Passive House Premium Erne Campus: Inspiring the Future of Education

Breakout Session 1: PH On Campus - Part 3 Case Studies

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Executive Summary

This paper will outline and elaborate on key aspects of the design along with an overview of the technical specification which will make this the first passive house premium and BREEAM outstanding education building in the UK. This 7,133 m² (TFA) new build is designed to these standards to produce a healthy learning environment which will inform the pedagogy, curriculum development and research outputs in relation to building performance for South West College Continued Estates development.

The building faces south in a curved form, maximizing daylight and solar gain, facing towards the town and the Erne River. The building arcs around a designed public space to the North; with a 15m deep atrium that provides functionality whilst encouraging daylight and ventilation. Classrooms are designed with a buffer zone and north facing windows to reduce glare and overheating risk. All passive house principles have been incorporated into the design to achieve a reliable indoor air temperature of 20°C.

Build Start date: June 2018
Completion date: August 2020
Treated Floor Area (TFA): 7,133 m²
Form Factor: 0.6
Construction: Mixed
No. of Occupants: 480 average
Cost/m²: £3,552 (based on 8200 m² floor area

The Ventilation strategy employs various systems, the primary systems are a mix of centralised, and local mechanical ventilation supplemented by natural ventilation. The heating system is a combination of a bio-oil micro CHP unit producing 80% of the space heating energy demand as well as 100% of the DHW Demand and finally an air to water heat pump technology providing the remaining 20% of space heating. The roof has significant capacity to allow a solar photovoltaic system which will provide a renewable energy generation figure of 121Kwh/m²/year. There is 480Kwh of battery storage in the design that will allow for reasonable amount of short-term storage.
Building Overview

Design Strategy

South West College is a further education college located in the west of Northern Ireland. The College is physically represented at campuses in Cookstown, Dungannon, Enniskillen and Omagh. The College employs over 500 full time and part time staff servicing some 14,000 enrolments with a turnover of £40m and makes a major contribution to the local and regional economy. This new college campus will replace our existing campus building located in at Fairview Enniskillen (Figure1). This existing multi storey building was built in 1971 and has a D energy rating. This 48-year-old campus uses 152 Kwh/m²/year for heating alone. The building is heated with Oil and uses approx. 100,000 liters a year costing c. £51,000.00 a year.

This is the second Passive House project for the client South West College, who completed the CREST Pavilion. The success of this initial scheme was the key to the decision for South West College to strive for Passive House Premium at Erne Campus. The brief was to achieve a building with world class teaching and learning facilities. The college felt incumbent against the climate change imperative to aim for the highest international environmental standards in sustainable innovation and design hence Passive House Premium and BREEAM Outstanding.

The site was a former hospital, which faces south and the topography of the site has informed the placement of a four-storey atrium and to provide the circulation. The building will accommodate 800 full time equivalent students and 120 staff. The concept is a contemporary lightweight transparent building, to the south facing the town and River Erne with a solid North/East/West wrap around elevation blue brick panels and glazing.

Figure 1: Existing Fairview Campus 8,890 m² (left) and New Erne Campus 8,200 m² (right)
Building Fabric

The total thermal envelope of the building has an average thermal $u$ value of 0.28 W/m$^2$K which includes the $u$ value of the windows installed. The proportions of the envelope are as follows:

<table>
<thead>
<tr>
<th>Building Element</th>
<th>Proportion of Thermal Envelope</th>
<th>U Value [W/m$^2$K]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor</td>
<td>27.8%</td>
<td>0.11 W/m$^2$K</td>
</tr>
<tr>
<td>Roof</td>
<td>27.8%</td>
<td>0.15 W/m$^2$K</td>
</tr>
<tr>
<td>Windows</td>
<td>26.8%</td>
<td>0.85 W/m$^2$K</td>
</tr>
<tr>
<td>Wall</td>
<td>17.6%</td>
<td>0.15 W/m$^2$K</td>
</tr>
</tbody>
</table>

The floor construction is constant across the building footprint with a number of different levels. The build-up consists of a is a 300 mm concrete slab construction on top of 175mm insulation above the sub floor. The floor has a corresponding $u$ value of 0.11 W/m$^2$K.

The roof build up consists grey single membrane roof sheeting followed by single ply membrane on 140mm insulation on vapour control layer on profiled metal deck. The roof has a corresponding $u$ value of 0.158 W/m$^2$K.

The wall build up is made up of the following layers. Facing Brickwork, 50mm cavity, Breather membrane on 9mm OSB sheathing on 140 x 38mm timber framing studs with 2 no. layers 70mm Phenolic insulation between. VCL (Air tightness layer). 100 x 38mm battens (service zone) with 100mm phenolic insulation between. Finished internally with 12.5mm plasterboard & 3mm plaster skim. The Wall has a corresponding $u$ value of 0.15 W/m$^2$K.

The windows are a curtain wall type system on the erne campus have an average installed $u$ value of 0.85 W/m$^2$K, the frame has an average $u$ value of 0.96 W/m$^2$K and the glass $u$ value is 0.53 W/m$^2$K with the PSI value at the glazing edge coming to 0.039 W/mK. Finally, the $g$ value of the glass is 0.41.

An important aspect of quality assurance was the careful, detailing planning of the thermal bridges, particularly in the steel frame connection to the foundation/floor. In the structural steel frame a thermal break had to be inserted at the point where it crossed the thermal envelope in order to mitigate the effect of the Thermal bridging. The fixings for the steel frame to the foundation also employed a thermal separation coupled with surrounding insulation in the subfloor.

The airtightness target for the project is an $n50$ of 0.3 ACH which is even lower than the Passive house limit of 0.6 ACH. This lower $n50$ target for airtightness is to take advantage of the favorable surface area to volume ratio (SA/V) for a large buildings c.4000 m$^3$. The airtightness system employed on this project is a membrane and type system applied on the warm side of the construction.
Ventilation

The ventilation strategy is mixed mode, employing both mechanical and natural ventilation systems.

The mechanical ventilation design strategy comprises a low-carbon displacement ventilation system which works well in open plan spaces such as auditoria and classrooms. Instead of conventional air conditioning, which delivers cold air at 8-12°C below the required room temperature at high level and which then mixes with room air / internal heat sources to give comfortable room temperatures in the occupied zone, displacement ventilation delivers air at low velocity at 19-21°C directly to the occupied zone and warmed air rises by buoyancy to the return air points at high level. The concrete soffit also acts as a very efficient heat absorber, helping accommodate peak cooling loads in summer. The fact that supply air only must be cooled to 19-21°C means that displacement ventilation can use fresh air directly from outside for most of the year without mechanical cooling and can save substantial energy compared with conventional systems. Extensive research has also indicated that displacement ventilation systems also give better internal air quality than conventional ventilation, due to the segregation of exhaust air by the stack effect.

The mechanical ventilation systems comprise a mix of centralised air handling units and localised MVHR units, as follows:

Centralised air handling units: AHUs with 84% efficient rotary wheel heat exchangers serve the lower 3 floors. Larger rooms such as the Central Hall/Lecture Hall and Open Learning Centre have dedicated air handling units, whereas the general classrooms and offices have primary air handling units feeding VAV boxes for local zone control. The centralised AHUs will use a ground to air heat exchanger matrix (also known as earth tubes) to pre-heat the air in the winter and pre-cool the air in the summer. This system consists of large tubes placed in the earth approx. 1.5m deep. Ventilation air is drawn through these underground pipes which will, at this depth, the ground temperature will range between 7-13°C throughout the year. This system can cool the air by up to 14k in the summer and heat it by 9k in the winter. It is a self-regulating technology in that a higher temperature difference between outside and inside will result in a greater heat exchange and as a result will mitigate any possible future climate change effects. The main fresh air intake for the earth pipe system is located >25m from pollution sources to ensure air quality. A fresh air bypass is provided to optimise the delivery temperature to the AHUs and this is controlled via the BEMS through a centralised mixing box and automatic dampers.

Top Floor: local mechanical ventilation units with counterflow heat recovery supplemented by user controlled natural ventilation serve each classroom / zone. The intakes and exhausts for these upper floor systems are located at roof level, away from pollution sources.

Atrium: The Atrium employs an automatic stack effect natural ventilation system using opening lights in the glazing system. Extensive solar shading measures are used to minimize heat gains in summer but allow maximum daylight penetration and useful solar gains in winter. All mechanical ventilation and the Atrium ventilation system are controlled by the BEMS to maintain set CO2 and temperature levels in response to varying occupancy requirements without user intervention.
At approximately 30 m³/h per person, the ventilation has been designed to meet the passive house specifications for hygienic air change. This is classified as IDA3 according to the DIN EN 13776. This ensures a high air quality of approximately 1,000 ppm CO₂/m³, the velocities, and therefore the noise levels in the room remain inaudible. The frequency of overheating events is generally regarded as a good indicator of the summer comfort in buildings. The passive house standard requires the indoor temperature to not exceed 35°C for more than 10% of the year, i.e. 876 hours. The lower the frequency with which 25°C is exceeded, the greater the level of comfort. Less than 5% is good practice (Siddel, 2015). Relative humidity and overheating are assessed at 0.2% and 1.93% respectively for the Erne campus.

**Figure 2: Ventilation Schematic for the Erne Campus**

**Heating**

The heating system is a combination of a bio-oil micro CHP unit producing 80% of the space heating demand as well as 100% of the DHW Demand and finally an air to water heat pump technology providing the remaining 20% of the space heating demand. Both these systems will use a mix of underfloor heating sections and responsive low water content radiators as the heat emitters.

In figure 3 we can see the energy balance for the erne campus. This provides a visualisation of the losses and gains from the PHPP software for the project. Key points to notice on this diagram is that the windows/curtain walling system will yield gains than losses over a calendar year. Effectively acting as additional radiators for the building. Finally, we can see again in figure 3 that orange section in the gains chart demonstrates the heat that will be utilised from the internal heat gains. i.e. students and staff coupled with the various IT and AV equipment particular to an education building of this scale.
Renewable Energy and Storage

On site generation and consumption at the Erne campus was significantly increased for the high demand of power consumption in the campus. The roof has significant capacity 3400m$^2$ to allow a solar photovoltaic system (520kwp) which will provide a renewable energy generation figure of 120 Kwh/m2/year. There is 480kWhr/180kWpk of Lithium battery storage in the design that will allow for a reasonable amount of short-term storage. Reduced primary energy demand of all electrical appliances is part of the overall college estates strategy. Excess energy can be transmitted to the adjacent listed workhouse building which the college is developing as a separate project.
The existing campus at South West College (Fairview 8,898m²) which in 2018 used 118 kWh/m²/year burning over 100,000L of heating oil which cost approx. £49,000 pounds or £5.50 per m². If we then apply the PHPP projected costs of the heat demand of the Erne campus which is 6.82 kWh/m²/year and assume a price of £0.10 per/kWh, then the total cost to heat the Erne campus will be £4,864.70. This would then represent an annual saving of £44,135.29 or a 90% saving for the college.

The total project cost of £29M including the college fit out and AV / IT installations, plus landscaping and other items. If we consider this and compare the construction cost alone then it seems competitive for the quality of the building. The total construction budget for the Erne campus is £29,128,000.00 which is the equivalent to £3,552.19 per m² of floor area.

### Predicted Energy Performance

**Table 2: Predicted Energy Performance Metrics.**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airtightness (&lt;0.6 ACH@50pascals)</td>
<td>0.3 ACH@50pascals</td>
</tr>
<tr>
<td>Thermal Energy Demand (&lt;15kWh/m²/y)</td>
<td>6.82 kWh/m²/y</td>
</tr>
<tr>
<td>Thermal Energy Load (&lt;10 W/m²)</td>
<td>8.75 kWh/m²/y</td>
</tr>
<tr>
<td>Primary Energy Demand (&lt;120kWh/m²/y)</td>
<td>52.8 kWh/m²/y</td>
</tr>
<tr>
<td>Primary Energy Renewable PER (&lt;30kWh/m²/y)</td>
<td>29.2 kWh/m²/y</td>
</tr>
<tr>
<td>Primary Energy Renewable Generation(&lt;120kWh/m²/y)</td>
<td>120 kWh/m²/y</td>
</tr>
</tbody>
</table>
Conclusion

This building in Northern Ireland is extremely significant to the region. As a showcase building at South West College, it is not just the aesthetic quality of the architecture but also the high level of energy efficiency for a public building. It will be the first Passive House Premium project in the UK. Recent reports have forecast that we now only have a few years left to reduce emissions enough to avoid a catastrophic rise in global temperatures. Significantly reducing the emissions of our buildings is vital if the UK is to make a meaningful contribution and would lead by example when many countries are also struggling to understand how to reduce emissions sufficiently.

The application of the passive house standard is still quite new in the UK and in particular Northern Ireland. The major challenge is not to adopt the passive house concept in a physically or technical way. The barriers are on in the construction culture in both minds and habits. South West College and CREST offer passive house training services in Northern Ireland which will help to break down the barriers. With the near Zero Energy Building (nZEB) standard coming into force for public sector bodies in the near future, this new campus building from South West College represents an excellent international demonstration of how to successfully implement energy efficient and cost effective nZEB through the use of passive house and renewables. The Project is on time and is due for opening in August 2020.

References


