LowCarb4Real; Design collection: GHA: Bladon Overview

Background

Lincoln Grove is a development of 9 x 2 and 3 bed homes near Woodstock, 9 miles from Oxford, constructed in 2007. The homes were awarded EcoHomes excellent, scoring 77 credits, the same as BedZED. The homes have been subsequently re-assessed under the Code for Sustainable Homes and achieved level 3

Thermal Design

- The shortcomings and complexity of standard cavity wall construction were clear to the developers Kingerlee Homes, so after considerable research, they specified NBT Thermoplan blocks - a single skin load-bearing wall system. The honeycombed blocks are planed top and bottom, enabling them to be laid to produce a single skin, robust, weather and air-tight structural wall, which is vapour permeable (air-tight and breathable). The blocks interlock on the vertical face and require no vertical mortared joints and the thin horizontal mortar joint increases the overall fabric performance. The wall, whose insulation value is entirely due to the block, is simply constructed without cavities, membranes or additional insulation. A thermal design checklist was drawn up and every junction detailed, to ensure continuity of air barrier and minimise thermal bridging and bypassing . Final airtightness tested at 3.8 – 4.8 m/h@50Pa.
- With **Thermal bridging:** calculated to an exceptionally low y-value = 0.024
- The design changed many times and it was hard for the whole team to keep up. In the end, there was a lack of ownership for the thermal checklist and it was not strictly adhered to.

Construction

- **Roof:** 300mm of Warmcell insulation blown in between 250 mm I-beam rafters with 35mm wood fibre insulating sarking board
- U-value: 0.11 kWh/m^{2}k (0.15) y of 0.04
- **Floor:** Concrete planks with 150mm Kingspan insulation under a 50mm screed with 50mm edge upstands;
- U-value: 0.12 kWh/m^{2}k (0.20)
- **Walls:** 365mm Thermoplan single skin cellular insulation monolithic clay blocks with stone or render facing
- U-value: 0.26 kWh/m^{2}k (0.28) y = 0.05

Ease and Speed of Construction

The developers had been impressed at the speed of construction of the Thermoplan system in Germany and the general understanding of the importance of thermal performance across all the site operatives. The construction system led to vastly reduced build times in Germany, potentially halving build times.

Materials

Kingerlee wanted to adopt a build system that was simple and effective, with lower embodied energy and with more sustainable materials. The Thermoplan system has very low embodied energy and environmental impact compared to conventional masonry building methods, which is recognised in their 'A' rating in the BREEAM Green Guide. Warmcel is also rated A in the Green Guide and FSC timber was used throughout

Process

- The integrated thermal design and detailing was a collaborative process between the developers and the material suppliers NBT and their consultancy arm NBT consult. The entire team – developers, architect, contracts manager, investors , QS and site manager visited sites in Germany to see the system in action and how quickly the build can progress. They also visited the Thermoplan factory.
- The QS was impressed with his findings and much more confident about costs and timelines
- Onsite training was delivered to the in house construction team and their main subcontractors and the site manager was suitably inspired by his trip to Germany. NBT Consult compiled a check list and details of junctions. Inspections were made by the teams at crucial stages of the build, to ensure the detailing was adhered to and effective, before work continued

Sequencing

- The render finish on the inside of the single skin block walls provides the bulk of the airtightness, so it was essential to ensure a cohesive shell - the render had to follow round the inside and form a continuous unbroken layer, which included rendering behind fitted kitchen cupboards and appliances, before fit out. If walls cannot be plastered before fit out then they should be parged whilst still accessible.

Planning

- There were issues with scaffolding, which took longer to erect than the Thermoplan walls and delayed the build process. The access was very tight for the crane.

Management and Supply chain

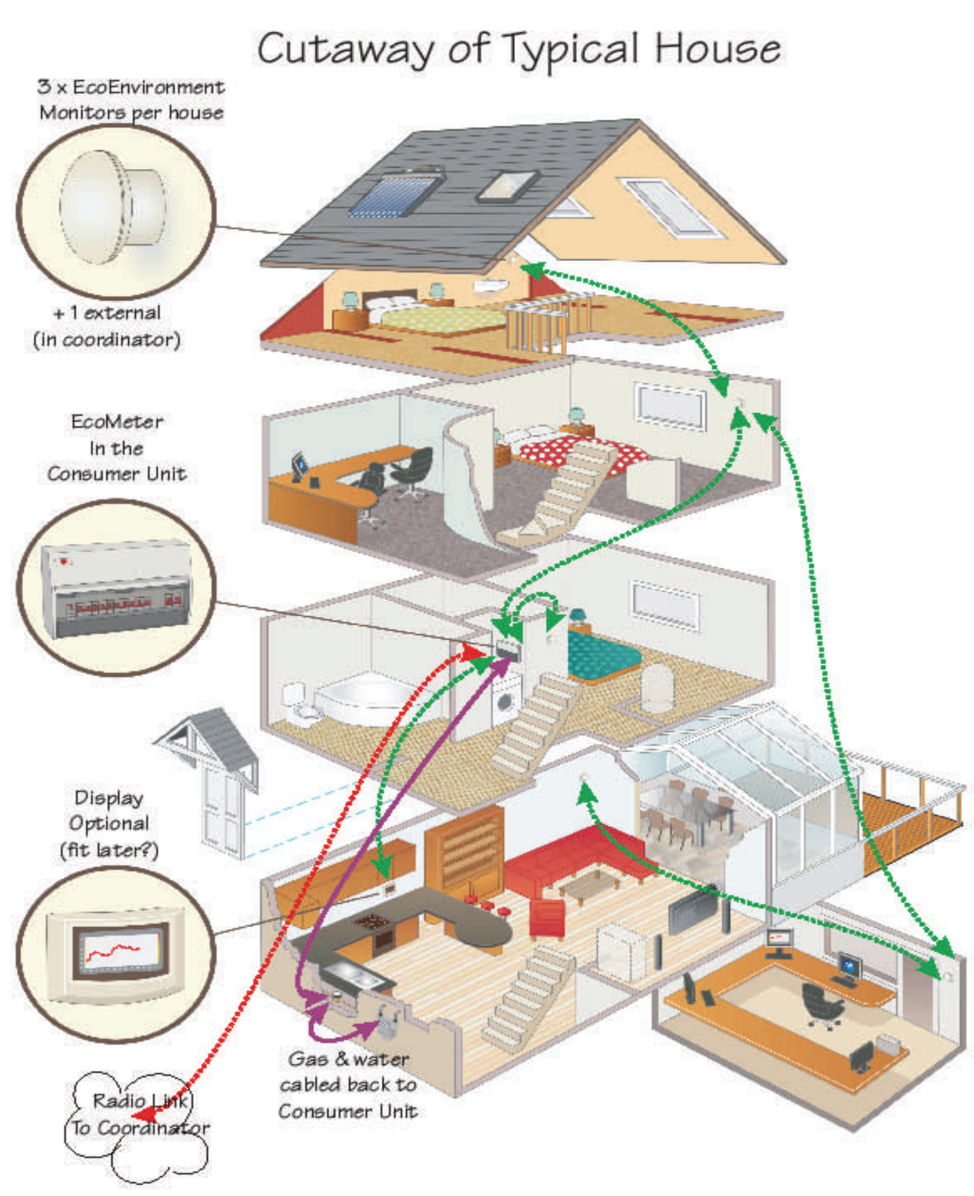
- Kingerlee made a Board level decision to move away from standard cavity construction and adopt the principles behind MMC.
- Working closely with NBT, the Thermoplan suppliers on the design for thermal efficiency ensured the forming on an effective collaborative team at an early stage

Post-Construction Monitoring

Kingerlee have understood that air tightness testing and thermographic imaging are essential tools during the build process. They also tested at a number of stages in the construction process which allowed easy remedial action at an early stage – much cheaper in the long run and help give better final results.

Post Occupation Monitoring

- Heating costs from the SAP Predicted Energy Assessment, based upon May 2007 fuel costs, are in the region of £150.00 per year, depending upon the size of the units
- On the same basis, the total fuel cost for heating and hot water will be approximately £200 per year including standing charges.
- Early indications from monitoring appear to confirm the performance anticipated in the SAP predictions.
- At Bladon, a whole house monitoring system allows both occupiers and the developers to access energy use across the 8 electricity circuits, the gas, the water and internal and external temperatures and internal humidity.
- Monitoring shows that radiators have been turned off upstairs, the wood burners have not been used, and the passive ventilation system is ensuring comfortable temperature and humidity throughout the homes.
- Kingerlee are also working with Oxford Brookes, who are monitoring the occupants behaviour, to understand better how occupants use their homes and how this behaviour reflects in consumption patterns - the links between energy use and occupancy behaviour will be made clearer



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LowCarb4Real; Design collection: GHA Bladon: Airtightness IS a Design Issue

Primary Air Barrier — Design it with CARE

Kingerlee had understood the importance of good thermal design and were aware of some of the early findings from Stamford Brook. Their search to maximise their own build quality took them to Germany to understand their systems better. They wanted a system that could consistently deliver air tightness performance twice as efficiently as demanded by Building Regulations – so they targeted 5m/h ach@50Pa

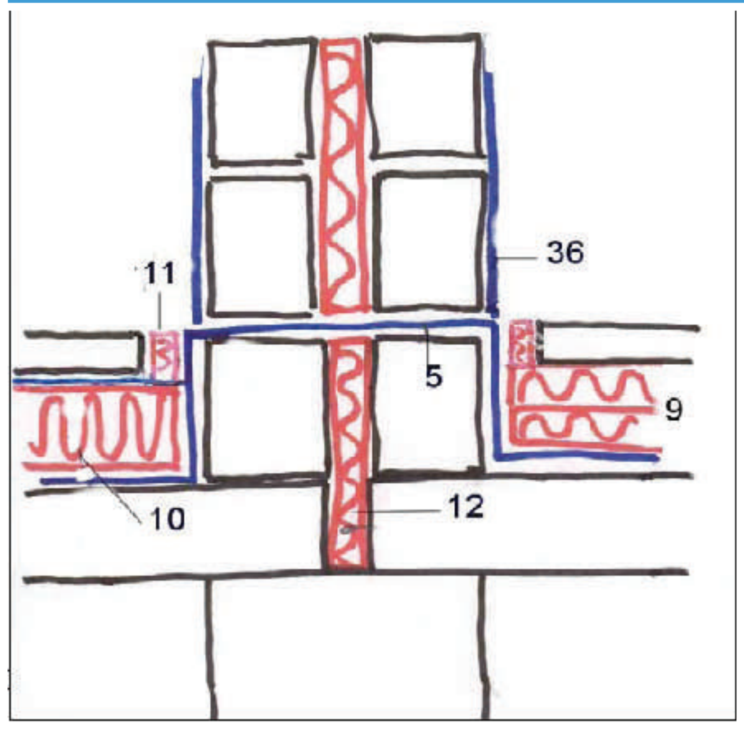
This research and learning on thermal design was fed through to the entire design team and the site operatives. Indeed the whole design team visited Germany and when the new site manager started, he also was taken over.

Further training at NBT for sub contractors laying the blocks on site helped improve understanding of good thermal design and helped ensure the design was actually constructed with this in mind as a priority.

The architects ALP also received training on the principles of good thermal design and airtightness. Complex areas like junctions, steel bedding and wall junctions and openings such as doors, windows and balconies were fully detailed and discussed and drawn – drawings were also annotated with EcoHomes credits . Detailed drawings referred to how continuity of the air barrier would occur on site. Complex detailing was removed where possible and complex areas like junctions and wall junctions and openings such as doors, windows and balconies are fully detailed and drawn – if you can't draw it you can't build it.

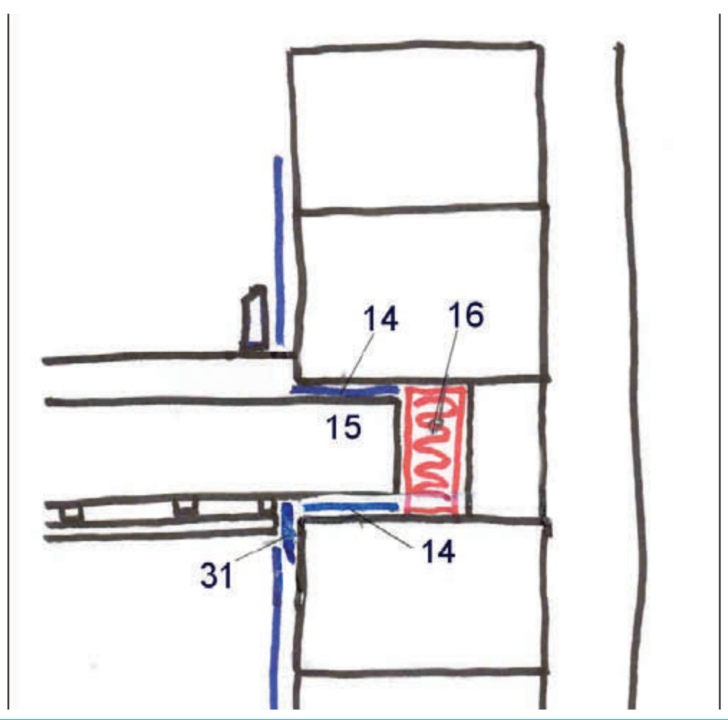
Working with Peter Warm and NBT consult, an airtightness schedule and 37 point checklist was devised to make sure that detailed checks on all complex junctions were made at the following stages of the build

- Completion of radon barrier
- First joist of the first floor construction
- First purlins
- Final membrane roof sealing



Airtightness around DPM/Radon barrier
1. Check seal around service entries - stove air (B)
2. Check seal around service entries - Electrical & BT incomer duct(s) (B)
3. Check seal around service entries - Drains (B)
4. Check seal around service entries - Water incomer duct (B)
5. Check continuous and sealed through insulated party wall (A)
6. Check seal to external wall/DPC (B)
7. Check seal where dropped around external doors (B)
8. Check under slab ventilation present to external air for Radon and combustion air (B)

Continuity of insulation
9. Either: uses 2 sheets 75mm polystyrene and offset joints (A)
10. Or: use 150mm polystyrene and extra DPM over top to prevent screed filling gaps (A)
11. Check 25mm polystyrene Edge insulation correctly installed before screed pour (A)
12. Check cavities filled with 75mm acoustic insulation, no snots or ties bridging (A)



Measurement and Feedback

Lesson - Test for air tightness at an early stage in the construction process – remedial action is cheaper AT THIS STAGE– and testing more than once will lead to better final figures

1) Completion of shell

Air tightness testing at this stage when the walls and roof were completed but before the render gave a result at Bladon of 22 m/h@50Pa. The tests showed that there was an unexpected significant air loss under the timber window sills, where the dpc was rounded off under the window sill, allowing air movement in the small gap between the dpc and the blocks. Testing at this stage allowed this problem to be easily solved at an early stage.

If you can't easily trace your finger around the air barrier on the plans, then you will have problems with thermal bridging

2) Once the thermal envelope has been completed and services are in

The plaster finish on the inside will provide the bulk of the airtightness so need to ensure that you have a cohesive shell which includes rendering behind fitted kitchen cupboards and appliances. The render has to follow round the inside and form a continuous unbroken layer. If walls cannot be plastered before fit out then they should be parged whilst still accessible.

Punctures in walls from service runs are the most common form of air leakage. Careful attention should be given to all service layouts and pipe runs minimised, but remedial action may be required to improve these figures. At Bladon, it was also noted that there was some leakage externally, where the dpc was dressed into the block joint, and so a polystyrene seal was placed over the joint

Testing at this stage revealed that air tightness was a range of 6.2 – 7 ach

3) Final testing

The above remedial action ensured that the final figures at completion showed a figure of 3.8 – 4.8 m/h@50Pa, comfortably within the target of 5

General testing

Acoustic testing at an early stage also showed that any penetrations through party walls rapidly reduces acoustic performance. This resulted in ensuring that electrical sockets were placed on external walls where possible and any sockets on party walls were surfaced mounted

Kingerlee have invested in a **thermographic camera** as a quick and easy way to understand how buildings are operating and which areas of the building are performing and which aren't.

Designing Airtight Dwellings– Guidelines

- Understand the subject area and train your design team
- If you can't draw it, you can't build it.
- Ensure the design and construction team, including sub contractor, understand the importance of good thermal design
- Help make energy visible by explaining about CO_2 emissions and homes

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LowCarb4Real; Design collection: GHA: Bladon, Thermal bridging

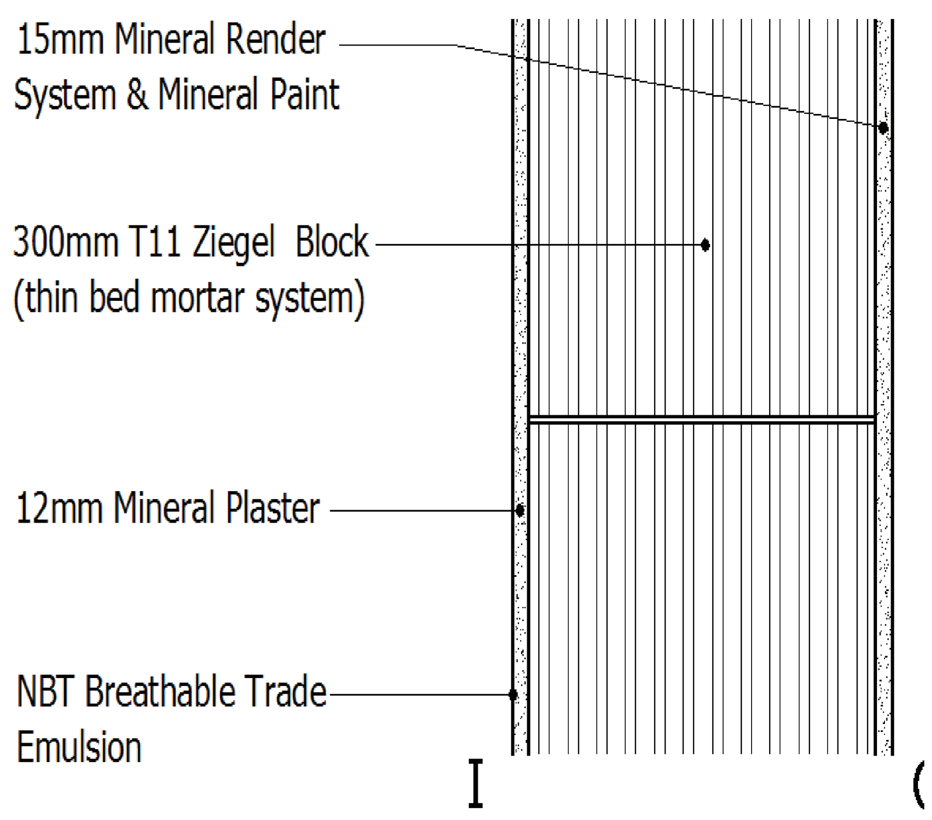
Bladon—Thermal Bridging

The first designs for this site reflected Kingerlee Homes' progressive approach with a modern design. The Planners were supportive of this and recommended the initial contemporary scheme for approval but the Planning Committee however wanted the scheme to be '*more like Bladon*', and were keen to mark the heritage of the site as a stone quarry for the adjoining Blenheim estate, and so the initial designs had to be significantly changed and then modified again. Planning restrictions on height meant the roof lines became complex as they were refined and the aesthetics and design constraints reduced the flexibility and potential for good, simple thermal design and resulted in an unwelcome level of complexity to the final design. Extra complexity leads to extra junctions and therefore lower performance.

The thermal design of the homes was based on a well insulted slab and 365mm Thermoplan single skin cellular insulation monolithic clay block walls with stone or render facing with U-value: 0.26 kWh/m^{2}k (0.28) y = 0.05

The roof is slated over low timber content I-beam rafters, supported by timber trusses and steel purlins. I-beam timber joists also form the first floor. Warmcel recycled insulation is used throughout the roof and first floor.

Careful attention was given to selection and use of a complete build system design that reduced thermal bridging to a minimum. Construction details using ThermoPlan were calculated to an exceptionally low y-value = 0.024



Geometric thermal bridges

The simple shape of the thermal envelope was compromised by the nature of the planning restrictions both on site lines, height and also aesthetics made junctions more complex. This together with a changing design, a structural engineer with no interest or knowledge in thermal design, led to a challenging build.

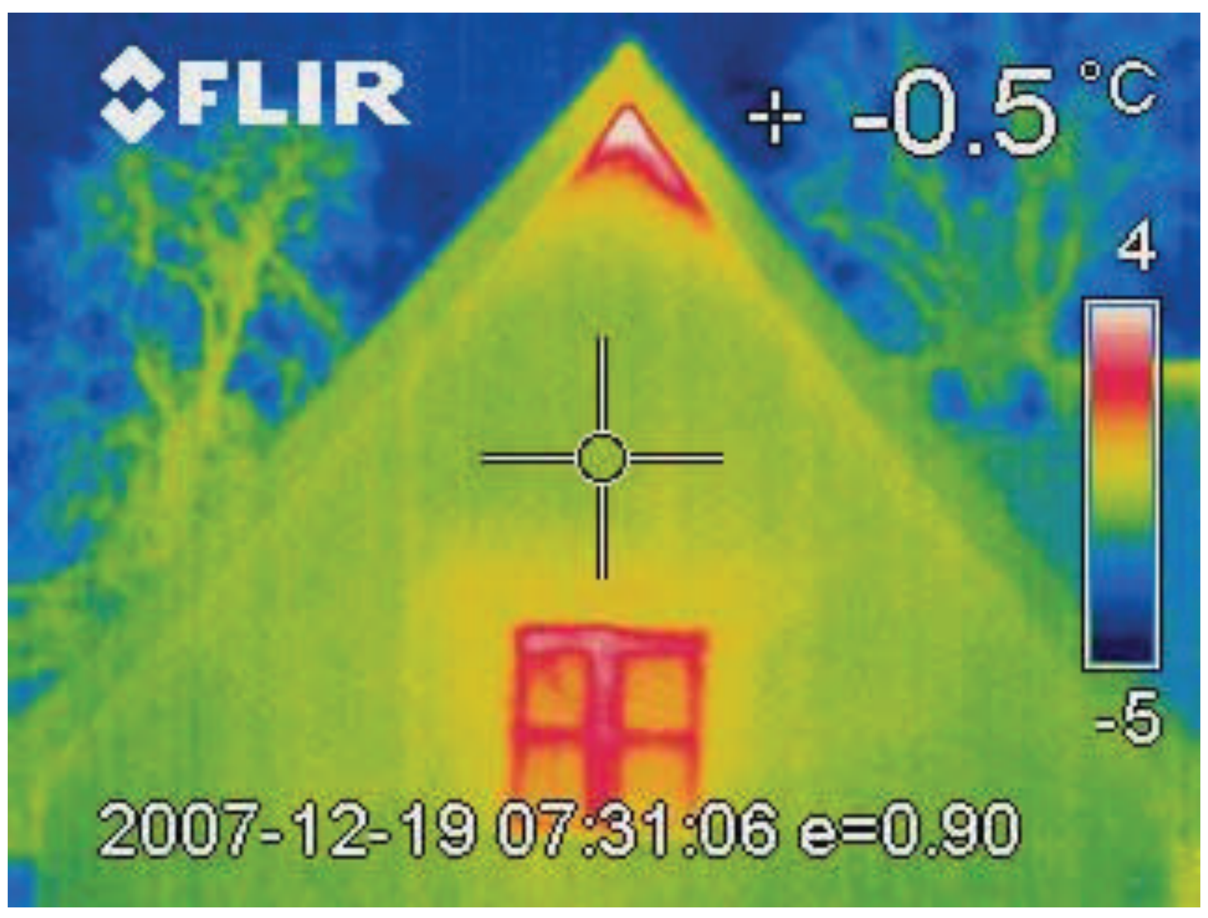
Junctions and joins were given careful attention to make sure operatives understood they they should be thermally broken

Repeating thermal bridges

The well insulated slab – two slabs of 75mm polystyrene with offset joints and 50mm polystyrene edge insulation – all were checked before pour, and the Thermoplan single skin wall system prevented the most common form of repeating bridge – the wall tie.

Junctions with steels were carefully detailed and extra insulation around the joints - included – thermal breaks

The timber I beam rafters also reduce thermal bridging as the web reduces the flow of heat



Non-repeating thermal bridges

Working with Peter Warm and NBT consult, an airtightness schedule and 37 point checklist was devised to make sure that all the following areas were checked

- Completion of radon barrier
- First plank of first floor
- First steel purlins
- Final membrane roof sealing

Also included on the check list was ensuring the lintels contained the insulation before casting and were cast, at First floor – fully filled bearing, insulated ends of I beams and careful attention to ends and sealing of steel purlins

Rules to assist in the avoidance of thermal bridging at Bladon

- Understand your subject
- Consider a build system or MMC with single skin wall – no additional insulation or wall ties
- Train design and construction staff
- Create a checklist for the development that defines the most likely points and stage in the construction process for loss of thermal performance
- Ensure that contractors take ownership and responsibility for thermal design on site.

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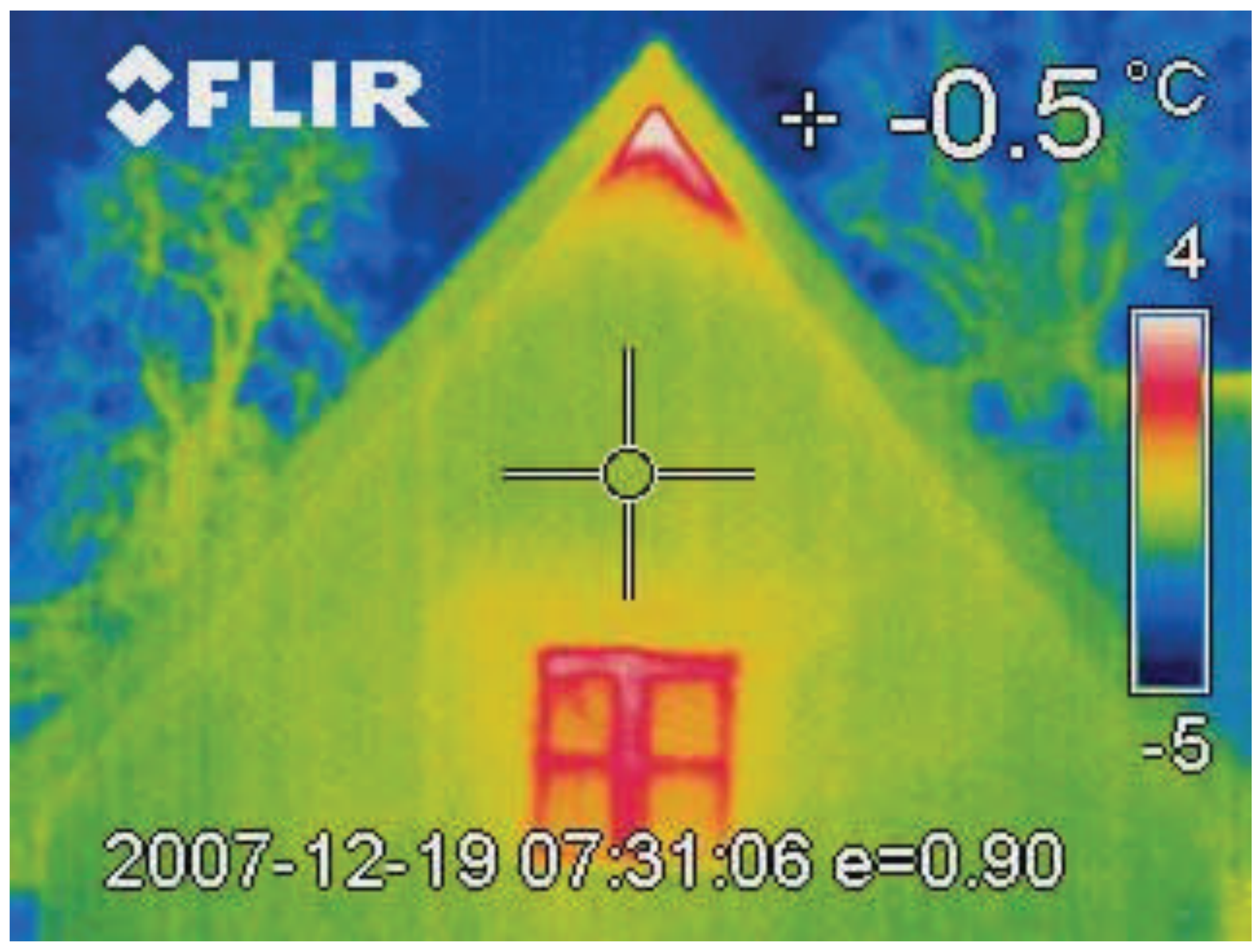
LowCarb4Real; Design collection: GHA: Bladon, Thermal Bypassing

Reducing Thermal Bypassing

Kingerlee were keen to find a solution to the problems being experienced with external cavity walls. They were aware of examples of cavity walls, where examination of the cavity after completion, revealed significant areas with floating or missing insulation. Breaks in the continuity of the insulation layer mean the immediate surrounding insulation is effectively useless.

They were also aware that incorrectly placed insulation batts could actually bridge the cavity and provide a route for damp transfer to the inner wall. Use of the single skin insulation Thermoplan block system at Bladon removed the need for cavities and the need for separately installed insulation.

Thermal bridging can be avoided by simply ensuring that the insulation does not have any cavities on either side and is contained on both sides



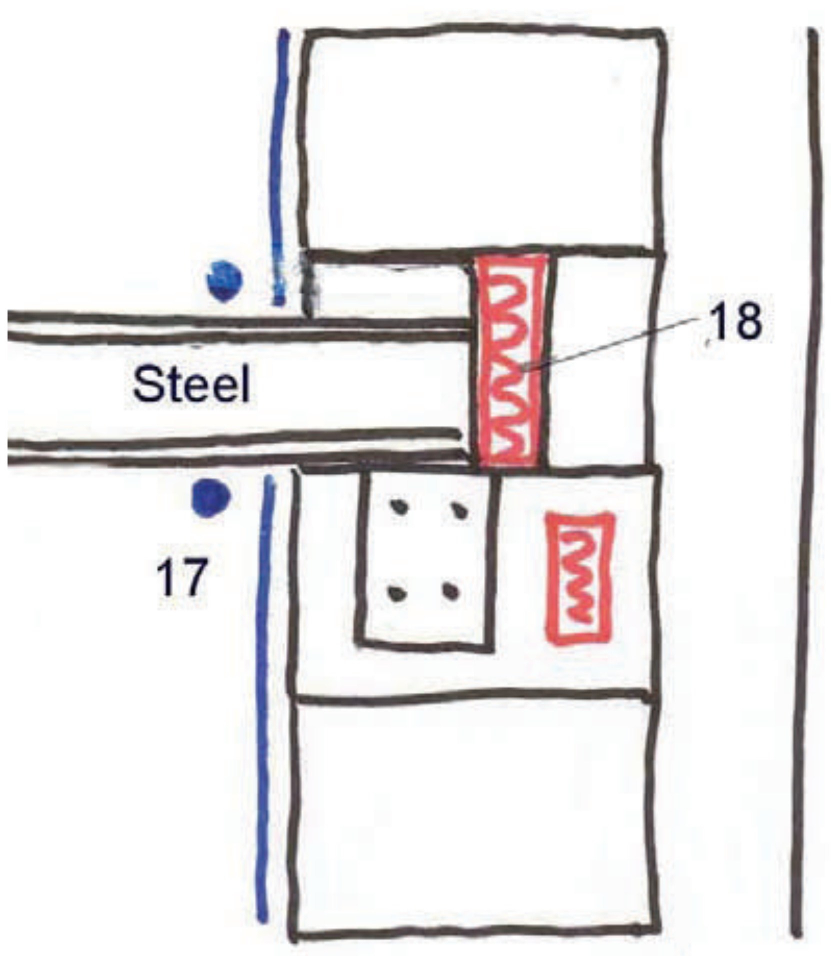
Type 1: Air Movement in Construction Cavities

An early discussion with Leeds Met regarding the early reports from Stamford Brook, warned Kingerlee of the risks associated with cavity party walls, and their ability to become 'chimneys' drawing warm air up through the cavity. At Bladon the Party Wall cavities were filled with 70mm acoustic grade Rockwool, thereby stopping air movement.

This problem was overcome at Bladon by fully filling the cavity

Type 2: Air Movement Within and Around Insulation

The use of the Thermoplan system meant that this problem was removed from the walls. Warmcel 500 was used in the roof and the advantage of this product is that it is blown in under pressure and fills any gaps and cracks, thus reducing any thermal bypassing.

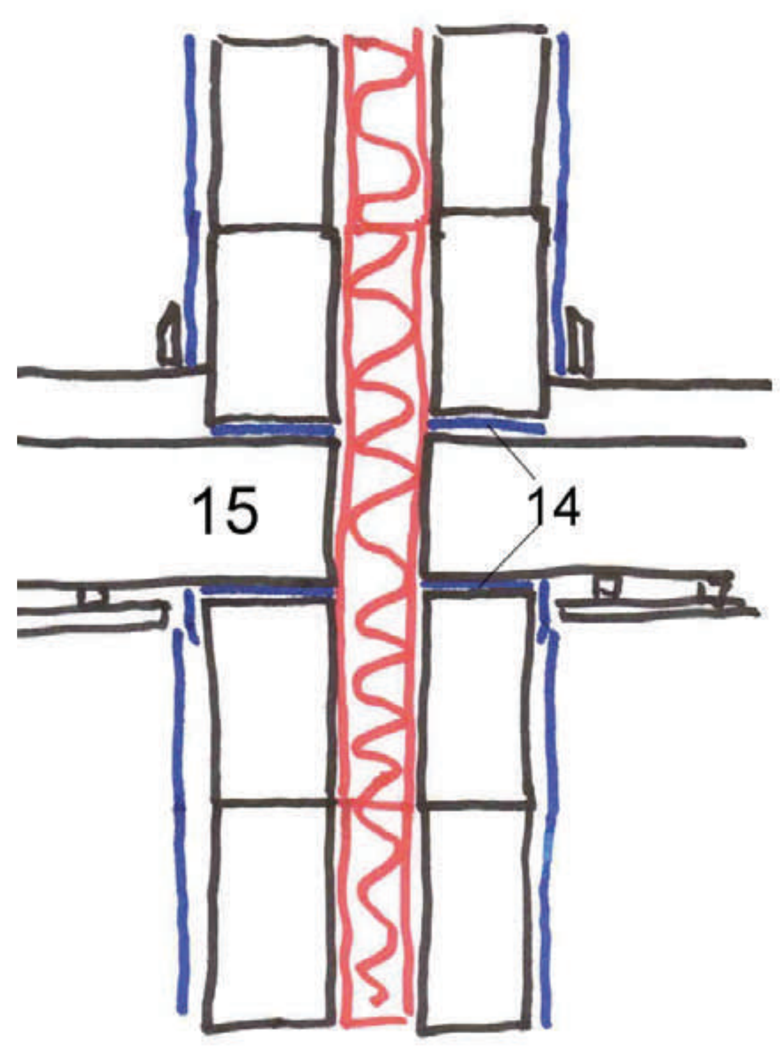


First Floor Plank bearing

14. Ensure fully filled bearing top and bottom for air seal (D,E)
15. Check perps for planks filled especially in built in ends (D,E)
16. Check Insulation strip on external walls on end of plank (D)

Steel Purlins

17. Check pads correct height and insulation block in lintel block (F)
18. Check insulation correctly placed at end of beam (F)



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