



The future of low energy,
carbon neutral homes

The Sigma[®] Home

There is no doubt that one of the major challenges to affect our future is climate change. The UK's 21 million dwellings are responsible for 27% of CO₂ emissions, consume half of water supplies and produce 8% of waste.

The Stewart Milne Group is at the forefront of housing innovation utilising modern methods of construction and is striving to address the highest standards of performance, as outlined in the Code for Sustainable Homes.

Our Sigma[®] Home, designed and developed to meet the requirements of the Code for Sustainable Homes was the UK's first five star rated home under the Code. It sets out a vision for the supply of homes to meet the zero carbon challenge and the needs of tomorrows customers. The home is permanently on display at the Building Research Establishment, Innovation Park at Watford.

Over the last two years, the Sigma[®] Home has been part of a research and development initiative in conjunction with the Energy Saving Trust and Oxford Brookes University, giving us the opportunity to explore the challenges, identify practical solutions and assist key influencers in the housing sector in the feasibility of building near zero carbon homes in an affordable fashion.

The Sigma[®] Home benefits from a co-ordinated approach using Modern Methods of Construction (MMC) with timber frame construction at its heart. As one of the most technologically advanced and sustainable forms of construction it satisfies the demands of Egan led methodologies and Government directives.

The Sigma[®] Home was designed as a contemporary 3 storey townhouse, arranged over 4 floors to minimise building footprint and maximise living accommodation while making the home affordable. Its semi open plan layout maximises natural light and suits modern informal lifestyles. The home has the ability to sub divide the ground floor to create a self contained apartment or home office. The flexible design provides for various layouts, elevation and finish options. Maximising family living in city centres is essential for sustainability and we believe that the Sigma[®] Home uses significantly less land than a traditional four bedroom home.

The home was built to embrace four key aspects:

- Code for Sustainable Homes – Level 5 performance
- Use of offsite technologies
- Customer centricity
- Architectural and design excellence

Level 5 Compliance

Designed to be carbon neutral in terms of space, heating, hot water, lighting and ventilation, it has high performance insulation and triple glazed windows along with low energy appliances, micro renewable technology and a high efficiency condensing gas boiler.

Water saving devices have been used throughout design to practically allow for 80 litres of potable water per person per day. Water butts are provided to collect rainwater from the roof for garden use.

It has an increased level of insulation, airtight construction, high efficiency whole house ventilation, heat recovery system and fresh incoming air recoups heat from extracted air. Solar collectors on the roof preheat the hot water cylinder and wind turbines export electricity to the national grid. Photovoltaic panels offset the remaining CO₂ associated with space heating, hot water, lighting etc.

A solar chimney on the roof positioned above the staircase, optimises passive ventilation by using the stack effect in the stair core, enabling us to draw air through the home for cooling.

With minimum requirement for wet trades on site, the build process is considerably faster. The construction of both plots took just 8 weeks from grass to keys.



Key features of the home

The key energy efficient features of the home are:

- Renewable energy via heating hot water from solar thermal and photovoltaic roof panels, wind turbines and solar gain
- Solar stack and 'whole house' mechanical ventilation and heat recovery system maintains the required internal temperature, using heat gain to offset the energy load on the home
- High levels of insulation provided by the wall, floor and roof elements coupled with high performance timber windows, providing excellent thermal performance of the external envelope
- Airtight construction and detailing, ten times better than Building Regulations requirements, delivering energy performance 100% better than Part L1A
- Timber and timber products from managed sustainable sources
- Low energy lighting (excluding the pod) and kitchen appliances (A+ or A rated)
- In-built grey water recycling system to reclaim shower and basin water for toilet flushing. Showers, taps and washing machine have low water consumption
- Three 7-litre internal bins holding recyclable waste
- Structure includes an automatic fire detection system together with sprinklers
- Internal face has two layers of plain plasterboard providing one hour fire performance, with a domestic fire sprinkler used, to comply with the four storey nature of the home

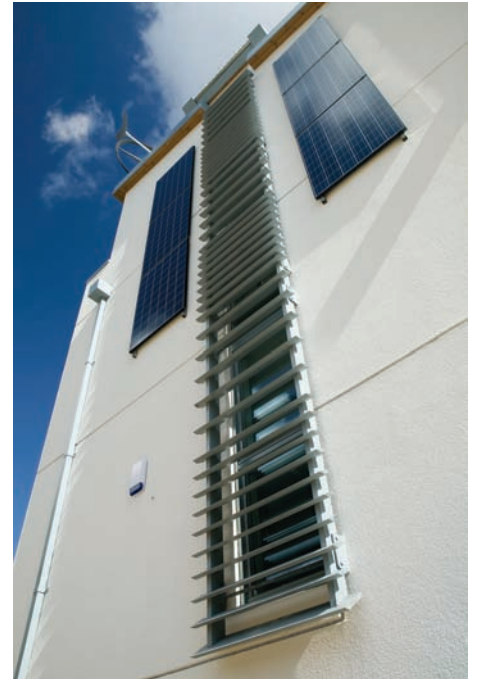


- A combination of three different pre-fabricated timber based floor systems to show the range of options available
- Enhanced acoustic values are provided (circa 2-3 dB) to reduce noise throughout the home
- Upper floors all utilise an under floor heating system negating the need for radiators
- Triple glazed high performance timber windows contribute to an overall targeted air tightness of $1.0\text{m}^3/\text{h}/\text{m}^2 @ 50 \text{pa}$
- Leading-edge offsite technologies including closed timber frame walls and pre-fabricated bathroom pods, using a smarter build process to reduce build time of two semi-detached four storey structures to 8 weeks compared to standard 24 weeks
- Modular foundation system enabling minimal site excavation with pre-cast piles and beams, taking just 5 days from bare site to completed foundations, whilst retaining high levels of insulation



Technical features

- Floors are designed to clearspan from gable to partywall giving flexibility of living space. Floor to ceiling heights are designed to suit standard plasterboard and OSB sheeting sizes, eliminating the need to cut sheets and utilising standard timber stud height components, reducing production and build costs and simplifying manufacture
- The design includes factory made pre-insulated closed roof cassettes with factory fitted roof membrane and air-guard vapour barrier to the ceiling side. Utilising the roof space to create an internal vaulted feature, enabled the roof to be wind and watertight quickly. Factory installed insulation contributes to an overall U-value of 0.15 W/m²K. On this project, six roof modules were installed in less than three hours
- Roof cladding system is a preformed zinc metal system, the fixing points for which are designed into the roof cassette
- Pre-fabricated bathroom pods were delivered in sequence to suit the timber frame erection process and craned into place on site, incorporating low water consuming elements and an Eco-play grey water recycling system
- External face is clad in standard breather membrane, completing the construction which is factory manufactured and crane erected as large panels on site. The external render is fixed directly onto a recycled backing board, vented cavity and rigid board insulation system
- A partnership approach with suppliers led to efficiencies in time and cost, and produced an enhanced end solution
- Designed primarily for urban locations the properties are to 'Secured by Design' standards
- External fabric utilises the Stewart Milne Prototype Generation 3 closed panel system which provides a U-value of 0.15W/m²K, comprises 140mm solid timber studwork, 0.035W/mK glasswool insulation between the studs and sheathed with 9mm OSB/3 boards on both faces. The inside face utilises a reflective vapour control barrier and self adhesive taping systems. 25mm service battens at 600mm centres completes the internal build up and is ready for services and dry lining
- Timber cladding features utilise heat treated modified timber rain screen cladding with a service life of up to 30 years
- Built-in health and safety features through extensive health and safety thinking during the design process along with early identification of principal build components, hazards and adoption of CDM principles with offsite technologies, delivered a safety conscious project and safe working environment for all



Research programme objectives

Background

In response to the UK Government's commitment to reduce carbon emissions by 80% by 2050 through the Code for Sustainable Homes, we undertook a two year programme of research aiming to expand our knowledge of the strategic impact, practical implementation and effect on consumers, of low/zero carbon homes.

The Stewart Milne Group believes in research and development to assist us in fully understanding how our products and services can benefit our customers. In December 2007, we commissioned the Oxford Institute for Sustainable Development and Architecture (OISDA), part of Oxford Brookes University, to evaluate and monitor the Sigma[®] Home, while it was occupied. Our aims were to better understand how the energy efficiency elements of the home performed and to provide key learnings to inform our development programmes and influence policy makers, through a structured research programme.

The key objectives of the research programme were to:

- 1 Establish a viable and robust technical solution, throughout all levels of the Code for Sustainable Homes
- 2 Establish the current build cost and potential for cost reduction over time
- 3 Product test the home to ensure the performance is as expected
- 4 Identify any potential latent problems and consider solutions
- 5 Evaluate the customer acceptance, impact and appetite for such a product
- 7 Retain the Stewart Milne Group at the forefront of innovation in the Built Environment

The Research Study

As part of the research programme, a family of four were recruited to occupy the Sigma[®] Home for 4 two week periods, one in each season of the year. The home was lived in very much as normal, with the family carrying out typical daily routines, in an uninterrupted manner.

The occupants experience was recorded using several research methods including video, interviews, log sheets and thermal comfort surveys. The induction process was evaluated. OISDA physically monitored the temperature, humidity, indoor air quality, energy, gas and water consumption, and window/external door openings.

An innovative wireless monitoring system was used with 55 channels recording data every minute. A co-heating test was also conducted to establish the actual fabric heat loss co-efficient. The qualitative experiential findings were then triangulated with the physical monitoring, to provide a comprehensive and forensic investigation of the home in use.

While it is recognised that this was a relatively small sample of a unique property and location, the data gathered has yielded a considerable amount of intelligence on the performance of the home and the occupants interface with the property. It is considered reflective of what a fully occupied and conventional home, built to normal timeframes and construction practice, would generate in terms of learning outcomes.

In addition, the Energy Saving Trust has gained a better understanding of post occupancy monitoring protocols, leading to the publication of their guidance document CE298 'Monitoring Energy and Carbon Compliance of Newbuild Homes'.

The key objectives of the Post Occupancy Evaluation and Monitoring study were to:

- 1 Investigate and establish the "As built" fabric heat loss
- 2 Evaluate thermal comfort and window/door openings
- 3 Evaluate indoor air quality
- 4 Assess the energy consumption and carbon dioxide emissions
- 5 Evaluate water consumption
- 6 Evaluate the user interface with the home over four seasons
- 7 Evaluate the effectiveness and design of the induction process for the user



Primary outcomes

Energy performance

The Co-heating test and thermal imaging clearly revealed the “as built” performance of the fabric, following construction. While the performance is significantly better than a conventional home built today, the findings indicate the “as built”, heat loss parameter was approx 40% worse than the predicted design stage assessment. Improvements can be made with greater focus on airtight-ness, thermal bridging, detailing and workmanship, resulting improved heat retention through the fabric.

Projected primary annual energy (electricity and gas back up) used 229kWh/m²/year in relation to grid consumption. This was considerably higher than anticipated and nearly twice the level of the PHPP energy standard. This suggests that more effort is required in delivering a energy demand reduction solution, rather than relying on renewable systems, to offset avoidable heat loss and energy consumption. This will require a re-examination of heating and ventilation systems, appliance use and fabric construction.

“A fit and forget fabric solution, putting low energy homes first, then low carbon”

We now have the solution to focus on heating and ventilation systems and improved fabric construction, moving Sigma® towards a low energy home range, as a first priority. Thereafter consideration of simple to build and use decarbonisation technologies, can be integrated.

The home maximises the use of solar gain with large areas of glazing. Whilst this is to be expected from this approach, the findings show a clear conflict with the need to retain privacy for the occupants, particularly when high density layouts are increasing.

The four seasonal occupancy periods provide enough variation in weather conditions to enable a projection of annual energy use figures for gas and electricity grid consumption.

The data gathered signals a conflict between the MVHR system and openable windows in terms of user behaviour, preference and functionality. Understanding is required to overcome this and prevent unnecessary heat loss, whilst retaining flexibility in why users wish to open windows.

Energy Consumption

Responding to everyday living requirements, there was a need for additional drying facilities and a tumble dryer was supplied to the family, adding to energy use. Future developments will need to consider including internal drying facilities, perhaps at the top of the home or within the plant room area, to capture the benefit of warm air sources. This will reduce the drying demand and lessen the need for daily tumble dryer use and additional energy consumption.

The artificial lighting conditions were felt to be excellent, although the sophisticated remote controls need simplification. Low energy bulbs were used throughout the home but comment was made on the slow response time of low energy fittings. These were generally unacceptable, particularly within the bathroom areas.

Water Consumption

The majority of the water efficiency measures in the home were generally accepted and performed well, apart from the washing machine and the toilets. The measured water usage was well within the Code for Sustainable Homes limits of 80 litres per person per day. Significant comment was made on the low water washing machine and dual low flush toilets. Both were deemed unacceptable, with the family commenting that these would need to be ideally removed and replaced.

Acoustic Performance

The acoustic performance of the home was good, due to the highly insulated fabric. Noises from appliances in the kitchen, and occasional noise from the windows and mechanical ventilation heat recovery unit (MHVR) unit, were recorded. Comment was made that the passive solar stack with the openable window at the top of the home, whilst allowing warm air to ventilate out, also acted like an acoustic funnel, channelling external noise from the M25, down into the home, when open.



Primary outcomes

Micro renewable technology

A significant part of the homes energy performance is provided by a selection of micro renewable technologies, incorporated into the home. The research investigated the performance of these during occupation and included events that occurred outwith occupations, which were significant and worthy of inclusion.

Solar Thermal

One issue that arose was that of obsolescence. The system installed has been removed from market, resulting in significant concern around the future repair, provision of parts and longevity of the system and who is liable for future output guarantee. This may be as a consequence of the early prototype nature of the evolving systems.

Due to the nature of the technology, it was not always possible to regulate the outputs generated in sync with the occupants needs. This resulted in output during sunny days, with little immediate use, as heating demand was required or desired during early morning or in the evenings. Effective heat storage is required, which adds complexity but is vital to capturing and using the benefit gained.

Micro Wind

Our evaluation concludes that by using Micro Wind technology, little effective electricity was generated. The systems underperformed and are not suited to a city centre low rise location. It is unlikely that this system would contribute positively to offsetting fuel bills in a home.

In addition there was a product failure, resulting in a concern around Health and Safety when one of the turbines fell from the roof. This signals issues, not just with Micro Wind, but in general around renewable technologies product life and the associated risk of failure.

The turbines have had several “in service” problems, relating to repair, noise and certification. Of significance is the potential concern around future repair and/or adaptation. A number of events occurred which related to the circuitry within the home and the complexity of isolating these, to the uneducated. The system is wholly dependant on our supplier and installer, and is not suitable for any future unapproved or DIY operations.

“Micro renewables are not effective. ‘Green the grid’ is the most effective approach. Energy provision should sit with energy providers.”

Photovoltaics

The PV generated 27kWh/m²/year, averaged over a year, which is slightly more than 50% of the electricity consumed, when interpolated from the measured consumption over the 8 weeks of occupancy and factored over the course of a year. This is generally productive and signals the benefits of this type of system, albeit the capital cost of installing this significantly outweighs the benefit with extended payback times, which in effect could render the system unattractive.

The home has a PV array mounted on the South facing gable wall, which has since been over shadowed by the construction on another property next door, signalling issues with future proofing and longevity of supply, for homeowners, when constructed at a plot level. This also indicates the frailties of designing homes which are dependant on solar orientation, to generate power.

From the evaluations, it is clear that all designs using this form of technology are at risk of Health and Safety issues. Access to the systems for repair and maintenance is necessary and effective installation is required in terms of fixings, weather tightness and storm damage risk to allow such maintenance to take place safely.

Given the various problems with the renewable energy systems, the storage space required and their servicing needs, it is highly questionable whether new homes should be individually provided with these types of renewable energy systems. ‘Greening the grid’ would appear to be a more effective way to reduce energy usage and create more sustainable communities.



Primary outcomes

Thermal comfort and health

The Post Occupancy Evaluation programme highlighted that the occupants experienced a high level of comfort, despite being unable to effectively control the heating temperatures at certain times. They adjusted their personal comfort levels according to the varying external temperature from season to season. The average predicted comfort temperature for the occupancy was over a degree lower than the actual temperature recorded, indicating that the home was always slightly warmer, than it need be.

Adaptive comfort behaviour was consistently observed during each occupancy. This relates to the individuals comfort perception and threshold. Generally the occupants recognised the seasonal changes and the varying hot or cold external temperatures and adapted their behaviour and perceptions accordingly. This was particularly evident in their daily routines, and clothing adjustment. This is adverse to the design concept for consistent and regulated cooling and heating functionality within the home. However the homes flexibility and variety of heating and cooling systems, met with a high degree of acceptance by the occupants. They felt they could respond to the thermal comfort conditions in the home, when they wanted to, keeping it warm in winter and cool in summer.

The Passive solar stack and automatic vent at the top of the house proved key to preventing peak day overheating. This automatically responded to the overheating spikes at peak summertime day temperatures, particularly when the occupants were returning to the home following work. The data supports a high level of thermal comfort and the passive vent system was easy to use, customer friendly, and a positive experience. Comment was made as to the feeling of air movement over the skin, which aided their comfort perception. The MVHR adequately copes with the base ventilation needs, and after initial teething problems proved very acceptable to the occupiers.

The overall relative humidity in the home was well within the range accepted for healthy living conditions. Positive comments were made by the occupants in relation to low levels of dust and the general feeling of good air quality. The MVHR unit created a hot spot with radiant heat evident in the adjacent bedroom. There were no traces of any VOC's evident in the home during occupation.

“The aim is - warm in winter,
cool in summer, delivered
through build tight and ventilate
right. People adapt so there is no
need to over engineer. One
solution does not fit all”

Evidence of adaptive comfort behaviour is a key finding and suggests we need to avoid the temptation to over-engineer homes, but to design homes and build systems that meet the needs of a mid-range of temperatures, which have fast acting functionality when required, to suit temperature peaks and troughs, out with the mid range levels.

During the window monitoring, it was established that only 4 out of 25 opening windows, were actually used on a consistent basis for ventilation. This signals the need for effective cross ventilation design and positioning of opening windows within the layout of the home. Whilst also saving cost, good window design, positioning and cross ventilation can significantly enhance comfort performance.

Windows will be opened for a range of reasons. Whilst this would be a concern in wintertime, effectively negating the benefit of saving energy, during the summer period, this is less of an issue, as little if any heating is used. This signals to behavioural change and the need for effective induction and education of the home owner.



Primary outcomes

Home user induction and interfaces

Occupants need greater time and simplification of information, at handover and induction stages, on explaining the complex technology involved in the home including heating, lighting and ventilation controls.

The walk through process was well received, but we recognised that the technology embodies a significant challenge for the sector in terms of easy demonstration and retention of information. This is particularly relevant to RSL's who will have to impart this knowledge on a regular basis. Development of a detailed demonstration and induction process is required to ensure that the occupants fully understand how to use the technology in their home and can do so with ease.

It is clear that the complexity of the technology will require a full review of how developers induct new home owners and will require a whole new skill set and process to be introduced. As part of this, a series of reminder sessions and/or helpline services, are almost inevitable to ensure customers feel fully supported, comfortable and confident in the use of the equipment in the home. This will demand new aftercare processes, so an effective collaborative approach can be delivered with confidence to the customer.

The induction process is a crucial aspect of building performance and is often underrated in terms of its affect on the occupants' subsequent behaviour. It has to be developed to ensure that all service providers are fully trained and can overcome occupier challenges with ease.

It is also important that occupants understand the energy saving features of their home so that they can maximise energy efficiency not just through the technology and home features, but through changing their own behaviours and lifestyles.

The guidebook requires simplistic diagrams, illustrations and descriptions which are bespoke to the particular home that the occupants are in. An extended induction programme, along with aftercare and maintenance service should be considered.

There will be a requirement for a support helpline to provide timely and effective support to homeowners with one point of contact, experienced in all aspects of the homes technologies.

The overall relative humidity in the home was well within the range accepted for healthy living conditions. Positive comments were made by the family in relation to low levels of dust and the general feeling of good air quality. The MVHR unit created a hot spot with radiant heat evident in the adjacent bedroom.

The evaluation of the induction process indicated that the occupants needed greater time spent on explaining the complex technology involved in the home and encouraging them to try it out.

“KISS - keep it simple stupid!
The induction process for low carbon homes needs to be simple, clear, easy and offer hassle free homes. Home maintenance agreements could be a thing of the future (just like a car). Aftercare is critical.”



Primary outcomes

Build complexity

The design and integration of services into the home is a key aspect for early consideration. These must be considered as early as the concept stage. Our learning has shaped future changes towards our design to a “heart and lungs” approach. This considers the location of the main services room and vertical/horizontal duct routes as the key priority, so that heat and ventilation can be produced and circulated, simply and in a cost effective buildable manner. These aspects are fully integrated in the home design.

It is crucial to ensure that design and layout is simple, easy to use, easy to maintain and that post handover, full support is provided for owners.

It is even more evident that with a range of varying technologies, provided by several suppliers, lines of responsibility must be agreed at the outset, to ensure good communication and a quality customer experience for the homeowner. This is for particular consideration of RSL's who must consider the interface of all aspects of the technology to ensure maintenance can be managed effectively.

The number of interfaces and/or touch points between technologies, is significant and can pose a significant and unacceptable level of risk and liability to the developer. Integration of suppliers and subcontractors to reduce interdependencies is a critical requirement moving forward.



“A heart and lungs approach is needed to consider services and plant room at the outset. Integration is a must to reduce inter-dependencies, suppliers and sub-contractors and define ownership. Technology must be easy to use, fix and built to last.”

Given the overall complexity of energy technology solutions, pre planning is imperative to ensure easy access to all equipment for maintenance and repair, providing an integrated energy system for heating and ventilating, with clear access routes, signage and work instructions.

Given the requirement for being able to upgrade and alter the home in the future, there is a question and unknown aspect about the ability to deconstruct and/or modify the home and the degree to which this can be accommodated and/or designed for. This includes any DIY type work that occupants may seek to do themselves in the future.

The effective commissioning of the home is a vital success ingredient. Sufficient time must be left to fully test the home's technology and remedy any problems, before handover. This will create new processes and skills and affect the project management and planning of the construction phase. Any pre-commissioning, in particular services, that can be done in advance of handover would be a worthy investment, particularly the interface points between systems. These tend to generate the most failure points and are difficult to fix, leading to the potential for poor customer satisfaction.



General outcomes

In terms of satisfaction, the home was very successful, with the occupants feeling increasingly relaxed and comfortable over the duration of the four occupancy periods. The home had significant user appeal in terms of layout, lighting, spaciousness and comfort. In particular the plant room can afford an opportunity to design additional storage and maximise space in the home.

The home worked well as a family environment, encouraging greater interaction and togetherness through the open plan, split level arrangement. The home was perceived as highly adaptable, room sizes were deemed generous and the home offers the flexibility to redesign the ground floor layout to provide alternative options for homeowners.

The stair zone was felt to be less attractive with occupants travelling up and down over four storeys. However the occupants adapted their behaviours to cope with this, by organising their routines around the extent of travel up and down the stairs. The benefits of more space and more open plan living in four storey homes outweighs the less attractive requirement to walk up more stairs.

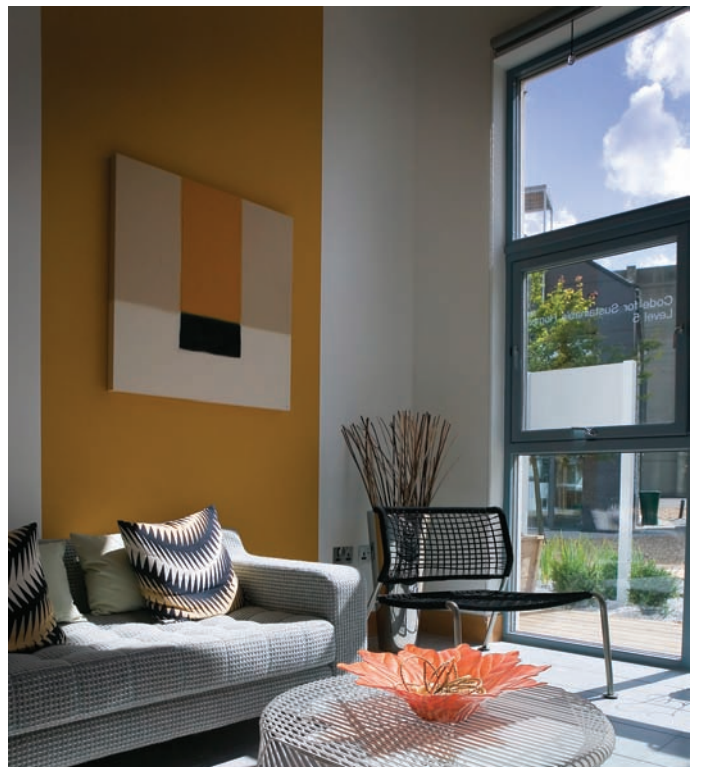
The feeling of space and good day lighting were very beneficial and the effectiveness of the stairs solar passive stack effect, was well received.

Although the windows were easy to use and brought welcome daylight and solar gain into the home, they also created a lack of privacy. While the design looks good, with too much glass, it is not a practical solution for this type of home.

The water efficiency measures in the home were generally accepted and performed well, apart from the small size of the washing machine and the need to double flush the toilets to make them function properly. Water usage was well within the Code for Sustainable Homes level 5 limits. Consideration needs to be given to internal and external drying facilities to negate the needs for tumble dryers.

The co-heating test itself was successfully carried out. The thermal imaging clearly revealed where some of the heat loss was occurring in terms of airtightness and fabric. The established figure for the heat-loss co-efficient, which was about 40% higher than predicted, must be treated with caution, as the full extent of thermal bridging could not be ascertained within the limitations of this study. It is likely that once these are taken into account, the difference between the figures may be greater.

“The feeling of space, connectivity and daylight helps to bring families together. Water saving features comply but are not necessarily what homeowners want.”



Conclusions

The Sigma® Home Research Programme

The Sigma® Home study, the first major study of its kind in the UK has been extremely successful, yielding significant data and considerable insight into occupants' expectations, perceptions and behaviour in relation to living in a innovative low carbon home designed to achieve Code for Sustainable Homes code level standards.

There are a number of clear lessons that can be learnt from this study in order to improve the design, specification, procurement, construction and operation of low carbon homes as they are developed for the future.

The occupancy of the Sigma® Home by a recruited family was remarkably successful. This was indicated by the fact that the family felt a sense of 'mourning' at the end of the final occupancy period and expressed how much they had enjoyed the project overall. Their active participation in the study yielded a very comprehensive thermal comfort survey, the first one ever to be undertaken, in a prototype home, designed to achieve the Code for Sustainable Homes code level standards.

The research provides hard evidence and occupancy feedback to improve future house designs and build systems. We now have evidence that will now shape the design and functionality of market leading products which are customer friendly, reliable, cost effective and easy to build.

We are actively progressing our designs and product development to maintain our position at the forefront of innovation within our industry.

We believe that this research provides a real insight into low energy homes, that will be used to inform key stakeholders, in the evolution of the governments zero carbon agenda, as well as benefiting the wider house building sector.



A quick review...

“Fabric, fabric, fabric...
focus on ‘fit and forget’
fabric solutions first

KISS...Keep it simple stupid

Low energy homes, before
de-carbonisation

Avoid the technology rush
or eco-bling

Keep the home owner at the
heart of all you do and decide”



Next steps: The Sigma[®] II build system

Introduction

As part of our product development initiatives and utilising learnings from our recent Sigma[®] Home research programme, Stewart Milne Group can now offer a second generation Build System, which responds to the requirements of low energy low carbon homes and provides a robust and practical solution.

Sigma[®] Home Learning Outcomes

The key learnings from the initial prototype build system, centred on the following:

- Fabric -v- renewable devices
- Wall thickness
- Air Tightness
- Thermal bridging
- Thermal Transmittance
- Materials
- Skills
- Build process
- Cost
- Repair, maintenance and longevity
- Ventilation

Fit and Forget - A New Fabric Solution

We have now developed a Fabric Solution which offers a more affordable, reliable and simple to install Build System, promoting a “Fit and Forget Approach”. By far, the ideal solution, the “Fit and Forget”, approach incorporates whole life-cycle costing, risk and home owner impact.

Our easy to build fabric solution provides longevity and focuses on construction complexity, installation interfaces, repair, maintenance and performance. This is now recognised and the recent consultation on The Definition of Zero Carbon, promotes energy efficiency, ideally through the fabric, as the first priority.

Space Stud Technology

Our approach has led to the introduction of high performance space stud technology with a wall width of 412mm. The Sigma[®] II Build System is finished with conventional bricks and 50mm cavity and plasterboard internally. The space stud technology can also be applied in party walls applications, delivering a thinner single skin party wall.

Performance Levels

The system is designed to achieve superior levels of fabric performance, suitable for projects up to 4 storey, seeking to achieve Code for Sustainable Homes, code level 4, 5 and 6 energy performance. The performance criteria offered is:

- Thermal U-Value of 0.15 W/m²/k
- Air tightness of 3.0m³/h/m² @ 50 pa
- Thermal bridging of 0.02 (better than Enhanced Construction details)
- Wall width of 412mm overall
- Suitable for 4 storey buildings



Off Site Construction Benefits

Our solutions provide all the benefits of off site construction, integrating several processes and suppliers into one solution.

The fitting of insulation, service cavities, air seals, windows and doors, results in numerous suppliers being removed from the supply chain and the on-site build process. As a result, improved cost savings, reduced site management/communications and surety of performance can be achieved.

In addition, we have developed optional ceiling cassette and ground floor cassette systems, which further reduce the number of processes and trades, at the key interfaces with foundations and roof elements. This ensures a more cost effective approach, not only improving slab tolerances with the ability to make wind and watertight main super structures, but also ensures air tightness performance can be achieved in a reliable manner.

The Build System also offers a range of Offsite Construction features, including:

- Closed panel
- Fully insulated
- Service cavity pre-fitted
- Improved fire protection during build
- Built-in air tightness detailing and seals
- Open web floor cassettes
- Principle service penetrations pre-formed
- Optional factory fitting of windows
- Optional insulated ground floor cassettes
- Optional insulated ceiling cassettes
- Optional insulated roof cassettes
- Potential to air test, immediately after kit erection

Next steps: The Sigma[®] II build system

Superior Air Tightness

The Sigma[®] II Build System is designed to a performance expectation of 3 m³/h/m² @ 50pa, achieving a consistent, reliable system that reduces dependency on site controls, supervision and site workmanship. It provides:

- Lock joints designed into panel connections
- Compressible foam seals, fitted in factory at head and foot of panels and soleplates
- Air membranes design out, in favour of OSB sheathing, as primary air barrier point
- Self adhesive tapes fitted at vertical junctions, by erectors
- Main Service penetrations pre-formed, with self adhesive grommet seals
- Option to factory fit windows, with pre-fitted air seals
- Floor cassettes ends, factory wrapped with air seal membrane
- Option to adopt pre-insulated, closed and sealed ground floor cassette
- Air membrane and service cavity, introduced at roof ceiling level
- Option to adopt pre-insulated, closed and sealed ceiling cassette, to underside of roof
- Potential to air test, immediately after kit erection, a key point in the build process

Thermal Bridging

The Sigma[®] II Build System is undergoing 3D thermal modelling to assess the specific y-values, for each junction detail. This will allow data to be entered into SAP for each building design, reducing CO₂ emissions, estimated to be equivalent to a y-factor of 0.02. As thermal bridging is likely to play an increasingly important role in the evolution of SAP software, used to secure building regulation approvals, this is a key benefit to developers.

A significant feature of the system is the adoption of a “space stud”, not yet available in the UK. Key aspects of the system are:

- Space stud structural studs to provide thermal break
- Ring beams within floor zones and insulated voids
- Pre-insulated edge junctions within floor cassettes
- Reduced cross grain timber at head and foot of panels, reducing bridging and shrinkage
- Improved detailing at ground floor and roof ceiling junctions, when using insulated cassette options
- Reduced wood content, due to the closed panel nature of the panels

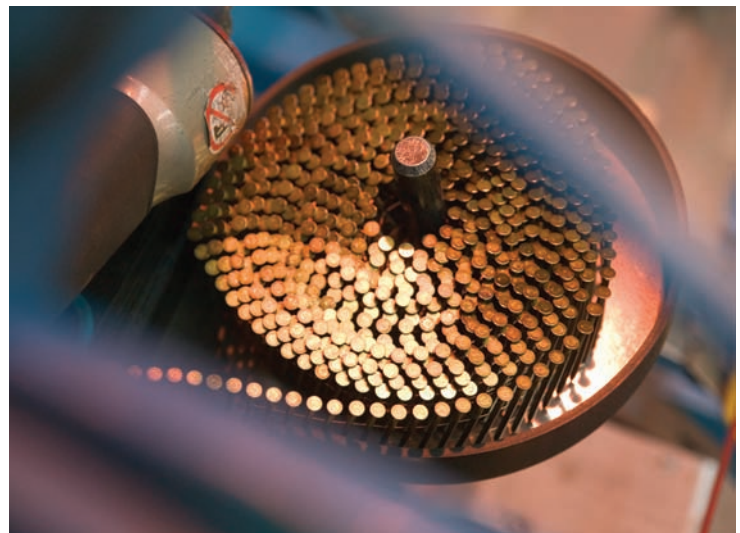
A Water Resistant, Durable Green Guide A Rated System

The Sigma[®] II Build System is designed to achieve U-Value of 0.15 W/m²/k, achieved through the use of Expanded Polystyrene Beads, with a lambda value of 0.032.

The blown insulation system is fitted in the factory and is a first for use in timber frame applications. The panels are fully encapsulated in OSB/3 sheathing, providing additional fire protection, during the build process.

A service zone is factory fitted and finished on site with conventional plasterboard. The EPS bead system is a bonded application, using fast cure water based adhesive, which sets the beads firmly into the panel cavities, preventing slump and settlement. Due to the nature of the EPS insulation, there is a high water resistance, long term durability and Green Guide A rating, with very low Global Depletion Potential.

All the materials used are conventional, readily available, cost effective and easy to replace with an A or A+ Green Guide rating.



Our Expertise to Deliver Your Project

The Sigma® II Build System is completely factory fitted and installed, using the Stewart Milne Group expert erection teams. Fully trained with specific project induction, we can deliver consistent high standards across all projects.

The only elements to then be fitted are conventional brickwork, cavity works and dry-lining, all of which utilise existing skills in a more cost effective way. As the wall system erection process is simplified, there is no complex jointing, taping or fixing issues to impact on the as built performance, following erection.

Ventilation and Solar Gain

Our new Sigma® II Build System ensures the thermal comfort of the building is in keeping with customer and occupant expectations, through design of an effective ventilation and solar gain strategy, providing high performance fabric solutions. As part of that strategy, we offer guidance on:

- Effective cross ventilation
- Passive ventilation, through the use of solar stacks and natural ventilation systems
- Mechanical ventilation and heat recovery (MVHR)
- Effective design of ventilation, maintaining flow rates
- Effective design of inlet and outlet points throughout the building
- Incorporation of surface mass, on floor, wall and/or ceiling finishes
- Cooling devices to allow exhaust ventilation of rising warm air, when required
- Appropriate proportioning of glazing to wall area
- Effective solar shading devices
- Solar orientation to optimise and balance solar gain
- Consideration of internal heat gain sources and balances
- Simple user friendly controls



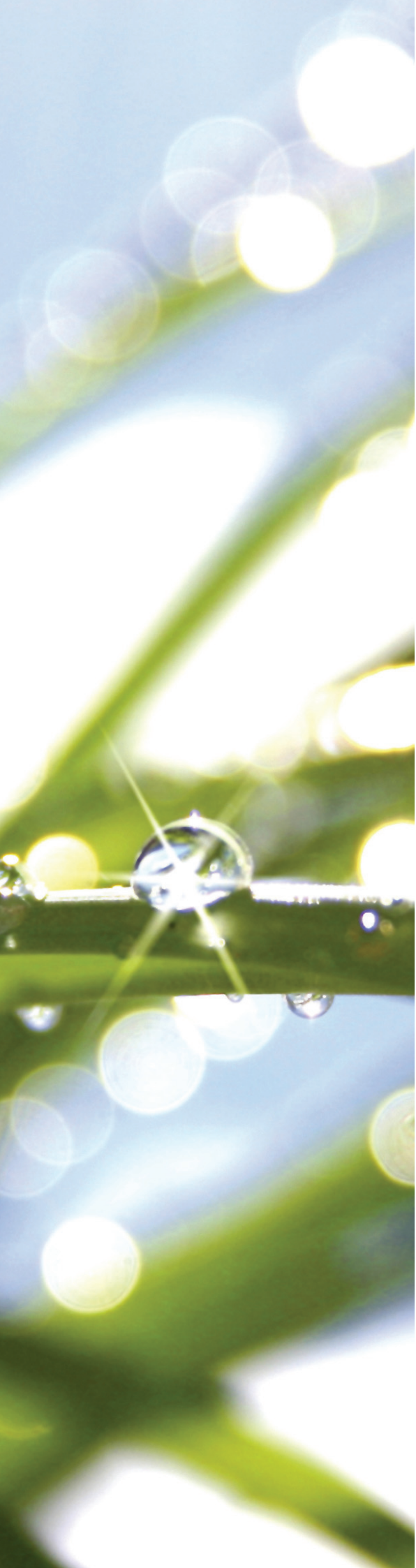
Cost Effective Solutions

The Sigma® II Build System offers reduced material related costs by adopting conventional materials, in a more innovative manner. The extent of site labour time is cost engineered through the simplification of the build system and the integration of several trades/suppliers into one package, thus eliminating non value adding site processes, which attract hidden capital cost and downstream cost overruns.

Repair, Maintenance and Longevity

The Sigma® II Build System provides a high degree of surety. The system has been reviewed by warranty providers and is fully compliant with the needs of current and forecasted future legislation, and designed for 60 year design life. The materials and skills used are all readily available and ease any concern, with finding replacement parts or making future adaptations. The Sigma® II Build System provides a “Hidden Solution”, which is not visible in the eyes of the home owner, and does not need significant aftercare, annual maintenance. It truly offers a “Fit and Forget Solution”, for achieving very low levels of energy performance.





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