



Building Solutions



INSPIRATION, INNOVATION, and INSULATION

STYROFOAM and the
Underhill House project

Introducing Underhill House and Hill Barn

This brochure documents Dow Building Solutions' involvement in the Underhill House and Hill Barn project, an inspirational and innovative development of a strikingly modern, environmentally-sustainable house under the ruins of a 300-year old barn in the UK's Cotswolds.

We set out the story of the development, highlighting how STYROFOAM™ and other products from Dow Building Solutions have been used to help turn an initial concept into a reality for a pioneering British architect and her family - **creating the first ever certified quality approved Passive House in England.**



Jayne Law, Dow Building Solutions (left)
with architect Helen Seymour-Smith.

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Overcoming planning obstacles with an ambitious design

Located in the heart of the English Cotswolds, Hill Barn was a derelict 300-year old barn situated in a prominent and beautiful location on a hillside in an Area of Outstanding Natural Beauty (AONB).

Designed to safeguard an important local environment, the AONB designation made the prospect of obtaining planning permission for any development of the barn a daunting prospect.

To address this challenge, architect Helen Seymour-Smith developed a bold and ambitious proposal which involved a breakthrough building - Underhill House - being constructed underneath and adjacent to the barn, which itself would be carefully restored and used as an office for Helen's architectural practice.

In contrast, the house - set to be home for Helen, her husband and young son - would be strikingly modern. Dug into the hill and invisible from the surrounding countryside, the development was designed to have minimal visual and environmental impact.

Despite a housing moratorium in the district of Stratford-upon-Avon, the local planning authority was impressed with the project's eco-credentials and its sensitivity to the local surroundings - and so voted to approve the proposals. However, because the development would go against local planning policy, final approval could not be achieved until the plans had been submitted to the Government Office for the West Midlands for its review.

Final planning approval was eventually achieved on 14 November 2007 and granted under paragraph 11 of PPS7, a policy which gives special dispensation for new houses in open countryside which are considered to be 'truly outstanding and ground-breaking' and reflect 'the highest standards in contemporary architecture'. Underhill House was only the 10th in the country to be granted planning under PPS7. Building work could get underway, with the first ground being turned in January 2009. So inspirational was the design concept and the unusual circumstances around the planning approvals that the build was chosen to feature on Channel 4's highly-regarded Grand Designs programme.



A truly sustainable home

Not only is the external form of Underhill House designed to minimise environmental impact, the interior form and construction materials were carefully chosen to make the building as environmentally sustainable as realistically possible.

The effort paid off for the architect, with Underhill House becoming the first in England to become a certified, quality-approved Passive House in January 2010.

Underhill House is entirely glazed to the south. The rest of it is earth-sheltered and highly-insulated, creating the perfect passive solar design. In addition, the structure of the underground house is constructed entirely from concrete, much of which has been left exposed internally to exploit the benefits of the thermal mass of the material. The basement walls, floors, and roof are all insulated with STYROFOAM-A and waterproofed externally for the same reason.

As a result of this carefully thought-through design, no manufactured energy is required to heat the building. Air tightness tests on the building - a key requirement for a structure to qualify for Passive House certification - gave impressive results, with Underhill House achieving an n50 result of 0.22 air changes an hour at 50 pascals. The Passive House requirement is 0.6 air changes an hour at 50 pascals.



The Passive House concept



The Passive House concept was developed in Germany (where it is known as Passivhaus) in the mid 1990s and is widely regarded as the world's leading standard in energy efficient construction.

The standard requires very high levels of insulation, a design that makes the most of solar energy and that creates a well-sealed building. The standard does not dictate the design or external appearance of a structure. It's simply a method of calculating the amount of insulation, glazing, thermal mass and other design properties required to make the best use of a building's solar gain and ensure that the resulting internal climate remains comfortable.

While the principles behind the Passive House concept are quite simple, exacting levels of construction quality and attention to detail are required in order to achieve the standard. This, in essence, requires impeccable quality assurance procedures for all construction materials and techniques used on the project.

Passive House buildings retain heat from passive solar gain, as well as activities such as cooking and showering, eliminating the need for central heating and resulting in a 90% reduction in energy use compared to that of an average home. The addition of renewable sources of energy can make a Passive House carbon neutral.

Although there are over 10,000 completed Passive House projects in Europe, Underhill House was the first certified Passive House in England. Certification was provided by the Scottish Passive House Centre, a leading certifier in the UK (www.sphc.co.uk).

SPHC has been very influential in the implementation and development of the Passive House standard in the UK, and provides impartial advice, consulting, training and design services to help clients implement the rigorous German Passive House energy standard.



Surrounded by STYROFOAM-A: delivering thermal performance and strength

Central to Underhill House achieving Passive House certification was the thermal performance and strength of a range of products manufactured with STYROFOAM-A blue extruded polystyrene. Produced at Dow's facility at King's Lynn in the UK, STYROFOAM-A products FLOORMATE™, ROOFMATE™ and PERIMATE™ insulate the floor, roof and basement walls of the structure.

The process of extruding polystyrene foam generates a mass of small, homogeneous closed cells which give the final product high design loads, low water absorption and excellent insulating properties. Such features mean the material can be installed outside the waterproof envelope, the right design choice when aiming for an 'envelope' of continuous insulation that minimises heat loss.

FLOORMATE 300-A proved to be the real star of the show when it came to insulating Underhill House. Because it resists moisture and has a high compressive strength, FLOORMATE 300-A is ideal for below-slab insulation, a growing practice in residential buildings and one which could support more energy efficient buildings in future.

Using the insulation in this way helps to avoid thermal bridges at floor and wall junctions and means concrete can be left exposed internally, making the most of its thermal mass properties.

Exposed concrete absorbs heat in warm weather, effectively cooling the buildings; and releases stored heat during cooler weather to provide a natural heating regime.

U-values achieved:

Floor: 0.1 W/m²K

Underground walls: 0.11 W/m²K

Roof: 0.097 W/m²K



STYROFOAM-A for tough insulation demands

As regulations around the thermal performance of buildings become tighter in the drive towards more energy-efficient buildings, insulation that can perform in demanding environments will play a vital role.

STYROFOAM-A products are manufactured in the UK using technology that takes CO₂ from industry and uses it as a blowing agent in order to create blue extruded polystyrene foam with a Global Warming Potential (GWP) of less than five.

STYROFOAM-A also maintains properties the building industry has come to rely on from STYROFOAM insulation products - lightweight yet robust performance, high strength and excellent moisture resistance, making it ideal for below-ground and exposed roof-top insulation demands.



FLOORMATE 300-A

FLOORMATE 300-A boards were laid beneath the entire floor slab of Underhill House, a growing practice in residential buildings and one which could support more energy efficient housing in future.

Because it resists moisture and is very durable with a high compressive strength, FLOORMATE 300-A is ideal for below-slab insulation, which is the right design choice when aiming for an 'envelope' of continuous insulation that minimises heat loss.

Laying insulation beneath the floor slab can help avoid thermal bridges at floor and wall junctions - a practice only possible with a product able to maintain insulating properties in such a demanding environment.

ROOFMATE SL-A

High compressive strength, excellent water resistance and long term durability make ROOFMATE the first choice of some of the UK's biggest names in roofing.

The product is the ideal solution for insulating flat, inverted roofs such as the one covering the earth-sheltered section of Underhill House, as the insulation boards are unaffected by conditions encountered in such environments, including wide fluctuations in temperature and repeated freeze/thaw cycles.

The product's rot resistance also makes it ideal for insulating green roofs - a great solution for architect Helen Seymour-Smith, as she intends to turn the roof of Underhill House into a kitchen garden and drinks terrace from where she and her family can enjoy the view over the stunning Cotswolds countryside!



ROOFMATE MinK system

ROOFMATE SL-A was used in combination with a vapour-permeable separation layer, ROOFMATE MK, on the roof of Underhill House, a system which allowed the architect to reduce the amount of insulation required to address the so-called 'rainwater cooling effect'.

Rainwater flowing between the insulation and waterproofing membrane usually requires an increase in insulation thickness in order to meet BS 6946. This increase can be substantially reduced by using the ROOFMATE MinK system, which helps to minimise the heat loss due to rainwater cooling and therefore the amount of insulation required.

PERIMATE DI-A

Insulating walls below ground requires a product that is highly-moisture resistant. PERIMATE DI-A boards have vertical channels cut into one face, to drain water away, with a filter fabric bonded to the face to prevent soil particles blocking the channels.

The below-ground walls of the earth-sheltered, Underhill House were covered with tanking membrane before being surrounded by FLOORMATE and then PERIMATE DI-A boards and backfilled.

The boards not only insulate the structure, but protect tanking material from damage from backfill material. They also drain water away from the structure, reducing hydrostatic pressure on the tanking membrane.



Adhesives and sealants

INSTA-STIK™ MP Multi-Purpose Adhesive polyurethane foam was used throughout the Underhill House construction project to adhere the STYROFOAM boards to a variety of surfaces, including concrete and waterproofing membranes.

The product can be applied both horizontally to floors and vertically to walls, and is quick and easy to use - the amount of adhesive can be regulated through the trigger and screw at the back of the applying gun, and can be applied directly to the substrate.

7-flex one component flexible polyurethane foam manufactured by Dow Building Solutions was also used to seal gaps, particularly around the triple-glazed window frames. Achieving air-tightness was key to Underhill House being awarded Passive House certification.



The architect's perspective

Why did you choose this part of the UK to create your design, and why select such a challenging site?

It's been a life-long ambition to design and build my own house - and what better place to do that than the area where you grew up? My father owns the land the original barn was built on and we used to come up here for picnics when I was a child. We can even see the church my husband and I got married in from the site, so it's a very special place for us.

Why was getting Passive House certification so important to you?

Passive House design achieves a staggering 90% energy saving compared to that of an average house, and we really believe it is the best standard available for achieving the reductions in carbon emissions that are so desperately needed.

My husband and I believe there's no excuse not to build a new structure according to Passive House standards, given 27% of the UK's carbon emissions come from residential buildings.

How did you go about choosing the materials to turn the vision into a reality?

Choosing a pre-cast concrete structure and exposing the material internally enabled us to make the most of its thermal mass properties and avoid the need for artificial heating and cooling. It was also a vital part of the design that we would have no visual impact on the surroundings, meaning an earth-sheltered building was the obvious choice.

In order to meet Passive House standards we needed a material which could maintain good thermal performance outside of the waterproofing envelope, as this would allow us to expose the concrete internally and make the most of the space.

Only extruded polystyrene insulation has the right level of moisture resistance and durability required to maintain thermal performance in such a challenging environment, and as STYROFOAM-A is the only product of its kind produced in the UK - and it has a Global Warming Potential of less than five - it was the perfect choice.



Once the concept was agreed and planning permission achieved, how technically difficult was the build?

Well, suspending a 300-year-old barn in mid-air whilst we excavated and built a brand new building beneath it was quite a challenge! This obviously required specialist help from very brave structural engineers.

Installing the pre-cast concrete sections and waterproofing also required support from specialist contractors. Installing the various STYROFOAM-A products was very easy to manage and, after initial guidance from Dow Building Solutions, all of this was managed by someone with no building experience at all!

How easy were the insulation materials to work with?

Very easy indeed. STYROFOAM-A is incredibly light and easy to shape, meaning all the various products we used could be installed very quickly. It was great to see a sea of blue being created as we installed the FLOORMATE 300-A to go beneath the concrete floor-slab, as it was the first time we started to get a real impression of the sheer size of what would be our new house.



Do you have a favourite part of the building and if so why?

I think it's the view of the house from the South. We get to see it in context of the old barn that I remember so well from childhood and how well it fits within the stunning landscape beyond.

It's fantastic to think we've been able to build the striking development that we wanted without impacting on the landscape that's so special to us, either visually or environmentally.

Do you have any advice for people looking to make their homes more sustainable?

Insulation that can perform effectively in its environment for the expected lifetime of a building is key. There's no point installing photovoltaics or a ground source heat pump if you're still leaking heat through the building fabric!

There are also lots of really simple and cost effective things that everybody should do, such as changing tungsten bulbs for low energy compact fluorescents or LEDs, and fitting low-flow and aerating taps and shower heads, for example.

Would you do this again?

I'm not sure we'll ever want to move away from here - our hearts and souls have gone into creating this building as well as a lot of blood, sweat and tears! But we hope Underhill House will inspire others and help set standards for the future.

Seymour-Smith Architects now has a stunning environment to work in and we're looking forward to showing our potential clients what you can do with a healthy dose of inspiration, a commitment to innovation - and a lot of insulation!

Visit www.styrofoam.co.uk for further information on STYROFOAM-A insulation products and adhesives and sealants from Dow Building Solutions, or email FKLMAIL@dow.com and one of the account managers will be in touch. Alternatively, please contact us at:



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