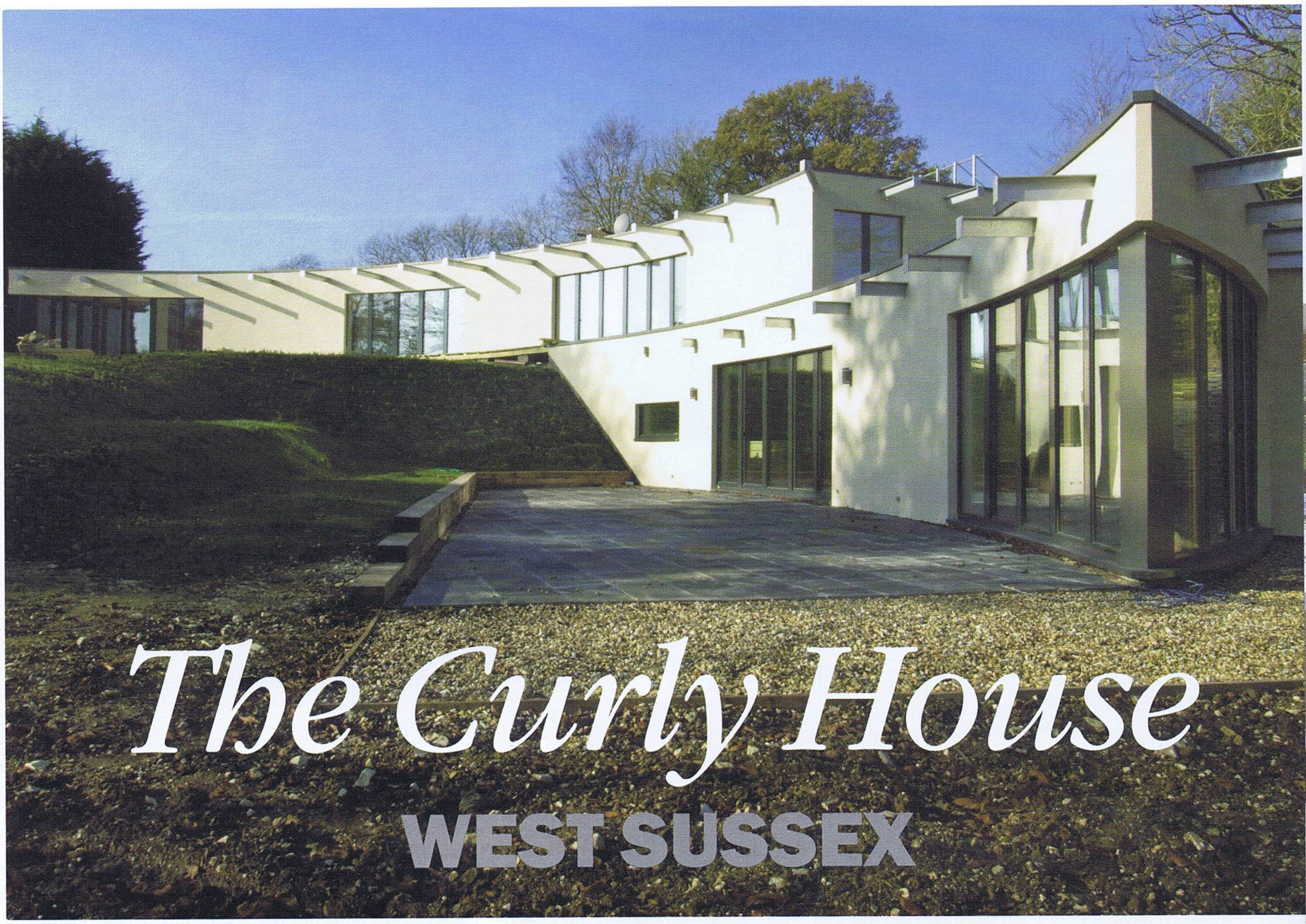

The Curly House
WEST SUSSEX

An insulated concrete formwork (ICF) building system was selected for the rebuilding of an existing cottage to Passivhaus Standards in an Area of Outstanding Natural Beauty with additional planning development restrictions. Jean-Marc Bouvier of Nudura Corporation reports

Above: The Curly House.

Below: Footprint of the house with first ICF blocks installed.

The client's brief for the project, which is known as The Curly House, was to design and build a dynamic and contemporary home measuring 410m^2 that would minimise the energy consumption and carbon footprint.

Semi-subterranean focus

Architects Ecotecture worked alongside consultant DMH Stallard to secure planning permission. A two-storey timber frame Passivhaus development had already been refused so the design was to focus on a semi-subterranean building that would meet both the local planning requirements and the client's accommodation demands.

The challenge was to design an affordable and very low energy building on a highly exposed site that is subjected to very cold winters and blisteringly hot summers. Ecotecture designed a crescent-shaped detached home that steps and slides into the slopes on the site. The building uses a mixture of three key design principles: its crescent form on plan, its stepped arrangement on the site and a curved *brise soleil*.

After considering a raft of sustainable construction options, Antoine of Kithurst Builders specified Nudura ICF for the walls and Op-Deck (thermally broken super-insulated deck system) for the floors and roof. The

Top left and right: Concrete pour for ground-floor slab.
Rest of this page: Op-Deck, an insulated slab system, was used for the floors and roof.

Op-Deck was specified to take a load of 5kN/m². The heavier construction option was chosen to provide thermal mass in order to balance the heating gains and losses due to the large areas of glazing. The insulating element of the ICF acts as a buffer to the thermal mass, allowing the slow release of heat into the building to ensure a constant internal temperature throughout the year. The semi-subterranean nature of the design also meant that materials susceptible to damp could not be considered, so no timber was used in the construction of the building envelope.

Structural engineer Dave Smart from BLB Engineers was responsible for the structural design of the building to meet Building Regulations. Reinforcement in the building was provided by vertical and horizontal reinforcement bar, lintels were designed to be poured in-situ and made up of reinforcement saddles. Due to the nature of the curved design, all reinforcement bar was shaped on-site. The use of steel beams was kept to a minimum and used only to frame the stairwell.

By combining Nudura ICF and Op-Deck it was possible to reduce thermal bridging to a minimum. It allowed the *brise soleil* main support system to be bolted back to the concrete core and the thermal bridge was further reduced by using stainless steel anchors.

Initial air tests show the property achieving 0.3 air changes per hour. By using ICF and detailed construction, the building has surpassed the air tightness standard required for Passivhaus compliance.

Constructing the building

ICF is highly suited for ease of build for both complex and curved structures, and the same system can be used for below- and above-grade walls. ICF is commonly used in North America and Canada, and Canadian Antoine had experience of ICF construction.

One issue was minimising the height of the structure without sinking the house too deeply into the ground and impacting on the costs for drainage or the need for a pumping station. To ensure the planning requirements were respected, Kithurst Builders brought on board Harry Skinner from Skinner Surveys. He provided a full GPS survey that was layered onto the CAD drawings. This allowed Kithurst to plot and monitor the exact layout and height of the building on-site. Some 250 trucks of chalk and subsoil were levelled onto the client's adjacent amenity land and reused for backfill.

Exterior and interior perspectives of the completed house.

First, the footing was poured and sealed with liquid damp-proof course ready to receive the knee-high wall. The curved section of the building was cut on-site but could have been custom-made and delivered preformed.

Some 340m^3 of concrete was required to build this 410m^2 home. The concrete specification comprised a C28/35 strength class mix with a 10mm aggregate to S3 slump class; a slump and cube test was performed on-site before each pour. Other ICF systems were not selected because the concrete cannot be vibrated within the formwork and there is no way of ensuring that there are no voids in the wall. During high-frequency vibration, air bubbles rise to the top of the concrete and voids are filled; this will reduce the level of the finished concrete by up to 75mm.

Continuous element

Once the Nudura blocks and Op-Deck floor were in place, concrete was poured into the formwork, forming the floor and walls as a continuous element. The Nudura bracing and working platform system was used to hold the formwork plumb; plywood gussets were used to reinforce straight joints in the blockwork.

With the floor and roof installed, construction of the walls continued in stages. Up to 1.115m^2 of the ICF system can be fitted in one step. Blocks are typically installed to a lift height to suit requirements: The Curly House was a 3.1m/lift. The flat roof was poured and tamped at an angle to achieve the required pitch of 10°. On pouring days during the main build, between 12 and 15 lorries continuously transported concrete to site, with one load required every 30 minutes.

The blocks arrived folded flat to reduce distribution costs and allow for easy handling and on-site storage. A four-way reversible interlock enabled sturdy construction and waste was almost eliminated. Safe and quick to install, no accidents were recorded on-site.

The north façade facing the road was finished using flint to mirror traditional local architecture. The remaining façades were rendered in off-white.

Heating typically accounts for approximately 60% of energy usage/costs in a dwelling. The Curly House demand has been modelled in IES thermal analysis software and based on actual consumption in late 2011; predicted heat demand is 3kWh/m^2/year. Compared with an average UK home in 2003, the ICF system has reduced energy demand by 98% and, to today's Passivhaus Standards, by some 80%. The project has been uploaded to the low-energy buildings database and, with the building now occupied, data being fed in.

Balance of temperatures

Jake White from Ecotecture describes how the concrete core within the ICF plays an important role in the balance of temperatures in the building, "When we first saw the system, we were not convinced that the product used its thermal mass in the most effective way. We were heavily reliant on Kithurst Builders' product experience and we are glad this is where we placed our trust.

"We now understand that having the core locked away from the internal environment has a positive effect on the temperature in the building. The issue with exposed thermal mass is that it can quite easily cause a feedback loop, each night emitting slightly less than the amount absorbed during the daytime. Using thermal mass that is isolated in this way increases the lag between absorption and re-emission. This is great for ironing out spikes of unusually hot October weather."

He adds, "This home will be passed from generation to generation, with practically no running cost. It's likely to be unaffected by fuel hikes and provides a healthy and comfortable environment."

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