Insulating concrete forms

Insulating concrete forms (ICFs) are proprietary modular units in the form of interlocking blocks or panels, made from polystyrene or polyurethane foam and filled with concrete.

Initially developed in Europe in the first half of the 20th century, the technique evolved rapidly in the 1960s with the use of modern foam plastics. During the last three decades, tens of thousands of ICF houses have been built in Europe and North America. Since its introduction into Australia in the 1980s, hundreds of ICF homes have been built here.

Insulating concrete form construction suits building designs with strong, simple lines.

ICFs create predictable high performance walls in which substantial thermal mass and structural support is contained in easily stacked and joined insulation. The sealed nature of the construction and the high levels of insulation make this method particularly suited to projects seeking to achieve the very high levels of performance benchmarked by programs like the increasingly influential 'passive house'.

Performance summary

Appearance

The appearance of finished ICF structures is determined by the render or facing materials used to cover the foam plastic formwork.

Structural capability

Typical ICF construction consists of fire-retardant polystyrene foam plastic blocks or wall panels that are interlocking and self-supporting and act as formwork for poured concrete. Some systems simply interlock blocks on corners, like traditional bricks, while others provide purpose-made corner blocks.

ICF's self-supporting blocks lock together to create a structure strong enough to hold poured concrete.

When the self-supporting blocks lock together they create a structure strong enough to withstand the pressure of poured concrete. The concrete, once it sets, provides the loadbearing structural capacity of the system. Reinforcement is placed within the formwork as needed. With some systems (e.g. Formcraft) reinforcement is laid on connectors that link the outer and inner skins of foam sheeting; in others (e.g. Thermacell) it is laid on the cross-linking elements of expanded polystyrene blockwork.

One typical variant of ICF construction consists of foam panels, sized to suit standard window head and floor heights, joined across a cavity with regular banks of connectors.

ICF flooring can reportedly weigh up to 40% less than conventional concrete flooring. It can be laid as independent decking or designed to form a continuous reinforced structure with the walls. The same approach can be used for constructing roof decks.

Timber flooring is also an option for use with ICF walling.

Passive house design

The design of a passive house aims to achieve ultra-low energy use with near zero emissions. The basic concept is to create an economical, tightly sealed, highly insulated building envelope through which all energy and airflows can be closely controlled to create continuous comfort for the building's occupants using sustainable energy. Mechanical ventilation with heat recovery is commonly used.

Conceived in 1988, the passive house concept is not copyrighted or controlled. Working with the services of an architect or design professional, anyone can seek to make their home project achieve passive house performance level. However, take care to recognise that in many Australian climate conditions the biggest problem of any highly insulated, well-sealed building is its propensity to overheat.

Thermal mass

The thermal mass in the ICF system is contained by insulation. The effect of this mass is to provide a stable core temperature to the ICF structure.

Insulation

The level of insulation provided by ICF construction depends on the type of ICF units used and the thickness of insulation in those units but it is often greater than R3. One of the German ICF products distributed in North America is available in insulation ratings ranging from R6 to R15. In Australia the insulation levels achieved in ICF construction tend to be in the range of R3 to R6 (see *Insulation*).

Sound insulation

The combination of rigid foam insulation with the mass of concrete and generally airtight construction makes ICF a good sound insulator with typical 300mm walls delivering a sound transmission class (STC) rating of around 48 (see the appendix *Noise control*).

Fire resistance

Polystyrene and polyurethane foam do not burn and support flame or fuel fire, but they do melt and release toxic fumes — reportedly no worse than the toxins released by burning wood. However, they are located behind layers of plasterboard or render or similar high density finishes that protect the foam from immediate heat. In addition, it is usual for manufacturers to add flame retardant to the expanded polystyrene, making it virtually self-extinguishing. The concrete structure within the forms is non-combustible and protected by the insulated forms. Altogether, the fire resistance is very good, with tests demonstrating that ICF foam does not support the spread of flame nearly as well as wood.

For ICF construction to achieve an acceptable fire rating, it must be lined with fire-rated plasterboard or similar material.

Vermin resistance

The foam insulation offers no food value to rodents or insects and tends not to attract or harbour infestation; however, as polystyrene foam insulation can provide easy passage for insects, some manufacturers treat blocks with insecticide to counter this problem.

Durability and moisture resistance

The materials that make up ICF construction will normally suffer little or no degradation over the life of a building and ICF's estimated durability is excellent.

The iconic image of a single house left standing after Hurricane Katrina was of an ICF home.

The inorganic nature of the materials means that they do not support mould growth. In a properly detailed and constructed ICF building there should be no points of entry for moisture to the structural elements and the foam insulation is impervious to moisture.

Houses constructed with ICF have a proven resistance to earthquakes, cyclones, fires and other natural hazards — the iconic image of a single house left standing after Hurricane Katrina was of an ICF home.

Toxicity and breathability

There may be some toxic outputs in the manufacture of the polystyrene or polyurethane foam but the materials in ICF are non-toxic in its manufactured and completed state. The plastic foam is non-breathable and does not allow moisture or air penetration. Because there are no cavities or other voids in ICF construction, there is almost no potential for moisture penetration or condensation in any structural elements.

Environmental impacts

ICF uses concrete (the manufacture of which is one of the largest single contributors to climate change), plastic derived from oil (the production of which is peaking and for which costs are bound to rise) and steel. However, all building construction uses these materials to a greater or lesser extent and their use in ICF is, arguably, a highly responsible way of using limited resources for long-life, energy efficient structures.

As ICF has a very long life, the energy investment is recouped over many decades. Industry sources report that the energy saving attributable to ICF means that, compared with conventional construction methods such as brick veneer, ICF effectively recoups its own energy cost of manufacture within 12 months.

Buildability, availability and cost

A typical polystyrene block is 300mm high, 200–300mm wide and 1200mm long. It is very light and easy to handle and needs no gluing to join with its neighbour. Once the forms have been stacked and reinforcement is in place, a concrete pump is needed to pour a consistent and continuous flow of concrete into the forms.

The buildability of ICF is a consequence of its modular, kit-of-parts construction and use of well-proven construction machinery. With little need for on-site adjustment and change, construction is generally faster than most other building methods.

There are manufacturers across Australia and the products are widely available. Costs depend on the type of system used and, in particular, the wall thickness specified.

Concrete being pumped into the blockwork.

Typical domestic construction

Construction process

The construction of most ICF buildings is fundamentally a process of stacking lightweight blocks together in a similar manner to children's building bricks, laying reinforcement where necessary, and pouring concrete into the voids of the blockwork. It does not call for the same skill set as solid brick or brick veneer construction.

Footings

The footings for ICF buildings are usually reinforced concrete rafts or strips that are flat and even enough to enable stacking of the foam blocks, with reinforcement starter bars set ready to connect with the concrete when poured into the formwork.

Loadbearing walls

Any ICF wall can be designed to be loadbearing.

Joints and connections

Joints and connections with other building elements are kept to a minimum, especially when the flooring or roofing elements are also made from ICF.

Fixings

The foam blockwork or formwork forms a poor basis for any fixings. Light loads are generally carried by the lining or facing materials, such as plasterboard, and heavier loads can be carried by supporting points drilled into the concrete that forms the inner material of the ICF.

Openings

Major openings for doorways, windows, etc., need to be set out in the formwork as it is relatively difficult to make changes later, owing to the fundamentally monolithic nature of the structural elements.

Once openings have been made, they can accommodate window and door frames of any type. A typical kind of fixing uses timber blocks set into the ends of the ICF blocks around the opening.

Electrical conduit and plumbing is generally run in chasing in the depth of the foam formwork.

Finishes

Finishes are dependent on the materials used to face the ICF units. Typically, the main finish is a render or render-equivalent covering or paint. Any additional cladding can be added to the ICF walls subject to making appropriate supports for it, although many sheet finishes, such as plasterboard, can be glued directly to the surface of the formwork.

External renders require a base or skim coat embedded with fibreglass mesh, followed by a second coat and then a texture coating, finally finished with an 'armour coat'.

Things to watch out for

The lack of industry standardisation means that although the basic principles of ICF construction are the same, every ICF system is different.

- When the concrete is drying out it may release sufficient water vapour to affect absorbent materials like plasterboard, and this should be factored into project timing.
- Building with ICF is a precise process with smaller margins for error than conventional or traditional construction allows.
- Modification of the structure after completion requires the use of specialist tools.

References and further reading

Eco Block Pty Ltd. www.eco-blockaustralia.com.au

Formcraft Pty Ltd. www.formcraft.com.au

Thermacell Australia. www.thermacell.com.au

Zego Pty Ltd. www.zego.com.au

greendesignetc.net

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