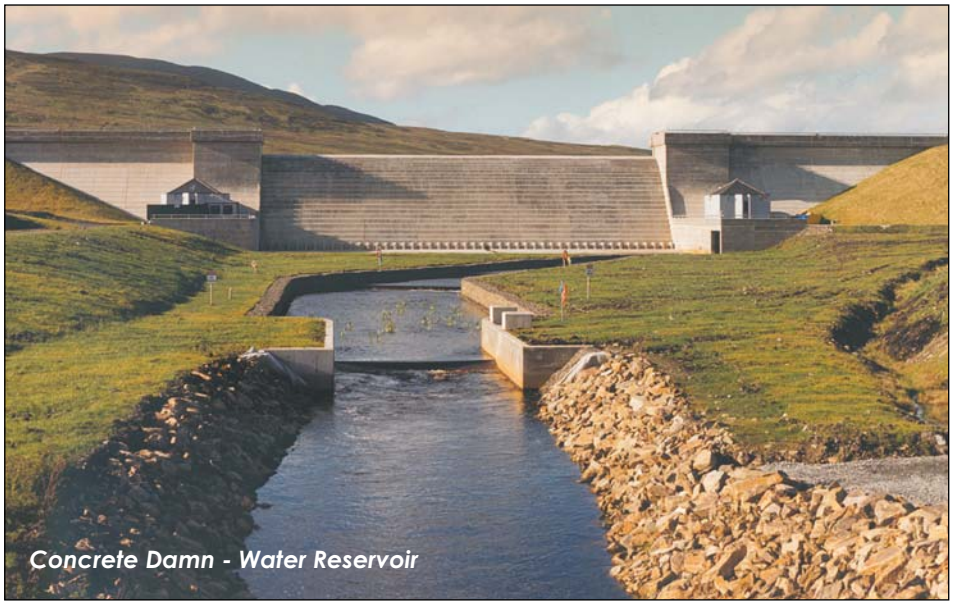
Concrete and Sustainability

by Brian Ó Murchú

The concept of sustainabile development is based on economic, social and environmental considerations which are often referred to as the three 'pillars' of sustainable development.

The role played by concrete in sustainable development is the subject of a great deal of misunderstanding. As a matter of historical fact, concrete has far better sustainability credentials than any other building material. After water, concrete is the most used material on earth. The reason for this is because it is the most cost efficient, durable, structurally efficient and flexible material. It is exactly because of its ability to contribute to Economic and Social well being - two of the three underlying pillars of sustainability, that concrete has been chosen world wide as the most proficient material for construction and civil engineering works. It may come as a surprise to many that concrete also has considerable credentials as an environmentally friendly material. This article will specifically address the environmental aspects of concrete.

In Ireland and worldwide, concrete makes a far greater contribution to sustainable development than any other building material. Damns, fresh water supplies, roads, bridges, sanitation, tunnels, transportation and all types of civil engineering and construction projects, including housing and commercial and industrial buildings are all delivered using concrete as the primary material. In many cases there are few if any realistic alternatives, since other materials simply cannot technically or economically meet the required performance criteria. Indeed, highlighting concrete's significant 'sustainability credentials' is far from overstating its importance. It is not and exaggeration to say that the development of concrete in all its diverse forms has accelerated the rise of modern civilisation and civic society.



Concrete Damn - Water Reservoir

Irish people are well disposed towards concrete construction, partially because the housing stock is predominantly constituted of concrete block, floors etc. which are known to be durable and virtually problem free. But there are other reasons why concrete is popular in Ireland. Compared to any other country in Europe we have substantially more resources per capita of the constituent materials which go into the manufacture of concrete. For this reason concrete is produced on a local basis and generally delivered within a radius of 30 miles with the resulting savings in the fossil fuel consumption associated with transport.

Restored Quarry Site with 9 Hole Golf Course and Fishing Lake Stocked with Trout and Carp

The popularity of concrete in Ireland is due substantially to its incredible proficiency and flexibility as a building material. Concrete is inherently durable, has inherent fire resistance, sound proofing and thermal properties. In layman's terms concrete does not warp, rust, rot or burn. Its popularity is also determined by concrete's suitability to our climatic conditions and to the absence of alternative 'native' materials. For example, despite very substantial funding both in tree planting and the construction of two major timber processing plants in Waterford and Leitrim, as little as 5% of Irish timber is suitable for use in construction in Ireland. Most of Ireland's timber is imported over long distances from South America, Russia and the Baltic States with very high transport costs and the accompanying fossil fuel consumption. In addition, Ireland is the largest importer of hardwood in Europe, much of it from endangered forest in the developing world. In short, much of logic which applies to the use of timber in some parts of the world, where native materials are suitable for construction purposes, does not apply in Ireland.

Of course, this is not to detract from the important role which timber can and does play as a key element in mixed construction in the Irish context.

While having to concede that concrete has made the single most important contribution in terms of social and economic well being, some will criticise concrete for its environmental performance. This criticism is generally speaking poorly informed.

Concrete is a low energy material

Embodied energy is a useful 'eco-scorecard' for comparing energy used in producing building materials and components. It includes extraction, manufacture, transport, building, maintenance and re-use. Embodied energy is expressed as energy per unit mass (GJ/tonne), or energy per unit floor area for a completed building (GJ/m^2) per unit floor area.

Embodied energy is separate from operational (in-use) energy, which can account for almost all of the energy used in a building. To put this into context, for a four to six storey building over 60 years, total operational energy is about 70GJ/m^2, whereas embodied energy in the structure is only about 3 GJ/ m^2. In simple terms this means that the thermal performance of the building is the crucial factor in determining the eco performance and this is where concrete excels.

On a purely mass basis, the manufacture of structural steel is about 30 times more energy consuming than reinforced concrete, but this comparison is less appropriate when comparing structural elements. Nevertheless, for a range of typical structures, reinforced concrete construction gives a better than average performance at 1.5 to 2.5 GJ/ m^2, compared with structural steel alternatives which range from 2.6 to 2.9 GJ/ m^2.

Embodied energy values typically take into account the energy and impacts associated with transportation. Concrete produced in Ireland does not rely on any imported products, whereas other structural materials, such as steel and timber are often imported from great distances.

Emissions

Production of building materials may also be compared with regard to their contribution to carbon dioxide emissions. This is expressed in kg of carbon dioxide produced per tonne of material and is useful because it can be compared with other activities such as traffic emissions and operational energy. On a purely mass basis, the carbon dioxide produced per tonne of structural steel is about 10 times greater than for reinforced concrete.

Thermal Mass

The 'thermal mass' of concrete, often referred to as 'fabric energy storage' can produce huge energy savings over the life of the building. In assessing concrete's sustainability credentials the importance of the 'thermal mass' is highly significant since the main energy consumption is expended in heating and cooling the building throughout its life cycle. On average 90% of the total embodied energy in a building is 'in-use' heating and cooling energy. Only 10% is related to the construction of the building. Designing with energy in mind can reduce in-use energy costs by up to 75%.

Whereas heating is an important cost factor in domestic buildings, the reverse is often true in office and commercial buildings where, lighting, computers and people create overheating. To counteract this, designers using light-weight construction methods, plasterboard, ceiling tiles, insulated panels etc., often have to install expensive air handling units. Using exposed concrete, as leading Irish Architects and Engineers have done in recent civic buildings, can reduce day time temperatures by 3°C to 4°C and delay temperature peaks by up to six hours. Using exposed concrete as an 'active system' offers up to 50% reduction in carbon dioxide emissions and 20% reduction in initial building costs.

Alternatively, water can be used as an 'active' concrete system, as an effective cooling or heating medium. Embedded pipes in floor slabs can achieve a cooling capacity of 64W/m^2. Other saving to be made by using exposed concrete soffits include savings in overall building height through the elimination of suspended ceilings which can deliver savings of 5% to 7% on construction costs.

Designing For Comfort and Efficiency

A recent study into the effect of the new Part L of the building regulations (thermal insulation) carried out by the Energy Research Group in UCD on behalf of the Irish Concrete Federation, established that **'all forms of concrete block construction can easily meet the new Technical Guidance documents (TGD) part L'**, even when the most stringent method of calculation (the elemental method) is used. A similar independent Cost Study by DLPKS Quantity Surveyors based on 5 different wall types established that the additional cost for a typical cavity wall house is €479.60. These independent reports are evidence of the ability of masonry construction to meet the most stringent energy ratings with minimum costs. The ICF's own investigations suggest that costs for masonry compliance with part L is in fact less than for alternative methods of construction.

It is sometimes suggested that some non-masonry methods of wall construction can have better thermal performance, but no evidence of any substance has been put into the public arena to back these claims up. It is well known that constructions which heat up quicker also cool down quicker, leading to expensive on-off patterns of heating. By storing heat for a period of up to 6 hours, concrete blocks and floors can moderate the temperature in the home, using more efficient heating patterns.

The performance of walls is determined primarily by the K-value of the insulation used and concrete block walls can accommodate the highest performing insulations. Another significant factor contributing to heat loss is 'airtightness'. Junctions between different materials are vulnerable, but the worst cases of low 'airtightness' are often seen in lightweight frame houses, which can be leaky unless designed and built with great care. With concrete it is easy to achieve airtightness. Several types of concrete homes have airtighness rates better than the demanding Swedish design benchmark of 2.88m^3/m^{2}hr @50 Pa. In comparison, typical rates for timber and steel buildings vary from 10 to 30m^3/m^{2}hr @50 Pa.

Towards a Sustainable Housing Stock

The worlds population is predicted to reach 10 billion in 2050 with 70% of people living in urban areas, almost twice the current number. Ireland's population has grown in recent years, based primarily on the return of immigrants and the arrival of new ethnic groups. There is a growing

awareness that our land mass is small and that sustainable practices in relation to the use of building land are required if our country is to retain at least some of its internationally renowned unspoiled beauty. In practical terms this means that ribbon development must be controlled and that people must live closer together in apartment dwellings. More than any other construction material, the inherent properties of concrete make it the ideal construction material for close proximity living.

Living closer together puts a far greater emphasis on fire safety and sound proofing in particular. Whereas many building materials contribute to fire and sound transmission, concrete has inherent fire and soundproofing properties. The importance of 'inherent' properties cannot be overemphasised since even the smallest breech of fire protection materials, such as plasterboard at a sink outlet or plastic wall sockets, puts the entire structure at risk in the event of fire.

In addition, concrete blocks and floors offer the best performance in relation to fire and sound transmission, producing safer, quieter homes. Building in concrete block avoids the use of 'stud partition' party walls which are often unpopular with homeowners and apartment dwellers. Tests on actual wall construction shows that 100mm concrete block walls achieve between 41db and 45db sound reduction compared to 31db to 35db for standard timber stud partitions. In layman's terms this means that concrete blocks offer approximately twice the sound reduction of standard timber studs. Similarly tests show the airborne sound insulation of a concrete upstairs floor to be in the range of 47db to 52db. A standard timber floor in a comparative test has a rating of only 30db to 38db.

The use of concrete upper floors in housing has significant advantages in the event of fire. Timber floors are typically supported on joist hangers, effectively leaving a 'straight through joint' between the upstairs and downstairs which can be vulnerable in the event of fire. In contrast, precast concrete upper floors supported on concrete blocks have a minimum 100mm overlap joint. The addition of a standard fire door to this construction creates a 'fire compartment' which is the safest and most desirable method of containing fire. This type of safe construction is used extensively in continental Europe where high safety standards apply. Using masonry/concrete construction, Irish designers can adopt similar safety standards at little or no extra cost, while at the same time contributing to a safer more sustainable housing stock. In this context, pressures from industry to adopt prefabricated lightweight housing should be considered in terms of the 'long term performance of the housing stock' rather than short term expedience. In terms of sustainability, concrete out performs all other building materials and this is why concrete is the main material used in the majority of sustainable housing developments.


Concrete Homes - More Energy Efficient

Better use of land also involves the maximisation of floor space. Looking at current house designs, the most obvious opportunity for the maximisation of floor space is development of the attic space and basements. Attic spaces can best be developed by the use of precast concrete floors as an alternative to attic joists, while the development of basements is a possibility in concrete construction only.

Concrete buildings have proven themselves over many years to be able to withstand Irish weather conditions, flooding and even fire. The latter is important both in terms of human life and damage to property. Evidence demonstrating the superior fire performance of masonry compared to timber construction is readily available as a result of scientifically monitored fire tests which were carried out in Ireland in 1981,1982 and 1984. Both scientific tests and observed performance over many years, suggests that masonry built buildings/houses have a high level of 'rebuildability' in the event of fire.

It has been shown that in the vast majority of cases where masonry built houses have been subject to fire that the main load bearing structure is not adversely affected. The opposite is true of timber and steel framed houses where damage to the structural frame which supports the floor and roof almost always requires the dismantling of the entire structure, including the external block and brickwork. Sustainability, demands that a structure must be able to reasonably withstand adverse weather conditions and offer a high degree of safety. In this respect concrete has demonstrable sustainability.

Recycling

In addition, to its many positive attributes as a sustainable material, concrete is 100% recyclable. Unlike liquids such as oil/petrol which are transformed to energy and gases in the process of combustion, the constituent materials of concrete are not lost in the process of hydration. Crushing the concrete retrieves the stone which can be re-used. In this respect the recent report by the Construction and Demolition Waste Management Group which will lay the foundations for greater recycling of construction material is to be welcomed. Recycling concrete is a real prospect and is essentially an organisational matter. Indeed some forms of Concrete such as Precast are particularly efficient in environmental terms, virtually eliminating the presence of waste concrete during the construction process.

The Sustainability Debate

Despite genuine and valid public concerns in relation to the environment, much of the debate in Ireland and Europe is strongly influenced (and distorted) by commercial and political interests. Much of what passes for environmental comment and debate is 'Maltusian', partisan and lacking in scientific rigour. The debate on sustainable construction in Ireland would be significantly enhanced by a thoroughly scientific, non-partisan approach. However, there are few signs that such a debate can take place in the near future given the general level of confusion that presently exists and the negative influence of a combination commercial forces and political interests.