DESIGNING LOW-CARBON CONCRETE BASEMENTS

Basements and below-ground structures are a vital part of using land efficiently, offering designers the opportunity to create energy-efficient spaces with a range of potential uses. Concrete is the most common material used for constructing basements and its inherent properties of durability, resistance to water and robustness are key factors in its popularity. Its use has additional benefits including its thermal mass and the opportunity to optimise mix specification. **Emily Halliwell** of **The Concrete Centre** and **The Basement Information Centre** discusses the factors designers should consider to achieve low-carbon basement designs.

(Photos: Newton Waterproofing and Arti Construction.)

ABOVE: Flexible basement space for a new community centre.

Optimising the design of structures is vital to achieving material-efficient designs which lead to lower embodied carbon. For below-ground structures and foundations, the ground conditions and site geometry will be key design drivers. As part of preparing for construction, sites will be levelled and the top layers of soil are typically removed. The depth removed will depend on the soil type, including any contamination, and the foundation design. For example, where shallow foundations are used, it may be necessary to excavate a significant depth of made ground to reach competent ground for the footings. In this case, it may be possible to make use of this excavated space by constructing a basement. The footings may be integrated with or replaced by the basement slab, thus optimising the design.

Similarly, on sloping sites, designers have the option either to build at the higher level, using a podium or infill beneath the building, or to build into the slope. Since building up will likely require excavation below the building for foundations, this excavated space may instead be used as a partial basement, within the slope.

Generally, these approaches may be used to create a single-storey basement but deeper basements require more consideration. In particular, if groundwater is present, a deeper basement may require tension piles or a deep raft to resist buoyancy forces, although these can be off-set by the weight of the building above.

WATERPROOFING STRATEGY

The waterproofing strategy is a key consideration for basement designs to ensure the internal space meets the performance requirements. BS 8102[1] outlines three methods of waterproofing, which are: Type A – barrier protection, Type B – structurally integral protection and Type C – drained protection. The optimum solution will depend on the ground conditions including groundwater, the proposed use and type of structure, and the consequences of a failure. To achieve a low-carbon solution, the embodied and operational carbon of the different options should be considered. Type B protection is typically achieved through limiting crack widths in the concrete structure and additional reinforcement is often required to control the cracking. The embodied carbon of the extra reinforcement may be compared with the embodied carbon associated with the membranes, liners and drainage systems required by Type A and Type C. Additionally, Type C systems often include pumps and monitoring systems which will have associated operational carbon. While designers should consider ways to reduce carbon associated with waterproofing systems, it is vital that the long-term performance requirements are met.

LOW-CARBON CONCRETE

In a basement, typically the walls and floor will be formed of concrete and the structure will be the largest contributor to the embodied carbon. Specifying a lower-carbon concrete is therefore the main opportunity for designers to lower the embodied carbon of the basement. It is useful to note that improving the water resistance of a concrete is usually achieved through limiting crack widths and better crack control can be achieved using cement with high levels of GGBS, due to the lower heat of hydration. GGBS is a cementitious material that is commonly used to lower the carbon footprint of concrete and therefore in cases where crack widths are critical, it can serve a dual purpose of reducing embodied carbon and improving crack control. A cement with 50% GGBS can reduce the embodied carbon of the concrete by over 40% when compared with a CEM I concrete.

THERMAL PERFORMANCE

Basements are energy-efficient spaces where the thermal mass of the structure may be used as part of the strategy to control temperatures within the building. The heavyweight nature of concrete construction can be utilised to naturally regulate the internal temperature of the basement and for small buildings, it can be part of an energy-efficient strategy for controlling the temperature of the whole building. The Met Office has projected average daily temperature rises throughout the UK, indicating the increasing need for passive methods to cool buildings, which basements are well placed to provide. The risk of overheating is recognised as a growing health risk and the creation of naturally cooled spaces is becoming increasingly essential.

Typically, the walls of a basement will be externally insulated (with externally applied rigid insulation material), which means the thermal mass may be fully optimised as the concrete structure can absorb and release heat within the space. This requires a suitable surface finish that will conduct heat freely, such as wet plaster, paint or visual concrete. Waterproofing strategies involving internal membranes or cavity drain systems may reduce the effectiveness of thermal mass in the concrete structure. However, in projects where the inner leaf is made of masonry or concrete, the thermal mass of this may be used, providing it has a suitable surface finish. The use of visual concrete offers potential cost, carbon and programming benefits, by omitting the need for subsequent use of finishing materials and trades, along with the associated waste produced on-site.

Controlling air permeability is identified as a key feature of improving the energy efficiency of the building fabric. This is easy to achieve with basements since the structure is below ground and typically also has an impermeable waterproofing layer.

RIGHT: New-build home set into a hillside.

ADDED BENEFITS

Basements give designers the opportunity to maximise usable space and deliver flexible, desirable spaces with excellent thermal performance. A concrete structure brings added benefits of inherent durability, water resistance, robustness and thermal mass. As with all construction, achieving low-carbon designs requires consideration of the whole life of the scheme and for basements, their longevity and energy efficiency are key to their role in low-carbon design.

Reference:

1. BRITISH STANDARDS INSTITUTION, BS 8102. *Code of practice for protection of below ground structures against water from the ground*. BSI, London, 2009.

BELOW: A basement sports bar nearing completion.

(Photo: Delta Registered Installers Network.)