EXPERT VIEW

Watertight considerations

A key consideration in the design and construction of basements is the degree of water tightness required and whether or not water proofing systems are necessary, writes **Tim Murnane**

From a basement design perspective, the crucial first question to be answered by a client is: "What is the basement's proposed use"? The answer to this question will determine appropriate watertightness design levels.

Basement watertightness levels are categorized from grades 1 to 4 (see table). It is very important that a client has a full appreciation of what each grade corresponds to when deciding on which one to use. For example, a car park may not need to be totally free from some water leaks, particularly if it is a private car park where the users are familiar with it. On the other hand, if it is a car park for a retail development which is frequented by large numbers of people the requirements may be more onerous with respect to water ingress. And if it is habitable space, water ingress and indeed the presence of elevated moisture content in the air will not be acceptable.

Leak

Basements leak because the external water table level is higher than the level of the basement slab. The height difference between the external water table and the basement slab determines the water pressure and the higher this water pressure is the greater the risk of water leaking through the concrete slab.

Preventing Water Ingress

There are two primary means of ensuring water ingress to a basement is avoided:

Keep the external water level below the level of the basement slab

Keeping the water table level below that of the basement slab is not easily achieved. If the basement is in a rural setting it may be possible to positively drain the water into a local authority approved water course. In an urban setting keeping the water table level down is likely to require pumping of ground water into the sewerage system and this is not allowed by local authorities as it is a highly unsustainable solution.

Design and construct the basement structure so to prevent water from penetrating through it

Designing the basement structure to prevent water penetration is the most common solution. And there are several ways of doing this depending on the grade of basement required.

Water Tight Concrete

Concrete by the very nature of its material composition has inherent water proofing properties. However, these break down for various reasons such as nominal cracking of the slab due to thermal, shrinkage and flexural cracking. Reinforcement in the reinforced concrete slab/wall ensures concrete cracking is controlled. The extent to which reinforcement is provided has a direct impact on the concrete cracks and by extension water ingress. General reinforced concrete design is to BS 8110 "Structural Use of Concrete" and this code limits concrete crack widths to 0.3mm. For a grade 1 basement as defined in BS 8102 "Protection of Structures against Water Ingress from the Ground" this size crack width is considered adequate to ensure nominal water ingress only occurs. For grade 2 basements the concrete crack widths are required to be reduced to 0.2mm. This is achieved by designing the concrete structure using the code BS 8007 "Design of Concrete Structures for Retaining Aqueous Liquids".

It should be noted that even with cracks widths limited to 0.2mm, some water ingress can still occur. However, over a period of time, the passage of water causes a chemical reaction with the concrete and a process known as "autogenous healing" of the concrete occurs, whereby the concrete crack effectively "heals" itself and the passage of water is stopped.

Concrete Pour Size and Workmanship

There are a number of other critical factors impacting on a basement's concrete structure resisting the penetration of water. The primary ones being concrete pour size and the quality of the workmanship.

In a basement slab or wall a critical factor in limiting shrinkage cracking is the size of the concrete pour. The larger the pour the greater the resulting crack widths will be due to greater shrinkage. Hence, smaller pours are essential to limit this. However, it is ironic that while smaller pour sizes help to address one area of risk with respect to watertightness, they do mean that there are more joints in the concrete structure. Considering the correct watertightness of joints is a direct function of the quality of the workmanship it receives, joints are always a key vulnerable area for water leaks. Hence, strict quality control on site by the contractor is critical if leaks are to be avoided, not just at joints but throughout the basement slab and walls. Additionally, high quality workmanship generally is crucial in constructing water retaining structures.

Waterproofing Membranes

Relying solely on the concrete as a means for preventing water leaks presents risks due to the nature of concrete and the varying degrees to which it can be impacted by quality issues. In effect the success or otherwise of a basement's concrete structure being watertight is only as strong as its weakest link. One poorly formed construction joint; one poorly compacted section of slab or one poorly tied section of reinforcement can result in a water leak/leaks. Hence, if this risk is not considered acceptable by the client, tanking of the basement is an option to provide added

security against water leaks. This involves a water proofing membrane being "wrapped" around the concrete structure. There are many types of water proofing membranes but they all generally prevent water ingress by reacting with water and swelling to form an impervious layer. Again these products tend to be very sensitive to the quality of workmanship which they are subjected to and inadequately applied products will not guarantee water leaks are avoided.

Cavity Drain Systems

For situations where the complete absence of moisture in the air is required such as archive storage a grade 4 basement is necessary. This grade of watertightness is only achieved by ensuring the element of structure which is in contact with the external water is separated from the internal environment by a ventilated cavity. The cavity ensures complete separation and also provides a space where any moisture that does penetrate the external concrete element can be captured and drained away. Additionally the provision of ventilation in the cavity ensures moisture build up is avoided and guarantees a moisture free internal space. ■

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THE NUMBERS

Basement grade definitions

Grade of Basement	Basement Usage	Performance Level	Form of Protection
Grade 1 (basic utility)	Car parking: plant rooms (excluding electrical equipment):	Some seepage and	Reinforced concrete design in accordance with BS8110
Grade 2 (better utility)	Workshops and Plant rooms requiring drier environment :	No water penetration but moisture vapour tolerable	Reinforced concrete design in accordance with BS8007
Grade 3 (habitable)	Ventilated residential and working areas including offices, restaurants etc., leisure centres	Dry environmental	With reinforced concrete design to BS8007. Additionally wall and floor cavity and DPM
Grade 4 (special)	Archives and stores requiring controlled environment	Totally dry environment	With reinforced concrete design to BS8007 plus a vapour-proof membrane Also ventilated wall cavity and vapour barrier to inner skin and floor cavity with DPM

Case study Intensive care given to new RSCI facility

The Patient

When completed, the almost 8,000m² new Royal College of Surgeons educational and research facility, at York Street, Dublin 2, its architect Brian O'Halloran & Associates and consulting engineer JB Barry & Partners, will have five floors overground and four floors below ground level, excluding substructure, with an estimated construction cost of €23 million. The basement depth is 17 metres and the sub-structure will be exposed to negative water pressure in excess of nine bar.

The Diagnosis

As the sub-structure is to be exposed to very high levels of negative water pressure (> nine bar), the choice of structural waterproofing system was critical and had to be able to withstand very high water pressure and maintain its integrity. The system needed to be flexible enough to meet the demanding challenges of the sub-structure construction. Quality and confidence in the efficacy of the system was an important factor in the specification decision and all component products of the overall system had to carry CE certification and have a visible track record of performing in these demanding conditions.

The Remedy

As the system had to have flexibility, IBC, one of Ireland's leading suppliers of structural waterproofing systems, decided to incorporate various waterproofing technologies rather than be limited to one proprietary technology. One of the key characteristics of the specified materials was their ability to be applied in all weather conditions. The first decision was to use CEMtobent CS Plus, a unique three layer geocomposite clay liner (GCL) bentonite membrane as a waterproof barrier for the walls and floor slabs. The CEMtobent CS Plus is placed at the water-side of the reinforced concrete and becomes active in contact with the water. When unconfined bentonite comes in contact with water it is capable of swelling to more than 12 times its dry volume. The CEMtobent CS Plus system ensures there is controlled swelling of the bentonite and therefore providing a dense, impervious waterproof membrane. CEMtobent CS Plus can also be applied in any weather conditions, is root resistant and most importantly radon-tight. The ground anchors were detailed with Maxseal Super; cement based waterproof coating with crystallisation and osmotic properties. A layer of Cemtobent Paste was placed over the Maxseal Super coating and the Cemtobent CS membrane was fixed tightly around the base of the Anchor. In every waterproofing specification, the most critical points are those with the greatest perceived weakness; the joints: CEMflex VB plate, the revolutionary steel plate waterstop with a patented crystalline coating on the both sides and inbuilt rain protection was used to detail the horizontal construction/day joints. Quellmax Plus, a benonite waterstop tape with crystallisation additives and a patented rain protection coating, was specified for the vertical joints.