# Case Studies of Basement Waterproofing of New Structures

### 1.0 Watertight Concrete Basement of a Car Park

This case study discusses waterproofing systems adopted in a basement at a new underground car park in London. The construction of this basement consisted of a car park serving five adjacent blocks of between 3 and 19 storeys which were multiple-usage developments comprising luxury hotels, residentials and retail/ commercial buildings located in the vicinity of London's Wembley Stadium. It mainly addressed the material requirements for the construction of a watertight concrete basement. After listing the waterproofing membranes and systems, including admixtures, the emphasis was laid upon providing increased resistance to water and water vapour.

All the concrete requirements were met including the minimum cement content and maximum water/ cement ratio for the inclusion of the admixture. Based on the cement content (350kg/m$^3$), the recommended dosage rate for the admixture was 4.1kg/m$^3$. An integral crystalline admixture was used as special chemical treatment, formulated to waterproof and protect concrete and was designed to be added at the time of batching. In this system, the active chemicals react with fresh concrete to generate a non-soluble crystalline formation. This seals the concrete itself against the penetration of water or liquid, inhibiting the ingress of water through small cracks or shrinkage and protecting it from the deteriorating effect of harsh environmental conditions. However, the most vulnerable parts in a basement are the joints. Those joints were provided with preformed waterbar in a ready-to-use roll which could swell up to 350% when in contact with water. When fully encapsulated by poured concrete, the expansive forces form a seal against concrete surfaces to resist hydrostatic pressure and to stop water from entering the substructures. It then returns to its original size if the concrete and substrate is completely dry but re-expands to seal the potential leaking joints when water or moisture is reintroduced. It withstands up to a 40 meter-head of water pressure. All the critical applications like rebated construction joints, service pipe penetrations etc. were taken care of by a gun-applied, one-component, hydro-reactive, expansion sealant that could swell up to 100 % when in contact with water to create durable waterproofing. It was observed that the minor and typical thermal/shrinkage cracks originally noted had actively self-healed. This active nature of water tight concrete admixture system used has more benefit than dormant pore-blocking systems.

[Source: Concrete, Concrete Society, UK, August, 2012, pp.36-37]

### 2.0 Twin Waterproofing System Ensures Dry Basements

This case study discusses a twin waterproofing system which was adopted in the construction of the basement at the new DMC Building at Goldsmiths, University of London. The basement was 4.5 m deep and extended to complete a 1800 m$^2$ footprint of the new two storey building above it.

In the first approach integral crystalline system was used to make watertight concrete. The blended cement used was 20% flyash with Portland cement of 350kg/m$^3$ admixed with integral crystalline admixture dosed @ 4.1 kg/m$^3$ (1.17% by weight of cement) with a water cement ratio of 0.45 to produce watertight concrete. All the construction joints to the capping beam, wall capping beam, wall-floor and floor-floor joints were waterproofed with a gun-applied one-component hydro-reactive expansion sealant and preformed waterbar forming a completely watertight concrete system. Where shrinkage cracks occured, the in-depth crystallization process of the admixture enabled those cracks to self-heal over a period of time, minimising the need for repair to non-structural cracks in the concrete. It also protected the steel reinforcement within the structure against harsh/ aggressive ground chemicals and enhanced the workability of the concrete.

Additionally a heavy duty, deep studded HDPE cavity drained membrane system was also used as a secondary waterproofing system to provide extra security. It involved the installation of a cavity drained membrane - 5mm thick for the walls and 20 mm thick for the floors - a liquid rubber membrane applied to external surfaces as primary external waterproofer and a double drain tough geo-membrane applied as a drainage/protection layer. Application of the 20 mm membrane to the floors was used so that a grater capacity of water could pass beneath the floor to reach the drainage sumps and could reduce the blocking effects of any free lime that would have leached from fresh concrete. Over the floor membrane reinforced screed of 150 mm thick was provided. To complete the cavity drained membrane system, 300 linear meters of Aqua channel (drainage conduit) were laid around the basement perimeter to direct any water to the sumps. Pre-formed inspection ports were installed at approximately every 12m of conduit to meet the requirement for a sustainable drainage system.

(Source: Concrete, Concrete Society, UK, February, 2010, pp.32-33)

### 3.0 Watertight Concrete Solutions Below Ground

This case study highlights the benefits of the integral protection system of waterproofing. The Millennium Mile project consisted of 219 luxury apartments built over a large underground car park very close to the River Welland in UK. Because of the close proximity to the river and its high water table, an integral system was adopted to make the basement slab watertight for keeping the car park dry.

The watertight ready-mixed concrete with liquid admixture was pumped directly through a batching plant's standard admixture dispenser. The specification used was a minimum cement content of 350 kg/m$^3$, and a maximum water cement ratio of 0.45 with liquid admixture of 1.5% by the weight of cement. The capillary pores were reduced by reducing the water:cement ratio of the concrete which was achieved by adding a high range water reducing admixture of @0.5-1.0% by the weight of cement. The remaining capillary pores were blocked by using a liquid admixture @1.5% by the weight of cement. The slump with the same mix was 130mm which was enough for achieving a self compacting concrete.

The basement was cast directly up to the sacrificial, welded sheet pile walls and was waterproofed at the interface with hydrophilic strips. Due to the available concrete cover, two strips were run parallel along this joint for additional security. The strips were glued in place using a single component hydrophilic polyurethane sealant that swells in contact with water. This gave a secure fixing to the substrate and, being hydrophilic, an extra level of protection at the joint. It saved significant time and money due to its simple detailing of the concrete in comparison to traditional systems such as membranes and cavity drainage.

(Source: Concrete, Concrete Society, UK, July, 2009, pp.33-34)

### 4.0 Watertight Concrete Solutions for Basements

The highlight in this case study was that the membrane prevented the natural autogenous healing of early-age cracks in concrete. It is therefore better to avoid external membranes and rely on a correctly reinforced, quality watertight concrete system. Cavity drainage systems have their own problems. There can be a tendency for silt to build up in the drainage system, and pumps need to be maintained at regular intervals to ensure the system works correctly.

A high range water reducer/superplasticizer was used to reduce the water:cement ratio along with a second admixture as a pore-blocking admixture. The second one reacts with the calcium ions in the cement paste to produce a hydrophobic layer within the capillary pores and to block the pores to provide an effective protection even at 10 bar (100m head of water). The admixture used was easily dosed liquid that was added during the batching process at the plant. The ready-mixed concrete obtained was a minimum cementious content of 350kg/m$^3$ and maximum water cement ratio of 0.45. Self compacting watertight concrete was used in this case. The pour sequences and bay sizes were planned properly in order to reduce the risk of shrinkage cracking.

Non-movement joints were sealed using hydrophilic strips, which swell on contact with water and come in various shapes and sizes. The strips often have a protective surface coating to reduce the risk of premature swelling if for instance it rains prior to casting the concrete. To effectively place and keep its profile in position, it is advisable to use a hydrophilic adhesive that also enhances the performance of the joint. The profile needs a minimum of 75mm concrete cover. Where a structure requires a higher level of protection, more advanced joint systems are available, like a combination of hydrophilic elements built into a resin injectionable hose. This provides an excellent secondary line of defence. Where movement joints are necessary, these can be sealed using Hypalon strips secured internally or externally using specialist epoxy adhesives, or traditional PVC waterbars.

(Source: Concrete, Concrete Society, UK, July, 2008, pp.40-41)

### 5.0 An Innovative and Engineered Solution for Basement Waterproofing

The present case study is of BVR Mall at Vijayawada in Andhra Pradesh, India. It was designed for 3 basements where the basement floor was –12 m below ground level, water table was very high and the sandy soil substrate of the coastal belt posed a problem for differential settlement of raft foundation. The retaining wall flushed with the secant piling was creating problems for the installation of waterproofing systems in the absence of working spaces.

A special design-engineered membrane was used in this case. The membrane comprised of a complex cell mesh bonded to a polyethylene membrane, which allows poured concrete to interlock with the membrane, forming a tenacious mechanical bond preventing water migration in case accidental damage occurs. These membranes were loose laid over compacted soil and secured vertically against formwork before the concrete was poured. The thickness of membrane was 4mm and reinforcement was placed directly over the membrane. The membrane roll was 1.27 m x 30 m and unrolled directly on the reinforcement and overlapped using selvedge inbuilt with the membrane. Pre-applied systems enabled installation with minimum surface preparation even in wet conditions without any protection screed, saving time and cost of the protection screed. The simple and effective joint detailing for pressure releasing valves piercing through the membrane made using standard accessories easy.

In the absence of working spaces, a membrane was fixed to the sacrificial shuttering provided on the secant pile for achieving positive side waterproofing.

(Source: Civil Engineering and Construction Review, Vol.25, No.3, March 2012, pp.136-137).