- Limitations/restrictions of the survey
- Client's required use of the basement and therefore the design grade required
- A description of the existing basement construction
- If known, the soil/ground type and permeability
- Defects/moisture sources that require rectification in conjunction with waterproofing works
- Proposed generic waterproofing method(s) e.g. Cementitious multi coat render, Cementitious slurry, Cementitious dry mortar etc.
- Suitability of the existing structure to accept the proposed system and any up grading works required e.g. a new floor slab etc. NB For type A internally applied systems, the floor slab should be designed by a structural engineer
- How existing staircases will be isolated from the walls and floor, or incorporated into the waterproofing system
- Reference to condensation control/ ventilation/ dehumidification.
- Reference to long term guarantee if applicable
- Detailed Specification for chosen method

In all situations where waterproofing treatments are recommended the specialist should include the following advice:

- The extent of the waterproofing must be clearly described/ indicated. If a full waterproofing system is not being specified then the reasons for this should be stated and the risks arising from a partial system explained. It should be made clear that the limitations of a partial system are at the client's own risk. Where a partial system is being offered it is advisable to offer a full system as an alternative so it is the client who makes the choice.
- Preparation works including removal of existing finishes, joinery items, services etc.
- Advice on fixing to/through the system
- Drawings showing areas to be waterproofed and other relevant details

Where a Cavity Drained System is used, the following information should be provided:

- Position and type of internal drainage including facility for cleaning/inspecting
- Position, size, number and type of pumps – the designed extraction capability of the pumps should be stated
- Pump outlet arrangements
- Pump wiring arrangements
- Membrane type & stud size for walls/floors/ceilings as applicable
- Joint sealing detail if applicable
- Finishes
- Pump/drainage servicing requirements and/or agreement

5.0 Conclusion

The basement should be inspected thoroughly to find out the exact source of leakage and the extent of leakage. All the leaking points should be marked to decide the treatment area. Surface should be cleaned to remove all the loose materials. Based on the findings of condition assessment, remedial measures should be carried out accordingly.

Case Studies of Remedial Waterproofing and Repair of Basements

1.0 Remedial Measures for the Uplift of Basement Rafts

The two case studies discuss the failure of basements due to uplift during monsoon, highlights the common errors in estimation of uplift pressures and indicates the remedial measures that were taken in two different sites in Mumbai.

At the first site in Bandra, a basement raft, 600 mm thick, covering an area of 18 m x 30 m was placed at a depth of 3.5 m below the ground. The overburden was filled with silty clay (murrum) overlying the volcanic tuff. The ground water was within a depth of 1 m. Continuous dewatering was adopted during the construction of both raft and basement wall but was stopped when floor slab construction began. Within a few days it was noticed that the basement was lifting up like a ship in water. The lift was uneven and varied from 0 to 560 mm, but there was no cracking of raft or walls. Drainage boreholes of 200 mm diameter were executed around the building and simultaneous dewatering was commenced. The building slowly started sinking down and rested on the founding strata, albeit unevenly. Perfect seating was not possible due to the presence of boulders and cobbles which had fallen from the sides and rolled underneath the raft when the basement was uplifted. Grouting was carried out with cement and sand mortar (1:1) through the 20 nos. 'Nx' size holes were specially drilled through the raft which went 5 m below the founding tuff strata. High yield strength deformed steel bars of 32 mm diameter were inserted in the grout holes before finally sealing them. The grouting pressure was limited to 100 kPa.

At the second site in Andheri (East), the building was planned with a basement and had 2 wings of 7 storeys each with 530 m^2 area per floor. The basement raft and columns had been cast and the superstructure was under construction. During heavy rains the adjoining natural drain started overflowing. One of the wings closer to drain got lifted up by damaging the box type tiled water proofing with an uplift varying from 0 to 200 mm. The tilt was seen in many columns and the basement raft that had cracked in the transverse direction. The footings on the crack line were damaged and tie beams connecting footings were sheared with diagonal cracks near the supports. Also, there were parallel vertical cracks in 3 bays in basement retaining walls. The raft was founded on fractured basalt rock which seemed to have provided easy access to water, creating excessive uplift pressure. Remedial measures involved the complete reconstruction of the damaged wing and grouting of the fractured foundation rock and installing two types of passive anchors. 60 passive anchors were of 50 T capacities (3 Tor rods of 32mm dia in 125 mm dia. holes of 6.5 m depth) and 48 passive anchors were of 33 T capacities (2 Tor rods of 32 mm dia in 4.5 m deep holes of 125 mm dia) were installed to resist the estimated uplift. Thereafter a neat cement grout of 0.5 w:c ratio with non-shrink additive at a dose of 330 g per 50 kg cement was pumped in the grout holes with maximum pressure limited to 150 kPa. The foundation grouting along the transverse line of cracking in the raft showed a remarkably high consumption of grout.

[Source: Indian Geotechnical Conference – 2010, GEO trendz December 16–18, 2010, IGS Mumbai Chapter & IIT Bombay,pp.795-796]

2.0 Early Protection Keeps Water out of Basements for Life

A great example of one such refurbishment project that has made smart use of waterproofing is the Lancasters overlooking Hyde Park in London. The 120 m-long terrace was in a state of considerable disrepair following its poorly executed conversion to a hotel in the 1970s. As part of a USD 80 million development project to convert the building into 77 prime residential apartments, the Grade II-listed facades are being retained, while an all new concrete interior has been built within the structure. To provide additional saleable space, three subterranean levels have been created to provide car parking, fitness suites, swimming pools and a business centre, all for exclusive use by the residents. An integrated waterproofing system was selected in the same project.

The system is a pre-bagged render that is a blend of kiln-dried specially graded aggregates and cements. Packaged in four grades, it includes a liquid waterproofing admixture that is mixed into the render and prevents water ingress. Once applied to the walls and floors, the multi-layered render system bonds monolithically to the prepared substrate. The admixture within the render reacts to water by turning into a jelly-like substance, blocking all gaps and capillaries and providing an impregnable and invisible seal.

The basement was divided into four areas: habitable, car parking, plant and leisure facilities, as well as a network of interconnecting corridors. The different areas required different standards of waterproofing in line with BS 8102. This classification of standards sees waterproofing ranged across four grades, from Grade One, suitable for environments where there can be a tolerance of slight seepage and dampness to Grade four, a 100% dry environment that is suitable for the storage of sensitive materials or electronics. At the Lancasters, all below-ground habitable areas, leisure facilities, kitchens and plant rooms were waterproofed to grade three. A high functioning ventilation system was installed to guarantee excellent air circulation, limiting the risk of mildew, mould and other forms of internal dampness, thus ensuring that these areas were suitable for prolonged usage by inhabitants and staff of the development. The car-parking areas were waterproofed to Grade 2, meaning that there will be no water penetration into these spaces. The communication rooms of the building, containing sophisticated electronic equipment, were all waterproofed to Grade Four, providing protection against any possible water or vapour ingress.

(Source: Concrete, Concrete Society, UK, Vol. 44, No.4, 2010, pp-17-18)

3.0 Waterproofing a Newly Created Basement in an Existing Property

This case study discusses how a new basement has been dug beneath an existing four-storey Victorian property in London and has been waterproofed with a cavity drain membrane and a vapour membrane.

Following a highly complex support and dig out process, which was carried out in sections, the new basement was formed using a contiguous pile construction with a concrete ring beam, providing a watertight concrete box - normally acceptable as a standalone system. In this instance there had not been the opportunity to carry out trial holes to check the soil conditions below the property and to ascertain water table levels, therefore a watertight concrete system could not be considered as a standalone system under the Standard; Management was asked to provide a specification for waterproofing and initially, a cavity drain membrane system was recommended to the walls and floor with Aqua Channel conduit around the perimeter discharging to sumps to the front and rear of the property.

However, the floor specification was amended to maintain minimum headroom to facilitate the client's requirements for the installation of under floor heating. Two coats of liquid-applied vapour membrane were laid to the floor slab instead, continuing up and over a perimeter step detail, which housed the drainage conduit and a 150 mm upstand to the internal walls.

The whole system was maintainable, as any leaks would present themselves through the kicker joints of the brick detail, where the aqua channel would direct water to the two sump chambers. The odour resistant non-return valves were incorporated on the outlets into the sump chambers, to avoid odours caused by any build-up of moss or other detritus. The vapour membrane was a single component acrylic modified coating that once cured, provides an effective, physical, waterproof barrier that bonds fully to the floor slab and therefore can not be punctured. Its speed and ease of application offered further benefits to the installation. The first coat can be applied 24 hours after installation of a new floor slab and the second coat just 40-60 minutes later. Although not a requirement in this particular application, the vapour membrane also formed an effective barrier against radon, methane and carbon dioxide and therefore all joints on the membrane system were double taped and sealed for gas retention as a further safeguard.

(Source: Concrete, Concrete Society, UK, July, 2009, pp-37-38)

4.0 Historic Restoration of National Archives and Records of an Administration Building

The Adam's Express Company Building was originally constructed in the 1911 to 1912 period, being part of the overall Union Station railway facilities in Kansas City, MO. The building is approximately 19.5 m wide by 46 m long, and also has a large-height basement or "concourse" that is connected to the original Railway Express Administration (REA) building to the east, via a 6.1 m wide tunnel that connects the Union Station head house with all of the original buildings in the area. At the southwest corner of the basement is the original tunnel access to the Union Station Power House, which is now under development to become the future home of the Kansas City Ballet. The building was principally vacant for a number of years, except for some storage and office use by Union Station on the first floor and basement and, as such, was not temperature controlled or maintained to any degree, leaving the aging structure to the ravages of corrosion and degradation. The structural condition study of the building was carried out in August 2007, so as to review the available record drawings, conduct visual, photographic, and sounding surveys of the exterior façade and interior framed slabs of the building, perform forensics testing of the existing concrete for strength, prepare preliminary repair plans and details, and summarize recommendations with an estimate of probable construction repair costs. The condition study was completed in September 2007, and construction was set for early 2008.The basement remedial was part of the same repair project.

Before the work could progress with any efficiency in the large basement or concourse space, the contractors had to remove many years of accumulated storage and debris; the basement slab was always wet from the many active leaks, and a number of holes in the foundation walls had to be mitigated. Following the general clean-up of the basement space, the contractor power-washed the walls and basement slab to remove many years of mud, coal dust, and various unsuitable materials in preparation for the specified repairs.

Some nonmoving, non-leaking structural cracks above the groundwater table were epoxy injected to re-adhere the concrete. The existing pipe penetrations and exterior loading dock freight and coal chute holes were fully in-filled with reinforced and doweled full-depth, form-and-pour concrete. The pipe penetrations were routed out and in-filled with vertical repair mortars. At the same time the concrete repairs were being made, the repair contractor injected the specified polyurethane chemical grout into the many active leaks to stop the constant infiltration which, of course, was of greater volume during wet weather conditions. Following completion of the concrete slab and wall repairs, epoxy crack, and urethane grout injections in the basement, the engineer required that the entire basement wall surfaces apply a crystalline waterproofing system to the first floor grade level, which amounted to a total of some 840 m^2 of wall surface. The leaks were checked.

(Source: Concrete Repair Bulletin, Vol. 23, No.1, pp.20-22)

5.0 Application of Crystalline Technology for Basement Waterproofing

Likhite Commercial Project in Dombivli, Thane, India at an area of 2000 m^2 faces several problems of leakage at the site like leakage in the retaining walls, active leakage from the three sumps and accumulation of water up to the top of the sumps, in spite of previous external box-type waterproofing from the outside. This basement waterproofing project was then finally rectified with the crystalline waterproofing method from the negative side. In the case of sumps, the side walls of the sumps had to be plastered. At the base of the sumps, screeding with cement and sand up to 25 mm was done. The sumps were then filled and on the top of the sumps, crystalline waterproofing product in the form of powder was sprinkled. The various chemicals used were crystalline waterproofing, proprietary joint filling material and proprietary plugging compound.

(Source: NBM & CW, Vol.13, Issue 1, July 2000 pp.216)

6.0 Moisture Ingress through Basement Walls Rectified with Crystalline Materials

The walls of a basement-level archive room at a leading Victorian University in Australia were experiencing severe concrete degradation and moisture ingress due to unforeseen placement and compaction issues during initial construction. The same rectification was carried out by National Concrete Solutions, Australia with crystalline repair products for reinstatement of the walls and to provide a protective barrier around steel reinforcement.

Preparation for the basement wall involved the removal of existing paint and other contaminants from areas that were damaged from water ingress. Additionally, all deteriorated concrete areas were pressure-washed to provide an open capillary, clean absorbent surface, and bony and honeycombed sections were chipped out to a square-edged substrate and surface laitance was removed. Upon successful completion of surface preparation, the substrate was saturated with water and crystalline was applied as a slurry coat to treat the exposed steel and reinstate a passive alkaline barrier around the reinforcement. A high-build repair mortar for the patching and resurfacing of deteriorated concrete was then used to repair back to contour with the surrounding concrete. Crystalline coating was uniformly applied to all concrete surfaces with a semi-stiff bristle brush. It produced a harder finish, providing enhanced concrete durability and additional waterproofing integrity.

A dense, fully-developed crystalline structure had formed within the capillary tracts of the concrete to completely block the flow of water after application of crystalline at a depth of 50 mm into the concrete sample at 28 days. A curing compound of self-dissipating (2-3 days), non-film forming product was applied as a fine mist spray, both during and after the coating to accelerate the crystalline process and assist in product curing for optimum performance.

(Source: ReBuild Vol.4, No 4, Oct-Dec 2010 and excerpted from News Bulletin of ACRA , Australian Concrete Repair Association)

7.0 Remedial Waterproofing and Restoration Measures of a Multi-storied Building

The basement floor of a multi-storied building in Pune, India had problems of leakage, dampness and pools of water on the floor. This posed problems of moving around and using the floor and also proved dangerous as the basement housed electrical circuits and a DG set. A fully dry environment was necessary to ensure safety to life and property against electric shocks and fire. The physical observations made at the time of inspection revealed the following distress at the site:

- Dampness in walls with water oozing out at several locations
- Water oozing out of the floor
- Ponding of water at certain isolated locations
- Puncturing of RC slab due to high pressure of water at few points.
- The main cause was rising moisture through the floor slab and masonry walls. This was further aggravated by the presence of a high water table.

The restoration measures were aimed at arresting the leakage of water and rising dampness by provision of suitable treatment to walls and floor.

a. Treatment of floor

I. Removal of existing cement plaster,
II. Pressure grouting of slab with neat cement slurry modified with plasticizing cum expanding additive and curing.
III. Provision of 1:2:4 dense concrete overlay: The concrete was modified with integral waterproofing admixture mixed at a dosage of 130 ml per bag of cement and a w/c of 0.45 and curing was done.
IV. Provision of acrylic polymer modified coating in two coats to a thickness of around 1 mm.
V. Provision of 25 mm thick 1:3 mortar screed: The screed was modified with the addition of integral waterproofing admixture at a dosage of 130 ml per bag of cement.

b. Treatment to walls

I. Removal of existing plaster to a height of 1 m above the floor system.
II. Raking of masonry joints to a depth of 25 mm and cleaning them.
III. Pointing the joints with 1:3 cement sand mortar. The mortar was modified with integral waterproofing admixture added at 130 ml/bag of cement and cured.
IV. Fixing of keys J pins to facilitate fixing of chicken mesh reinforcement.
V. Provision of acrylic polymer coating, to a thickness of around 1 mm in two coats.
VI. Provision of 25 mm thick, 1:3 cement mortar screeds reinforced with chicken mesh. The screed was modified with integral waterproofing admixture added @ 130 ml per bag of cement.

c. Treatment to walls

I. Excavation of soil along the periphery of the walls to a depth of 1.2 m and a width of 0.8 m to form a trench, the bottom of which was compacted
II. A PCC bed of 1:3:6 was provided at the bottom to a thickness of 150 mm.
III. Side wall of the trench was constructed in stone masonry.
IV. A concrete overlay of 1:2:4 was provided over bed concrete to a proper slope and this was continued and connected to a natural water source.

(Source:http://www.constructionupdate.com/products/constructionworld/2002/JUNE2002/017.html)

8. 0 Cavity Drained Membrane Waterproofing System Introduced in an Existing Basement in a Business Park

The project was to waterproof an existing basement under a country house business park in Bowcliffe Hall,Bramham, UK. The customer needed a solution that would give a completely dry internal environment as the room was to hold state-of-the-art computer equipment, telephone lines and power supplies. The contractor finalized the most reliable and trouble free waterproofing option available. They decided on the cavity drain membrane system to make the basement dry and fit for its intended use. The vaulted ceiling and walls were lined in cavity mesh membrane, which allowed for plaster directly onto it. This maximized space and ensured the shape of the vaulted ceiling was retained. The floor was lowered and a new concrete slab installed with a recess at the wall/floor junction in to which base drainage conduit was applied then the whole slab was overlaid with cavity mesh clear membrane. Water collecting in the drainage conduit was then managed into a predesigned sump which was equipped with two medium duty NP400 Pumps. Those were controlled by an automatic control Panel which provided alternate pumping, programmed pump testing, alarming in the event of a pump failure, and switching to a battery backup in the event of a mains power failure. The floor had to be load-bearing as some computer equipment weighed up to 500 kg. Another layer of concrete was applied on top of the floor membrane to give the required strength. All other tasks such as joinery and plastering, avoiding any future split responsibility issues were provided with an insured guarantee for the waterproofing.

(Source: http://newton-membranes.co.uk/wp-content/uploads/2011/05/CaseStudy_Newton-Basement_BowcliffeHall_Bramham_Dec10.pdf)

9.0 Combined Cementious and Cavity Drained Membrane Waterproofing Systems used to Combat Extreme Water Ingress

A century old property in the idyllic countryside location of Lingfield, Surrey, UK had undergone a significant renovation programme including the full underpinning of the existing property to create an expansive basement living area. During the construction the existing footings were exposed and a full underpinning schedule was initiated during the same period (summertime) and no evidence of water was present and the concrete placement. The slab construction was performed within a timely manner. However, after a prolonged period of rainfall the surrounding areas reached saturation and the property was subjected to extreme hydrostatic pressure which in turn resulted in over 20,000 litres of water entering the property overnight.

The source of the water ingress was through the drypack construction joints between the existing brickwork footings and the underpin. With the situation looking desperate, the design and build contractor called a specialist basement contractor to provide a fully guaranteed basement waterproofing solution.

With such extreme amounts of water entering the through the pins, the flow of water needed to be slowed down significantly in order to put in a maintainable and guaranteed basement waterproofing system into the construction. Two basement contractors specialized in cementious system and cavity drained waterproofing system respectively put together a combination of fast setting cementious products into the specification to deal with the problem. Initially the flow was impeded using a water plugging compound, a fast acting cementitious product which cures within 40 seconds of contact with water. Once the same product was applied to a 300mm band each side of underpins then followed by two coats of flexible cementitious slurry to support and stop as much water as possible. Once the cementitious slurry products were applied then the full internal drained cavity system was installed (Fig.1). This included cavity mesh wall membrane curtain hung down (Fig.2) the earth retaining walls terminating into the base drain for allowing the water to be drained to the sump for further pumping.

Fig. 1: View of cavity drain installation

Fig. 2: Cavity mesh wall membrane curtain being hung down during installation

(Source: http: //newton-membranes.co.uk/wp-content / uploads/2011/05/CaseStudy_Newton-Basement-Waterproofing_Lingfield-Surrey_Nov10.pdf)

10.0 Cavity Drained Membrane Waterproofing System in a Refurbished Basement Waterproofing Project

The project was to install a waterproofing system to the basement vaults of the east residence of the British Museum, London. This highly sensitive listed structure needed to be waterproofed to a Grade 3 Habitable environment in accordance with BS8102. The area was previously waterproofed with a Type A cementitious system which had failed and the artifacts stored in the area were subjected to water damage. The cavity drained membrane system was installed with cavity mesh applied to the vaulted arches and walls with base drain installed within a rebate at the wall floor junction. A rendered finish was applied and cavity mesh was laid to the floors with a screed finish. The base drain allowed for non pressurised movement of water to the sump and pump system for removal.

(Source:http://newton-membranes.co.uk/wp-content/uploads/2010/01/Case-Study_BritishMuseum_Aug09.pdf)