Remedial Waterproofing of Basement

[Source:http://www.property-care.org/files/cop_structural_waterproofing.pdf and http://www.foundation-repair-guide.com]

1.0 Introduction

Remedial waterproofing of basement is very critical since one has to check many factors before going for remedial waterproofing. The aim of monitoring in basement is to locate the leaks at the earliest possible opportunity so that remedial works may be taken immediately without damaging the structure further. The designer of the waterproofing system should also consider the implications of any future failure if the system and how any defects can be repaired in the future. Basements can flood from almost any point including the walls, floor, pipes, windows, and hatchway entrances. The solution to a flooded basement depends entirely on what's causing the flood in the first place. In basement the primary cause of defects and damages are due to ingress of water vapour or ground water along with chemicals such as chloride, sulphates or other aggressive chemicals causing corrosion of reinforcement. This may happen due to failure of waterproofing system. A regular inspection and proactive maintenance policy will limit the damage to the basement. Visual inspection along with selected non-destructive testing such as infrared thermal imaging, moisture meter should be carried out the find out the nature of damage and defects. If required a concrete core from wall, floor of basement may be taken to find out the in-situ strength of the concrete. The same core sample may be used for chemical analysis tests for chlorides, sulpahte and pH or alternatively a drilling machine may be used to extract powered concrete samples for all chemical analysis tests. Knowing the exact cause of deterioration a systematic approach for remedial basement waterproofing should be taken.

2.0 Surface Preparation

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. All damaged concrete areas should be repaired with polymer modified mortar as per standard specifications.

The substrate which is to receive the remedial waterproofing system must be well keyed to achieve a good bond and sound to prevent de-bonding. Any old renders, coatings or general contamination must be removed by suitable means such as grit blasting, high pressure water jetting, scabbling, or other suitable means. Care needs to be taken if wire brushing is used as it can leave the surface soft and dusty. Bush hammering tends to compact the surface and can result in the system pulling away, taking the surface with it. Soft mortar joints should be raked out, and any unsound and defective areas cut out and made good. Open joints should not be repointed but the mortar should be pushed into the open joints when applying subsequent renders. Excessive suction should be controlled prior to applying renders by saturating with water, or applying a suitable bonding agent as a primer or slurry. Unless the substrate is reasonably flat and true, a render leveling coat should be applied prior to application of the waterproofing system.

On basement floor, unsound or loose coatings such as screeds, laitance, salt residues, mould growth or adhesives must be removed. If mould is present, the floor should be treated with fungicidal wash, (care should be taken to avoid contamination of watercourses when using fungicides). Uneven substrates should be dubbed out with a suitable mortar, to achieve a flat finish. This must be allowed to harden before laying the membrane. Check and remedy, using appropriate methods, any unacceptable leaks in the concrete or masonry substrate before the system is installed. For basement flooded with water, the dewatering should be done to remove the water from the base slab for carrying out the inspection. Wire brushing should be done on the surface to remove all the loose particles before applying any coating material. If required, the grinder shall be used to open up the surface pores which will allow better penetration of the product.

3.0 Application Methodology

Before doing any remedial waterproofing treatment either at positive side or at negative side all the cracks need to be repaired and all corrosion related cracks should be made as per standard procedures. Any cracks lower than 5 mm to be filled with ready to use polymer modified crack filling material. Cracks larger than 5 mm to be filled with polymer modified mortar. In remedial situations most jobs require the application of waterproofing systems to be internal. For this type of work, cementitious coatings, multi-coat renders, epoxy coatings or cavity drain membranes with integrated drainage channels are most common. If the dampness is present all over with minimum dripping leakage, the same can be treated with a crystalline product. All the dripping leakage points should be grouted with PU foam injection system. After completion of remedial treatment wherever required, tiling work has to be carried out over the finished mortar screed with non shrink waterproof polymeric tile adhesive and filing the joints with non shrink tile grout.

Though positive side waterproofing is difficult but it is more effective than negative side waterproofing. The various positive and negative side remedial

waterproofing systems are discussed as follows:

3.1 Positive side Application Treatment

3.1.1 Elastomeric Bitumen Emulsion based Polymer Coating

Bitumen emulsion based elastomeric polymer coating is suitable for basements in normal soil condition for positive side application. It is ideal waterproof coating, which forms an elastomeric membrane capable of withstanding small movements of concrete. It has excellent adhesion and is flexible and non-toxic. Two coats of elastomeric polymer coating should be applied on the clean surface at coverage of 2 m^2 per kg in two coats. The second coat should be applied after 6-8 hours of drying of the first coat and sprinkle sand on the second coat. In the event of the coating being discontinued, resumption of the coating should be done by providing an overlap of 50 mm on the old layer. A screed of 15 mm plaster should be given on top of the coating to avoid any puncturing of the membrane while back filling.

3.1.2 Coal Tar Epoxy Coating

Wherever the treatment has to be given in contaminated soils, a two component coal tar based epoxy system for coating for protection of concrete structures against aggressive environment. A full cured coal tar epoxy coating effectively waterproofs and gives protection against corrosion. It has high bond strength and abrasion resistant properties. It has to be applied in two coats @ 3-4 m^2 per kg with a brush. The backfilling should be carried out after 3- 4 days of laying of coal tar epoxy.

3.1.3 Elastomeric Polyurethane Coating

In remedial water proofing "elastomeric" is more popular. The term elastomeric simply means that the material- whatever material is being discussed- is flexible throughout its lifetime. For the basement waterproofing application, a synthetic material called "urethane" or "polyurethane" (a colourless, odourless, crystalline compound) has been formulated into a liquid which can be applied with a roller to form a monolithic basement waterproofing membrane on positive side. The polyurethane basement waterproofing membrane is equally impermeable and has a much longer useful lifetime than the asphalt-based material. Some urethane waterproofing products are manufactured as "bitumen-modified" so that the bituminous component is still out there. The application process for the elastomeric basement waterproofing system is similar to the asphalt-based system. One or two coats are usually sufficient. Reinforcing material is not normally required. A good sub drain system with perforated pipe placed entirely below the top of the footing is essential and protection board must be installed against the new membrane prior to the placement of any backfill. The polyurethane elastomeric basement waterproofing system is most successful in numerous basement waterproofing jobs over the years without any failure of the waterproofing membrane. The cost is competitive with the asphalt-based system but the durability is much improved. Since it is applied on positive side the excavation and filling of backfilled soil is more difficult in a deep basement whereas it can be managed in a shallow basement. But positive side application is most effective for any remedial works in all kinds of soil.

3.1.4 Bentonite and Blind–side Waterproofing

Bentonite is very effective as a basement waterproofing material because it swells up when brought in contact with moisture. Bentonite-based systems are supplied in rolls. The bentonite comes impregnated into a geotextile mesh. One can also find it adhered to polyethylene sheets. Bentonite rolls or sheets, like the other basement waterproofing materials are designed for a "positive-side" application. However, there are also other approaches to basement waterproofing. A modified version of the negative-side system has the material injected from the negative side but applied to the positive side can be more effective in remedial waterproofing. Then there are the so-called "blind-side" waterproofing methods.

Blind-side basement waterproofing is where you put the waterproofing up first and then place a new basement wall up against it. In blind-side basement waterproofing; everything is done in the reverse order of normal new basement waterproofing system. The filter fabric side goes in direct contact with the soil of the vertical cut. The drain sheets came next, providing free drainage to relieve any hydrostatic pressure. The dry bentonite clay goes away from the vertical cut where it will be in direct contact with the freshly poured concrete. At the bottom, a perforated pipe is run through and wrapped it in more filter fabric. After installing the reinforcing steel, the formworks are set to create the inside face of the new basement wall and then we poured the new concrete. Blind-side basement waterproofing is often required for new construction and retrofit jobs where property lines and adjacent structures prevent excavation and access which would allow positive side waterproofing to be installed after completion of the basement walls. In addition to poured walls, bentonite sheets are used behind "shotcrete" walls and "soldier-beam" walls with wood "lagging". "Tiebacks" and other penetrations of the bentonite membrane present challenges to the installer. Bentonite mastic is needed to work around penetrations and irregular surfaces. On contact with moisture, the bentonite expands into small irregularities and aids in the sealing process. Bentonite rolls or sheets are also used on conventional positive-side basement waterproofing jobs. The natural clay material would not be expected to degrade and the swelling characteristics give bentonite an added component of performance.

While bentonite can be an outstanding basement waterproofing product, one must consider the material and installation cost. Bentonite is significantly more expensive than the polyurethane membrane systems which seem to be well accepted for most positive-side applications.

3.2 Negative–side Application Treatment

"Negative-side" waterproofing system is that system where the material is applied to the inside surface of the wall. Negative side waterproofing consists of either a waterproof coating or hydraulic cement that is designed to coat the inside of a basement wall, sealing any cracks in the wall as well as stopping moisture that is constantly seeping into basement from the earth through porous cement basement walls and floors.

3.2.1 Crystalline Coating

The "crystalline" basement waterproofing systems is more popular for negative side application. It consists of a liquid solution of cementious base which is applied to an existing concrete surface. Also called a "capillary" basement waterproofing system, the solution penetrates into existing concrete and seals the capillaries within the concrete mass. Proprietary chemicals within the solution react with lime in the concrete to form needle like crystals which fill the capillaries and reduce the permeability of the concrete. Moisture must be present in the concrete in order to form the chemical reaction. Water entering through the crack reactivates the chemicals and causes new crystals to form and grow, which self-seal the new cracks and maintain a watertight seal for which it is a permanent crack repair solution. This self-sealing property is one of most unique and useful features and can often reduce long-term maintenance and repair costs if only active crystalline forms. The crystalline basement waterproofing system gives the contractor an option when the owner does not have the budget to do a positive-side job or approach to the positive side is not possible because of space constraint. This system is more of a maintenance program than a repair. The general idea is to apply the material to the concrete and then wait for the moisture to seep in from the outside. The chemicals dissolve and follow the water, sealing up the cracks and capillaries in those zones of moisture. The next month or the next year, it may be necessary to apply more solution as the chemicals seep into the zones of moisture and are used up. The effectiveness depends upon the amount of moisture penetrating into the basement and the ability of the crystalline system to form crystals in passive state. Rather than one time remedial solution it can be a regular maintenance system. Since it is a negative-side basement waterproofing system on existing structures it has huge advantage. The removal and replacement of the perimeter soil and other improvements is not required. However, a negative-side system which offers the level of protection one get from a positive-side application can not be compared. The Fig. 1 shows that basement wall applied with a crystalline coating.

Fig. 1: Crystalline waterproofing on negative side

3.2.2 Cementuious Systems

Another type of material which is used frequently on basement repair jobs is the "cement-based" or "cementitious" coating applied on negative side. However, it should not be used on basement waterproofing jobs where hydrostatic pressure may be a factor. Certain cement-based coatings used in basement waterproofing applications have failed due to a significantly higher permeability to moisture. These coatings are relatively inexpensive and easy to apply. Whilst damp, but free of standing water, cementious coating should be applied in two coats to the clean and saturated surface to achieve 1 mm thickness of the coating. Sand should be sprinkled on the top surface of applied coating while still tacky over the second coat. This system can be used only in smaller amount of dampness or seepages but can not be effective in heavier leakages. In this system the substrate must be strong enough to accept this stress. Non-structural floors and half brick walls are not suited to the application of this system due to their inability to withstand bending stress. Cementitious systems may not be suitable where they are likely to be subject to heavy vibration or substantial seasonal movement i.e. below roads, railway lines etc. Care should be taken for proper curing for cementious coatings or rendering.

3.2.3 Injected Basement Waterproofing

Another type of basement waterproofing system which can be installed from the negative side but applied to the positive side is injected basement waterproofing with pressure pump equipment as shown in Fig.2. "Injected bentonite is being used to create waterproof barriers beneath floors or behind walls. "Injectable polyurethane" is pumped into holes drilled in floors or walls to form a waterproof barrier. Before using bentonite beneath a floor, one should ensure that changes in moisture levels in the surrounding soil would not result in heaving or settlement of the floor or foundation due to expansion or contraction of the bentonite material.

The injected polyurethane (PU) material is

Fig. 2: Injection equipment setup

"hydrophilic" or attracted to water. The drilled holes are used as injection points and also to gauge and monitor the penetration of the material. Crack sealing can also be accomplished by injecting "hydrophobic" polyurethane into the cracks. The urethane and bentonite injection systems provide an alternative to the capillary system for basement waterproofing of existing underground structures. Though significantly more expensive than the capillary system, bentonite or urethane injection offers a positive side application. When used on concrete floors- whether above or below grade- bentonite or urethane injection is a less-expensive option than membrane applications which require the removal and replacement of the concrete, exterior soil and other perimeter improvements. PU foam injection carried out in a deep basement for arresting the water leakages is shown in Fig.3.

Fig. 3: Foam injection carried out in a deep basement wall

However, one should not favour a waterproofing system on below-grade walls which does not include a drain system to eliminate hydrostatic pressure. One should never assume that an existing French drain system is working properly. Therefore for most basement waterproofing repair jobs, first recommendation would be a positive-side treatment with a liquid-applied elastomeric membrane together with a carefully installed perimeter French drain. With the relief of hydrostatic pressure, one should go ahead with injecting a below-slab hydrophilic polyurethane barrier to complete the job. Fig. 4 shows grouting carried out in a basement wall. Where ever rising dampness in the basement is the concern the grouting should be made with a Silicone based material as shown in Fig.5.

Fig. 4: Grouting of basement wall

Fig. 5: Injection to basement wall at floor level for preventing rising dampness

3.3 More Basement Waterproofing Systems

Protection boards help prevent damage to the waterproof membrane during backfill and can be in the form of sound board, asphalt board, plastic drain sheets, or foam sheets the latter having the added function of providing insulation to the basement waterproofing job. Other accessories to basement waterproofing jobs would include flashings and fasteners, waterbars for control and construction joints, and a wide variety of adhesives, sealers and mastics. Basement waterproofing systems should include an integrated package of products for surface preparation, membrane installation, protection board, and drainage system.

3.3.1 Interior Footing Drain

The best and most reliable approach is the interior floor drain basement waterproofing system. While other approaches can work some of the time, this is the one that works all the time. It is a piping system engineered (Fig.6) specifically for wet basements designed to avoid the problems of other approaches. It is an interior floor

drain, but unlike the traditional footing drain it sits on top of the footing and prevents debris from entering the pipe thus eliminating clogs. It is installed next to basement wall, on top of the footing, and collects water seepage from the walls, floor-wall joint, wall crack and pipe penetration .

Fig. 6: A view of interior footing drain pipe channel with perforations for collecting and draining water

This system works with the sump pump so any water that's collected is removed. As with any waterproofing system of this type, this method leaves a gap between the floor and wall (Fig.7) that allows water from the wall to flow down into the drain. When this system installation begins, the perimeter of the floor is removed. This process is used on the floor only. The footing and foundation are not damaged by this process. If there is any block foundation walls, weep holes are drilled into each core of each block so that the water contained within the hollow cores of the wall is continually drained away. Clean gravel is laid down on the bottom of the trench that has been removed around the perimeter. Specially manufactured rectangular drainage pipe is laid on top, and then gravel is laid on top. Once this is completed, concrete is laid back down on top of the system, it's smoothed over and the area is cleaned.

Fig. 7: Installation of footing drain pipe at wall and floor junction

If there is any floor crack through which ground water is penetrating then lateral drainage piping is laid under the floor and connected to the interior floor drain system. The wall drain is a molding with spacers that create a neat-looking drain against the wall. Because it sticks up above the floor about 25 mm so that dirt and small objects from the floor can't get inside and clog it.

Since such drainage system is not sitting in the soil and the fact that it is sitting on top of gravel, it is extremely unlikely that heavy soil particles will wash through the gravel and upwards into the system and make it clog. This system will still be clean and free draining system for all leaking basements.

3.3.2 Baseboard Drainage System

One of the most effective and least invasive methods of waterproofing a basement is with a baseboard drainage system. With this system, weep holes are drilled into the floor/wall joint or, in the case of a block wall, into the walls themselves. This relieves the hydrostatic water pressure. Once this is done, a hollow vinyl baseboard or PVC base board having square inlets (Fig. 8) is fixed to the floor. The water creating hydrostatic pressure on the foundation walls is directed into the system and drained to a sump pump system.

Fig. 8: PVC base board channels with square inlets for drainage in basement with different laying arrangements

The sump pump is installed with a feed pipe to the sump. The sump pump then discharges the water out of the house through a drain pipe that's buried and runs across the yard. The pipe extends past the backfilled soil and is directed to a location where the water can run downwards and away from the house. Once the water is away from the foundation walls, the hydrostatic pressure created by it is relieved.

3.3.3 Improving the Drainage System

The French Drain system is designed with a grated opening on top that collects water and sends it to sump (Fig.9) to a perimeter drain. It is designed with a half-round pipe section, with a grated top fitting. When installed, it's flush with the rest of the concrete floor for

a clean, professional job. It is meant to be used as part of an existing perimeter drain system. It spans the staircase area, collecting water that spills down and directs it to the drain and sump pump system. Drains with alarm devices shall be so arranged that there will be no danger of overflowing at the alarm apparatus (Fig.10) and automatic pumping from drainage should continue without flooding the basement. This system can span the entrance of the stairway or it can be extended inside. This is the most reliable and effective basement waterproofing system available.

Fig. 9: Sump chamber for housing two medium duty Pumps

Fig. 10: Control Panel provides advanced power back-up and telemetry systems for automatic pumping

4.0 Factors Need to be Considered During Backfill

As a basement repair contractor, one has to encounter many problems in remedial waterproofing. On a positive-side basement waterproofing replacement project, the task of removing and replacing the perimeter soil and all the improvements can greatly overshadow the scope of the actual installation of the waterproofing materials. Significant settlement of the backfill soils would damage the waterproofing system. There may be gaps between the bottom of the footings and the soil. The extensive below-grade concrete demolition would be required to access the below-grade wall surface for waterproofing.

4.1 Safety

Trench safety must be paramount during construction. Never permit workers to go into un-shored trenches. Expect wet weather which will weaken the trench walls. Keep trenches covered. To reduce exposure, backfill trenches as soon as possible. Fence off the job and post keep-out signs.

4.2 Excavation and Compaction for Remedial Waterproofing of Basement

Before any excavation takes place on a basement waterproofing repair job, the contractor should verify underground utility locations with hand-dug potholes. An important decision on any positive-side basement waterproofing repair job involves the method of excavation to expose the failed below-grade walls. The choice of compaction equipment on a basement waterproofing backfill job depends upon jobsite access. For very large jobs where access is excellent, track rolling with a track loader or dozer may work. However, large track equipment is seldom practical when working closely around existing buildings. Good compaction requires that the soil be layered in "lifts" with the "optimum" moisture content. For compaction of large volumes of earth around existing building, a "sheep foot" roller should be considered.

4.3 Alternatives to Compaction

The gravel and the earth backfill should be brought up in lifts. The geotextile fabric is installed between the gravel and the earth backfill. Gravel costs more than common fill but, unlike soil and fill, gravel does not have to be compacted. This is because the large individual rock pieces fall quickly into a "closest packed" configuration upon placement. The added cost of the gravel will probably be more than offset by the cost savings on compaction.

5.0 Conclusion

The basement waterproofing repair should be undertaken by an experienced repair contractor and not a new construction waterproofing specialist. The liquids and gases in the soil can easily penetrate normal concrete which is permeable because of the tiny capillaries generated during hydration. A variety of waterproofing materials available and one should make a distinction between positive and negative-side applications. It is important to keep in mind the important tasks of a basement waterproofing repair job, the majority of which require knowledge and skills which are not directly related to the application of basement waterproofing materials. A successful repair contractor will possess knowledge and ability in broad variety of trades, and basement waterproofing is among the most important.