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WHITEPAPER

Elevator Pit Waterproofing with Crystalline Technology

Abstract: *Elevator pits—the concrete boxes that sit at the bottom of the shaft below the elevator cars—are a simple structural system but can be highly susceptible to water intrusion, which will directly affect the structural and mechanical integrity of the elevator system. The following whitepaper evaluates various elevator pit waterproofing methods based on their reliability, accessibility and long-term durability. Particular emphasis is placed on crystalline waterproofing and its application as a long-term solution in new construction and remedial repair techniques for existing elevator pits.*

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Elevators come in all shapes, sizes and different types ranging from a simple three story hydraulic elevator to a standard cable hoist to today's advanced carbon-fiber rope systems. Building owners and occupants take the efficiency and reliability of the elevator for granted – until there is a breakdown. While the disruption could be mechanical, in some cases, water intrusion or flooding of the elevator pit is the culprit, forcing the shutdown of the elevator system until the problem is rectified.

Water Ingress in Elevator Pit

In the following, we will examine the advantages of crystalline technology compared to other methods for the waterproofing of elevator pits in both new construction and for the repair and maintenance of existing structures.

Inside the Elevator

Whether constructing a low-rise or high-rise building, vertical mobility is a critical component in modern day structures. First invented by Archimedes in 236 BC, elevators have evolved considerably since then. In 1832, Burton and Horton introduced the ascending room and Elisha Otis first installed a commercial safety elevator in New York in 1874. Today the Taipei 101 Building boasts elevators that can travel at 37-mile-per-hour and now the owners of the 3,281 feet high Jeddah Tower are installing double deck elevators that will rise 2,165 feet. It has been estimated that on a worldwide basis 7 billion elevator journeys are taken in tall buildings daily.

Yet even with continual improvements in technology, all modern elevator systems still have a common element – the elevator pit, a concrete box found at the lowest point of the elevator structure. By definition an elevator pit is that part of an elevator shaft that extends from the threshold level of the lowest landing door to the floor at the bottom of the shaft. The pit itself normally consists of a cast-in-place base slab and four walls which will either be constructed of concrete or concrete block. In some cases, there may be a requirement for a sump and, if the pit is for a hydraulic piston elevator, it will also have a center casing extending through the base slab to accept the piston shaft as the elevator descends. Depending on the size of the building, construction may require just a single pit or multiple pits for the various elevators throughout the building.

Whatever the arrangement, the pit must be completely waterproof. Since elevator pits are constructed with concrete, which is inherently a porous and permeable material, measures need to be taken to protect the structure against water ingress and, when necessary, the aggressive action of dissolved chemicals such as chloride ions and sulfates which penetrate concrete via its pores (capillary tracts) and cracks and can rapidly deteriorate the structure.

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Elevator Pit Waterproofing with Crystalline Technology

Waterproofing Techniques

Typically, elevator pits are waterproofed by applying a membrane, coating or bentonite based blankets under the slab and on the exterior of the pit walls. These acts as barriers on the surface of the concrete to prevent the penetration of water.

Positive side, below grade waterproofing in elevator pits requires unencumbered access to the exterior wall surfaces and sufficient space for applicators to work effectively. This is especially true when it comes to the fine details such as lap joints, termination bars and corner details, all of which are potential failure points.

Blindside waterproofing is more of a description of how the waterproofing system will be installed than a specific material system. When site restraints limit the ability to excavate a larger area around the elevator pit to give access for waterproofing the exterior, the waterproofing system must be applied to a shoring or soil nailing system. The concrete walls are then poured against the selected waterproofing system. Because the waterproofing system is hidden, it is vital that all joints, seams and corner details are detailed perfectly as once the concrete has been poured there is no way to rectify any problems with the primary waterproofing system itself.

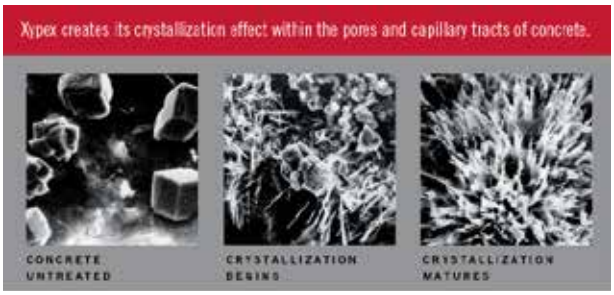
The Crystalline Advantage

Unlike traditional barrier systems, crystalline waterproofing technology, which has been used successfully for many years, can be installed as an admixture in the concrete at the batch plant or applied as a surface treatment to either the interior or exterior of the structure.

Integral crystalline technology is manufactured in the form of a dry powder compound consisting of Portland cement, very fine treated silica sand, and a unique blend of proprietary chemicals. The proprietary chemicals react with the by-products of cement hydration and combine within the concrete matrix to produce a non-soluble crystalline formation that fills and plugs up the capillary tracts and fine shrinkage cracks in the concrete. Specific formulations are produced for application either as a coating material, concrete admixture or dry shake product.

When a cement particle hydrates, the reaction between water and the cement causes it to become a hard, solid, rocklike mass. The reaction also generates chemical by-products that lie dormant in the concrete. Crystalline technology adds another set of chemicals to the mixture. When these two groups, the by-products of cement hydration and the crystalline chemicals, are brought together in the presence of moisture, a chemical reaction occurs which produces a new non-soluble structure in the capillaries, micro cracks and shrinkage cracks that are found in the concrete substrate. By means of the crystalline reaction the porosity of the concrete is greatly reduced and hairline shrinkage cracks are sealed against water leakage.

The crystalline formations can be seen with Scanning Electron Microscope (SEM) images which show how the crystalline formation fills and heals capillary tracts and cracks significantly reducing the diffusion of aggressive substances into the concrete while increasing durability and extending the life of the structure.



Crystallization Process

Scientific Verification

In addition to visual evidence of the crystalline formation within the concrete provided by SEM images, both independent permeability and chemical resistance testing demonstrates the ability of crystalline technology to waterproof and protect concrete structures.

Waterproofing effectiveness has been verified in multiple hydrostatic permeability tests using either a modified U.S. Army Corps of Engineers CRD C 48-92 or European DIN 1048 (EN 12390-8) testing procedures. In the CRD C 48 method, using 2" thick concrete samples, it has been shown that the integral crystalline technology can withstand water pressures equivalent to over 400 feet of head pressure. In EN 12390-8 testing using a head pressure equal to 233 feet and measuring for depth of water penetration after 72 hours of applied pressure, crystalline technology reduced depth of water penetration by up to 90%.

Crystalline concrete waterproofing is resistant to most aggressive chemicals with a pH between 3 and 11. This means that it will provide chemical resistance where mate-

rials coming in contact with the concrete have a pH of 3.0 - 11.0 in constant contact and 2.0 - 12.0 in periodic contact.

Testing for both sulfate resistance and chloride attack have shown a significant improvement in performance when compared to control samples further enhancing concrete durability in adverse soil or groundwater conditions.

Integral crystalline waterproofing technology is also able to help the concrete self-heal static hairline cracks up to 0.4 mm in width. In cases where the cracks are wider and there is active leakage, a remedial repair system can be used from the negative side to seal the structure.

Concrete enhanced with crystalline waterproofing admixture not only has similar waterproofing and chemically resistant properties as concrete treated with a crystalline coating, but it may also achieve higher compressive strength than the same mix without the crystalline additive. Testing has shown that compressive strength increases in the range of 5% - 10% at 28 days are possible.

Field Verification

More important than laboratory testing Crystalline technology has proven its effectiveness in the field, with more than 45 years of experience in waterproofing and protecting concrete structures.

Crystalline waterproofing technology is a proven, accepted and effective method of waterproofing concrete structures ranging from water treatment plants to deep foundations and this applies equally to elevator lift pits. When used as a coating it is less costly than other systems, not subject to physical deterioration and resists extreme hydrostatic pressures. Unlike a membrane it does not require that the surface be smoothed and leveled prior to the coating application. There are no laps or seams, no special details needed at corners and edges and it does not require protection during backfilling.

The use of the integral crystalline admixture system shares all of the above mentioned advantages with the additional benefits of even lower installation costs and faster scheduling for the waterproofing of elevator pits.

How It Is Used

In terms of design, the use of the crystalline waterproofing system requires no structural changes. The base of the elevator pit is poured as a structural slab with the walls mounted on top of it and the construction joints are detailed with crystalline waterproofing, a PVC waterstop or an expandable waterstop such as a bentonite or hydrophilic rubber material.

Deciding whether to use the crystalline waterproofing coating or the crystalline admixture will depend on both the job site conditions and the thickness of the concrete element. Normally elevator pit walls and slabs are less expensive to waterproof with crystalline admixture versus crystalline coating and both are less expensive than traditional membranes.

Because crystalline waterproofing can be introduced as an admixture directly into the concrete at the batch plant it is a very clean and efficient waterproofing approach. The process ensures thorough dispersal of the chemistry throughout the concrete with no alteration to the appearance of the concrete.

The dosage rate for crystalline admixture can vary depending on the concrete mix design, but it is generally in the range of 2% - 3% by weight of cementitious materials. Once the waterproofing chemicals are mixed into the concrete at the batching plant, all other operations such as pumping, placement and finishing are the same as with regular concrete. The use of crystalline waterproofing requires nothing other than standard concrete construction practices.

When a surface applied coating application of crystalline waterproofing is required the procedure is relatively simple. The concrete is prepared by using a 3,000 psi - 4,000 psi water blast to clean and opens the porosity of the concrete surface. When the concrete is in a saturated surface-damp condition, the crystalline coating material is applied by either brush or spray equipment.

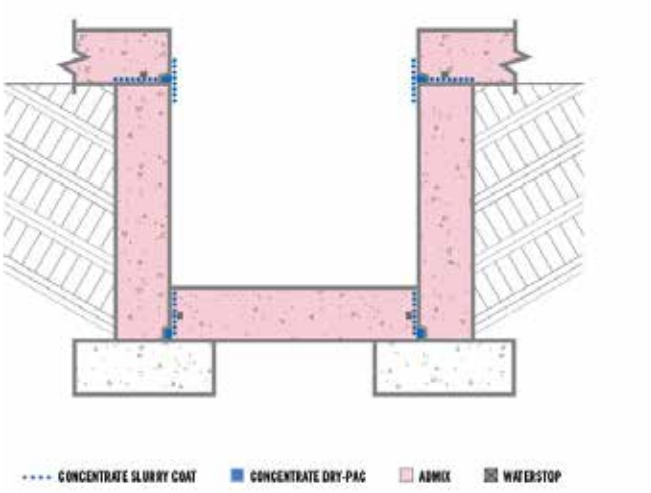
Once on the surface of the concrete, the active chemicals in the coating diffuse into the substrate where they react with the byproducts of cement hydration in the capillary tracts and form a new non-soluble crystalline structure thus blocking the path of any water intrusion. After application, the coating must be water cured 2 to 3 times a day for two days or treated with a specialized curing agent.

New Construction

For new construction the choice of whether to use the crystalline waterproofing integral admixture or coating system is fairly simple.

Both materials can be evaluated on a “cost per-square-foot” basis. As a general rule, the cost of the admixture system is less expensive on structures that are 18” (450 mm) thick or less. If the cross-sectional thickness becomes greater than 18” (450 mm), then taking into account the cost of surface preparation, application and curing the coating system will usually be less expensive.

ELEVATOR PIT / SUMP PIT

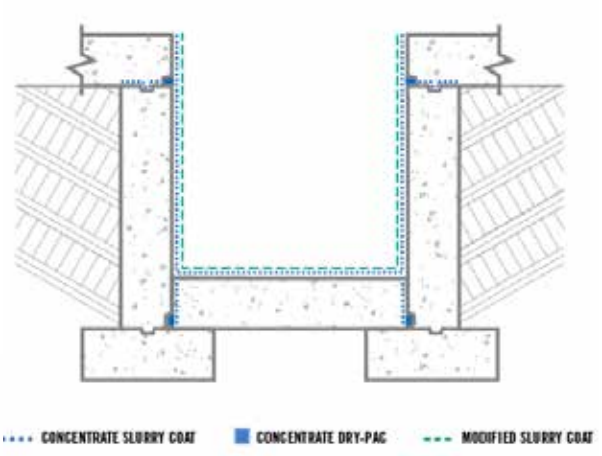


Admix included in the concrete mix

For new construction, the integral crystalline waterproofing admixture powder is added to the concrete at the ready mix batch plant at a rate of 2% - 3% of the Portland cement content and mixed for at least 5 minutes prior to departing to the jobsite. A mix design that includes slag or Type C fly ash will also affect the dosage rate. If the mix design uses Type F fly ash, normally only the Portland cement and slag contents are included in the dosage calculation.

The admixture is available in water soluble bags of 10 pounds, 12 pounds or 15 pounds which makes it convenient for the ready mix user in terms of adding the correct amount of material.

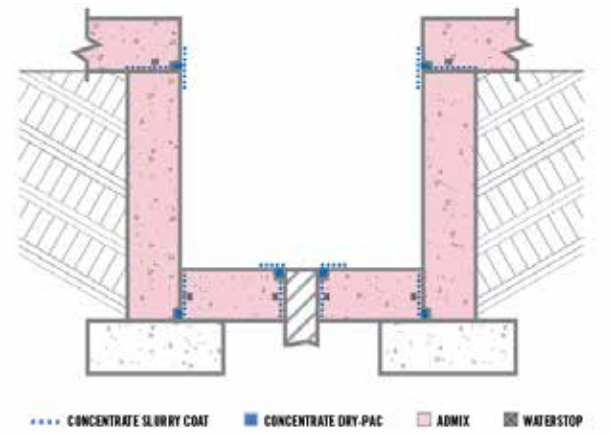
As an alternative to the use of the crystalline admixture, the design could specify the crystalline coating system be applied to the concrete elevator pit walls and floor surfaces once the forms have been removed.



Application of crystalline waterproofing coating on negative side

For new construction the most important detail after the selection of either the admixture or coating waterproofing system is the treatment of the joint lines as these are the areas which are most vulnerable to water intrusion. Depending on the groundwater table and hydrostatic pressure there a few different options that can be looked at but one thing that should be kept in mind is that the small investment in using redundant systems at the joint line will always pay off in the long term.

HYDRAULIC ELEVATOR PIT

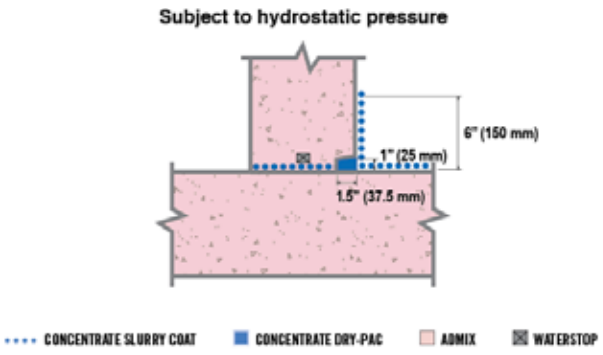


Detail for hydraulic elevator pit construction

Construction Joint Sealing

The best way to help ensure watertight joints is to have two levels of protection. The primary system should consist of a waterstop, either a PVC type or an expandable waterstop (bentonite or hydrophilic rubber) and a secondary system consisting of a sealing strip of crystalline reactive material as well as a slurry coat of crystalline waterproofing material.

The crystalline sealing strip is formed by means of a wooden reglet which is attached to the forms and creates a linear groove in the cast-in-place concrete. The linear groove is aligned with the wall/slab joint line and should be 1" (25 mm) high by 1½" (37 mm) deep as per the schematic shown below.



Joint details

The full procedure includes installing the chosen waterstop product and applying a slurry coat of crystalline reactive waterproofing material to the footing or structural slab 24 - 48 hours prior to pouring the wall. Once the wall has been cast and the reglet has been removed, the slot is then filled with the crystalline waterproofing material in dry pack form.

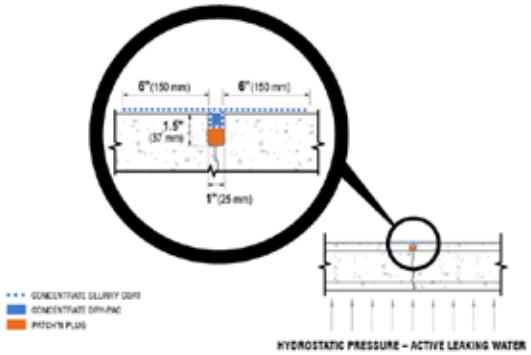
This is achieved by mixing the crystalline powder with water at the ratio of 6 parts powder to one part water by volume and then tightly compressing this material with either a mechanical packer or block and hammer to the full depth of the slot. One coat of crystalline slurry is applied over the area extending 6 inches up the wall and 6 inches out onto the slab.

Waterproofing Existing Elevator Pits

Existing elevator pits that are actively leaking through construction joints or cracks in the concrete can be waterproofed and repaired from the interior (negative side) using either a crystalline technology repair system by itself or in conjunction with a water reactive injection grout as they are compatible materials.

When using crystalline waterproofing materials, the process for waterproofing existing leaky elevator pits typically involves chipping or cutting a groove along joint lines or any cracks and forming a cavity at any specific point of water ingress such as tie-hole or defect in the concrete.

Depending on the volume of water flow through the crack or construction joint, the repairs can be undertaken using the methods outlined in the following drawings.



Details for crack or joint sealing (against a flow of water)

First, the water flow must be stopped using a fast setting hydraulic cement such as Xypex Patch'n Plug. Then Xypex Concentrate in dry-pack consistency can be used to fill the remainder of the cavity.

Once the ingress of water has been stopped through cracks, joints or defects in the concrete, the surfaces should be treated with a two coat application of crystalline waterproofing (Xypex Concentrate). This will stop water seepage through the concrete pores, capillaries and micro-cracks that are too small to cut or chisel open.

A full repair method statement can be found at:
http://xypex.com/technical/statements

Conclusion

Although elevator pits are a simple structural system making them waterproof is a challenge highly influenced by location, soil conditions, construction methods and other criteria.

The use of integral crystalline waterproofing added to concrete at the batch plant as an admixture or applied at the surface of hardened concrete is an effective waterproofing technique for new construction and for the repair and maintenance of existing structures.

Case Study: The Willis Building, London

Willis Building, London, England

The Willis Building in London stands over 26 stories high. Xypex Admix was used to waterproof the basement slab (2,500 cubic yards) against hydrostatic pressure. Admix was also used on the lift pits of the structure's 21 elevators which are designed to travel at 15 miles per hour.

The concrete used in the floor slab (including the elevator pit slab) was treated with Xypex Admix C-1000 NF. A Xypex Concentrate slurry coat was applied to the joint surfaces and Xypex Concentrate in Dry-Pac form was used on all floor joint details.

Case Study: Pismo Beach, California

Images of elevator pit before and after application of crystalline waterproofing

The elevator pit originally had 12" of standing water that flowed into the pit at a steady rate. Repairs using Xypex Patch'n Plug and Xypex Concentrate were successfully completed from the interior side.

Case Study: Transbay Transit Center

Transbay Transit Center cross section

The Transbay Transit Center is a new transit center which, when fully developed, will be the keystone in a full new neighborhood development project.

The first phase of construction involves a new, five story multimodal Transit Center. Xypex products were used in all elevator pits, escalator pits and utility vaults.

Case Study: Capitol Visitor Center

Capitol Visitor Center, Washington, DC, USA

Xypex Concentrate and Xypex Modified were applied to the cast-in-place concrete elevator pits of the Capitol Visitor Center in Washington, DC as well as the foundation walls.

Jim Caruth is a Civil Engineering graduate from the University of Waterloo in Ontario Canada. He is a member of the Association of Professional Engineers of British Columbia and has 25 years of experience in the concrete construction industry. Jim's background includes experience managing a fly ash importing and distribution company as well as managing the marine transportation division of a large ready mix plant and as the Operations Manager of 500,000 cubic yard per year ready mix operation. Jim also has experience with technical sales for a worldwide manufacturer and leader in the areas of concrete restoration and protection of which he has extensive knowledge.

Jim's background also includes time on various ACI committees and as a Board Member of the British Columbia Chapter of ACI. He has been a voting member of the CSA A-3000 Cementitious Materials Compendium committee. Jim has also worked on and chaired several committees for the BC Ready Mixed Concrete Association including being awarded a Leadership and Contribution Award in 1998 and the BCRMCA 2003 Award for Outstanding Contribution to the Concrete Industry.

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