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STATE OF THE ART WATERPROOFING TECHNOLOGY

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Abstract: *This paper aims at presenting an efficient waterproofing system, which can be used to stop water infiltration in concrete elements. It can be applied both for pouring fresh concrete and for repairing existing constructions. The complete system includes crystalline waterproofing – which contain multiple activating chemicals that provide the most effective permanent concrete waterproofing and protection system available. waterstops and liquid sealers.*

Key words: *concrete durability, crystalline admixture, waterproofing, alkali-aggregate reactions, alkali-silica reaction.*

1. Introduction

In terms of durability there are several causes of concrete deterioration such as:
- freezing and thawing;
- corrosion of metals;
- chemical reaction of aggregates;
- abrasion;
- aggressive chemical exposure;
- chemical exposure;
- repair of concrete and the use of protective-barrier systems.

For example, freezing and thawing in the temperate regions of the world can cause severe deterioration of concrete.

Increased use of concrete in countries with hot climates has drawn attention to the fact that deleterious chemical processes, such as corrosion and alkali-aggregate reactions, are aggravated by high temperatures. Also, the combined effects of cold winter and hot summer exposures should receive attention in proportioning and making of durable concrete. [1]

Alkali-aggregate reaction (AAR) is a reaction in concrete between the alkali hydroxides, which originate mainly from the portland cement, and certain types of aggregate. Two types of AAR are currently recognized; these are alkali-silica reaction (ASR) and alkali-carbonate reaction (ACR). As the names imply, these types of reaction differ in that they involve reactions with either siliceous or carbonate phases in the aggregates. [2]

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Repairing damaged concrete has a starting point the evaluation of damage and selection of repair method. There are several types of repairs as they are presented in Guide to Durable Concrete reported by ACI Committee 201, ACI 201.2R-01:

- concrete replacement;
- dry pack, which consists of ramming a very stiff mixture into place in thin layers;
- preplaced-aggregate concrete, advantageously used for certain types repairs;
- shotcrete that can provide an excellent bond with new or old concrete if properly applied;
- repair of scaled areas and spalls in slabs. [1]

2. Waterproofing Technology

The modern technology described in this article is called Penetron. It enhances the durability, strength, overall performance and lifespan of concrete. Its cementitious capillary waterproofing products combine high quality cements, quartz, (special grade) sand and proprietary active ingredients to provide the most effective system to permanently reduce permeability and waterproof concrete. [7]

2.1. Permeability-reducing admixtures

While it is generally accepted that well-proportioned and properly cured concrete produced using a low w/cm will result in a finished product with good durability and low permeability, no concrete structure is absolutely waterproof or “bottle tight” (Perkins 1986). Concrete is a porous material, and water can penetrate concrete through pores and microcracks due to capillary absorption (often referred to as wicking) or due to hydrostatic pressure. In some cases, porosity may be exacerbated by external factors such as incomplete consolidation and curing, which may ultimately lead to reduced durability. The addition of supplementary cementing materials (SCMs) into concrete mixtures has been gaining acceptance with respect to improving durability and reducing permeability (Munn et al. 2005). In addition, a class of materials referred to as permeability-reducing admixtures (PRAs) have been developed to improve concrete durability through controlling water and moisture movement (Roy and Northwood 1999) as well as by reducing chloride ion ingress (Munn et al. 2003) and permeability (Munn et al. 2005).

PRAs encompass a range of materials with variances in performance. Although PRAs are traditionally subcategorized as dampproofing and waterproofing admixtures (Ramachandran 1995; ACI 212.3R; Aldred 1989), perhaps it is too absolute to state that concrete can be made waterproof. For the purpose of this article, admixtures intended to reduce water ingress will be split into two subcategories: PRAs for concrete exposed to nonhydrostatic conditions (PRAN) and PRAs for concrete exposed to hydrostatic conditions (PRAH). [3]

Penetron admix is a non-toxic, 3rd generation crystalline admixture in powder form that is added to new concrete during batching. Some of its properties are:

- it reduces concrete permeability by permanently sealing microcracks, pores and

capillaries and effectively protecting the concrete against water penetration and the effects of deterioration, even under high hydrostatic pressure;

- it provides projects with self-healing concrete with the ability to reseal cracks that develop during the lifetime of the concrete;
- is compatible with all commonly used workability admixtures (e.g. superplasticizers, retarders) and mix design formulations (trial mixes recommended prior to casting). [7]

2.2. The Operating Principle

When Penetron admix is added to the concrete, the crystalline components react with water, calcium hydroxide and aluminum as well as various other metal oxides and salts contained in the concrete. The chemical reaction that follows causes these voids and cracks to be filled with insoluble crystals. Therefore, water is unable to pass through these crystal formations, and as a result the concrete becomes impermeable.

The whole process is shown in Figures 1, 2 and 3. [7]

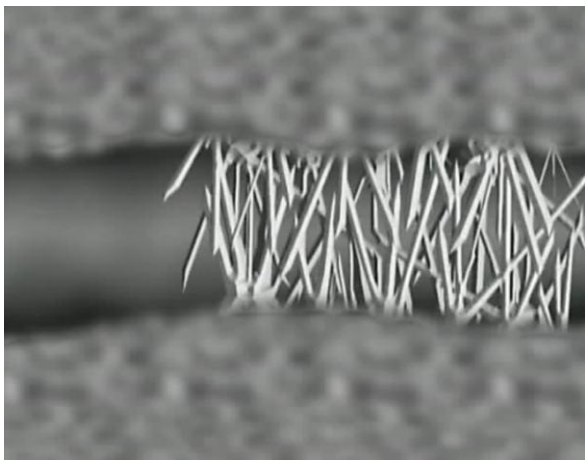

Fig. 1. *Chemical reaction that occur after Penetron admix is added to the concrete*

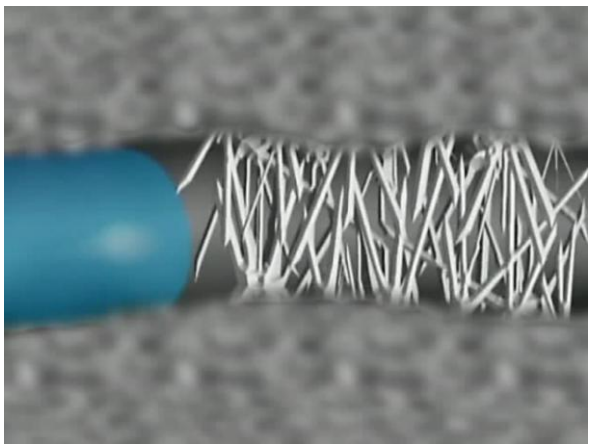

Fig. 2. *Water blocked from passing through crystal formations*

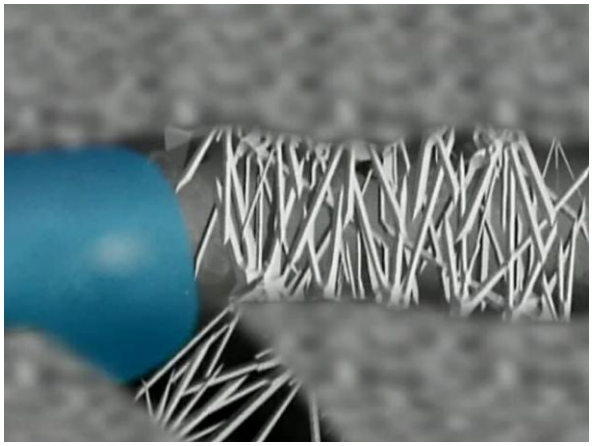

Fig. 3. *Crystals formed even if new cracks appear throughout the life of the concrete*

2.3. Penetron System

The complete Penetron system includes the products: crystalline waterproofing, waterstops and liquid sealers.

From crystalline waterproofing category we mention Penetron admix, Penecrete mortar (used for filling non-moving cracks and construction joints, form-tie holes, honey-combed areas and structurally damaged concrete), Peneplug (a rapid-setting, crystalline-based, cementitious compound designed to stopping active leaks even under high hydrostatic pressure), Penetron Plus (specially formulated for dry-shake applications on horizontal concrete surfaces or precast segments where greater impact and abrasion resistance is required) and Penetron inject (an advanced crystalline-based two-component injection grout with integral crystalline waterproofing ability, by filling and sealing deeply embedded voids, cracks and fissures).

Waterstops are Penebar sw-55 (creates a physical barrier against water penetration through cast-in-place concrete joints that expand - in a controlled fashion - when exposed to water), Penebar sw-45 rapid (recommended for building foundations, slabs, retaining walls, storage tanks and other immovable cold construction joints) and Penebar primer (enhances the bonding between pre-formed sealants, such as sw type, and concrete surfaces aiding in the installation process).

In the liquid sealers box we can find Peneseal fh (a clear, reactive penetrating sealer designed to permanently protect, preserve and strengthen concrete and masonry building materials that penetrates deep into concrete surfaces and reacts with the elemental concrete ingredients to solidify them into a harder, denser, stronger concrete mass) and Peneseal pro (a spray-on liquid sealer that forms a barrier to seal hairline cracks and protect concrete against water penetration; it also creates a sub-surface gel that seals the pores, capillaries and cracks). [7]

2.4. Case studies

It is obvious that the above system has applicability all over the world. We mention

furthermore two applications, both in Brasov department.

The first one aimed to waterproof an existing basement against water under hydrostatic pressure. In order to achieve these goals at a Sp+P+E height regime building Panetron admix, Penecrete mortar, Penebar sw-45 and Peneplug components were used. [4]

The application of Penebar primer waterstop product is shown in Figure 4:

Fig. 4. *Penebar primer waterstop application*

The second case study was carried out at two reinforced concrete decanters. According to the design project, the characteristics of the concrete used for the raft foundation and the walls are: C35/45 XC4XD2XF1XA2 CEM IIA-S 42.5R Cl 0.2% D16 S4 concrete class, degree of impermeability P12, waterproofing additive, G150 freeze-thaw degree [5].

The concrete pouring procedure respected technical instructions and regulations. Batch samples were taken at the frequency indicated by norms. [6]

In this case Penetron admix, Penecrete mortar, Peneplug and Penetron plus compounds where used.

Fig. 5. *Filling cracks with Penecrete mortar*

3. Conclusions

The main Penetron technology characteristics are:

- penetrates deeply: up to 1 meter; seals capillary tracts and cracks in concrete up to 400 microns in width;
- permanent: once the concrete is treated, the Penetron crystals remain active and part of the concrete for life;
- enhances durability: greatly reduces permeability, allowing concrete to resist chemical attack and provides a wide range of protection from freeze-thaw cycles, corrosion, aggressive groundwater, sea water, carbonates, chlorides, sulfates and nitrates;
- economical: more effective and less costly than membranes, clay panels, pore blockers, and coatings;
- cost-effective: does not require protection during backfilling, placement of steel or wire mesh or other common procedures; can be applied to moist or green concrete;
- versatile: can be applied to either new or existing concrete;
- safe: nontoxic.

Some of the benefits of Penetron admix component, are:

- a one step solution that integrates Penetron protection from the beginning;
- available in portion-controlled sizes in soluble bags for quality control and easy dosing;
- product tracer provides easy identification at any stage of use;
- greatly reduces impacts to construction scheduling;
- added at the time of batching and not subject to climatic conditions.

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