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Waste Water Treatment Plant Project

The Wastewater Treatment System in a city is a combination of wastewater pipe and canal, pumping station and wastewater treatment plant. Some outlying areas have no system and wastewater is not treated before discharge into a wastewater canal system.

Wastewater treatment plants treat household sewage and industrial waste. Discharges from the plants are sent into waterways or spread on land. Most wastewater plants have primary treatment (physical removal of floatable and solids) and secondary treatment (the biological removal of dissolved solids).
Why Concrete Structures Deteriorate

Moisture, water and chemicals damage concrete

- **Even Concrete of high quality is a porous material**
  - Excess water evaporation during hardening will leave millions of pores and capillaries in concrete
  - The zones between cement and aggregates are prone to cracking during hardening due to drying shrinkage, temperature stress and outside forces

- **Porosity of concrete**
  - Allows moisture, water and chemicals to move freely throughout the concrete
  - Increases absorption of deleterious chemicals

- **Moisture, water and chemicals intrusion**
  - Results in corrosion of the concrete due to chemicals dissolved in water
  - Results in concrete neutralization (carbonization)
  - Results in alkali-aggregate reaction
  - Freeze/thaw cycles can lead to concrete cracking and damage
  - Reduces structural property
Moisture, water and chemicals damage to reinforcing steel

Millions of pores and capillaries are left in untreated hardened concrete

Chlorides penetrate into concrete with the help of surface moisture and water

When chlorides penetrate to reinforcing steel, corrosion begins

Further penetration of chlorides results in further corrosion, deterioration and spalling

Over time,
any untreated concrete structure will slowly succumb to damage due to the presence of water and chemicals,
What are Penetron products?

- **Penetron products are cementitious capillary crystalline waterproofing materials**
  - Powders consisting of Portland cement, quartz sand and multiple activating chemicals
  - A range of activating chemicals in powder form that can be applied to concrete as an admixture, slurry and dry-shake

- **Penetron products can effectively stop water and moisture penetration into concrete, and provide the best protection for concrete by improving the capillary structure and reducing porosity**
  - Penetron: Applied by brush or spray on hardened concrete surface
  - Penetron Plus: Dry shake application on horizontal fresh concrete surface
  - Penetron Admix: An additive mixed into new concrete at the time of batching for complete integral waterproofing

- **Application**
  - Water towers & storage tanks
  - Subway & other tunnel systems
  - Off-shore & marine structure
  - Sewage and water treatment plants
  - Reservoirs & dams
  - Bridge decks
  - Basements
  - Traffic-bearing structures
  - Swimming pools
  - Parking decks
  - Foundations
  - Elevator shafts

- **Company passed ISO 9001 quality system authentication**
How Penetron products waterproof and protect concrete

- Penetron or Penetron Plus

1. Typical concrete structure with moisture
2. When mixed with water and applied as a coating, the active chemicals in Penetron cause a reaction leading to the formation of non-soluble crystals within the pores and capillary canals of concrete.
3. The concrete becomes permanently sealed and neither water nor any other liquids are able to penetrate the concrete from any direction.

Concrete is previously saturated with water so that there is an adequate amount of liquid present to allow movement of chemicals into the concrete pores. The chemicals are pushed into the concrete through the action of diffusion. Under the right conditions, the chemicals can also move into the concrete by seeping water, or by the natural wicking action of the concrete.

Once into the concrete, the chemicals react with unhydrated cement particles and, by-products of cement hydration to form needle-like crystals, which fill and block the pores and capillaries in the concrete. Water can no longer pass through the concrete and thus the concrete is said to be “waterproof”.

In the absence of moisture, the activating chemicals remain dormant in concrete for years. Any penetrating moisture can activate the dormant materials. Any time any minute cracks recur, the chemical reaction and sealing process will repeat itself automatically.
**Penetron Admix**

Penetron Admix is a unique crystal-forming additive that provides permanent protection for buildings and other structures by waterproofing concrete from the inside out.

Penetron Admix is added to the concrete mix at the time of batching. The activating chemicals of the product react with water, unhydrated cement particles and by-products of cement hydration in concrete to form needle-like crystals. These crystals grow and migrate through the concrete to fill in hairline cracks and microscopic voids that would otherwise serve as passages for harmful moisture.

Penetron Admix enhances the natural hydration process in concrete by intensifying hydration crystal growth, increasing compressive strength and reducing cracking caused by shrinkage.

In absence of moisture, the activating chemicals remain dormant in concrete for years. Should cracks recur at any time, these dormant materials are activated by any penetrating moisture, and the chemical action and sealing process repeats itself automatically.
Features, Advantages & Benefits

- **Features and Advantages**

  -- Penetron Admix

  **Permanent waterproofing admixture**
  - Impermeability lasts as long as the concrete
  - System becomes an integral part of the concrete
  - Does not require re-application

  **Resists high hydrostatic pressure from either positive or negative surface**
  - Idea for below grade application
  - Does not need any other form of waterproofing
  - Protects against waterborne ground contaminants

  **Protects reinforcing steel from corrosion**
  - Highly resistant to waterborne aggressive chemicals
  - Stops ingress of water required for AAR
  - Allows concrete to breathe, eliminating vapor buildup and leaving the concrete completely dry

  **Will grow crystals years after initial construction**
  - Will re-activate in the presence of moisture
  - Self-heals hairline cracks of up to 0.4mm and stop water ingress that may occur from subsequent damage to the structure
  - Continually improves with time

  **Multifunctional admixture**
  - Does not contain stearates, sodium’s or silicates
  - Not a hydrophobic type product
  - Not a surface densification product
  - Assists concrete in the hydration process, acting as a catalyst to un-hydrated cement particles already existing in the concrete
  - Water-reducing, increasing workability of fresh concrete
  - Increases compressive strength of hardened concrete
  - Non-toxic
  - Approved for portable water use
-- Penetron or Penetron Plus

**In-depth waterproofing property**

- Penetrates deeply, and impermeability lasts as long as the concrete
- System becomes an integral part of the concrete, forming a complete body of strength and durability
- Waterproofing and chemical resistance property remain intact even if the surface is damaged

**Completely effective against high hydrostatic pressure**

- Idea for below grade application, reservoirs and pipelines
- Does not require protection during backfilling, placement of steel or wire mesh and other common procedures
- Protects against waterborne ground contaminants

**Protects reinforcing steel from corrosion**

- Resists chemical attack (PH3-11 constant contact; PH2-12 periodic contact) and provides a wide range of protection from freeze/thaw cycles, aggressive waters, sea water, carbonates, chlorides, sulfates and nitrates
- Stops ingress of water required for AAR
- Allows concrete to breathe, eliminating vapor buildup and leaving the concrete completely dry

**Will grow crystals years after initial application**

- Will re-activate in the presence of moisture
- Self-heals hairline cracks of up to 0.4mm and stops water ingress that may occur from subsequent damage to the structure
- Continually improves with time

**Efficient application method**

- Can be applied from either the positive or negative side
- Can be applied to moist or green concrete
- Can be used for new or existing concrete
- Compatible with water based glues and surface coatings

**High-growth technology**

- Zero VOC
- Does not contain stearates, sodium’s or silicates
- Not a hydrophobic type product
- Not a surface densification product
- Non-toxic
- Approved for portable water use
• **Benefits of Penetron Technology**

-- Penetron Admix

**Benefits to Property Owners**

- Cost effective
- Lowers overall project costs
- Permanent waterproofing system
- Requires no maintenance
- Increases the quality of the concrete for structural performance and integrity
- Increases usage of infrastructure
- Eliminates down-time and costs associated with maintenance and repairs
- Reduces project time requirements
- Long-term manufacturer’s warranty
- Manufacturer’s history of international success in various climatic & environmental conditions

**Benefits to Contractors**

- Unmatched technical support
- Reduces application errors associated with installation of other systems
- Improves pouring and placement of concrete
- Eliminates construction delays due to elimination of traditional waiting period to install membranes on cured concrete

-- Penetron or Penetron Plus

**Benefits to Property Owners**

- Cost effective
- Lowers overall project costs
- Permanent waterproofing system
- Requires no maintenance
- Long-term manufacturer’s warranty
- Manufacturer’s history of international success in various climatic & environmental conditions

**Benefits to Contractors**

- Unmatched technical support
- Reduces application errors associated with installation of other systems
- Reduces risk of membrane failure
- Requires no protective cement mortar in comparison with other systems
Comparison of Penetron Products to Other Waterproofing Systems

<table>
<thead>
<tr>
<th>Penetron Penetron Plus</th>
<th>Penetron Admix</th>
<th>Membranes (Positive Side)</th>
<th>Other Surface Applied Products</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>Cementitious material applied on concrete surface to transfer needle-like crystals to infiltrate the concrete mass</td>
<td>Cementitious material added into fresh concrete to form needle-like crystals within the concrete mass</td>
<td>Liquid and sheet applied bitumens and polymers affixed to the concrete surface</td>
</tr>
</tbody>
</table>
| **Resistance to hydrostatic water pressure** | • Improves with time  
• Resistance to exceeding 150m head pressure  
• Withstands 3Mpa in permeability test | • Improves with time  
• Continuous self-healing ability  
• Initiates full hydration | • Protection breached by any pinhole or seam  
• Once leaking, will require replacement | • Reduces initial absorption but will deteriorate with time  
• Limited penetration leads to poor resistance to hydrostatic pressure |
| **Protection of reinforcing steel** | • Prevents corrosion of reinforcing steel by stopping passage of water and chlorides | • Permanent protection  
• Prevents any permeation of water and chlorides | • No negative side protection  
• Easily leaks at the joints and seams | • No negative side protection  
• Limited protection as it slows the water ingress in uncracked areas |
| **Crack self-healing ability** | • Will re-activate in the presence of moisture to seal new cracks even years later | • Will re-activate in the presence of moisture to seal new cracks even years later | • No self-healing ability | • No self-healing ability |
| **Crack resistance** | • Rigid material, can not bear excessive transformation, but self heals minor cracks of up to 0.4mm | • Reduces cracking in plastic and curing stage  
• Self heals minor cracks of up to 0.4mm in the presence of moisture | • Can bear excessive transformation  
• Limited time protection at existing cracks locations | • No crack resistance  
• Temporarily fills existing cracks |
| **Freeze/thaw durability** | • Improves durability by removing water within concrete  
• Eliminates water penetration at cracks | • Improves durability by removing water within concrete  
• Eliminates water penetration at cracks | • Slow deteriorating factors initially | • Slow deteriorating factors initially  
• No durability at crack locations |
| **Repair requirement** | • Permanent waterproofing protection, does not need repair | • Easily repaired from positive or negative side  
• Wide range of options are available  
• Repairs are cost effective | • Difficult to repair  
• Difficult to locate pinholes and poor joints  
• May require total removal & repair  
• Expensive and sometimes impossible due to accessibility | • Repairs may require removal of previous materials |
<table>
<thead>
<tr>
<th>Application</th>
<th>Penetron Penetron Plus</th>
<th>Penetron Admix</th>
<th>Membranes (Positive Side)</th>
<th>Other Surface Applied Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Applied by brush/ spray to positive or negative side of old/new concrete • Or, dry shake application on horizontal fresh concrete surface</td>
<td>• Mixed at batch plant or on-site • No additional applications required</td>
<td>• Liquids: brush application • Sheets: glued or welded to the concrete surface • Correct joints and seams critical to performance</td>
<td>• Only applied to positive side • Substrate profile critical to performance</td>
<td></td>
</tr>
<tr>
<td>Surface preparation</td>
<td>• Needs coarse, water saturated, clean surface for brush or spray • No surface prep for dry shake</td>
<td>• No surface preparation</td>
<td>• Clean surface • Dry surface • Smooth surface</td>
<td>• Need surface prep depending on products requirements</td>
</tr>
<tr>
<td>Construction schedule</td>
<td>• Can be applied during concrete finishing or anytime following</td>
<td>• Added into fresh concrete at the time of batching • Saves 10-50% time and construction costs</td>
<td>• Must be applied at completion of structural work • Require protective cement mortar</td>
<td>• Some require 28 days cured concrete • Similar scheduling as membranes</td>
</tr>
<tr>
<td>Effective land usage</td>
<td>• Can be applied to the negative side of concrete allowing construction tight to property lines</td>
<td>• Can build tight with property lines</td>
<td>• Spaces required between property line and concrete for membrane installation</td>
<td>• Spaces required between property line and concrete for surface application</td>
</tr>
<tr>
<td>Sub-surface drainage system</td>
<td>• Not required</td>
<td>• Not required</td>
<td>• Require drainage under high hydrostatic pressures</td>
<td>• Require drainage under high hydrostatic pressures</td>
</tr>
<tr>
<td>Additional coatings</td>
<td>• Can be finished with coatings, tiles, etc.</td>
<td>• Does not affect coatings • Adhesion excellent for coatings or tiles</td>
<td>• Require protective mortar prior to surface finishes</td>
<td>• May require special preparation prior to surface finishes</td>
</tr>
<tr>
<td>Maintenance</td>
<td>• Not only as a surface coating • Maintenance not required</td>
<td>• Maintenance not required for the life of the concrete</td>
<td>• Costly replacement generally required</td>
<td>• Re-application required under hydrostatic conditions</td>
</tr>
<tr>
<td>Service life</td>
<td>• Permanent and improves with time</td>
<td>• Life time of concrete</td>
<td>• Become brittle with age resulting in cracks and openings • Surface damage will eliminate protection</td>
<td>• Best when first applied • Deteriorate with time • Vulnerable to surface damage</td>
</tr>
</tbody>
</table>
Penetron for a Wastewater Treatment Plant Project

- Proposal for Tanks

Concrete self-waterproofing treatment or Concrete surface waterproofing treatment

-- Concrete self-waterproofing treatment

Penetron Admix is added into concrete at the time of batching for complete integral waterproofing.

-- Concrete surface waterproofing treatment

Penetron is applied on the surface of tanks by brush or spray.
**Proposal for Tunnels or Wastewater Canals**

Concrete self-waterproofing treatment or Concrete surface waterproofing treatment

--- Concrete self-waterproofing treatment
Penetron Admix is added into concrete at the time of batching for complete integral waterproofing.

--- Concrete surface waterproofing treatment
Penetron is applied on the surface of tunnels or wastewater canals by brush or spray.

**Proposal for Auxiliary Structures**

Concrete self-waterproofing treatment or Concrete surface waterproofing treatment

--- Concrete self-waterproofing treatment
Penetron Admix is added into concrete at the time of batching for complete integral waterproofing.

--- Concrete surface waterproofing treatment
Penetron is applied on the surface by brush or spray.
Application of Penetron Products

- **Application of Penetron**
  
  -- **Surface Preparation**
  
  The concrete surface to receive the Penetron system must be structurally sound and free of dirt, soil, oil, release agents, laitance or any other foreign materials which may impair the bond, penetration and/or overall performance of Penetron materials.

  Extremely smooth concrete surface must be waterblasted or sandblasted to make sure the concrete surface has an open capillary system.

  Rout out visible cracks exceeding 0.4mm in size to a depth of 20mm to 25mm. Also rout out honeycombed pockets and faulty construction joints to sound concrete. Construction joints are routed or provided with a formed 20mm*20mm reglet.

  Wet down dry surfaces prior to the application of Penetron materials. Moisture must be present in the concrete strata to ensure maximum chemical penetration. Surfaces must be damp when Penetron products are applied.

  -- **Mixing**

  Brush application: 0.8-1.5kg/m², 5 parts Penetron to 2 parts water

  Spray application: 0.8-1.5kg/m², 5 parts Penetron to 2.75-to-3.25 parts water (varies with climate and spray equipment)

  Penetron should be mixed to the consistency of thick latex paint. Stir the slurry mixture frequently during the application and prepare only as much as can be applied within a 30-minute period.

  -- **Application**

  Apply Penetron coating by masonry-type brush (artificial fibers, if available). For spray application, drop hopper or piston pump type equipment is recommended.

  Prior to application of Penetron coatings, fill form tie holes, rout out cracks, honey bombs, reglets and seal strips at construction joints with Penecrete Mortar in laminating layer of 2.5cm to 3cm. Prime concrete surface of these areas with one slurry coat of Penetron prior to applying Penecrete Mortar.

  Penetron slurry must be applied to damp concrete surface. Second coat should be applied when first coat is dry to the touch. A light misting of water may be required between coats in hot/dry climates.
Horizontal concrete surfaces: Apply Penetron slurry in one coat with stiff bristle brush/broom or squeegee.

Dry sprinkle Penetron or Penetron Plus on “still plastic” concrete by broadcasting or use of a fine mesh sieve, in quantities that are specified. Work Penetron powdered slab surface with wood flat or power trowel until required finish has been achieved.

-- Coverage

Horizontal concrete surface: Penetron at 1.4 to 1.6kg/m$^2$. Apply in one slurry coat or powder application when concrete reaches initial set. Trowel or float to specified finish. Penetron Plus powder application at 0.5kg/m$^2$ when concrete reaches initial set. Trowel or float to specified finish.

Vertical concrete surfaces: Penetron at 1.4 to 1.6kg/m$^2$. Apply in two coats (0.8kg.per coat).

-- Curing

Except for extremely hot weather and very low humidity, curing of the Penetrone system is not required. In these extreme conditions curing, using a light water misting, must begin as soon as the Penetron coating has hardened sufficiently. Under most conditions it is sufficient to mist the areas treated with Penetron three times a day for the first day. In extremely hot climates spraying may be required more frequently and for several days.

Penetron Plus (trowel applied): Follow concrete specifications for curing procedures.

-- Temperature requirement

Penetron system can be applied in coating or in mortar form when the temperature is above 32 degrees Fahrenheit or 0 degrees Centigrade.

Penetron Plus (trowel applied) can be applied in temperatures where concrete can be placed. Follow concrete specifications for protection requirements according to standard concrete procedures.
• **Application of Penetron Admix**

  -- Dosage rate

  Penetron Admix: 0.8%-1% by weight of the cementitious materials, including fly ash, silica fume, etc.

  Note: Under certain conditions the dosage rate may have been increased 2%-3%, depending on the project conditions.

  -- Application

  Ready Mix Plant-Dry Batch Operation: Add Penetron Admix in powder form to the drum of the ready-mix truck. Drive the truck under the batch plant and add 60%-70% of the required water along with 136-227kg of aggregate. Mix the materials for 2-3 minutes to ensure the Admix is distributed evenly throughout the mix water. Add the balance of materials to the ready-mix truck in accordance with standard batch practices.

  Ready Mix Plant- Central Mix Operation: Mix Penetron Admix with water to form a very thin slurry (e.g., 18kg of powder mixed with 22.7 liters of water). Pour the required amount of material into the drum of the ready-mix truck. The aggregate, cement and water should be batched and mixed in the plant in accordance with standard practices (taking into account the quantity of water that has already been placed in the ready-mix truck). Pour the concrete into the truck and mix for at least 5 minutes to ensure even distribution of Penetron Admix throughout the concrete.

  Precast Batch Plant: Add Penetron Admix to the rock and sand, and then mix thoroughly for 2-3 minutes before adding cement and water. The total concrete mass should be blended using standard practices.

  -- Note

  Penetron Admix is compatible with other water-reducing admixtures and superplasticizers.

  Retardation of set may occur when using Penetron Admix. Trial mixes should be carried out under project conditions to determine setting time. Once the concrete mix design is determined any adjustment of the dosage rate is prohibited without testing.
QA/QC of Penetron Products

- **QA/QC of Penetron**

  Project: ________________________________

  Application Section: ________________________________

  Client: ________________________________

  Contractor: ________________________________

  Date of Inspection: ________________________________

**Before-Application Inspection:**

- **Surface Repair:**
  - Crack repair [ ]
  - Spalling repair [ ]
  - Void repair [ ]
  - Construction debris removed [ ]

- **Smooth Surface Treatment:**
  - Sandblast [ ]
  - Acid Etch [ ]
  - Waterblast [ ]
  - Scabbling [ ]

- **Final Wash-down (High pressure water)** [ ]

**Comments on surface preparation:** ____________________________________________________________

**During-Application Inspection:**

- **Mixing Product:**
  - Mix water quality [ ]
  - Mix rater [ / ]
  - Application rate [ kg/m² ]
  - Number of coats 1[ ] or 2 [ ]

- **Application by brush** [ ]
  - Or spray [ ]
After-Application Inspection:

Observe and comment on consistency of application:

Thick ness: ________________________________
Coverage: ________________________________
Joints: ________________________________
Overlap: ________________________________
Penetration: ________________________________

Curing Program:

Water fogging [   ] times per day, for [   ] days

Volume of product used in this section: [   ] kgs
Surface area treated: [   ] m²

Comments: __________________________________________
_____________________________________________________
_____________________________________________________

Inspected by:

Date:
QA/QC of Penetron Admix

Pre Casting

Project: ________________________________
Type of Structure: ____________________________
Section Identification: ____________________________
Date of Inspection: ____________________________
Date of Proposed Casting: ____________________________
Curing Proposed? Yes/No Curing Period _____ Days
Curing Type: Water Burlap (Wetted) Plastic
Sand/Water Chemical (Note Brand or Type)

Site Condition Report:
Construction Debris Removed Yes/No
Formwork Clean and Sound Yes/No
Rebar Clean, Secure (well tied) Yes/No
Construction Joints Prepared Yes/No

General Site Conditions: ____________________________
Casting Surface- Construction Joint/ Lean Concrete/ Plastic Sheeting/Packed Earth/ Formwork/ Other__________________________
Evidence of Ground Water Flow or Seepage? ____________________________
Surface Water Runoff or Drainage Points Created? ____________________________
Waterbar Installed Yes/No Type__________________________
Condition of Waterbar Installation: ____________________________
Nature and location of all defects to be described in detail

________________________________________________________________________
________________________________________________________________________

Inspected by:__________________________ Witnessed by:__________________________
## Concrete Mix Design

**Specification**
- Specified Characteristic Strength: ____________ 28 days
- Target Mean Strength: ____________
- Free-water/Cement Ratio: ____________
- Type of concrete: ____________
- Concrete Slump: ____________

**Cementitious Materials**
- Cement: Type: ____________
  - Content: ____________
- Silica Fume: Content: ____________
- Fly Ash: Content: ____________
- Other: Type: ____________
  - Content: ____________

**Aggregates**
- Type: Coarse: ____________
- Fine: ____________
- Relative Density of Aggregates: ____________
- Nominal Coarse Aggregate Size: ____________
- Grading of Fine Aggregate: ____________
- Coarse Aggregate Content: ____________
- Fine Aggregate Content: ____________

**Water**
- Free Water Content: ____________

**Admixtures**
- Type: Penetron Admix
  - Dosage: ____________ per 100kg cementitious materials
- Other: Type: ____________
  - Dosage: ____________
  - Type: ____________
  - Dosage: ____________

**Inspected by:** ____________  
**Witnessed by:** ____________  
**Date:** ____________
### Post Casting

<table>
<thead>
<tr>
<th>Volume of Concrete:</th>
<th>Cast Section Identification:</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

<table>
<thead>
<tr>
<th>Date of Inspection:</th>
<th>Date of Casting:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Date of Formwork Removed:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Curing Applied?</th>
<th>Yes/No</th>
<th>Curing Period</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Curing Type:</th>
<th>Water</th>
<th>Burlap (Wetted)</th>
<th>Plastic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand/Water</td>
<td>Chemical</td>
<td>Formwork</td>
<td></td>
</tr>
</tbody>
</table>

**Condition Report:**

- Evidence of Honeycombing?: Yes/No/Photo
- Evidence of Cracking?: Yes/No/Photo
- Evidence of Water leakage?: Yes/No/Photo
- Exposed rebar?: Yes/No/Photo
- Tie Bolt Holes?: Yes/No/Photo

**Finish Surface Condition:**

<table>
<thead>
<tr>
<th>Waterbar Installed</th>
<th>Yes/No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Condition of Waterbar Installation:**

- Is it continuous?:
- Re-welding required?:
- Cleaning required?:

All defects to be described in detail, including location, extent, apparent depth, etc.

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

Inspected by: ___________  Witnessed by: ___________
History Project Cases

Penetron in Milano Water Treatment Plant

The Milano Water Treatment Plant, scheduled to be completed in the autumn of 2004, will drain the water of Southern Lambro with a catchment area of 1,000,000 inhabitants.

Upon completion of the first part treated with the Penetron system, the managing engineers considered its performance excellent and decided to use the Penetron system for the treatment of all purifying basins as well. The total area of these basins was about 120,000 m². Altogether, the total surface covered with Penetron was about 150,000 m² with a product consumption of about 250,000 kg.

The Penetron system was applied in three different ways on this project: spraying (on vertical surface), by brush and by dry shake (on horizontal surface) on different parts of the water treatment plant.

Penecrete mortar was used together with Penetron for waterproofing of concrete “bugholes”, repairing of spalled and damaged areas, patching some tie holes, and filling of routed out cracks.

Spray Application on the Surface of the Adduction Canal

- before application
- spray application
- spray on top
- spray on wall

Spray Application on the Vertical Surface of the Different Tanks

- sandblast
- cycle of watering
- spraying
- after spray
Penetron in Milano Water Treatment Plant

Brush Application on the Hardened Concrete Floor of the Tanks

Dry-shake Application on the Fresh Concrete Floor of the Tanks

Repairing Concrete with Penecrete
# History Project Cases

<table>
<thead>
<tr>
<th>Project</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Riga’s Waste Water Treatment Plant</strong></td>
<td>Riga municipality enterprise &quot;Rigas Udens&quot; Waste Water Treatment plant &quot;Daugavgriva&quot; renovation</td>
</tr>
<tr>
<td><strong>Sewage and Water Treatment City Utena, Lithuania</strong></td>
<td>Penetron was applied for insulating of two (2) Sewage Tanks.</td>
</tr>
<tr>
<td><strong>Coney Island Waste Water Pollution Control Plant, Brooklyn, NY</strong></td>
<td>In 1992, Penetron was applied to personnel tunnel under &amp; between influent &amp; effluent channels, and all underground rooms and facilities.</td>
</tr>
<tr>
<td><strong>Cedar Creek Waste Water Pollution Control Plant, USA</strong></td>
<td>In 1993, Penetron was applied to personnel tunnel under and between influent &amp; effluent channels.</td>
</tr>
</tbody>
</table>
Test Data

• Penetron

  -- Laboratory Testing of PENETRON Waterproofing System
    Riga Technical University Determination of Waterproofing
    RTU Testing Review Nr.64-98 Determination of Waterproofing
    Scanning Electron Microscope (SEM) Tests X-Ray Diffraction Analysis
    Test Report/Shenzhen, China

    -- Compressive Strength     -- Water Permeability Tests
      Shimel and Sor 12/21/94    Shimel and Sor 12/21/94
      Shimel and Sor 11/22/93    AITA 8/7/85
      AITA 4/3/85                AITA 12/10/90

    -- Microscopic Examinations     -- Analysis of Concrete for Penetron Content
      Shimel and Sor 12/21/94    Shimel and Sor 12/21/94

    -- Chemical Resistance     -- Chloride Content
      Shimel and Sor 10/19/93    Shimel and Sor 12/21/94
      Chemical Resistance/Corrosion Chart

    -- Shear and Bond Tests     -- Toxicity
      Shimel and Sor 12/21/94    Acute Oral Toxicity
      AITA 3/7/85                Migration of toxic Element
      AITA 3/8/85                Cytotoxicity Test
      Riga 4/97

• Penetron Admix

  SETSCO Singapore-crack bridging report on Terminal 3, Changi Airport
  Impermeability, University of Aleppo
  Penetron Admix effect on concrete- Helsinki
  ACCI-University of NSW, Australia- full examination of Penetron Admix effect on concrete
  SETSCO Singapore-microscopic examination of crack bridging effect of Penetron Admix on PBFC concrete
  SETSCO Singapore-performance assessment of Penetron Admix
MICROSCOPIC ANALYSIS ON THE CONCRETE CORES FROM RETAINING WALL AT CHANGI AIRPORT TERMINAL 3

Prepared for:
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Report prepared by:
Chen Hong Fang
Senior Engineer
Construction Technology Division

Report received and approved by:
Wong Chung Wan
Devisional Director
Construction Technology Department
1. INTRODUCTION

Cracking and seepage of water on the retaining wall at Changi Airport Terminal 3 was reported by Reverton Engineering(s) Pte Ltd (herein refers to as the client). SETSCO has been engaged by the client to carry out laboratory analysis to determine the crack width and crystal growth in the crack on the concrete cores extracted from the said structure.

The proposed basement was constructed with three sides of wall, labeled as wall 1-3 in this report (refer to figure 1 in Appendix A). Thickness of the wall was about 600mm. PENETRON waterproofing admixture was said to be used in the concrete. Water leakage was found along the crack line and tie pin after backfill. However, the water leakage has been stopped on wall 1, which was cast somewhere in 2001. Sign of efflorescence was found on all three sides of the walls. Most of the efflorescence emanated from the tie pins, but cracks with some sign of efflorescence were also noted at some areas (Refer to the photographs in Appendix).

A total of three core samples were extracted from wall 1 on 05/10/2002. Samples S1 and S3 were extracted from crack area while sample S2 was taken at the tie pin. During extraction, the cores were drilled to a depth of 400mm but due to the presence of reinforcement, the length of the core S3 removed was only 240mm.

The concrete mix design furnished by the client is given in Appendix A.

2. MICROSCOPIC ANALYSIS

The microscopic analysis was performed on a ground section using a stereo microscope and metallurgical microscope and on a thin section with a polarizing and fluorescent microscope (PFM) under transmitted and reflected light. For preparation of the ground section, a small block of the sample was cut and ground to attain a smooth finish. For preparation of a thin section, a small concrete block was sawn from the core sample, glued to an object glass and impregnated with an epoxy resin containing a fluorescent dye. After hardening of the epoxy, a thin section with a surface area of approximately 33*63mm and a thickness of 20-30mm was prepared for PFM analysis.
Under transmitted light, the various components (type of cement and aggregates), air voids content, compaction pores and damage phenomena in the samples were identified. Under reflected light, the fluorescent microscopy made it possible to study the homogeneity of the mix and cement paste, capillary porosity, microcracks and other defects in the samples. Scanning Electron Microscope (SEM) and Energy Dispersive X-ray (EDX) Analysis technique was also applied for semi-quantitatively analysis of the element composition of the crystals present in the crack and topography of the crystals.

In summary, SEM utilizes a beam of electrons in a vacuum environment to form an image of the surface topography of a sample. Such magnified images are characterized by a high level of resolution and good depth of view. The characteristic X-ray emitted from the sample surface upon being irradiated with the electrons are then analyzed using an EDX accessory/detector that is coupled to the SEM, allowing evaluation of the % elemental content at the irradiated areas/spots on the sample.

3. RESULTS

i) Visual examination

The length of the cores varied from 240mm to 310mm. Crack perpendicular to the surface was noted in samples S1 and S3. The width of the crack ranged from 0.04mm to 0.3mm. The paste matrix appeared light gray in color while the paste matrix was noted to be generally light gray.

Thin sections were prepared at the top of sample S2 and the end of sample S3 for further microscopic analysis. Stereo microscope and SEM-EDX analysis were performed on sample S3 to determined the presence of the crystals in the crack and their elemental composition.

ii) Microscopic analysis

Under stereo microscope, a lot of coarse-grained elongated crystals were seen lining the crack. Thin section of sample S3 showed that coarse-grained elongated crystals and fine-grained needle-like crystals in the crack. All these crystals showed low birefringence under crossed polarized microscope.
Further scanning electron microscope and energy dispersive X-ray analysis were performed on the crystals present in the crack. The coarse-grained elongated crystal (BEI image in Appendix) contained mainly Calcium (Ca), Oxygen (O) and Silicon (Si). The fine-grained needle-like crystal was predominantly made up of Calcium (Ca), Silicon (Si), Oxygen (O), Sulfur (S), Aluminum (Al), which was probably ettringite (C₆AS₃H₃₂).

Well-formed CaCO₃ crystals were present as laminated texture on the surface of sample S2.
APPENDIX A

Wall 2

Wall 3

Wall 1

Figure 1: The layout of the retaining wall

Casting date of extracted cores

<table>
<thead>
<tr>
<th>Sample reference</th>
<th>Date of cast</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>19/12/2001</td>
</tr>
<tr>
<td>S2</td>
<td>19/12/2001</td>
</tr>
<tr>
<td>S3</td>
<td>06/08/2001</td>
</tr>
</tbody>
</table>
# CONCRETE MIX DESIGN

Project: Pile Foundation & Basement Construction For Terminal 3  
Singapore Changi Airport  
Contractor: Sato Kogyo., Ltd  
Date: 8th March 2001  
Ref: RE/SK/PU/40P/01

## Concrete Grade

<table>
<thead>
<tr>
<th>Grade</th>
<th>Slump</th>
<th>Cement</th>
<th>Coarse Agg</th>
<th>Fine Agg</th>
<th>Water</th>
<th>Admix</th>
<th>A/C</th>
<th>W/C</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>100±25mm</td>
<td>398</td>
<td>1000</td>
<td>695</td>
<td>185</td>
<td>Penetron Penetrant 3.18</td>
<td>4.26</td>
<td>0.46</td>
<td>2281.18</td>
</tr>
</tbody>
</table>

**Concrete Grade 40**

Pump

### Specification

1. **Specific Characteristic Strength**: 40N/mm² at 28 days in accordance with BS 5328
2. **Designed Standard Deviation**: 4.6 N/mm²
3. **Design Margin**: 7.5 N/mm²
4. **Target Mean Strength**: 47.5 N/mm²
5. **Free Water/Cement Ratio**: 0.46
6. **Type of Concrete**: Pump Concrete
7. **Concrete slump**: 100±25mm

### Cement

1. **Cement Type**: Ordinary Portland Cement
2. **Cement Content**: 398kg/m³

### Aggregates

1. **Coarse Aggregate**: Crushed Granite
2. **Fine Aggregate**: Natural Sand/Manufactured Sand
3. **Relative Density of Aggregates**: 2.60-2.65
4. **Normal Aggregate Size**: 20mm
5. **Grading of Fine Aggregate**: BS 882 Table 5
6. **Coarse Aggregate Content: SSD**: 1000 Kg/m³
7. **Fine Aggregate Content: SSD**: 695 Kg/m³

### Water

1. **Free Water Content**: 185 Kg/m³

### Admixtures

1. **Admixture Type 1**: Penetron (mix design) Admixture
   - Dosage: 0.8 kg per 100 kg of cement
2. **Admixture Type 2**: Daratard 88. Water reducing, plasticizing and set retarding
   - Dosage: 550 ml per 100kg cement

### Summary

- **Concrete Mix Design**
- **Project Details**
- **Materials**
- **Technical Specifications**
- **Aesthetic Considerations**

---

**Note:** 
Further details on site conditions, testing methods, and quality control procedures may be found in the complete documentation available upon request.
APPENDIX B   PHOTOGRAPHS

A6127/CHF

A crack connecting with tie pin with sign of Efflorescence was observed on wall 1.

Sign of efflorescence was found along the crack line on wall 1.

The location of sample S1 extracted at the cracked area on wall.

A 75mm diameter core containing a crack at Wall 1 was extracted for laboratory analysis.
A crack perpendicular to the exposed surface was seen in core S1.

Core S2 was extracted at the tie pin on wall 1.

Relative thick whitish substance was on the surface of core S2.

Sign of efflorescence was found along the crack line where core S3 was taken on wall 1.

A crack perpendicular to the exposed surface was seen in core S3.

A crack perpendicular to the exposed surface was seen in core S3.
Sample S3: Some crystals grew in the crack.

Sample S3: Abundant coarse-grained crystals in the crack.

Sample S2: Laminated CaCO3 crystals on the surface of the concrete. The width of the field is 3.88mm under plane light.

Sample S2: Laminated CaCO3 crystals on the surface of the concrete. The width of the field is 3.88mm under crossed polarised light.

Sample S3: Coarse-grained elongated crystals and fine-grained needle-like crystals were lining the crack. The width of the field is 3.88mm under plane light.

Sample S3: Backscattered electron image (BEI) showed some crystals was in the crack.
Sample S3: Backscattered electron image (BEI) showed elongated crystals and fine needle-like crystals in the crack.

Sample S3: Secondary electron image (SEI) showed coarse-grained flaky crystals in the crack.

Sample S3: High magnified view of needle-like crystals in the crack.

Sample S3: SEI image showed the crystals in the Crack.
At the Client's request, additional studies were performed to determine and photograph the type of materials penetration or diffusing into the concrete from the Penetron coating. In order to perform these tests, the test techniques used were scanning electron microscopy and energy dispersive x-ray diffraction methods.

TEST RESULTS

1. Scanning Electron Microscope (SEM) Tests

The concrete core section tested, was coated with a minimum of gold in order to provide a surface which could be studied by light microscopy and compared to the SEM images.

The photographs taken under SEM are presented on Attachment I.

2. X-Ray Diffraction Analysis

According to the attached four spectrums of x-ray diffraction, there is a calcium accumulation in the concrete below the Penetron coating to 25 to 50 mm depths. Calcium appears to be in the form of Ca(OH)2 and calcium-silicate gel. Obviously, these crystalline growths are the diffusion products of the components of the Penetron coating on the concrete surface. Below 50 mm depths Ca(OH)2 is less while the silica content (from the cement) becomes dominant.
CONCLUSIONS

Based on these test results, it is our opinions that Penetron coated concrete surfaces develop improved concrete microstructure and waterproofing properties.

KS/smd
cc: (1) Client
Robert Revera
At the request of the Client, laboratory tests were performed to determine the chemical resistance of Penetron treated concrete.

Experimental Design

The concrete used for the study had a design strength $f''c = 4000$ psi. The concrete mix proportions are presented on Attachment 1.

The concrete specimens used were saw-cut from 6 x 12 inch concrete cylinders. The specimens were 2 inches thick and 6 inches in diameter. At the time of the study, the concrete was 28 days old.

The Penetron material (which was received in powder form in a sealed bag) was mixed with water into a slurry. The ratios were:

- 2 parts Penetron
- 0.8 parts water

The slurry was then applied on all surfaces of the concrete specimens by brushing. After the final setting of Penetron the surfaces of the specimens were moistened and placed in a regular concrete curing room for 14 days at 73 °F and 100% relative humidity.

At the end of 14 days, the specimens were removed from the curing room and placed in various chemical solutions that provided a wide range of pH levels and corrosive conditions.
<table>
<thead>
<tr>
<th>SAMPLE NO.</th>
<th>SAMPLE TYPE</th>
<th>TYPE OF TREATMENT</th>
<th>PH</th>
<th>OBSERVATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>Penetron Treated</td>
<td>Dilute HCl</td>
<td>3</td>
<td>No Effect</td>
</tr>
<tr>
<td>1B</td>
<td>No Penetron</td>
<td>Dilute HCl</td>
<td>3</td>
<td>No Effect</td>
</tr>
<tr>
<td>2A</td>
<td>Penetron Treated</td>
<td>Dilute H2SO4</td>
<td>3</td>
<td>No Effect</td>
</tr>
<tr>
<td>2B</td>
<td>No Penetron</td>
<td>Dilute H2SO4</td>
<td>3</td>
<td>Surface Weathered</td>
</tr>
<tr>
<td>3A</td>
<td>Penetron Treated</td>
<td>Rain Water</td>
<td>4</td>
<td>No Effect</td>
</tr>
<tr>
<td>3B</td>
<td>No Penetron</td>
<td>Rain Water</td>
<td>4</td>
<td>Surface Weathered</td>
</tr>
<tr>
<td>4A</td>
<td>Penetron Treated</td>
<td>CaCl₂</td>
<td>7</td>
<td>No Effect</td>
</tr>
<tr>
<td>4B</td>
<td>No Penetron</td>
<td>CaCl₂</td>
<td>7</td>
<td>Slight Effect</td>
</tr>
<tr>
<td>5A</td>
<td>Penetron Treated</td>
<td>NaOH</td>
<td>11</td>
<td>No Effect</td>
</tr>
<tr>
<td>5B</td>
<td>No Penetron</td>
<td>NaOH</td>
<td>11</td>
<td>No Effect</td>
</tr>
</tbody>
</table>

**CONCLUSIONS**

Based on these test results, the following conclusions were drawn:

1. The Penetron treated concrete was found to be resistant to acidic and alkaline conditions ranging between pH values of 3 to 11. Also, chloride containing solutions did not have any measurable effect on the Penetron concrete.

2. The untreated concrete (control samples) had surface weathering when exposed to pH of 3, rain water chlorides and sulfate solutions.

KS/smdcc: (1) Client

Doug Quick
**ATTACHMENT I**

**CONCRETE MIX DESIGN USED**

**FOR THE PENETRON TREATMENT TESTS**

<table>
<thead>
<tr>
<th>MATERIALS</th>
<th>AMOUNTS PER CUBIC YARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portland Cement, Sacks</td>
<td>6.0</td>
</tr>
<tr>
<td>Portland Cement, Lbs</td>
<td>564</td>
</tr>
<tr>
<td>*Sand, Lbs</td>
<td>1450</td>
</tr>
<tr>
<td>*Coarse Aggregate</td>
<td>1860</td>
</tr>
<tr>
<td>Water, Ga</td>
<td>36.3</td>
</tr>
<tr>
<td>Water, Lbs</td>
<td>302.4</td>
</tr>
<tr>
<td>W/C Ratio</td>
<td>0.54</td>
</tr>
<tr>
<td>Slump</td>
<td>4.0</td>
</tr>
<tr>
<td>Entrapped Air, %</td>
<td>1.8</td>
</tr>
</tbody>
</table>

(*) SSD basis