Integral Crystalline Concrete – Optimising Durability

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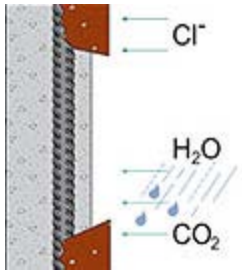
Concrete is the world's most popular building material and is used in every country and on almost every type of construction project.

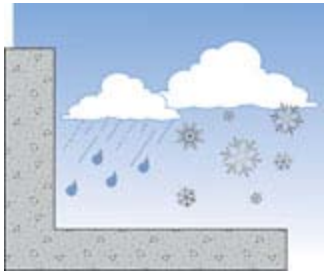
What appears to be the problem?

The 4 main reasons why concrete deteriorates

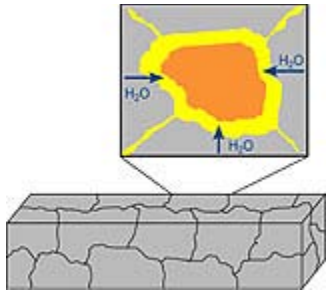
- Corrosion of reinforcement steel



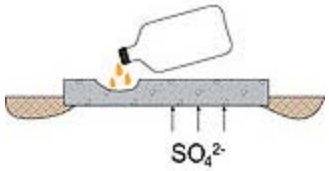
- Exposure to freeze / thaw cycles



- Alkali-silica reaction



- Chemical attack



CORROSION

Strong in compression but weak in tension, concrete requires the use of reinforcement steel to stop it from disintegrating under pressure

However, through cracks, voids and pores, concrete allows **water** to penetrate and deliver corrosive chemicals that eventually attack the steel designed to strengthen it.

Once corrosion starts, it is difficult to determine the extent of the damage as it can occur anywhere along the network of steel reinforcement.

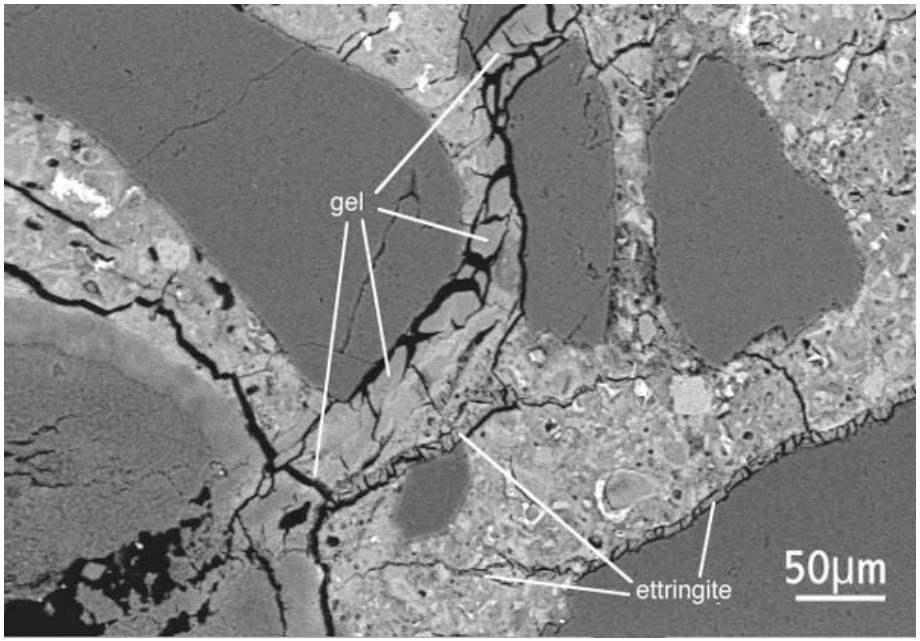
FREEZE-THAW cycles

Under freezing conditions, **water** trapped inside concrete turns into ice and expands, creating cracks.

When the ice melts, the **water** travels yet deeper into the concrete, where the same freeze/thaw cycle is repeated

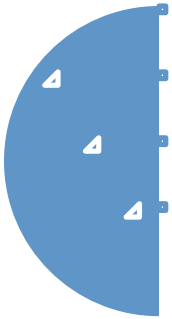
The use of road salts and other de-icing chemicals only worsen the problem by introducing aggressive chemicals to the concrete.

Alkali-Silica reaction



ASR, or concrete cancer, is caused by a reaction between the alkaline cement pore solution and silica in the aggregate.

A gel is produced which increases in volume by taking up water and thereby creates an expansive pressure , causing internal cracking.



The conditions required for ASR to occur are:

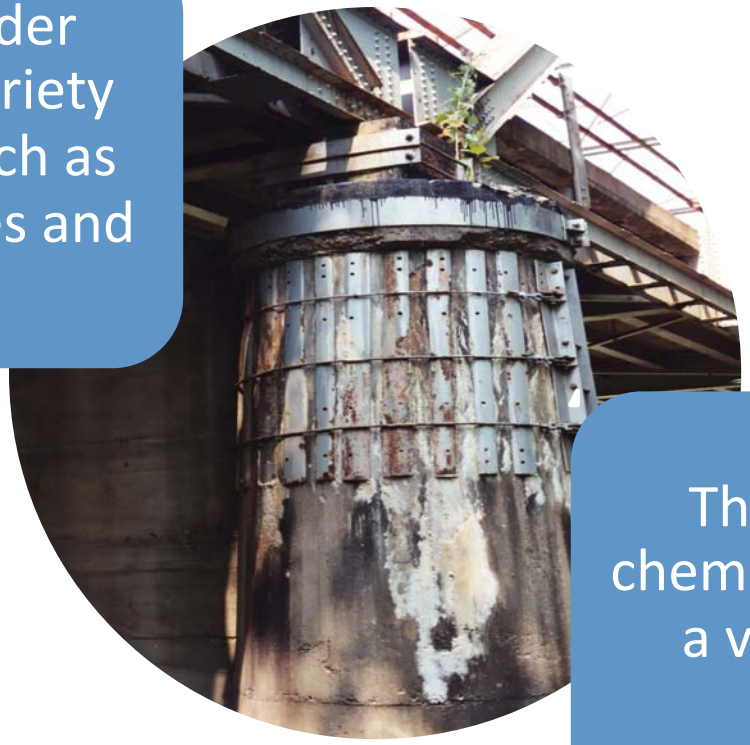
A sufficiently high alkali content of the cement (or alkali from other sources)

A reactive aggregate, such as chert

Water - ASR will not occur if there is no available water in the concrete

AGGRESSIVE CHEMICALS AND GROUNDWATER DAMAGE

Concrete is under attack from a variety of chemicals, such as chlorides, sulfates and acids.

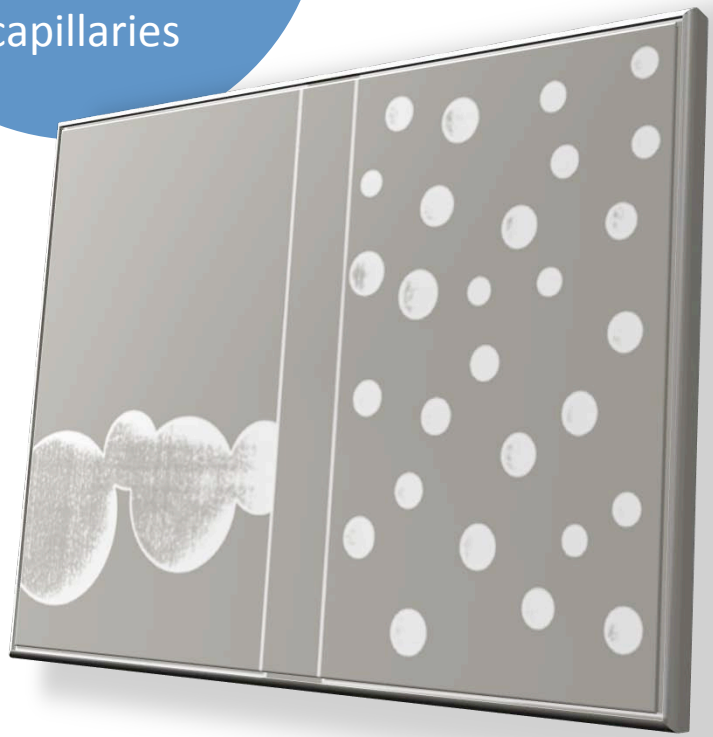


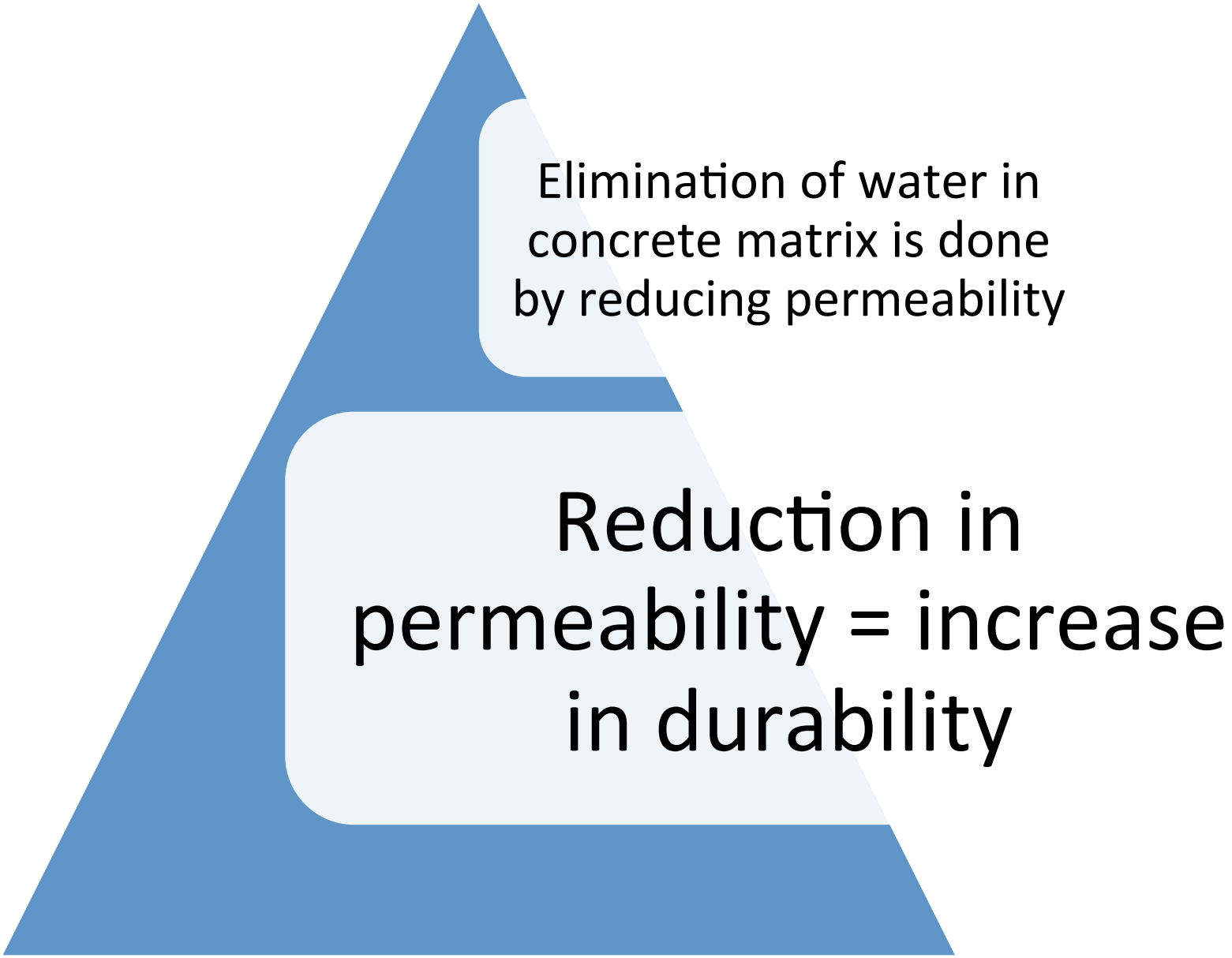
These aggressive chemicals use **water** as a vehicle to enter concrete.

PERMEABILITY: rate of flow of a fluid into a porous solid

Average Concrete is very porous due to shrinkage cracks, voids and capillaries

The better connected these voids are, the more permeable the concrete is and the easier it is for waterborne contaminants to enter the concrete.




Elimination of water in concrete matrix is done by reducing permeability
Reduction in permeability = increase in durability

American Concrete Institute®

Advancing concrete knowledge

The American Concrete Institute, widely recognized as the top authority in concrete matters around the world, has now included this new category of Admixtures in their most recent Report on Chemical Admixtures for Concrete

ACI 212.3R-10

Report on Chemical Admixtures for Concrete

Reported by ACI Committee 212

American Concrete Institute®

Report on Chemical Admixtures for Concrete (ACI 212.3R-10)

Table 15.1—Reduction in permeability of concrete using PRAs

Admixture type	Coefficient of permeability of reference concrete	Coefficient of permeability of test concrete	Percent reduction in permeability
Crystalline	4.29×10^{-14}	1.28×10^{-14}	70
Colloidal silica	1.98×10^{-13}	1.61×10^{-13}	19
Hydrophobic pore blocker	2.23×10^{-12}	1.14×10^{-12}	49

Crystalline admixtures are superior to colloidal silica and hydrophobic pore blockers in regards to permeability reduction in concrete and increasing durability of concrete.

What are crystalline admixtures ?

A mixture of active ingredients in powder form that reacts with water in concrete to form an insoluble crystalline structure. The crystals penetrate deep inside the concrete, sealing the pores, capillary tracts and shrinkage cracks from water penetration.

Key features

- Permanent dry concrete
- Self healing throughout service life
- Versatile, can be applied in different ways
- No known incompatibilities with workability admixtures
- Non toxic
- Resists chemical attacks from a variety of chemicals (pH 3-11)

Crystalline products can be applied in 3 different ways

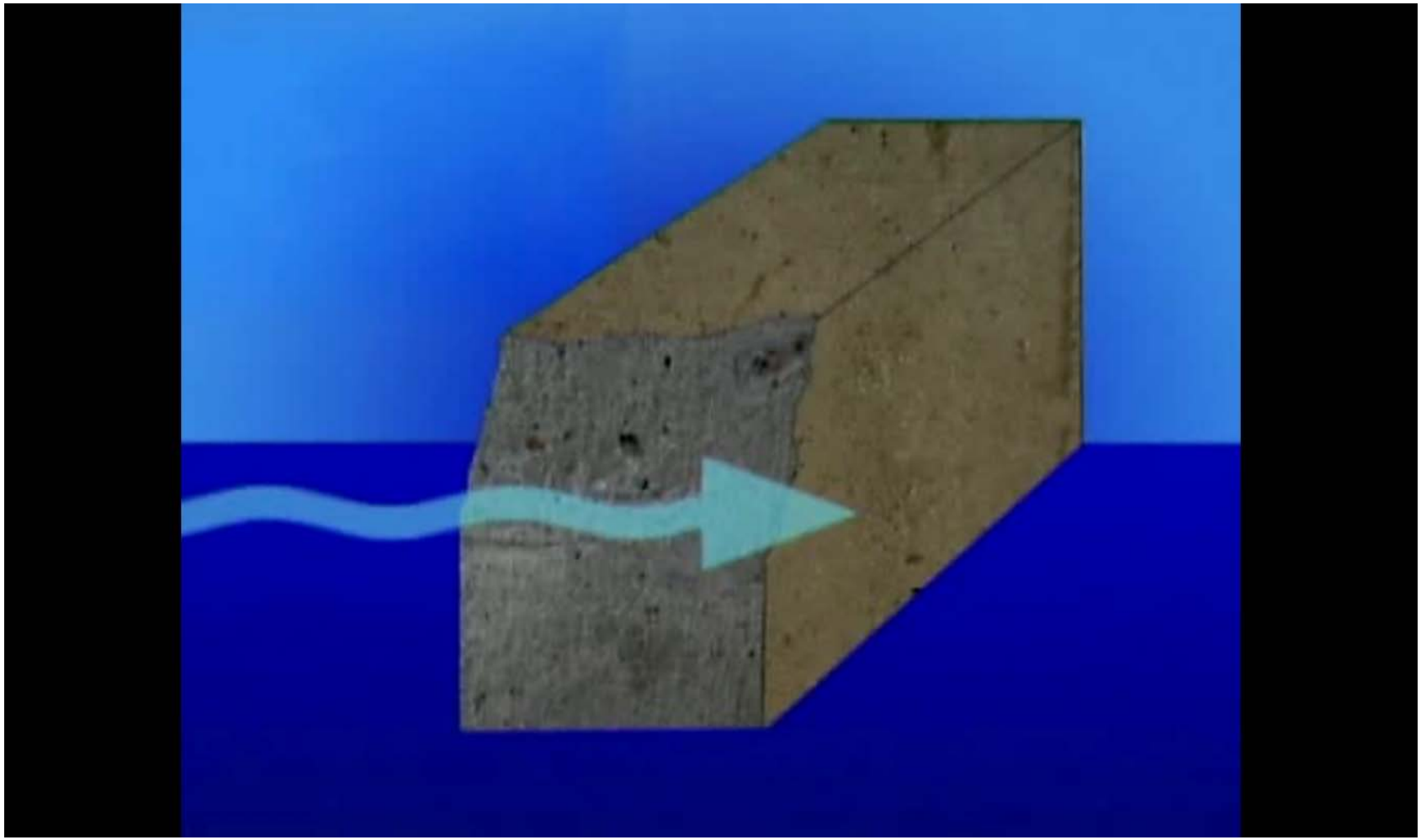
admixture

coating

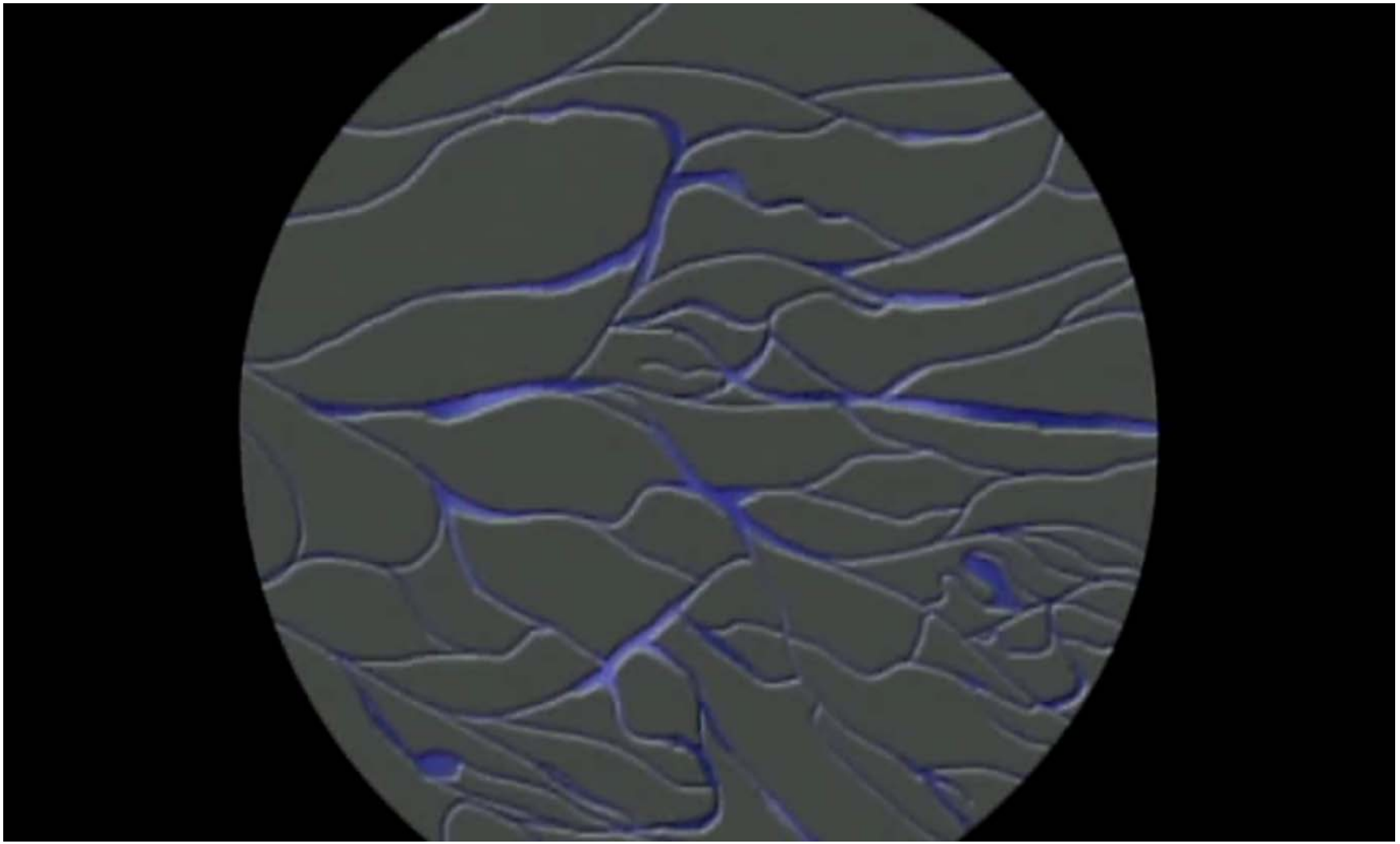
Dry shake

How does it work ?

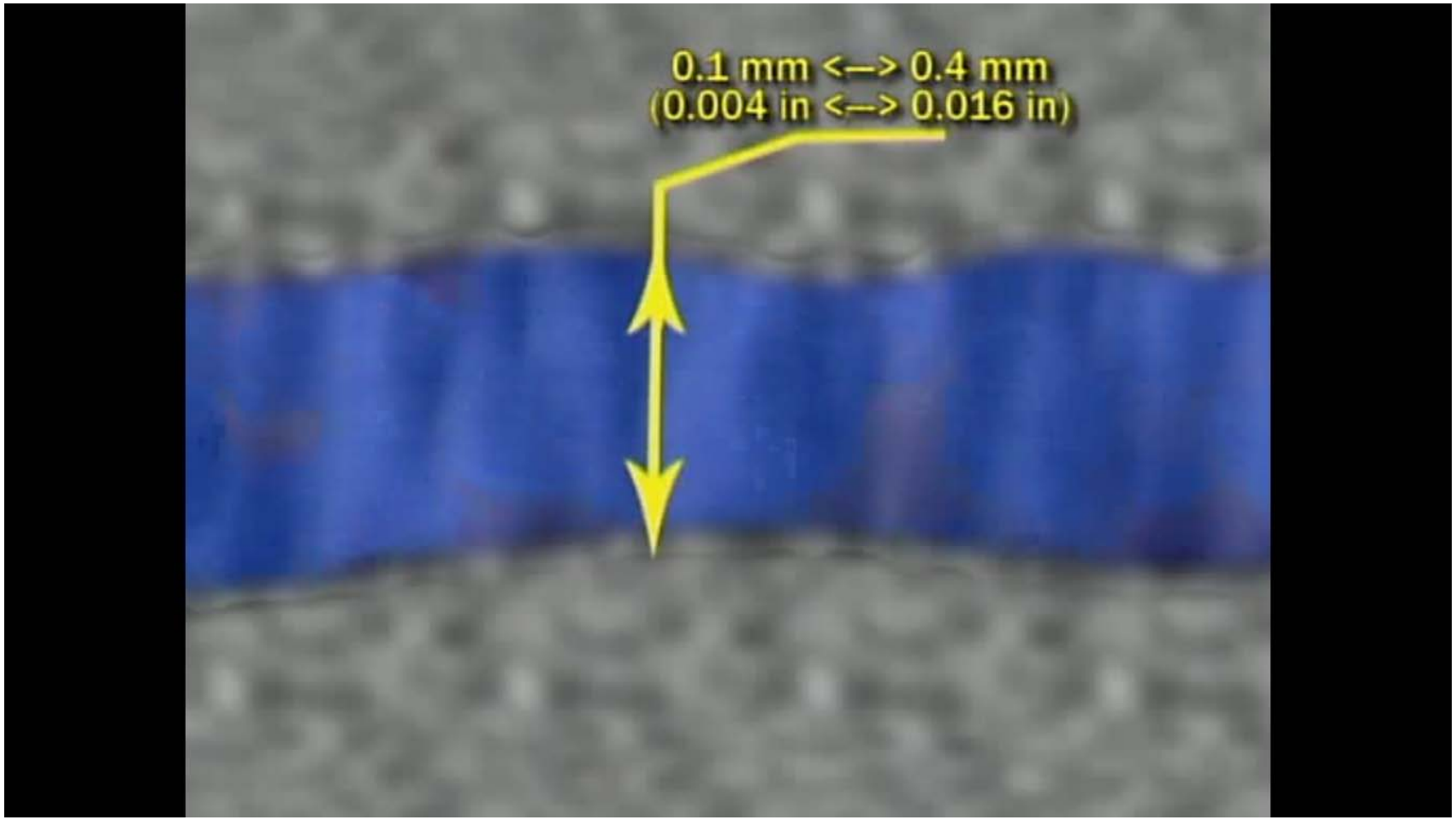
a conventional concrete matrix has a multitude of micro-cracks, pores and capillaries through which water enters the concrete



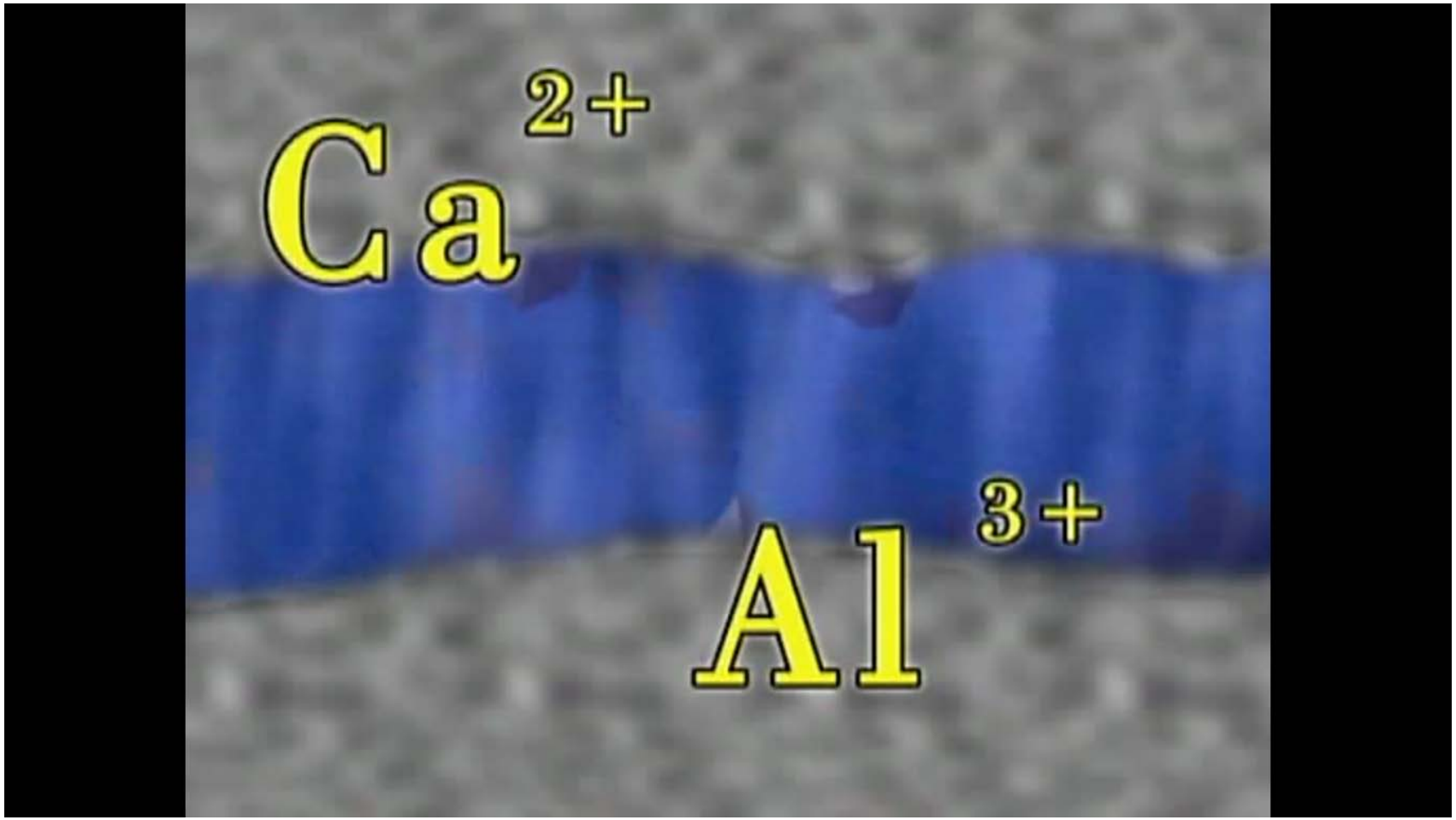
Water passes through the micro-cracks and capillaries in the concrete



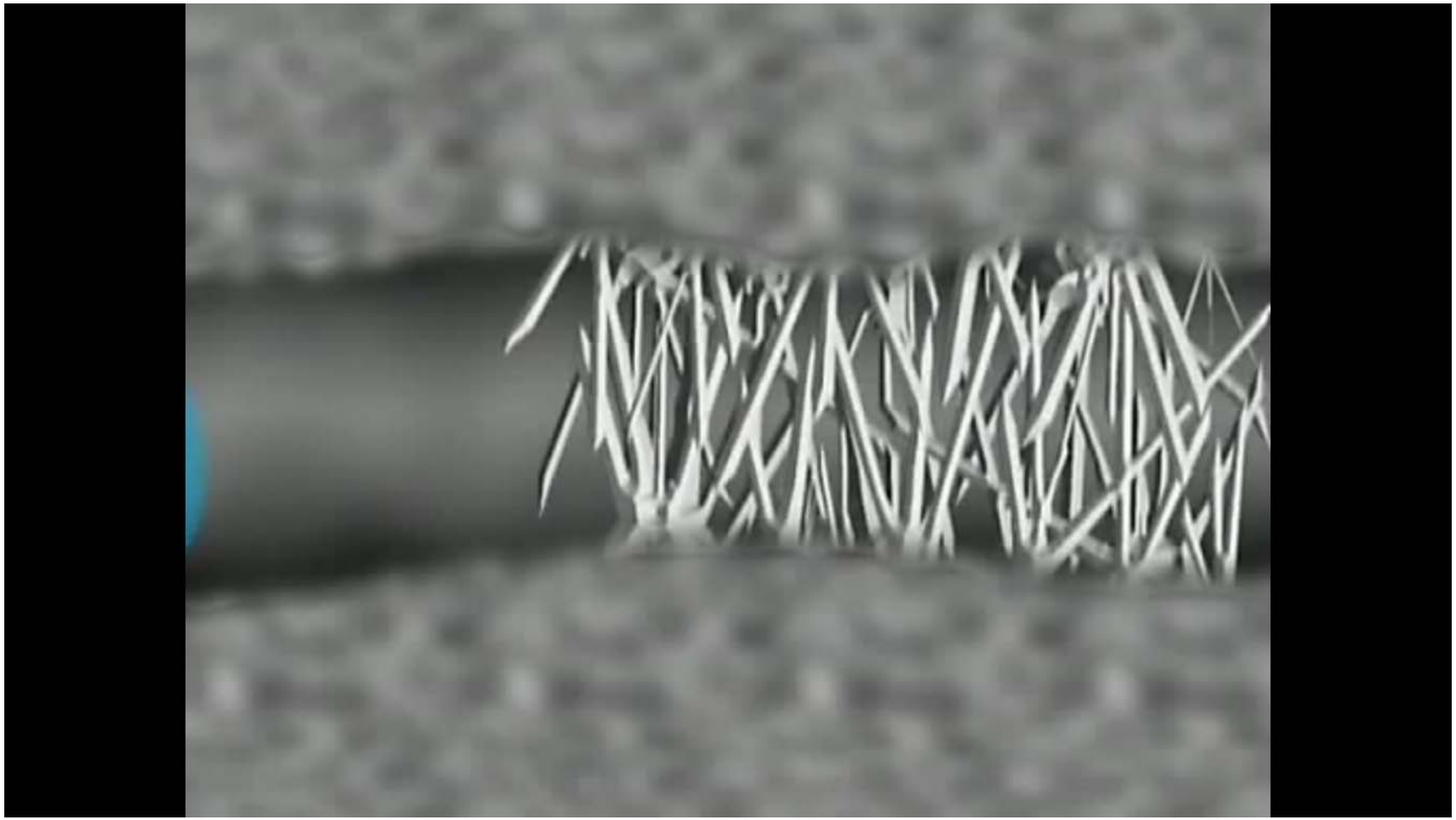
these pores typically have a width of between 0.1 – 0.4 mm



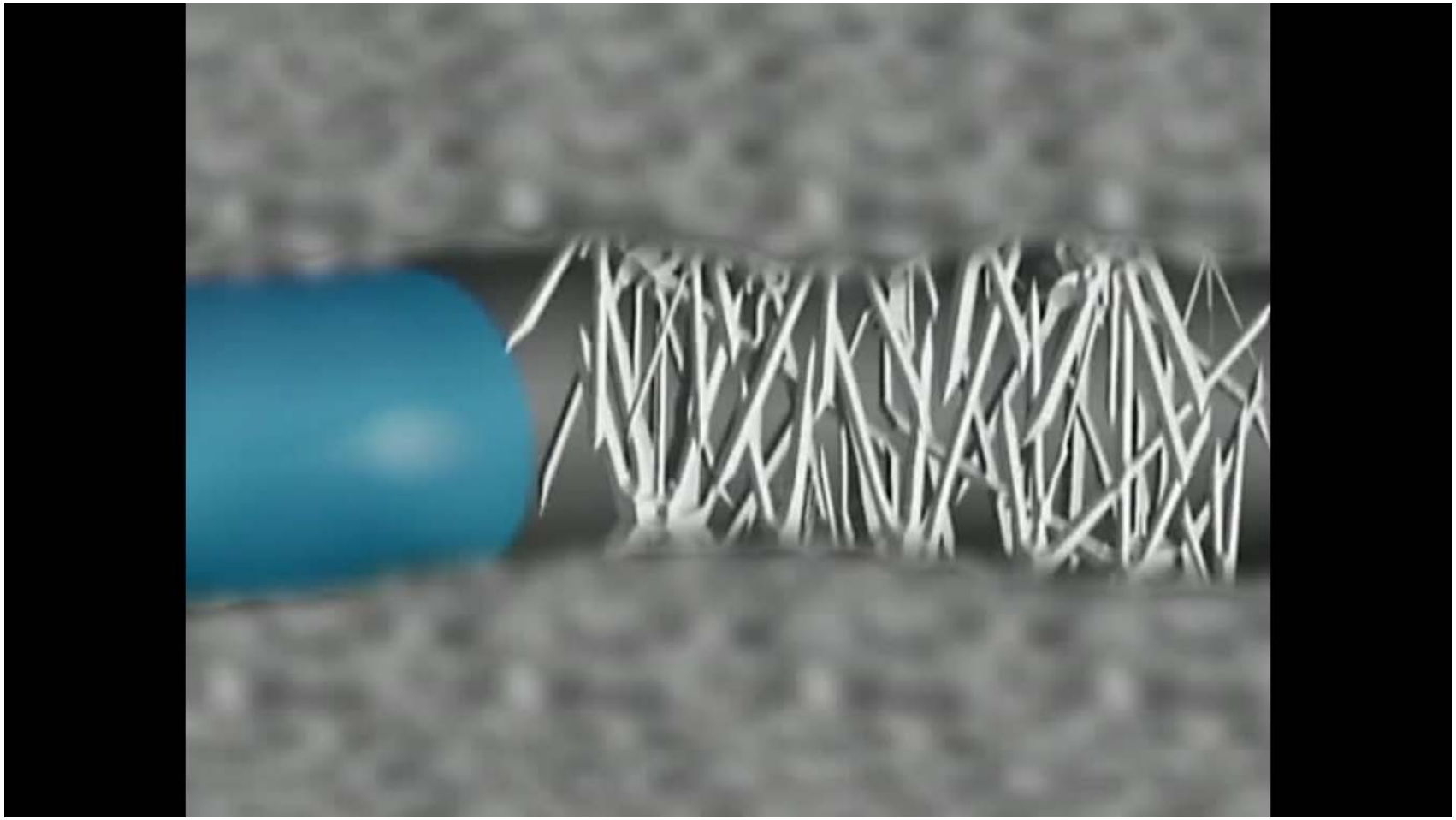
Once inside the concrete, the crystalline components react with water, calcium hydroxide and aluminum as well as various other metal oxides and salts contained in the concrete



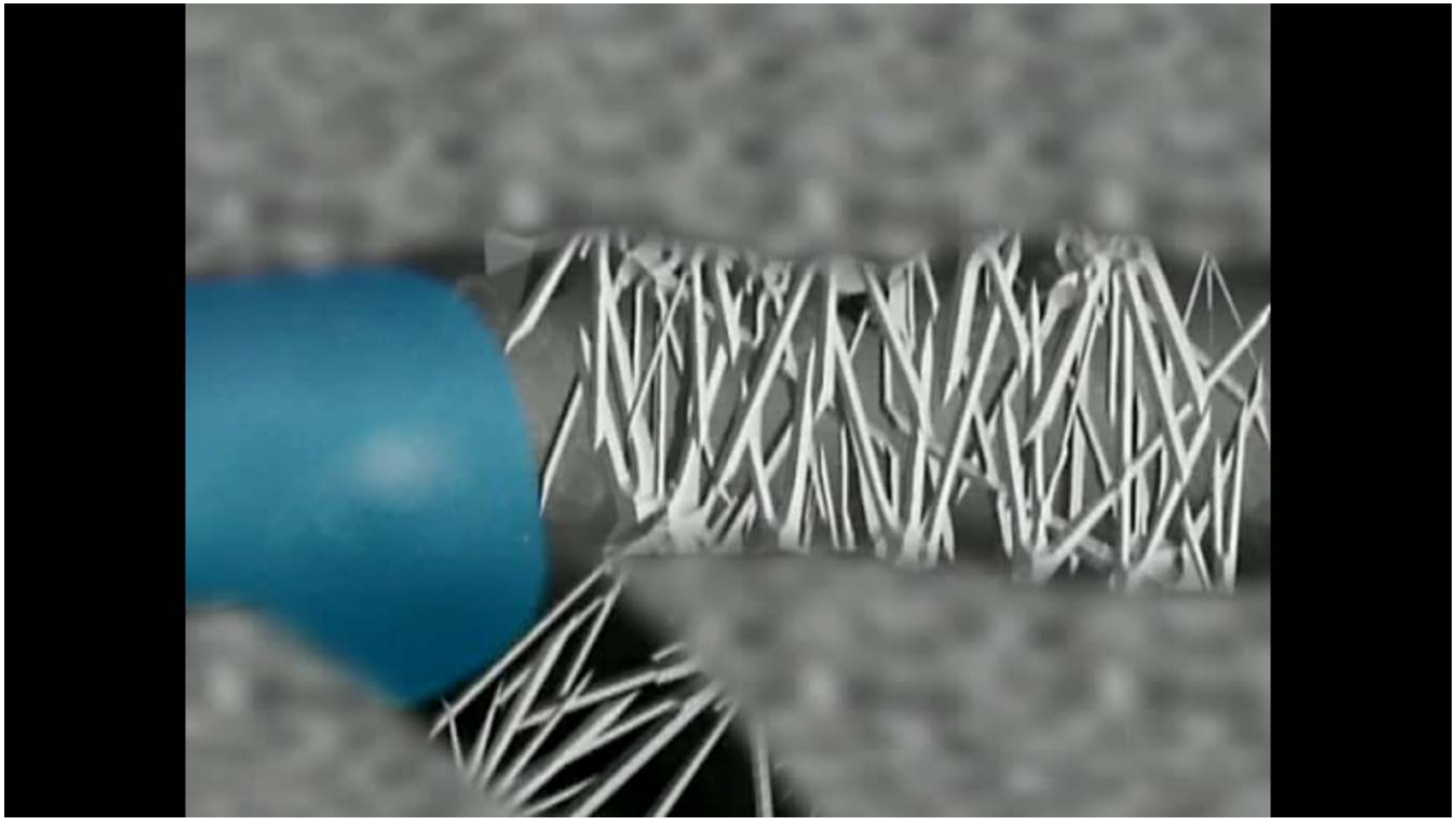
the chemical reaction that follows causes these voids and cracks to be filled with insoluble crystals



water is unable to pass through these crystal formations, and as a result the concrete becomes impermeable



should new cracks appear throughout the life of the concrete, crystals will appear in these cracks as well, preventing water from finding new ways to get through



The result is a completely dry and durable concrete structure

When choosing a crystalline admixture, ensure it meets the generic standard

- it is a 3rd generation product that has no negative effect on setting time and strength development of concrete
- It comes in powder form and can be dosed at 0.8 – 1% of the cement weight in the concrete mix
- It does not require a maximum W/C to perform
- It has the ability to self heal cracks of up to 0.4mm
- It has a longstanding and worldwide track record and has been used on major projects

IPT
Instituto de Pesquisas Tecnológicas

Penetration of water under pressure – NBR 10.787/94 (April 2007)
Concrete: CPII-E 32
at
IPT (Technological Research Institute of São Paulo State), Brazil

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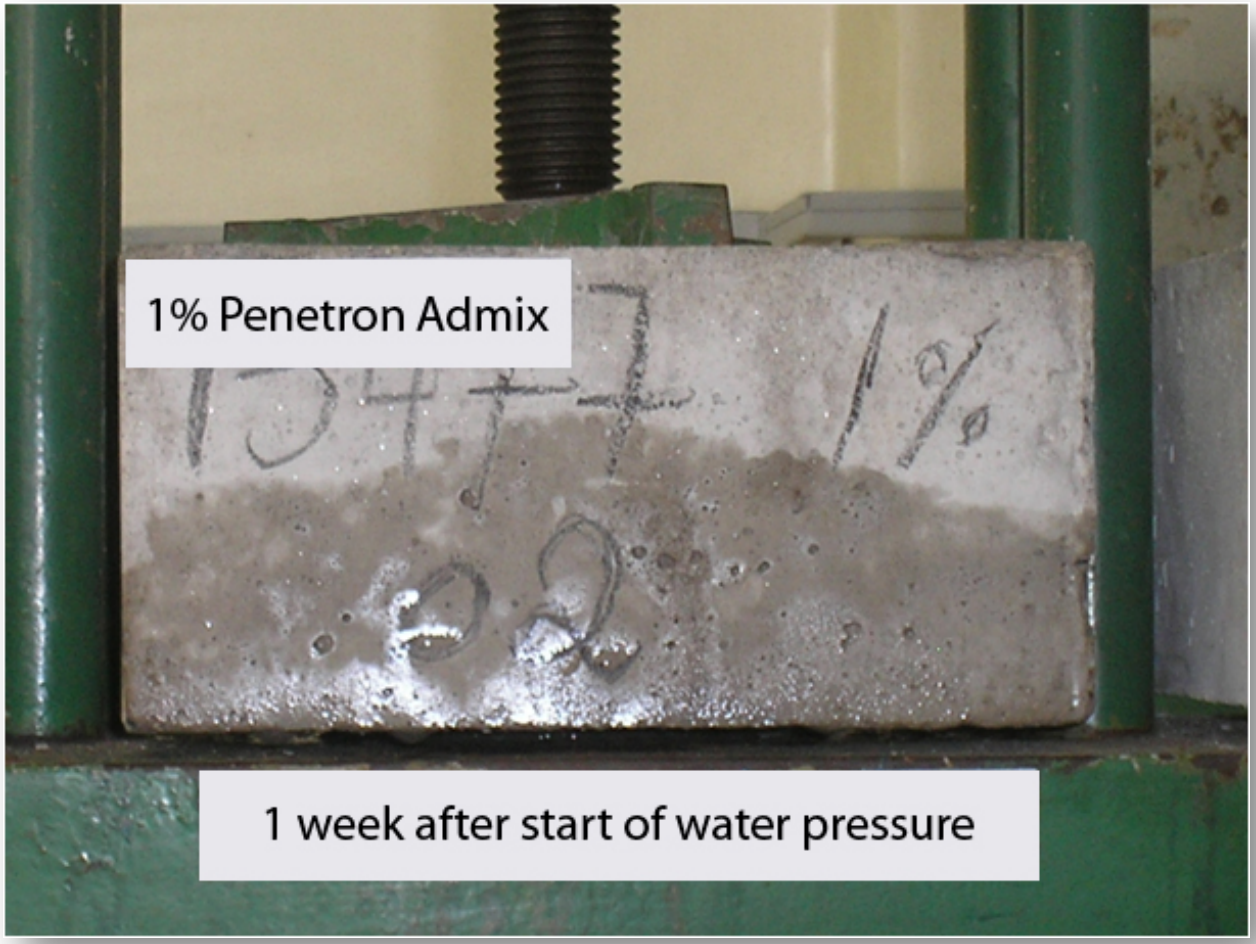

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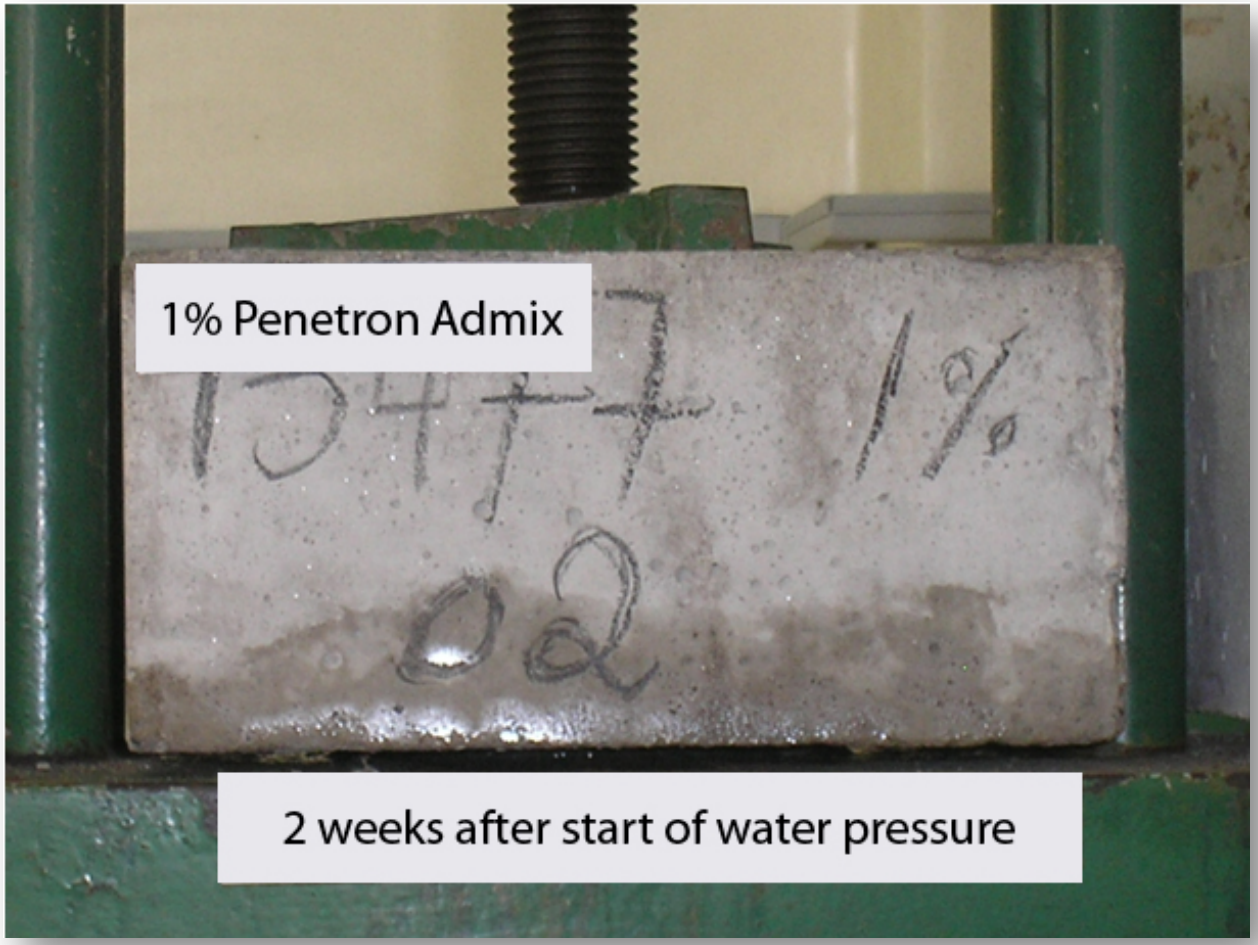

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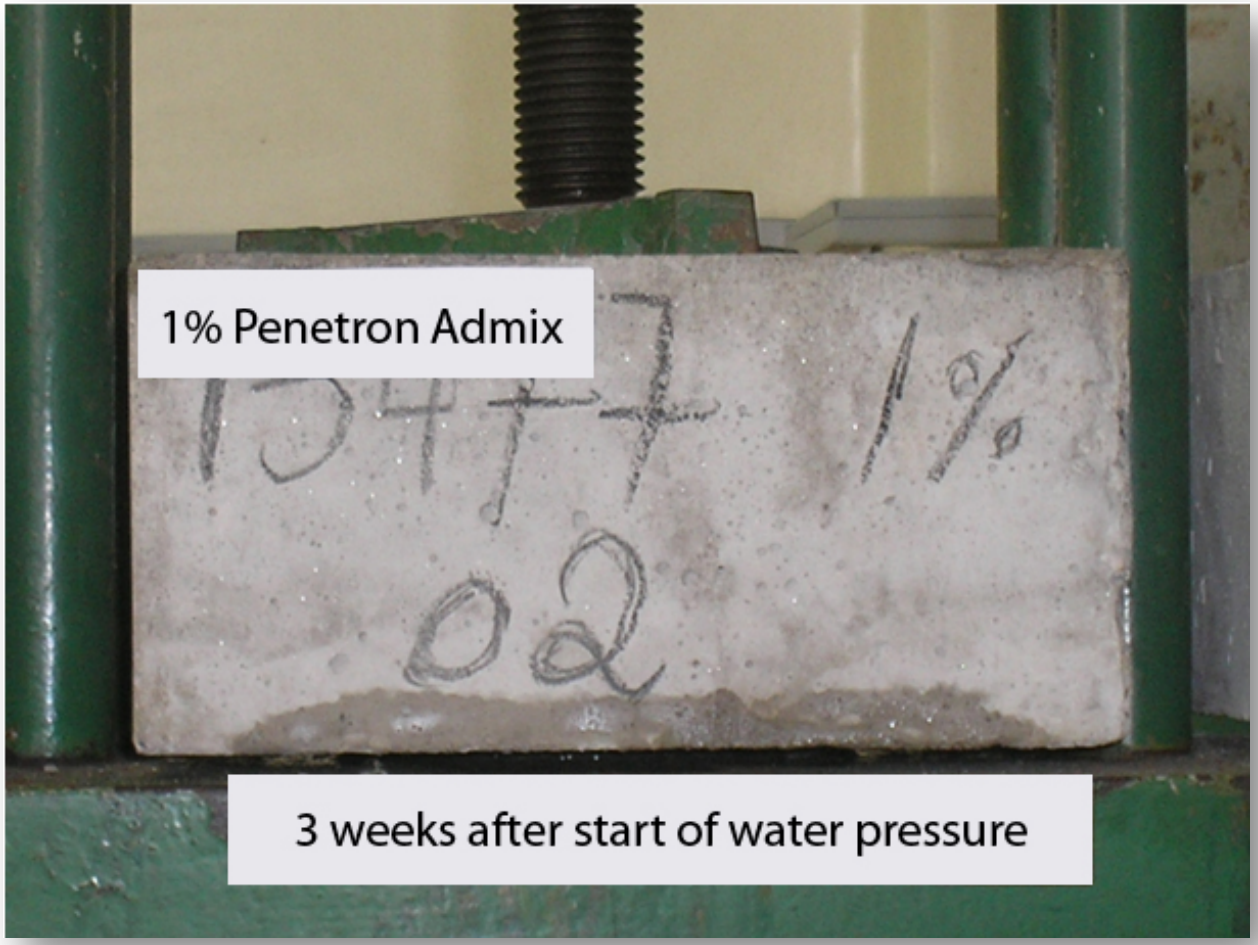

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