

Technology in Practice

What, Why & How?



TIP 24 - Permeability of Concrete

This TIP discusses the permeability property of concrete, when low permeability is required, test methods, and developing mixtures for low permeability.

WHAT is the Permeability of Concrete?

ACI Committee 201 on Durability defines permeability as the ability of a given concrete to permit liquid or gases to pass through. Concrete is a porous material. It needs a minimum amount of water for workability. Much of this water gets consumed by cement hydration. The remaining original water-filled space is referred to as capillary porosity. Water and dissolved chemicals move through these capillary pores. Permeability can be due to permeation, absorption, and diffusion. Permeation is the flow of a liquid, gas, or vapor within a solid under a pressure gradient. Absorption is the movement of water or any other liquid into non-saturated concrete. Diffusion is the movement of dissolved chemicals (ions), gas, or vapor, from an area of higher concentration to an area of lower concentration, independent of the bulk motion of a fluid.

WHY is Permeability Important?

Permeability impacts the durability of concrete. For most mechanisms, the durability of concrete and its potential service life is improved if the concrete has a lower permeability. Concrete with a high permeability can lead to:

- ingress of chloride ions and carbon dioxide that carbonates surface layers causing corrosion of steel reinforcement.
- increase in the saturation levels in concrete resulting in scaling and deterioration if exposed to cycles of freezing and thawing.
- ingress of dissolved sulfate salts resulting in sulfate and physical salt attack.
- exacerbates and increases the rate of deterioration due to other durability problems like acid and chemical attack.

The rate of permeation of water and diffusion of gases and dissolved chemicals is reduced in low-permeability concrete. This results in greater resistance to deterioration from chemical and physical durability mechanisms. Low-permeability concrete is more durable against aggressive exposure conditions and has a greater potential for extended service life with lower repair and maintenance costs.

WHERE is Low Permeability Required?

Low permeability is especially important for concrete members exposed to seawater, deicing salts, substances that can damage concrete, and soil where moisture and dissolved chemicals can cause a durability problem.

Permeability of concrete is a key design consideration for bridges, parking garages in cold weather regions, foundations in soils with high sulfate concentrations, and environmental structures like water treatment plants. Concrete in direct contact with water, such as water retaining structures, water tanks, and concrete pipes should be constructed with low-permeability concrete.

Related to durability, the ACI 318 Building Code establishes four exposure categories: freezing and thawing (F), sulfate (S), in contact with water (W), and chlorides (C); and defines exposure classes for each category based on the severity of the exposure. Requirements for concrete mixtures are established for each exposure class