Oxygen diffusion

EMPA
Materials Science & Technology

Author: Roman Loser
Contact: roman.loser@empa.ch

Introduction

Since mortar and concrete are porous materials, liquids can penetrate into cement based materials. If the pores are at least partially emptied, gases can also diffuse into such materials. With the described test, the resistance of cement based materials against ingress of oxygen is determined. Oxygen is used as the penetrating gas since it does not react with the cement paste and therefore the pore system is not altered.

In contrast to the oxygen permeability test there is no pressure difference between the both sides of the samples but only a difference in gas concentration.

Relevance for our Field

- durability of cementitious materials is strongly related to diffusivity => determination of a physical constant under defined conditions
- assessment of resistance against ingress of gases which can react with cement (eg. CO_2)

Measurement Principles

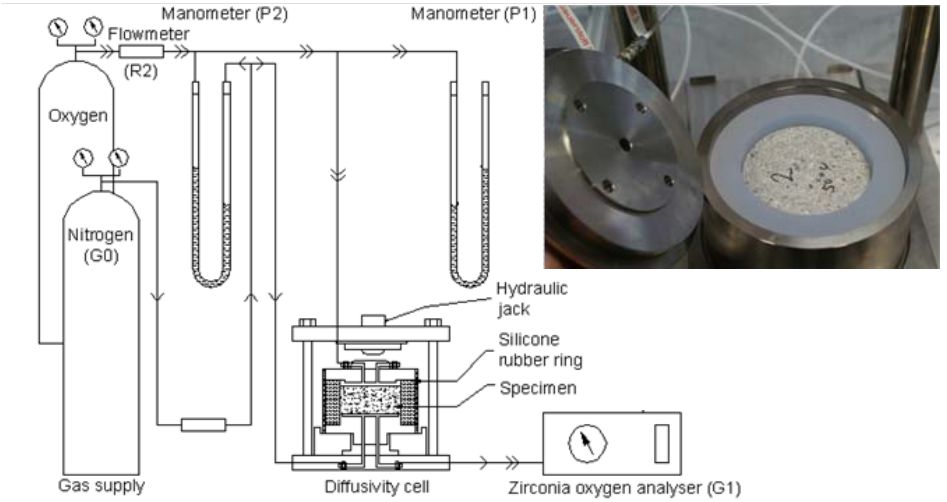

Figure 1: Schematic experimental setup for measuring oxygen diffusion coefficient and detail of the diffusion cell.

Specimens: cores Ø100 / 50 mm for concrete and Ø100 / 20 mm for mortars

Conditioning: 7 days drying at 35% r.h. followed by 7 days drying in the oven at 50°C

Measurement: In a diffusivity cell an oxygen flow is applied on one side of the core and a nitrogen flow on the other side. Gas pressure on both sides of the core is identical (controlled by manometers). The oxygen content in the nitrogen flow is measured using a zirconia oxygen analyser until equilibrium is reached. Oxygen diffusion coefficient is then calculated by diffusion equations. The higher the diffusion coefficient, the higher the diffusivity.

Example

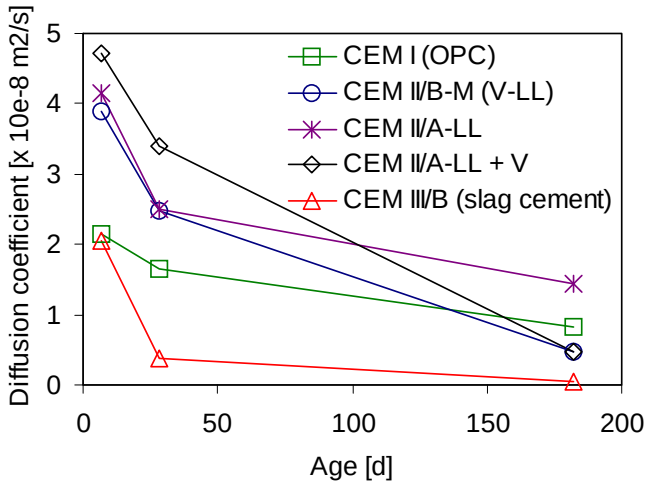

Figure 2: Influence of binder type and age on oxygen diffusion coefficient. Mortars with w/b = 0.50

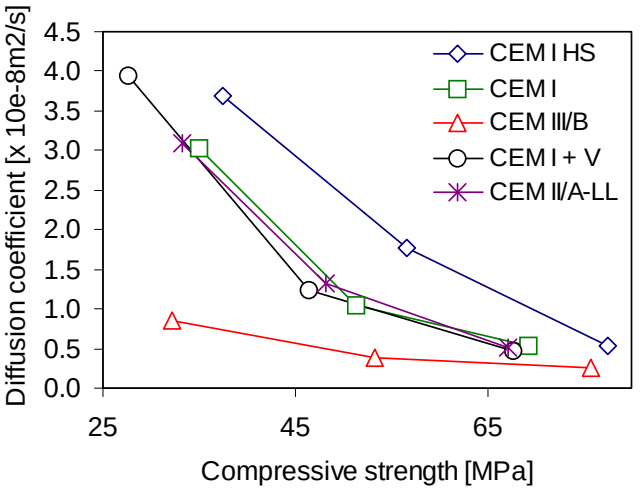

Figure 3: Oxygen diffusion coefficient versus compressive strength (different w/b-ratios) for concretes made with different binders

Applications & Potentials

- Performance of new binder or concrete types
- Diffusion constant can be used as input for durability models.

Limitations

- Diffusion is strongly dependent on the moisture content of the specimen. To reach constant moisture content for all type of specimens would take very long time (months). Defined drying time is feasible only.
- conditioning (drying) of the samples can cause cracks in cement paste samples leading to increased diffusivity.