Oxygen permeability (OPI)

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Introduction

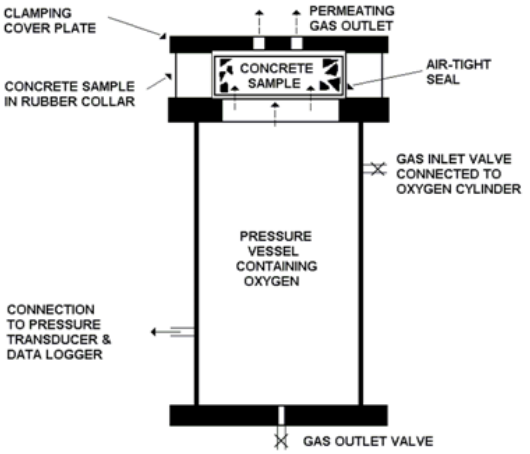
Since cement paste is a porous material, liquids can penetrate into cement based materials. If the pores are at least partially emptied, gases can also diffuse into such materials. With the described test, the resistance of cement based materials against ingress of oxygen under pressure is determined.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

In contrast to the oxygen diffusion test there is a pressure difference between the both sides of the specimens.

Relevance for our Field

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

Measurement Principles



OPI = $-\log_{10} k$ with k being

$$k = \frac{\omega V g d}{R A \theta t} \cdot \ln \frac{P_0}{P}$$

Figure 1: Schematic experimental setup for measuring oxygen diffusion coefficient (OPI)

Specimens: cores Ø68 / 25 mm
Conditioning: 7 days drying at 35% r.h. followed by 7 days drying in the oven at 50°C
Measurement: The specimen is placed on a pressure vessel with an air tight sealing. After applying a pressure of about 1 bar, the connection to the oxygen cylinder is cut and sealed. The only way out for the oxygen is then through the concrete specimen. The pressure decrease in the vessel is recorded in function of time. From the slope of the straight line produced by this plot, the oxygen permeability index (OPI) may be determined according to the equation in Fig. 1, based on the D'Arcy equation for permeation. The higher OPI, the lower the permeability

Example

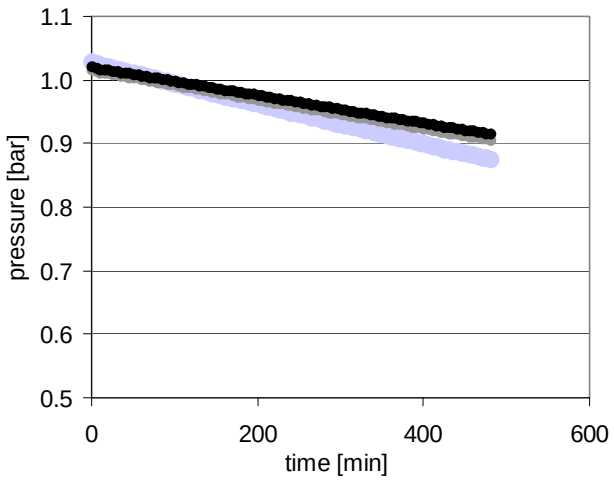


Figure 2: Example of the measured pressure decrease of three concrete samples from the same mixture. The slope of the straight line is used to calculate the OPI.

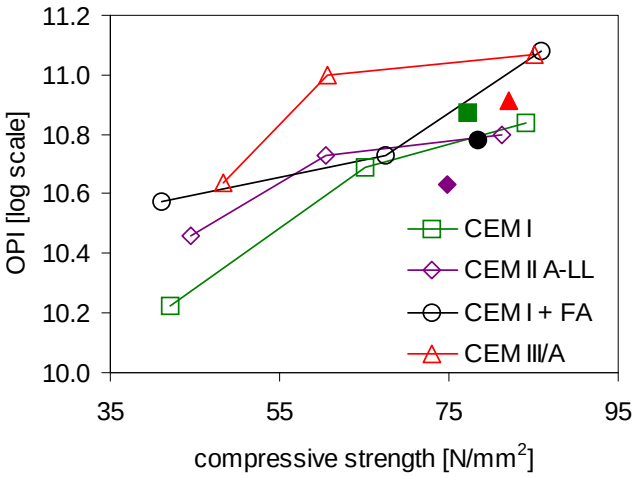


Figure 3: OPI versus compressive strength (different w/b-ratios) for concretes made with different binders. Empty symbols = conventionally vibrated concrete, filled = SCC.

Applications & Potentials

- new binder types
- new concrete types such as:
  - SCC
  - concrete with recycled aggregates
  - lightweight concrete
  - insulation concrete

Limitations

- In practice, the gases penetrate in most cases by diffusion and not by a pressure difference => results may be not directly transferable into practice.
- conditioning (drying) of the samples can cause cracks in the cement paste => as soon as microcracks occur, pressure is decreasing very fast and a proper measurement is impossible.