

# Permit<sup>o</sup>

// PERMIT Ion Migration Test for the measurement of chloride diffusivity of concrete cover *in situ*



Developed by Structural Materials Research Group at Queen's University Belfast, Northern Ireland, UK

**PERMIT** measures **ionic diffusion resistance** of the near-surface zone of concrete and other building materials, including natural stone, without causing damage. It is a unique instrument for determining the coefficient of diffusion *in situ* without the need to extract cores from structures for laboratory testing for this property.

**PERMIT** can measure the ionic diffusivity both on site and in the laboratory.

- PERMIT**
- measures ionic diffusivity to enable **SERVICE LIFE PREDICTION** of reinforced concrete structures.
  - is particularly suited to assess the susceptibility to chloride induced corrosion of steel.
  - is non-destructive, easy to use and portable for site use
  - allows tests to be completed within a day on site even for the most impermeable concrete encountered at present.
  - enables the assessment of the effectiveness of mineral admixtures in improving resistance of concrete to chloride penetration
  - is supported by internationally accepted research

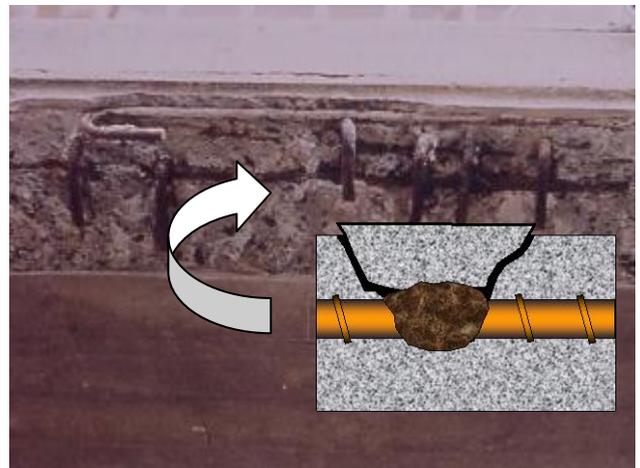
## BACKGROUND

The durability of reinforced and prestressed concrete is severely affected by the ingress of chlorides. Chlorides are transported through the cover concrete in the form of water-borne salts and ions. Penetration of chlorides in solution form is possible only if the concrete is dry. In reality concrete is in a state of saturation, with the near surface concrete at a lower degree than that inside a structural member. Therefore, the primary mode of transport of chlorides (and in fact most ions) is diffusion. The resistance of concrete to ionic transport can be determined by extracting cores and testing them in a laboratory. However, this is very cumbersome and introduces damage to the structure. The PERMIT Ion Migration Test allows tests to be carried out *in situ*.



## PERMIT APPLICATION AREAS

- Assessment of resistance to chloride ingress
- Determination of chloride diffusion coefficient so as to enable service life predictions
- Prediction of salt induced corrosion of steel in concrete
- Assessment of the influence of mineral admixtures on chloride penetration resistance
- Assessment of the protection provided by sealants, coatings and hydrophobic surface treatments against chloride ingress
- Measurement of the effect of curing of concrete
- Measurement of the influence of special formworks, such as controlled permeability formwork
- Determination of the effect of shrinkage and settlement cracking on chloride penetration
- Compliance testing for chloride diffusion coefficient.



## RANGE OF TESTING

Ionic diffusion tests can be carried out on most building materials for which the coefficient of diffusion is within the practical ranges used in construction; that is the PERMIT can be used to measure ionic diffusivity in the range  $1 \times 10^{-8} \text{ m}^2/\text{s}$  to  $1 \times 10^{-14} \text{ m}^2/\text{s}$ .

The duration of PERMIT Ion Migration test depends on the quality of the material under test. Normally the test lasts for 1.5 hours to 10 hours.

### 01 CHLORIDE DIFFUSIVITY

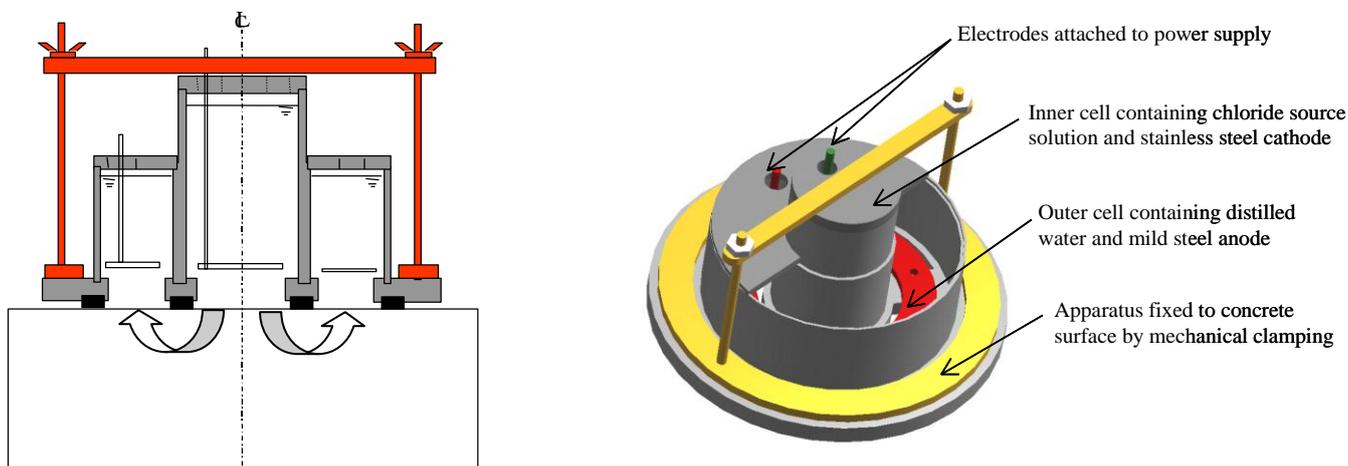
Related to chloride induced corrosion and hence can be used in service life models where corrosion is caused by chlorides.

### 02 OTHER IONS

Deterioration caused by ions such as sulphates can be assessed using the PERMIT Ion Migration Test

## Functional purpose of the PERMIT

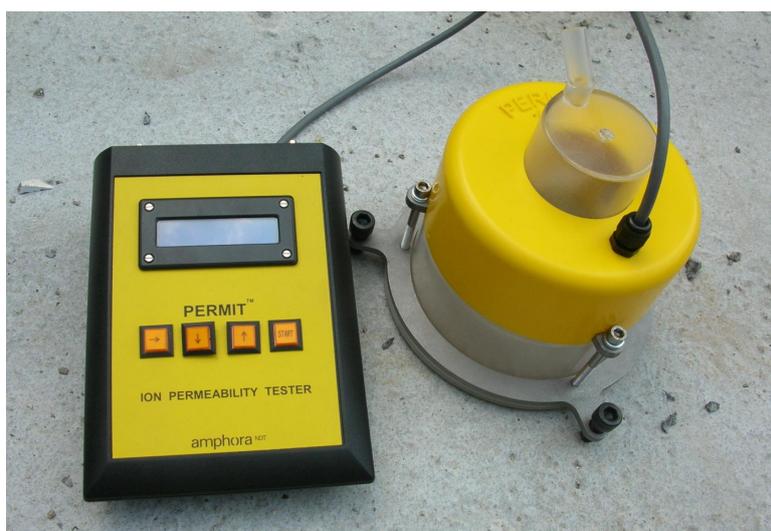
The PERMIT Ion Migration Test is a unique instrument that is capable of measuring the ion penetration resistance of concrete and other building materials both in laboratory and on site. Using this equipment, ions are forced to move through the near surface by applying a potential difference between two chambers containing an ion source solution and a neutral solution (Fig. 1). The rate of ions arriving in the neutral solution is monitored using electrical conductivity measurements and when a steady state has been found the flux is determined by analysing samples taken from the outer chamber. By utilising this steady flux and employing Nernst-Planck equation, the ionic diffusivity (or the coefficient of ion diffusion) is calculated.



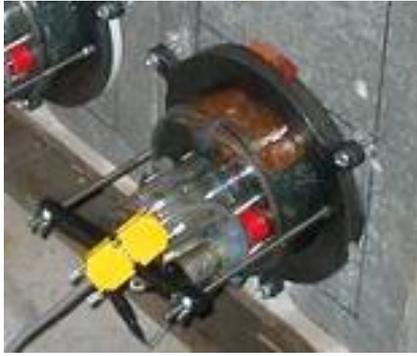
**Fig. 1** Schematic of the PERMIT Ion Migration Test

## The components of the PERMIT

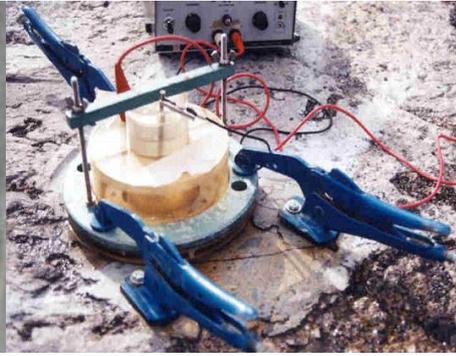
The PERMIT is supplied in a portable carrying case, and consists of two parts, the PERMIT body and its electronic controller and data recording system (Fig. 2a). Figures 2b and 2c show two methods of mounting the PERMIT body on test surfaces. As can be seen in these figures, the PERMIT can be applied to both horizontal and vertical surfaces.



**Fig. 2a** PERMIT Ion Migration Apparatus



**Fig. 2b** Fixing using bolts



**Fig. 2c** Fixing using clamps

**PERMIT body:** It accommodates –

- an electronically controlled system to apply the test voltage, stir the solution and measure conductivity and temperature of the outer chamber.
- two reservoirs; one to hold sufficient quantities of the ion source solution and the other to hold a neutral solution, such as deionised water.
- a circular electrode in the inner chamber (cathode) and an annular electrode in the outer chamber (anode) of suitable materials.
- a clamping ring to fix the body of the apparatus onto test surfaces, either by bolting or using clamps.
- all necessary connections to the electronic controller

**The electronic control box** contains all the custom designed electronic control and recording hardware. On its top panel (Fig. 2a) is a back-lit digital liquid crystal display screen and test selection keys. There are two sockets at the back of the control box, one of which is used to connect the PERMIT body to the control box and the other is used to connect the control box to a PC. Also supplied with the kit is a DC power supply unit.

During the progress of the test and at its completion, the data can be transferred to a PC for further analysis.

## Technical details of the PERMIT

Test voltage	:	60 v DC
Operating temperature	:	0 - 50 degrees C
Warm-up time	:	30 seconds

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## Supplier Information

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