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Breakdown voltage and transition zone of concrete

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Abstract

The breakdown voltage test shows that the weakest pathway of the concrete is the interface of paste/aggregate, i.e., the transition zone. This is also a special proof for the critical voltage of concrete (CVC) test.

Keywords: Concrete; Electrical properties; Permeability

1. Introduction

It is well known that the weakest path in a compact concrete is the transition zone, i.e., the interface of paste/aggregate. This can be proved by the investigation of SEM or other optical spectroscopy techniques. It is assumed that the transition zone should determine the permeability of high performance concrete since the paste is very condensed in this case. However, there is no direct proof given in the literature. Fortunately, a direct proof has been found during the investigation of the breakdown behavior of concrete. It will be given as the following.

2. Experimental procedure

The concrete mixes are listed in Table 1. The specimens about 3–10 mm thick are cut from the 100 × 100 × 300 mm prism after being cured at 20±2°C, RH 90% for 4 weeks, and heated at 50–75°C for 24–168 h. The breakdown voltage test is carried out at room temperature using a CY2661 Breakdown Voltage Detector with a range of 5 kV, 0–20 mA DC and AC; or a High Voltage Generator made by the High Voltage Research Laboratory of our university with a range of 50 kV, 2 mA, DC. The experimental arrangement is illustrated in Fig. 1.

If the specimen is in breakdown, it will leave a black point or a crack on the surface. Then, it can be photographed.

3. Results

It is not easy to find the breakdown behavior of concrete since it is not a good insulator when compared with ceramics [1] and capacitance paper. It can only be found when the specimen has been dried enough and with proper thickness since thick specimen require very high voltage, which may be beyond the range of the instrument.

Fig. 2 is obtained at 0.026 mA/cm^2 at about 16 kV/cm for specimen C with thickness of about 3 mm using CY2661 Detector. A very similar photograph is also obtained at 0.005 mA/cm^2 at about 36 kV/cm for specimen S with thickness of about 10 mm using the High Voltage Generator. It can be seen that the breakdown area is at the interface of paste/aggregate. Before the test, there is no obvious crack on the surface. This proves that the weakest area in the concrete is the transition zone.

This characteristic also implies that the transition zone may determine the permeability of concrete, especially of the high performance concrete since large pores and cracks may be absent in it.

Table 1
Concrete mix

Specimen	W/C	Portland cement (kg/m^3)	Sand (kg/m^3)	Coarse aggregate (kg/m^3)	Compressive strength at 28 (MPa)
C	0.40	480	663	1081	62.3
S	0.30	558	660	1077	75.4

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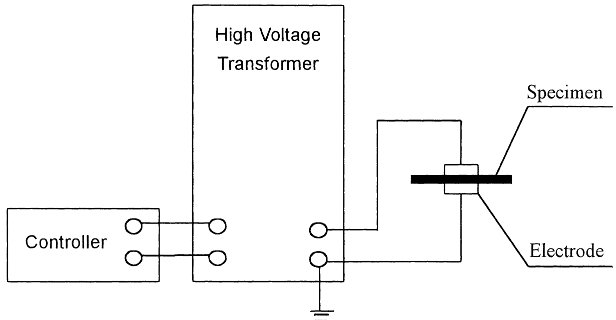

Fig. 1. Schematic of high voltage generator.

4. Conclusion

The breakdown behavior demonstrates that the weakest area in the condensed concrete is the transition zone. The transition zone may play a predominant role in the permeability of concrete.

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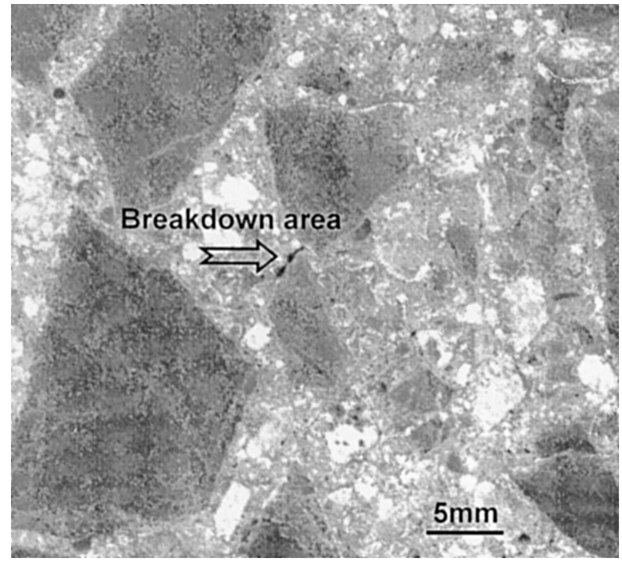

Fig. 2. Breakdown of C specimen with magnification 4.

References

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