FALLING HEAD PERMEAMETER FOR MEASURING CEMENT PASTE PERMEABILITY

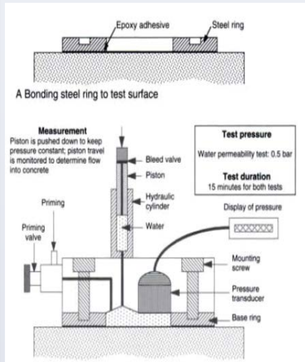
Xinyao Li, Peter C. Taylor, and Kejin Wang

Civil, Construction & Environmental Engineering, Iowa State University

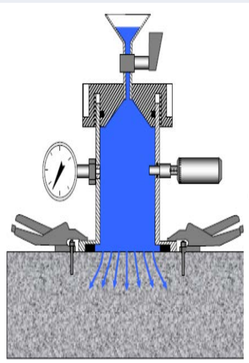
ABSTRACT

This paper describes the development and evaluation of a falling head permeameter for measuring water permeability of saturated cement paste. The apparatus is developed based on an existing device used to measure gas permeability of concrete. The paper discusses the background to the method and the activities conducted to minimize variability in the test data.

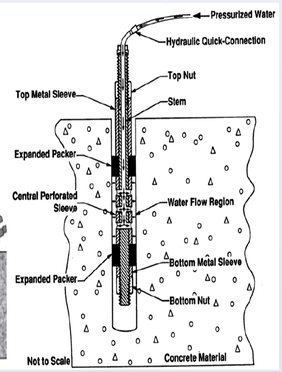
EXISTING WATER PERMEABILITY TESTS



Autoclam test (Basheer, 1993)



Germann water permeability test (Germann Instruments Inc. 2009)



Field permeability test (Florida test)- FPT (Meletiou, Tia and Bloomquist in 1990s)

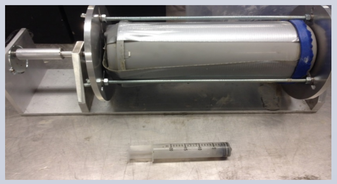
APPROACH TO CHALLENGES

- oTake the Ballim oxygen test and invert
- oTest a vacuum saturated sample
- oSame sample can be tested at different ages
- oAdvantages
  - o Cost is low compared to other apparatus
  - o The operation is simple
  - o Testing period is relatively short (one to two days)

MATERIALS AND MIX PROPORTION

Group	w/c	Cement (g)	Water (g)	NRWR (g)	Total (g)
1. Type I/II cement	0.35	3037	1063	24 (0.8% by weight of cement)	4124
2. Type I/II cement	0.45	3000	1350	12(0.4% by weight of cement)	4362
3. Type I/II cement	0.55	3000	1650	0	4650

Horizontal rotator & high shear mixer



EXPERIMENTAL DESIGN

Cut section view

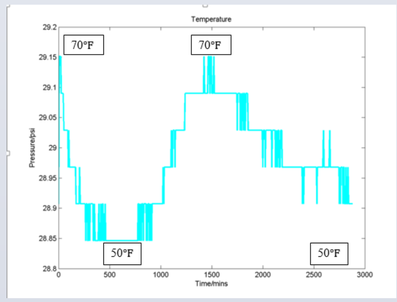
Water permeameter

SOURCES OF ERROR

1. Leakage

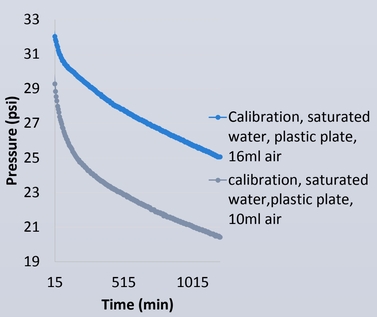
2. Temperature

Effect of temperature on permeability measurement (steel plate)



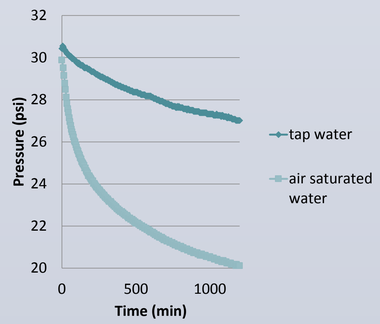
3. Initial air volume

Effect of initial air volume on permeability measurement (at 70°F, steel plate)



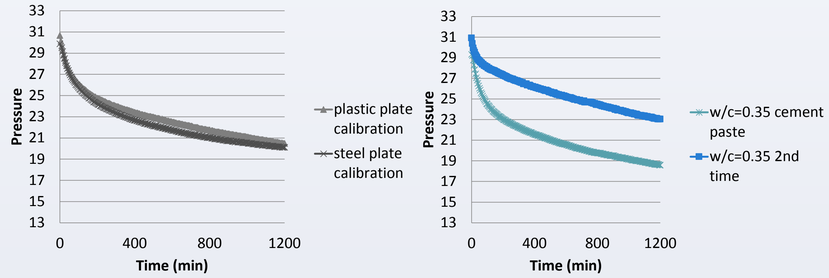
4. Dissolution of air

Effect of air saturation on permeability measurement (steel plate)

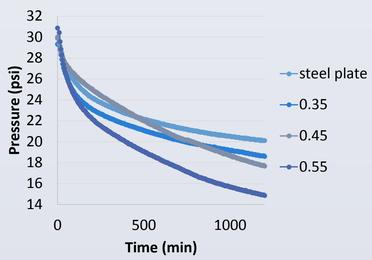


5. Repeatability

Effect of repeatability on water permeability measurement



WATER PERMEABILITY CALCULATION



w/c ratio	P1 (psi)	V1(ml)	P2 (psi)	V2(ml)	L, Thickness (cm)	t, Time (s)	K, Permeability (m/s)
0.35	29.34	10	28.36	10.34	2.30	72000	3.42E-13
0.45	30.01	10	27.44	10.93	2.26	72000	9.15E-13
0.55	30.86	10	24.63	12.53	2.78	72000	3.15E-12

CONCLUSIONS

- o A newly developed water permeability test device is simple, cheap and easy to operate. However, the test results are not reliable at this point.
- o The major factors affecting test results include sealing of the system, temperature, and initial air volume.
- o Test results of cement paste samples indicate that the “true” pressure drop increasing with time. The rate of the pressure drop becomes constant after certain time. The permeability of cement paste can be calculated based on the pressure drop measured, which increases with water-to-cement ratio.
- o Further refinement is needed to obtain consistent test results for given samples and test conditions.

REFERENCES

1. T.C. Powers, H.M. Mann, L.E. Copeland, "The Flow of Water in Hardened Portland Cement Paste," *Highway Research Board Special Report*, July 1959.

2. P. Kumar Mehta, Paulo J.M. Monteiro, Concrete Microstructure, Properties, and Materials, McGraw-Hill, 2006, p. 140.

3. "Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration".*ASTM C1202.*