NUMERICAL SIMULATIONS OF LABORATORY AND FIELD TESTS OF PERMEABILITY

A. Garwolińska, M. Kaczmarek
Institute of Environmental Mechanics and Applied Computer Science
Kazimierz Wielki University, Bydgoszcz, Poland

1. Background

Surrounding environment strongly influences the durability of concrete structures. A first symptom of deterioration of concrete structure is an increase of the permeability of its cover layer. Increase of permeability causes deeper and faster ingress of water and aggressive agents which accelerates the deterioration of deeper layers of concrete. Thus, the evaluation of permeability of concrete cover plays significant role in prediction of its quality.

Description of number of different field tests of permeability can be found in literature [1,2,5]. Most of them and few other specific techniques [3,4] can be used in laboratory. In general, there is a possibility to test permeability with liquid or gas but in case of the high-performance concrete, liquid tests are practically not possible. Such concrete is almost completely water-resistant and gas methods are preferred.

2. Aims and method

The paper deals with modeling transient flow of compressive gas in porous materials. Mathematical model describing the phenomenon including viscous interaction and Klinkenberg effect was formulated. Simulations by Finite Element Method in COMSOL environment assuming different boundary and initial conditions are shown and results are analyzed.

3. Results and discussion

A number of simulations within model describing transient phenomenon of compressible fluid flow in porous media were performed assuming that initially in the gas reservoir:

a. The pressure is significantly lower (technical vacuum) than in the pore space of tested material (suction),
b. The pressure is few times higher (overpressure) than in the pore space of tested material (pumping).

Such conditions correspond to the main groups of presently used practical methods in laboratory and field permeability testing.

Since laboratory tests are made on samples with sealed lateral surface then the fluid flows along the axis of the sample and the corresponding model of flow is one dimensional (1D). In turn most field tests relay on configurations for which gas flows both in axial and radial directions and then the two dimensional model (2D) is appropriate. The results shown in this paper refer to transient flow of compressible gas in concrete for both cases.

The simulations show that the influence of Klinkenberg coefficient on pressure distribution in the porous material is essentially greater in case (a) than in case (b). The same undergoes for the time dependence of pressure in the reservoir. The facts can be justified by a physical argument that the longer mean free path (more rarefied gas) the stronger slippage effect must appear.

Taking into account that the most convenient for measurement is observation of pressure changes versus time in the gas reservoir Figure 1 presents distributions of changes in reservoir pressure for 1D and 2D cases. In both simulations the same material constants and geometry were assumed. The initial pressure in reservoir was equal fife times the pressure in the pore space of tested material.

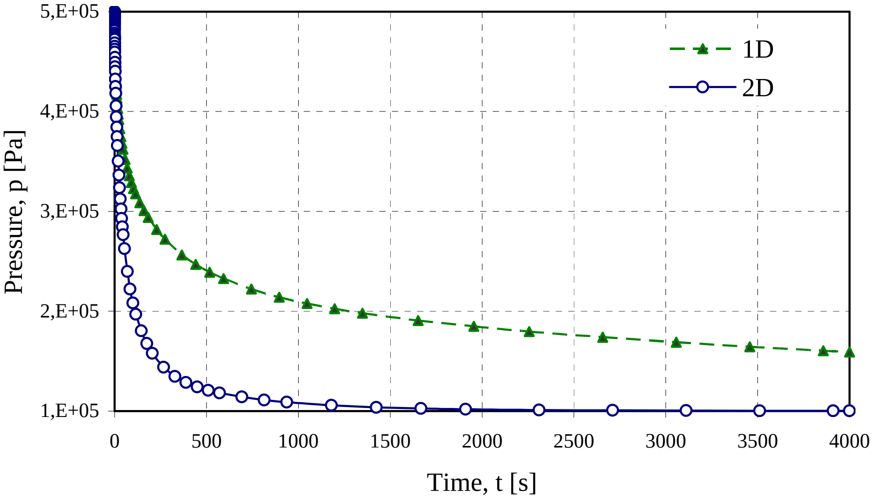

Figure 1. Distributions of pressure changes in reservoir for one and two dimensional simulation of compressible fluid flow in porous media

4. Final remarks

The paper presents simulations of one and two dimension transient flow of compressive gas in porous material. Material constants, initial pressures in pore space of tested material and reservoirs as well as the geometrical conditions of simulated problems are assumed in the way corresponding to practice in laboratory and field tests of concrete permeability. The obtained results show great importance of testing conditions for time dependence of pressure in reservoir and pressure distribution in the porous material. A particular sensitivity to testing conditions shows the Klinkenberg effect. Currently experimental works are made to verify the results obtained from simulations.

6. References

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