SVAIRFLOW™

2D / 3D Airflow Modeling Software

Verification Manual

Written by:
Robert Thode, P.Eng., B.Sc.G.E.

Edited by:
Murray Fredlund, P.Eng., Ph.D.

SoilVision Systems Ltd.
Saskatoon, Saskatchewan, Canada

Software License

Software Support

Support for the software is furnished under the terms of a support agreement.

Copyright

Disclaimer of Warranty

SoilVision Systems Ltd. reserves the right to make periodic modifications of this product without obligation to notify any person of such revision. SoilVision does not guarantee, warrant, or make any representation regarding the use of, or the results of, the programs in terms of correctness, accuracy, reliability, currentness, or otherwise; the user is expected to make the final evaluation in the context of his (her) own problems.

Trademarks

1 INTRODUCTION

The word “Verification”, when used in connection with computer software can be defined as “the ability of the computer code to provide a solution consistent with the physics defined by the governing partial differential equation, PDE”. There are also other factors such as initial conditions, boundary conditions, and control variables that also affect the accuracy of the code to perform as stated.

“Verification” is generally achieved by solving a series of so-called “benchmark” problems. “Benchmark” problems are problems for which there is a closed-form solution or for which the solution has become “reasonably certain” as a result of long-hand calculations that have been performed. Publication of the “benchmark” solutions in research journals or textbooks also lends credibility to the solution. There are also example problems that have been solved and published in User Manual documentation associated with other comparable software packages. While these are valuables checks to perform, it must be realized that it is possible that errors can be transferred from one’s software solution to another. Consequently, care must be taken in performing the “verification” process on a particular software package. It must also be remembered there is never such a thing as complete software verification for “all” possible problems. Rather, it is an ongoing process that establishes credibility with time.

SoilVision Systems takes the process of “verification” most seriously and has undertaken a wide range of steps to ensure that the SVAIRFLOW software will perform as intended according to the theory of saturated-unsaturated air flow.

The following models represent comparisons made to textbook solutions, hand calculations, and other software packages. We at SoilVision Systems Ltd. are dedicated to providing our clients with reliable and tested software. While the following list of example models is comprehensive, it does not reflect the entirety of models, which may be posed to the SVAIRFLOW software. It is our recommendation that water balance checking be performed on all model runs prior to presentation of results. It is also our recommendation that the modeling process move from simple to complex models with simpler models being verified through the use of hand calculations or simple spreadsheet calculations.

2 TWO-DIMENSIONAL STEADY-STATE AIR-FLOW

The steady-state model is used to compare SVAIRFLOW results to those recorded in a study by Baehr & Hult (1991).

2.1 BAEHR & HULT (1991)

Baehr & Hult (1991), present two analytical solutions for steady-state axisymmetric airflow to a single will that is partially screened in the unsaturated zone. Input data was collected from a series of pneumatic tests. One model considers a stratum of relatively low air conductivity, separating the stratum in which the well is completed from the atmosphere. In the other scenario there is no separating stratum between the material layer and the atmosphere. This second analytical model with no separated stratum as presented by Baehr & Hult has been created in SVAIRFLOW and is presented below.

Project:	WellPumping
Model:	BHuzPeq

In this scenario, a single material layer is present and is exposed to the atmosphere. A well has been drilled to a depth of 2.88m and a horizontal water table existed at a depth of 3.37m.

Axisymmetric Model Geometry:

Well depth	= 2.88m
Well screen height	= 0.6m
Well radius	= 0.115m
Model radius	= 20m
Model depth	= 3.37m

Boundary Conditions:

Ground Surface	= Pressure of 101.458 kPa (atmospheric)
Well screen side and base	= Normal Flux Expression of 0.13785 m/s
Model base	= Zero Flux (water table)
Wellbore	= Zero Flux
Model side	= Zero Flux

Material Properties:

Intrinsic Permeability	= 1.4E-10 m^2
Vertical anisotropy ratio	= 0.3142

An initial air pressure of 101.458 kPa is applied to entire material.

2.1.1 Model Description

In this scenario, a single material layer is present and is exposed to the atmosphere. A well has been drilled to a depth of 2.88m and a horizontal water table existed at a depth of 3.37m.

Axisymmetric Model Geometry:

Well depth	= 2.88m
Well screen height	= 0.6m
Well radius	= 0.115m
Model radius	= 20m
Model depth	= 3.37m

Boundary Conditions:

Ground Surface	= Pressure of 101.458 kPa (atmospheric)
Well screen side	= Normal Flux Expression of 0.13785 m/s
Model base	= Zero Flux (water table)

Wellbore	= Zero Flux
Model side	= Zero Flux

Material Properties:

Intrinsic Permeability	= 1.4E-10 m^2
Vertical anisotropy ratio	= 0.3142

An initial air pressure of 101.458 kPa is applied to entire material.

2.1.2 Results and Discussions

Figure 1 through Figure 4 show the normalized air pressure versus the radial distance from the pumping well at various depths. The square symbols represent the values obtained from the field tests. The dashed line indicates the analytical results. The results of the SVAIRFLOW analysis are presented as the solid line and are in good agreement with both the analytical and field results.

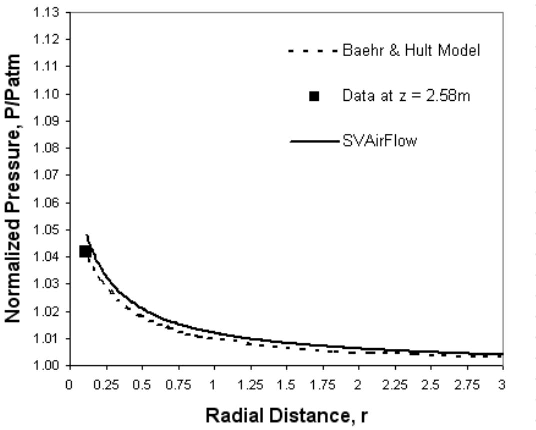

Figure 1 Normalized pressure as a function of cylindrical coordinates (*r,z*) in the upper unsaturated zone for *z* = 2.58m

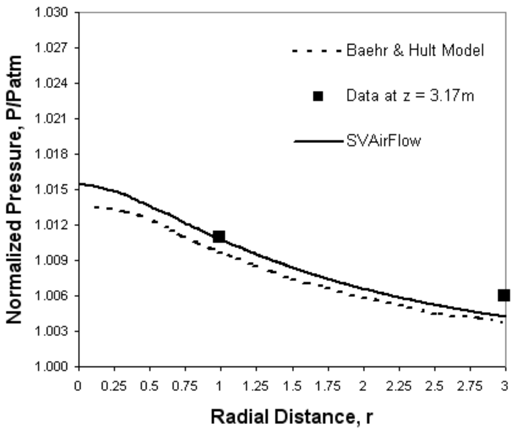

Figure 2 Normalized pressure as a function of cylindrical coordinates (*r,z*) in the upper unsaturated zone for *z* = 3.17m

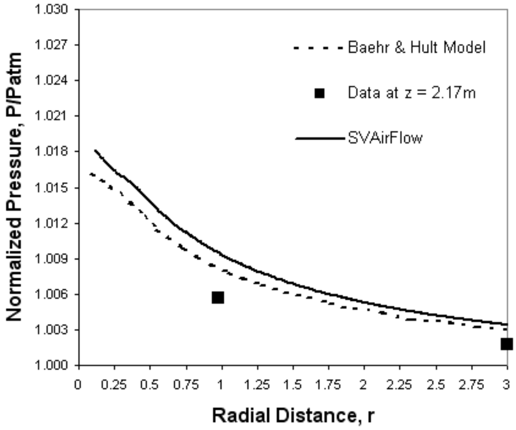

Figure 3 Normalized pressure as a function of cylindrical coordinates (*r*,*z*) in the upper unsaturated zone for *z* = 2.17m

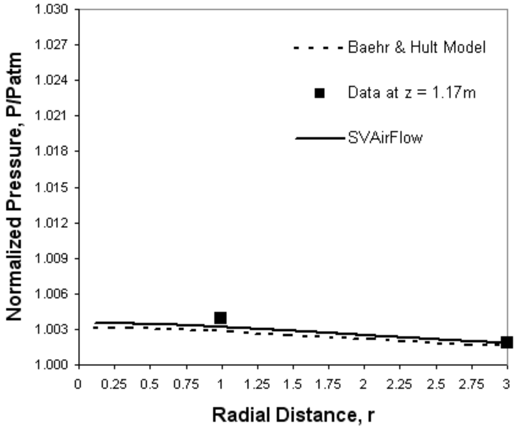

Figure 4 Normalized pressure as a function of cylindrical coordinates *(r,z)* in the upper unsaturated zone for *z* = 1.17m

3 REFERENCES

Baehr, A.E., and Hult, M.F. 1991. Evaluation of Unsaturated Zone Air Permeability Through Pneumatic Tests. Water Resources Research, 27(10): 2605-2617.

This page has been left blank intentionally.