AD FALCON API Manual

Van Genuchten Permeability Model

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Contents

1 Van Genuchten Permeability Model **3**
1.1 Syntax 3
1.2 References 3

1 Van Genuchten Permeability Model

1.1 Syntax

```
@Perm: VanGenuchten m <m> k_sat <k_sat> [e_ref <e_ref>]
@Perm: VanGenuchtenKe m <m> k_sat <k_sat> [ke_ref <e_ref>] [k_min <k_min>]
```

The Van Genuchten permeability model uses a more complex relationship to capture the nonlinear variation of relative permeability with effective saturation, S_e. The relative permeability for water is given by:

$$k_{rw} = \sqrt{S_e}\left[1 - \left(1 - S_e^{1/m}\right)^m\right]^2 \tag{1}$$

and for gas by:

$$k_{rg} = (1 - S_e)^{1/3}\left[1 - \left(1 - S_e^{1/m}\right)^{2m}\right] \tag{2}$$

To account for the effects of void ratio, a correction factor is applied. This factor is computed as:

$$k_c = \frac{e^3(1 + e_{ref})^2}{e_{ref}^3(1 + e)^2} \tag{3}$$

Therefore, the effective relative permeabilities become:

$$k_{rw}^{eff} = \max\{k_{rw} \times k_c,\ k_{min}\} \tag{4}$$

$$k_{rg}^{eff} = \max\{k_{rg} \times k_c,\ k_{min}\} \tag{5}$$

Equations (1)-(2) correspond to the Mualem-van Genuchten relative-permeability model (Mualem, 1976; van Genuchten, 1980). Equation (3) uses a Kozeny-Carman-type void-ratio multiplier.

1.2 References

- Mualem, Y. (1976). *A new model for predicting the hydraulic conductivity of unsaturated porous media*. Water Resources Research, 12(3), 513-522.
- van Genuchten, M. Th. (1980). *A closed-form equation for predicting the hydraulic conductivity of unsaturated soils*. Soil Science Society of America Journal, 44(5), 892-898. https://doi.org/10.2136/sssaj1980.03615995004400050002x
- Carman, P. C. (1937). *Fluid flow through granular beds*. Transactions of the Institution of Chemical Engineers, 15, 150-166.