AD FALCON API Manual

van Genuchten SWRC Model

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1 van Genuchten SWRC Model

1.1 Syntax

Specify this model in `% Materials` using `@SWRC::`

```
@SWRC: NonHysteretic alpha_1 <alpha_1> n <n> m <m> omega_prime <omega_prime>
[SW_max <SW_max>] [SW_min <SW_min>] [st <st>]
```

Notes:

- `NonHysteretic` is the model keyword for the van Genuchten SWRC in input files.
- `SW_max`, `SW_min`, and `st` are optional.

1.1.1 Parameters

Input keyword	Symbol	Meaning
`alpha_1`	α_1	Shape/air-entry parameter (used in Eq. (1)).
`n`	n	Shape parameter controlling slope.
`m`	m	Shape parameter controlling curvature.
`omega_prime`	Ω'	Void-ratio influence in modified suction $p_c^* = p_c e^{\Omega'}$.
`SW_max`	$S_{r\text{-max}}$	Maximum degree of saturation (optional).
`SW_min`	$S_{r\text{-min}}$	Minimum degree of saturation (optional).
`st`	st	Threshold parameter in the suction correction factor $C_s(p_c)$ (optional).

Modified van Genuchten Model

To account for the effects of volume changes on the soil water retention curve (SWRC), we define a modified suction, $p_c^* = p_c e^{\Omega'}$, where Ω' is a material parameter representing the influence of the void ratio, p_c is the suction, and e is the void ratio.

By neglecting hydraulic hysteresis, the non-hysteretic van Genuchten model for the SWRC is expressed as

$$S_e = \left[1 + \left(\alpha_1 \, p_c^*\right)^n\right]^{-m} \tag{1}$$

where α_1, n, and m are model parameters that control the shape of the retention curve. In addition, the model considers the maximum and minimum degrees of saturation, denoted by $S_{r\text{-max}}$ and $S_{r\text{-min}}$, respectively, so that the effective degree of saturation is given by

$$S_w = S_{r\text{-min}} + (S_{r\text{-max}} - S_{r\text{-min}}) \, S_e \tag{2}$$

A correction factor, $C_s(p_c)$, is introduced to account for additional effects due to suction. This factor is defined as

$$C_s(p_c) = 1 - \frac{1 + \ln\left(\frac{\max(p_c, \text{TINY})}{st}\right)}{1 + \ln\left(\frac{10^6}{st}\right)} \tag{3}$$

where TINY is a small constant, 1E-12, to avoid singularities and st is a threshold parameter. Note that the threshold parameter st is not compulsory; if the user does not provide a value for st, the correction factor $C_s(p_c)$ is assumed to be deactivated (i.e., set equal to 1).

The modified van Genuchten SWRC is then given by

$$S_w = C_s(p_c) \left[S_{r\text{-min}} + (S_{r\text{-max}} - S_{r\text{-min}}) \left(1 + \left(\alpha_1 \, p_c^*\right)^n\right)^{-m}\right] \tag{4}$$

This formulation integrates the influence of volume changes through the modified suction and adjusts the retention curve via the correction factor $C_s(p_c)$.

Equations (1)-(2) are based on the classical van Genuchten retention law (van Genuchten, 1980). The additional void-ratio and suction-correction terms used here are part of FALCON's modified SWRC implementation for deformable unsaturated soils.

1.2 References

- 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