
AD FALCON API Manual

# Effective Stress Model – Ghorbani and Kodikara (2024)

Javad Ghorbani

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# 1 Effective Stress Model – Ghorbani and Kodikara (2024)

## 1.1 Syntax

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

```
@EffectiveStress: GhorbaniKodikara Beta1 <Beta1> Beta2 <Beta2>
```

The effective stress in unsaturated soils is influenced by both pore water and pore air pressures. Ghorbani and Kodikara (2024) proposed a generalized formulation that introduces a saturation-dependent weighting function to interpolate between Terzaghi's effective stress (for saturated soils) and Bishop-type expressions (for unsaturated conditions).

The model is expressed as:

$$\sigma' = \sigma - \chi(S_w)\, p_w\, I - [1 - \chi(S_w)]\, p_a\, I \tag{1}$$

where:
- $\sigma'$: effective stress tensor
- $\sigma$: total stress tensor
- $p_w$: pore water pressure
- $p_a$: pore air pressure
- $S_w$: degree of saturation
- $I$: identity tensor
- $\chi(S_w)$: effective stress weight function

The weighting function $\chi(S_w)$ is defined by:

$$\chi(S_w) = S_w^{\left(\frac{\beta_1}{S_w^{\beta_2}}\right)} \tag{2}$$

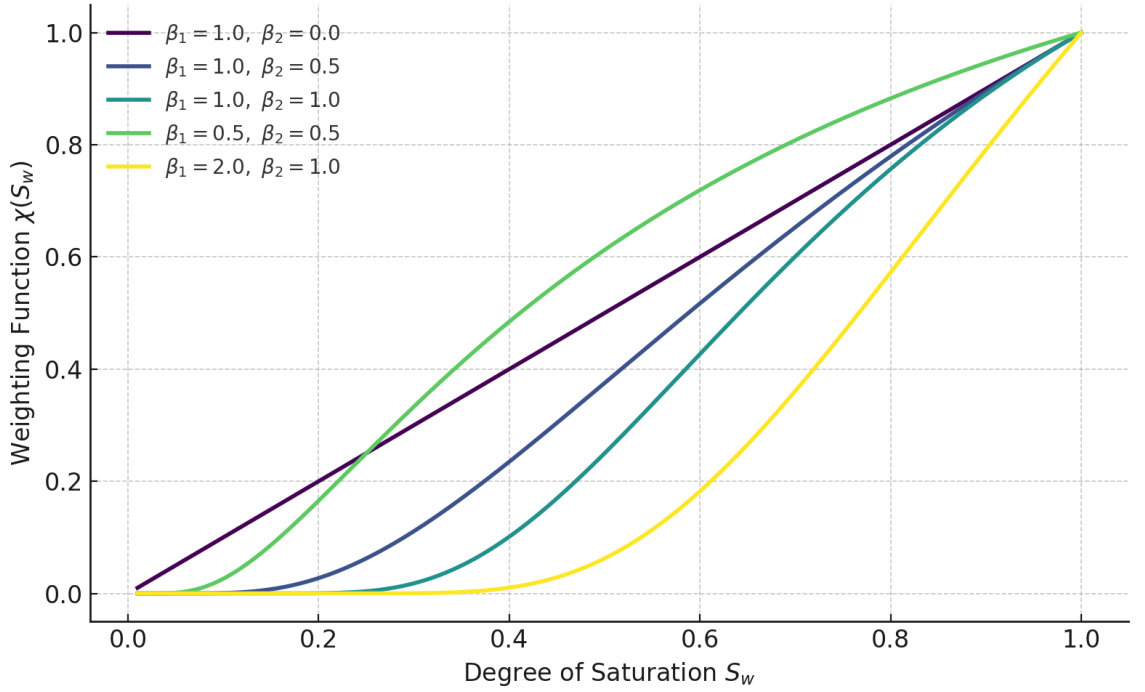
with model parameters:
- $\beta_1$: exponent controlling the saturation influence
- $\beta_2$: scaling parameter for nonlinear saturation behavior

## 1.2 Special Cases

- If $\beta_1 = 1$ and $\beta_2 = 0$, then $\chi(S_w) = S_w$, recovering the classical Bishop's model.
- If $S_w = 1$, the formulation reduces to Terzaghi's effective stress.

This model provides greater flexibility in capturing intermediate saturation effects and enables a smooth transition between saturated and dry states. It is particularly useful for coupling hydro-mechanical processes in unsaturated soils, especially when dealing with strong suction regimes or complex loading paths.

Influence of $\beta_1$ and $\beta_2$ on $\chi(S_w)$




Equations (1)-(2) follow the effective-stress formulation proposed by Ghorbani and Kodikara (2024).

## 1.3 References


- Ghorbani, J., & Kodikara, J. (2024). *Thermodynamically consistent effective stress formulation for unsaturated soils across a wide range of soil saturation*. Computational Mechanics, 73(5), 1077-1094.