

Shear Contact Constitutive Models in DEM

This document presents the application of linear and polynomial elastoplastic softening contact models in shear to incorporate in the discrete element method. The proposed contact model utilizes the fracture energy concept and relies on the contact stress update algorithm embedded into the available explicit solution scheme in 3DEC. Note that developed contact models are suitable for quasi-static analysis of brittle materials, such as concrete, rock, and masonry. Readers may find the mathematical formulations, applications, and sensitivity analyses of the proposed contact models in [Pulatsu et al., 2020](#). If you use the following contact models, please cite the paper given below.

Pulatsu, B., Erdoganmus, E., Lourenço, P.B., Lemos, J.V. and Hazzard, J., 2020. Discontinuum analysis of the fracture mechanism in masonry prisms and wallettes via discrete element method. *Meccanica*, 55(3), pp.505-523. DOI: 10.1007/s11012-020-01133-1

Linear Softening Model:

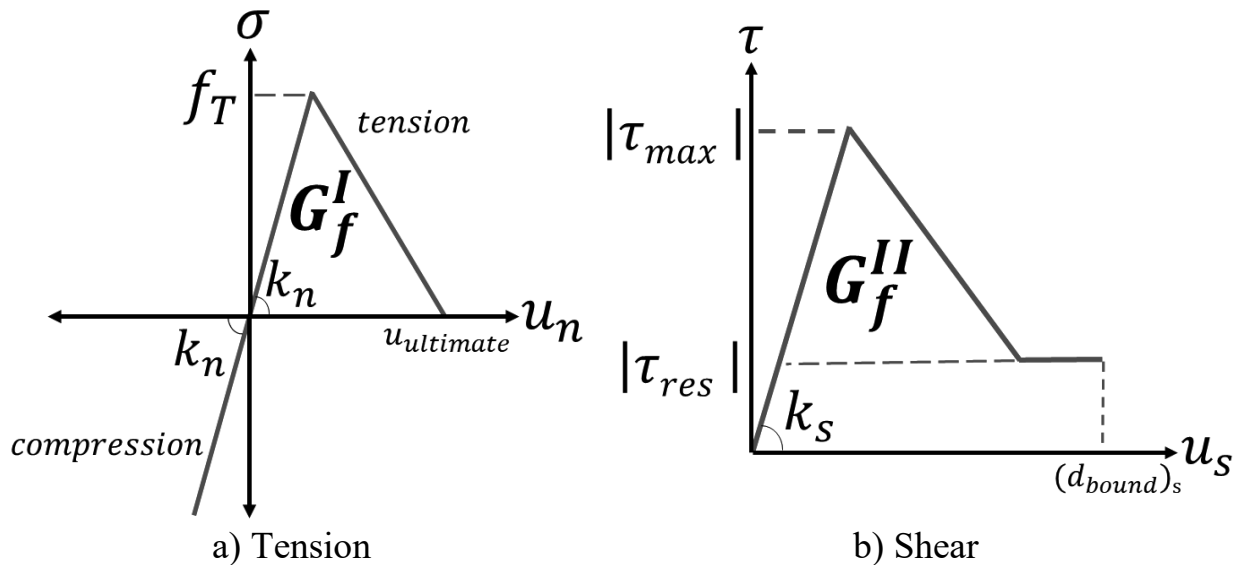


Figure 1. Linear softening – Contact constitutive model.

Nonlinear Softening Model:

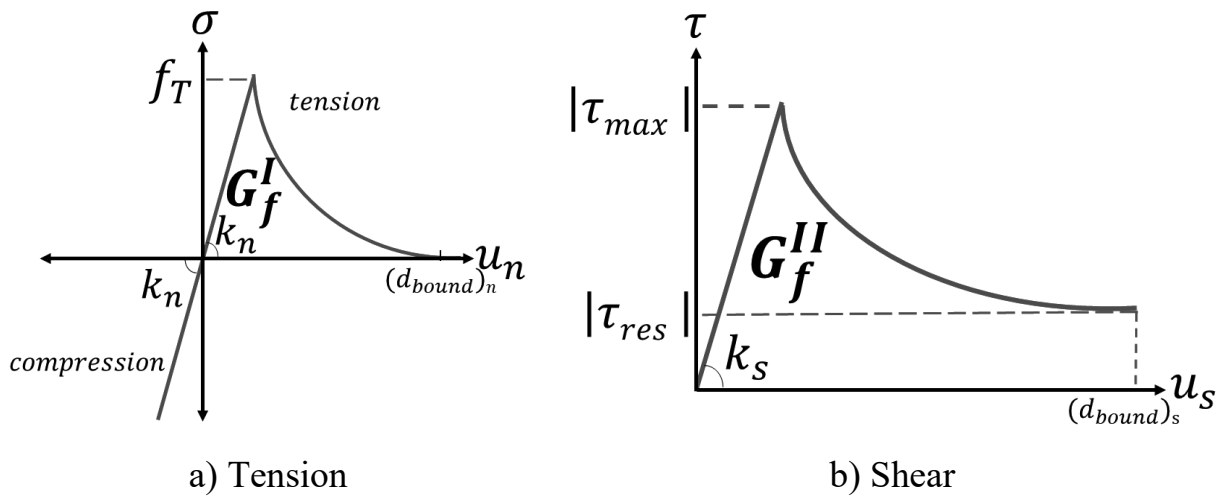


Figure 2. Polynomial softening models.

Example – (Compression + Shear Test Simulation)

```

config cppudm
set small on
damp local

; GEOMETRY ::::::::::::::::::::
poly brick 0 1 0.0 0.5 0 0.25 r 1
poly brick 0 1 0.5 1.0 0 0.25 r 2
gen quad ndiv 2 2 4 single_quad

; ::::::::::::::::::::
zone model elastic range y -1 +1
zone bulk 13.89E9 shear 10.42E9 density 2000 range y -1 +1

; --- SOFTENING MODELS -----
; --- LINEAR ::::::::::::::::::::
; jmodel model TSlinear range rint 1 2
; jmodel jkn 100E9 jks 100E9 range rint 1 2
; jmodel cohesion 2E6 friction 35 dilation 0 tension 1E6 range rint 1 2
; jmodel zerdilation 0.0 rescohesion 2E4 resfriction 25 range rint 1 2
; jmodel Gf_tension 60 d_bound_s 0.05 Gf_shear 150 range rint 1 2
    
```

```
; --- POLYNOMIAL ::::::::::::::::::::::::::::::::::::::::::::  
jmodel model TSpoly range rint 1 2  
jmodel jkn 100E9 jks 100E9 range rint 1 2  
jmodel cohesion 2E6 friction 35 dilation 0 tension 1E6 range rint 1 2  
jmodel zerdilation 0.0 rescohesion 2E4 resfriction 25 range rint 1 2  
jmodel d_bound_n 1E-3 alpha 3 Gf_tension 60 range rint 1 2  
jmodel d_bound_s 1E-3 beta 3 Gf_shear 150 range rint 1 2
```

```
fix range region 1
```

```
bound stress 0,-1E6,0,0,0 range y 0.95 10
```

```
bound xvel +1E-2 range r 2
```

```
hist sstress 0,0.5,0 id 1
```

```
hist xdisp 0,1,0 id 2
```

```
plot hist 1 vs 2
```

```
cy 5000
```

