# GNG Material

This command is used to construct a Grip 'n' Grab (GNG) uniaxial material object, which was developed to model a ratcheting, tension-only dissipater. Usage of the command is outlined below and the required input parameters are provided in ***Table 1***. All fields are required.

uniaxialMaterial GNG $matTag $E $sigY $pitch $eta

***Table 1 GNG material command input parameters***

| **Command** | **Description** |
|---|---|
| $matTag | Integer tag identifying material |
| $E | Elastic modulus |
| $sigY | Stress or force at which material reaches plastic state |
| $pitch | Pitch size of the GNG rack |
| $eta | Hardening ratio $\left(=\frac{E_2}{E_1}\right)$ |

**Figure 1** shows a sample hysteretic response of the GNG material. The response progresses via the sequential letters labelled in ***Figure 1***:

A. The system is initially at rest, before tensile motion begins.
B. The initial yield force is reached and the material enters the plastic response region.
C. The applied load is reversed, and elastic recovery in the material begins.
D. Elastic recovery in the material ends, and the device begins compressive motion with no forces modelled in the system. Ratcheting occurs each time the compressive motion after elastic recovery exceeds a new integer multiple of the pitch. Multiple ratcheting actions can occur during a single compressive loading cycle.
E. The applied load is reversed, and tensile motion begins. Initial tensile motion is not resisted until the device engages at a displacement related to the pitch size and the number of ratcheting actions that have occurred during compressive motion. This motion prior to engagement is referred to as the free-travel ($x_{free\text{-}travel}$). The free-travel is equal to the compressive motion after elastic recovery ($x_E - x_D$) minus the product of the pitch size ($p$) and the floor integer value $\lfloor\ \rfloor$ of the compressive motion after elastic recovery over the pitch size:

$$x_{freetravel} = (x_E - x_D) - p\left\lfloor\frac{(x_E - x_D)}{p}\right\rfloor$$

F. Engagement of the ratcheting mechanism occurs at the last ratcheting point.
G. The new yield force, updated due to strain-hardening, is reached and the material enters the plastic response region.

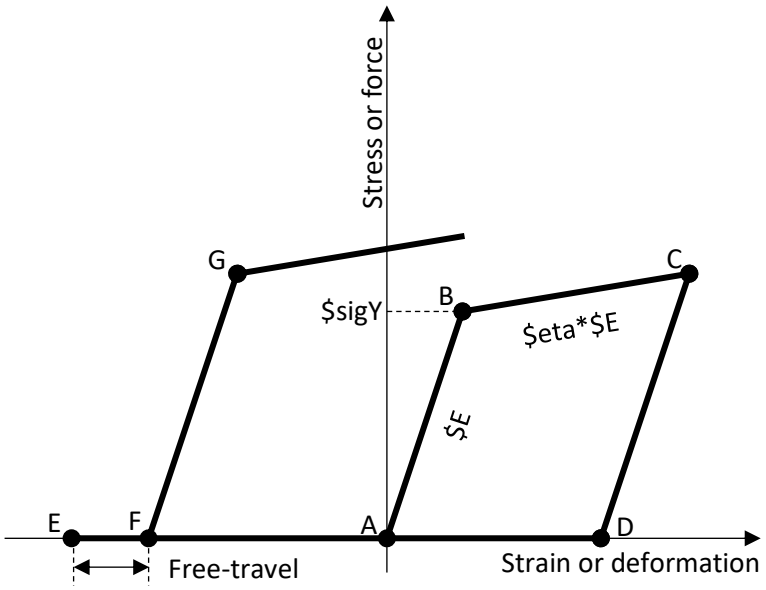


***Figure 1 GNG material hysteresis***

Two additional material outputs are available via the eleResponse command when using the GNG material model, and are defined in ***Table 2***.

***Table 2 Additional outputs available via eleResponse***

| **Command** | **Output** |
|---|---|
| ratchetCount | the total number of ratcheting actions |
| demand | the total inelastic displacement |

Please note that material failure mechanisms have not been included in the GNG material model algorithm, and careful consideration of results is required. More details on the GNG device are available in this paper:

Jarrod Cook, Geoffrey W. Rodgers & Gregory A. MacRae (2018) Design and Testing of Ratcheting, Tension-Only Devices for Seismic Energy Dissipation Systems, *Journal of Earthquake Engineering*, DOI: 10.1080/13632469.2018.1441765

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