

# Accepted Manuscript

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PII: S0749-6419(17)30085-2

DOI: [10.1016/j.ijplas.2017.02.004](https://doi.org/10.1016/j.ijplas.2017.02.004)

Reference: INTPLA 2155

To appear in: *International Journal of Plasticity*

Received Date: 30 October 2016

Revised Date: 6 February 2017

Accepted Date: 12 February 2017

Please cite this article as: Lee, J.-Y., Lee, M.-G., Barlat, F., Bae, G., Piecewise linear approximation of nonlinear unloading-reloading behaviors using a multi-surface approach, *International Journal of Plasticity* (2017), doi: 10.1016/j.ijplas.2017.02.004.

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## Piecewise linear approximation of nonlinear unloading-reloading behaviors using a multi-surface approach

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**Abstract** A multi-surface approach is suggested to describe nonlinear and hysteretic unloading-reloading behaviors of sheet metals, adopting the concept of multiple yield surfaces in the Mróz model. This approach divides the elastic domain into many fields that have different values of elastic modulus, resulting in a piecewise linear, hysteretic unloading-reloading stress-strain curve. Because this approach simply divides the elastic domain, it can be used in conjunction with any phenomenological plasticity models. The proposed model was implemented into a commercial finite element code and applied to springback simulations and stiffness analyses, demonstrating that its computational efficiency is comparable (1.66 times) to that required for linear elasticity and its accuracy is as good as the nonlinear elasticity model. It was further verified that the proposed model provides a stable solution even when the numerical simulation involves small stress oscillations during unloading or reloading.

**Keywords** Elastic modulus reduction; Nonlinear elasticity; Springback prediction; Panel stiffness; Advanced high strength steel

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