Stress Error Calculation in visualNastran Desktop

Dr. Steven C. Rennich
MSC.Working Knowledge

June 15, 2000

The visualNastran Desktop products (4D and Inside) aid the user by automatically estimating the errors present in the results of a finite elements stress calculation. There are many different methods for computing or approximating the error in a solution. The specific method used by the visualNastran Desktop products is given here.

The finite element method does not enforce continuity in stress between adjacent elements. Consequently, if a node is shared by multiple elements (i.e. it lies on a boundary between two or more elements) the stress computed at that node by each element will be different. As the mesh is refined and the solution becomes more accurate, these differences will diminish. It is these differences in nodal stress that are used to estimate the error in the solution. In all cases the it is the Von Mises stress component that is used to compute the stress error.

The following notation will be used to describe the method.

i	index of individual nodes in an problem	i	$=$	$1 \rightarrow I$
n	index of volume elements attached to node i	n	$=$	$1 \rightarrow N$
σ_i^n	stress value at node i due to attached element n			
v_i^n	volume of element n attached to node i			

The method begins by computing the mean stress, $\bar{\sigma}_i$, and root mean square of the of the error (relative to the mean), e_i, at each node.

$$\bar{\sigma}_i = \frac{1}{N} \sum_{n=1}^{N} \sigma_i^n \tag{1}$$

$$e_i = \left[\frac{1}{N} \sum_{n=1}^{N} (\sigma_i^n - \bar{\sigma}_i)^2 \right]^{\frac{1}{2}} \tag{2}$$

A volume weighted global stress error norm, E, gives a scalar (dimensional) representation of the global error. Weighting this norm by element volumes permits convergence even in the presence of stress singularities.

$$E = \sum_{i=1}^{I} \left(e_i \frac{1}{4} \sum_{n=1}^{N} v_i^n \right) \tag{3}$$

A volume weighted global stress norm, Ω, is computed in a similar manner.

$$\Omega = \sum_{i=1}^{I} \left(\bar{\sigma}_i \frac{1}{4} \sum_{n=1}^{N} v_i^n \right) \tag{4}$$

The ratio of the stress error norm, E, to the stress norm, Ω, gives the (dimensionless) relative error in the solution, η.

$$\eta = \frac{E}{\Omega} \tag{5}$$

For display purposes, the error at every node, e_i, is scaled such that the point of maximum error displays the relative error in the solution, η. The purpose of this rescaling is to convey both the total error and the error distribution with a single error field.

$$e_i^* = \eta \frac{e_i}{|e_i|_{max}} \tag{6}$$