

MECH 151: DOF numbering

Degrees of freedom (DOF) are the independent variables that we solve for in finite element analysis. They consist of displacements at nodes. Displacements can be translations or rotations. The number of degrees of freedom at each node depends on the kind of elements we are using. The translation in the x direction at node 2 is d_{2x} , for example, and the rotation about the z axis at node 3 would be ϕ_{3z} .

When we solve problems, we stack all the independent DOF in a column vector called a *global displacement vector*. Following is the indexing arithmetic needed to store and retrieve displacements to and from displacement vectors.

Consider first truss elements in two dimensions. There are just two DOF per node, d_{ix} and d_{iy} and there are n number of nodes (`nnodes` in MATLAB). They are stacked into a global displacement vector which the text calls $\{d\}$ and which we call `bigd` in MATLAB:

$$\text{bigd} = \left\{ \begin{array}{l} d_{1x} \\ d_{1y} \\ d_{2x} \\ d_{2y} \\ \dots \\ d_{nx} \\ d_{ny} \end{array} \right\} \begin{array}{l} \text{Row 1} \\ \text{Row 2} \\ \text{Row 3} \\ \text{Row 4} \\ \dots \\ \text{Row } 2n-1 \\ \text{Row } 2n \end{array}$$

Displacements for node 1 appear in rows 1 and 2, for node 2 in rows 3 and 4, etc. For node i they appear in rows $2i - 1$ and $2i$ of `bigd`. Please verify this formula for node 3 and 4.

Sometimes we use an index variable such as j to denote x and y . Given i and j , d_{ij} would be placed in row number $2*i-2+j$. Please verify this formula for nodes 3 and 4.

For a beam bending element in two dimensions, there are three DOF per node: d_{1x} , d_{1y} and ϕ_{1z} (rotation about the z axis). They appear in rows $[3*i-2 \ 3*i-1 \ 3*i]$. When we use an index j running from 1 to 3 to indicate d_{ix} , d_{iy} , ϕ_{iz} the formula is $3*i-3+j$.

$$\text{bigd} = \left\{ \begin{array}{l} d_{1x} \\ d_{1y} \\ \phi_{1z} \\ d_{2x} \\ d_{2y} \\ \phi_{2z} \\ \dots \\ d_{nx} \\ d_{ny} \\ \phi_{nz} \end{array} \right\} \begin{array}{l} \text{Row 1} \\ \text{Row 2} \\ \text{Row 3} \\ \text{Row 4} \\ \text{Row 5} \\ \text{Row 6} \\ \dots \\ \text{Row } 3n-2 \\ \text{Row } 3n-1 \\ \text{Row } 3n \end{array}$$