Step 2 : Selection of displacement models (or) Interpolation models.

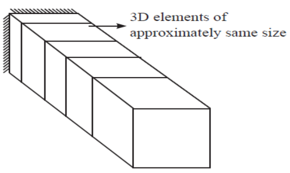
- The interpolation equations are used to approximate the results obtained at the node over the entire element.
- Before getting the results, we assume how results vary over entire domain & based on the assumed variation, a proper displacement equation are selected.
- The assumed interpolation equations may be polynomials (or) Trigonometric functions.
- Polynomials are most commonly used interpolation equations.

Step 3 : Derivation of element stiffness matrix

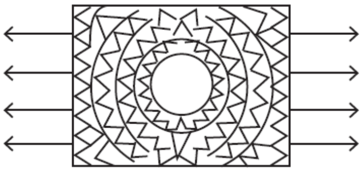
- Different methods like direct method, Potential Energy method & so on will be used to determine stiffness matrix.
- A real time structure having multi DOF will have many stiffness terms associated with these DOF. All these are written in matrix form and such a matrix is called as stiffness matrix.
- Stiffness matrix ~~can be~~ is a matrix that relates the force vector to the displacement vector.

Mathematically, $[k]\{q\} = \{f\}$

where, $[k]$ = Stiffness matrix
$\{q\}$ = Displacement Vectors
$\{f\}$ = Force Vector.



Uniform size of the elements



Irregular size of elements

12. Aspect Ratio

Aspect Ratio

- Important parameter that affects the accuracy of the analysis.
- It is the ratio of longest dimension to the smallest dimension.
- defines the shape of the element.
- Element with aspect ratio equal to unity will yield better results

Aspect ratio = 4 Aspect ratio = 1.

13. Location of Nodes

tion of Nodes

- If there are no discontinuities in the body, then the body can be divided into equal number of subdivisions & hence spacing of the nodes can be uniform as in fig

- If the body has discontinuities then nodes have to introduced in the regions of discontinuity.
  a) Discontinuities in Geometry
  b) Discontinuities in load
  c) " " Material properties.
  d) " " Structure.

15. Banded Matrix or Half Band width

Stiffness matrix in FEA is a banded matrix, & Symmetric

In a banded Matrix, all non zero elements are present in a band Outside the band all elements are zero.

Consider a [n x n] symmetric banded matrix (n = No of Nodes).

$$
\begin{array}{c c}
 & \begin{array}{ccccc} 1 & 2 & 3 & 4 & 5 \end{array} \; (j) \\
(i) & \\
\begin{array}{c} 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} &
\begin{bmatrix}
4 & 6 & -2 & 0 & 0 \\
6 & 3 & 1 & 9 & 0 \\
-2 & 1 & 6 & 8 & -2 \\
0 & 9 & 8 & 4 & 3 \\
0 & 0 & -2 & 3 & 1
\end{bmatrix}
\end{array}
\longrightarrow (\text{Eq } 1)
$$

(5 x 5) (n x n)

$$
\overset{\longleftarrow \; nbw \; \longrightarrow}{
\begin{bmatrix}
4 & 6 & -2 & & \\
 & 3 & 1 & 9 & \\
 & & 6 & 8 & -2 \\
 & & & 4 & 3 \\
 & & & & 1
\end{bmatrix}}
\longrightarrow (\text{Eq } 2)
$$

→ 3rd Diagonal.

→ 2nd Diagonal

→ Main (1st) Diagonal

In the above matrix, nbw is called as half-band width.

Since only non-zero elements are to be stored, the order of the matrix will be (n x nbw).

$$\begin{array}{ccc} 1^{st} & 2^{nd} & 3^{rd} \\ \end{array}$$
$$\begin{bmatrix} 4 & 6 & -2 \\ 3 & 1 & 9 \\ 6 & 8 & -2 \\ 4 & 3 & \\ 1 & & 0 \end{bmatrix} \begin{matrix} (5 \times 3) \\ (n \times nbw) \end{matrix} \longrightarrow (Eq\ 3)$$

The principal diagonal (or) 1^{st} diagonal will be in the 1^{st} column, 2^{nd} diagonal in the 2^{nd} column & so on.

The relation b/w (Eq 1) & (Eq 3) is of the form, $a_{ij} = a_{i(j-i+1)}$

Banded matrix will help to reduce storage space.

Bandwidth of stiffness matrix depends on node numbers.

Half Band width,

$$B = (D+1) f.$$

D = Max. difference b/w the two successive node numbers

f = No of DOF at each node.

Advantages of Banded Matrix

- Only half of the matrix can be stored
- Reduces storage space
- Reduces computational time

Node Numbering Scheme

Bandwidth of a stiffness matrix depends on Node numbering scheme.

If Bandwidth reduces, storage space reduces & hence the computational time will also reduce.

This can be achieved by using proper node numbering scheme.

There are basically two types of node numbering scheme

a) Node numbering scheme along the dimensions

b) Random & Continuous node numbering scheme.