

Shear-Wall Elements

The Shear-Wall Elements included on the Finite Element Library of the MIDAS Family Programs are formulated as special types of super elements without internal nodes. A schematic interpretation of the concept of Shear-Wall Elements is illustrated in Fig. 1. First type of Shear-Wall super element is termed as the Membrane-Wall Element and is capable to resist the in-plane forces and moments about the axis normal to the wall plane. The Membrane-Wall Element is constructed as an assembly the rectangular 4-node plane stress element and 4 beam elements as shown in Fig 1(a). It should be noted that in the Membrane-Wall Element bending stiffness in out of plane is neglected.

Second type of Shear-Wall super element is termed as the Plate-Wall Element and is constructed by combining a rectangular 4-node plate (shell) element and 4 beam elements, as shown in Fig. 1(b), so as to be able to resist in- and out-of-plane forces and bending moments.

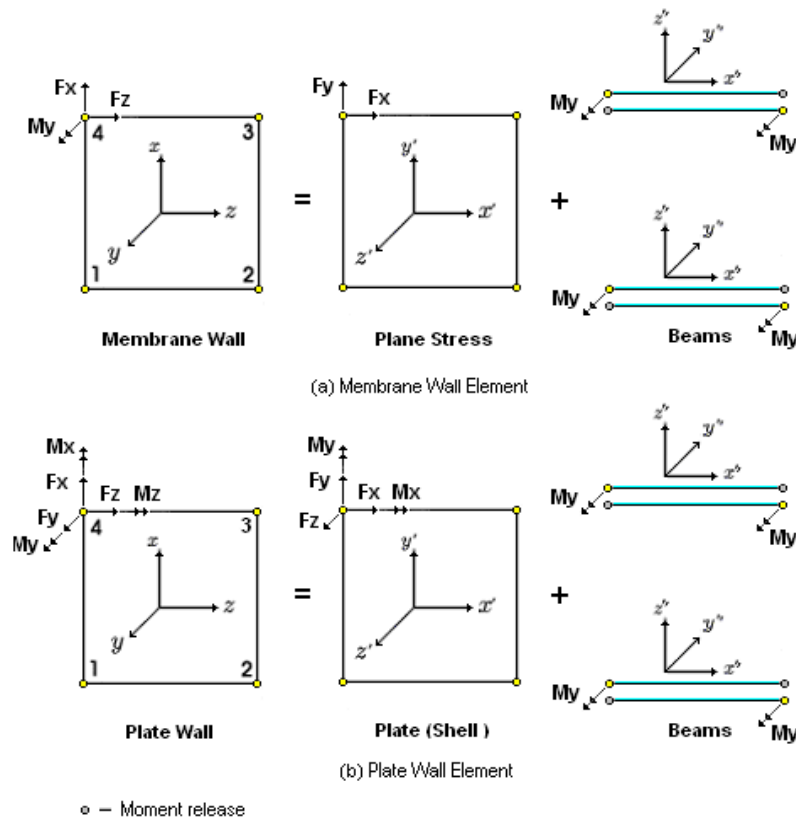


Figure 1 Concept of Shear-Wall elements

The formulations of the plane stress element, plate element, and the beam element are described in details in the formulation procedures of each element individually. After the stiffness matrix of each constituent

element is constructed and transformed from its local coordinates to the global (wall) system of coordinates it is assembled into shear-wall super-stiffness matrix. It should be noted that the shear wall properties such as wall thickness t_{wall} and height h_{wall} are used to define the stiffness matrices of constituent elements.

The stiffness matrix of the 4-node rectangular plane stress element or plate element in the global coordinates is given by,

$$\mathbf{K}_p = \begin{bmatrix} \mathbf{K}_{11} & \mathbf{K}_{12} & \mathbf{K}_{13} & \mathbf{K}_{14} \\ & \mathbf{K}_{22} & \mathbf{K}_{23} & \mathbf{K}_{24} \\ & & \mathbf{K}_{33} & \mathbf{K}_{34} \\ \text{sym.} & & & \mathbf{K}_{44} \end{bmatrix}$$

where, each \mathbf{K}_{ij} block is defined using as plate thickness equal to t_{wall} and wall material properties.

Beam elements are introduced in the shear-wall formulation in order to be able to resist the moments about the axis perpendicular to the plane of the wall element. Each beam element has at one end hinge (moment release) about local y - axis and thus transfers the moment only to one node related to the wall element (see Fig.1). Every beam element is assumed to have a rectangular cross-section with properties defined by the wall geometry as follows: $b_{\text{beam}}=t_{\text{wall}}$ and $d_{\text{beam}}=h_{\text{wall}}$

There are two types of beam stiffness matrices. One is for the beam released at i -end, and the other is for the beam released at j -end. Their stiffness matrices in global coordinates are given by,

$$\mathbf{K}_b^i = \begin{bmatrix} \mathbf{K}_{ii}^i & \mathbf{K}_{ij}^i \\ \mathbf{K}_{ji}^i & \mathbf{K}_{jj}^i \end{bmatrix}, \quad \mathbf{K}_b^j = \begin{bmatrix} \mathbf{K}_{ii}^j & \mathbf{K}_{ij}^j \\ \mathbf{K}_{ji}^j & \mathbf{K}_{jj}^j \end{bmatrix}$$

Accordingly, the shear wall super-stiffness matrix in global coordinates is obtained by assembling the stiffness matrix of the plane element and the stiffness matrices of the 4 beam elements as follows:

$$\mathbf{K}_w = \begin{bmatrix} \mathbf{K}_{11} + \mathbf{K}_{ii}^i + \mathbf{K}_{ii}^j & \mathbf{K}_{12} + \mathbf{K}_{ij}^i + \mathbf{K}_{ij}^j & \mathbf{K}_{13} & \mathbf{K}_{14} \\ & \mathbf{K}_{22} + \mathbf{K}_{jj}^i + \mathbf{K}_{jj}^j & \mathbf{K}_{23} & \mathbf{K}_{24} \\ & & \mathbf{K}_{33} + \mathbf{K}_{jj}^i + \mathbf{K}_{jj}^j & \mathbf{K}_{34} + \mathbf{K}_{ji}^i + \mathbf{K}_{ji}^j \\ \text{sym.} & & & \mathbf{K}_{44} + \mathbf{K}_{ii}^i + \mathbf{K}_{ii}^j \end{bmatrix} \quad (1)$$