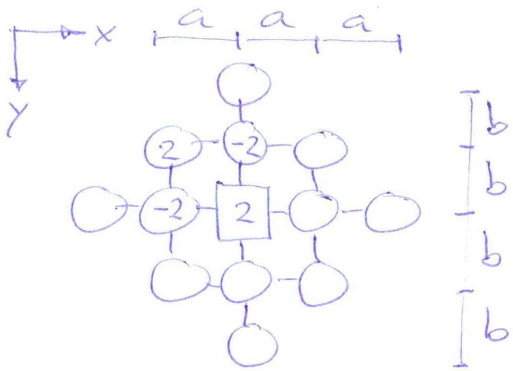
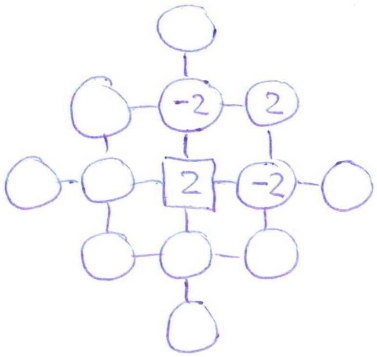
torsion panels

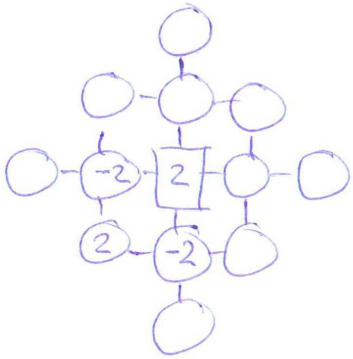
$$\begin{bmatrix} F_1 \\ F_2 \\ F_3 \\ F_4 \end{bmatrix} = \frac{(1-\nu)D}{ab} \begin{bmatrix} 2 & -2 & -2 & 2 \\ -2 & 2 & 2 & -2 \\ -2 & 2 & 2 & -2 \\ 2 & -2 & -2 & 2 \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ w_4 \end{bmatrix}$$



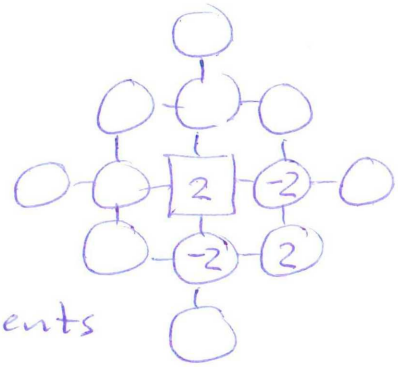
$$\begin{bmatrix} F_1 \\ F_2 \\ F_3 \\ F_4 \end{bmatrix} = \frac{(1-\nu)D}{ab} \begin{bmatrix} 2 & -2 & -2 & 2 \\ -2 & 2 & 2 & -2 \\ -2 & 2 & 2 & -2 \\ 2 & -2 & -2 & 2 \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ w_4 \end{bmatrix}$$



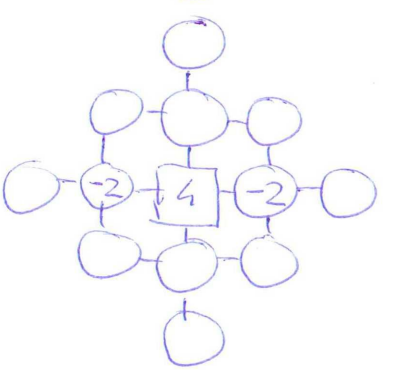
$$\begin{bmatrix} F_1 \\ F_2 \\ F_3 \\ F_4 \end{bmatrix} = \frac{(1-\nu)D}{ab} \begin{bmatrix} 2 & -2 & -2 & 2 \\ -2 & 2 & 2 & -2 \\ -2 & 2 & 2 & -2 \\ 2 & -2 & -2 & 2 \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ w_4 \end{bmatrix}$$

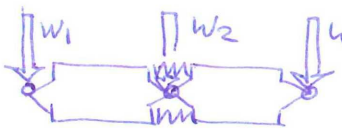


$$\begin{bmatrix} F_1 \\ F_2 \\ F_3 \\ F_4 \end{bmatrix} = \frac{(1-\nu)D}{ab} \begin{bmatrix} 2 & -2 & -2 & 2 \\ -2 & 2 & 2 & -2 \\ -2 & 2 & 2 & -2 \\ 2 & -2 & -2 & 2 \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ w_4 \end{bmatrix}$$



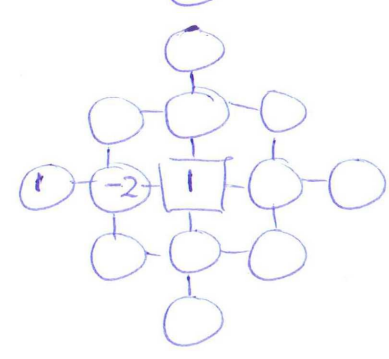
$$\begin{bmatrix} F_1 \\ F_2 \\ F_3 \\ F_4 \end{bmatrix} = \frac{(1-\nu)D}{ab} \begin{bmatrix} 2 & -2 & -2 & 2 \\ -2 & 2 & 2 & -2 \\ -2 & 2 & 2 & -2 \\ 2 & -2 & -2 & 2 \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ w_4 \end{bmatrix}$$





bending elements

$$\begin{bmatrix} F_1 \\ F_2 \\ F_3 \end{bmatrix} = D\frac{b}{a^3} \begin{bmatrix} 1 & -2 & 1 \\ -2 & 4 & -2 \\ 1 & -2 & 1 \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ w_3 \end{bmatrix}$$

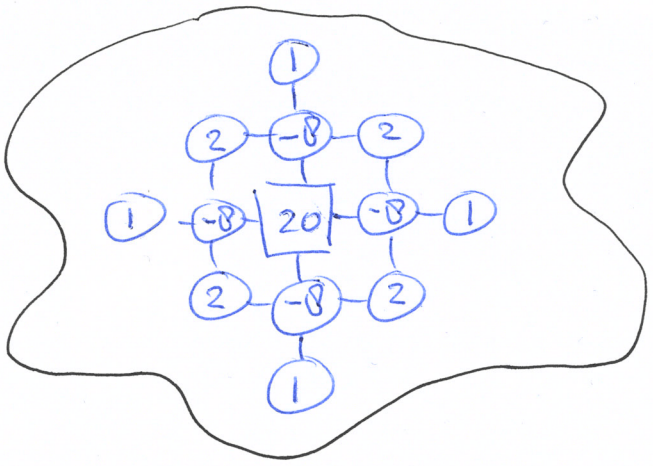


$$D = \frac{Et^3}{12(1-\nu^2)}$$

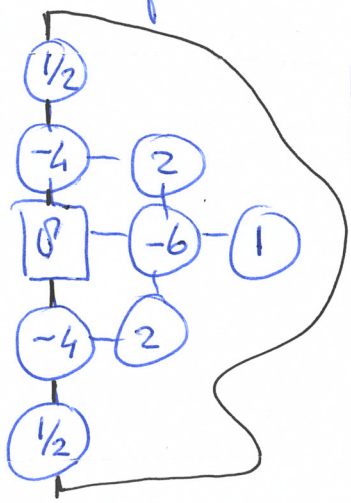
$$\begin{bmatrix} F_1 \\ F_2 \\ F_3 \end{bmatrix} = D\frac{b}{a^3} \begin{bmatrix} 1 & -2 & 1 \\ -2 & 4 & -2 \\ 1 & -2 & 1 \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ w_3 \end{bmatrix}$$

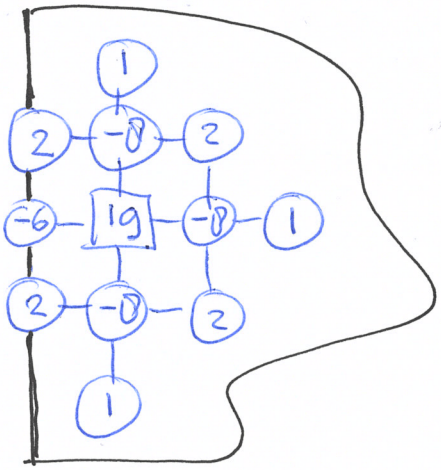
Add the discrete elements to obtain the molecules $a=b,\ v=0$

interior molecule

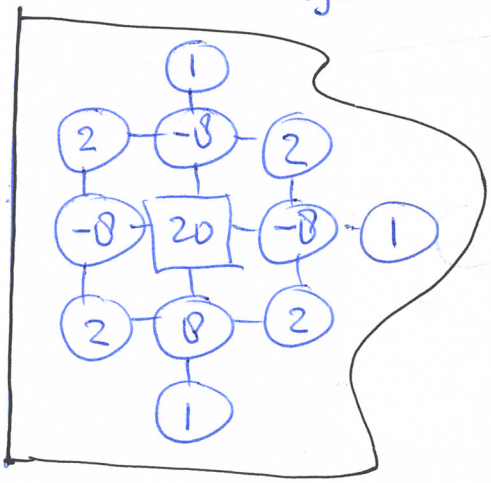


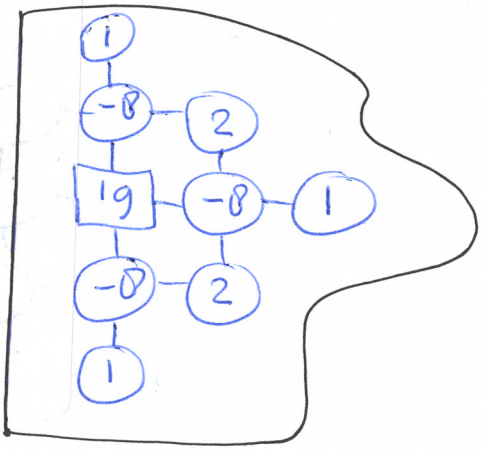
free edge molecules



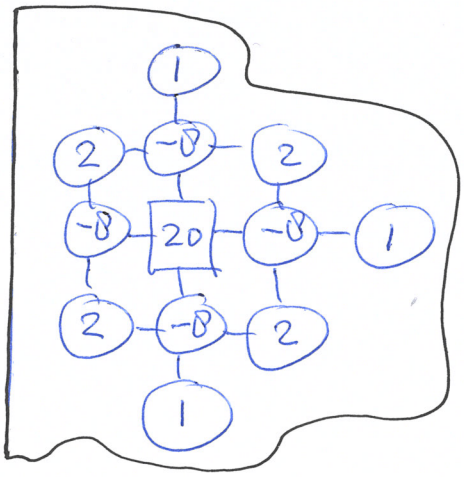


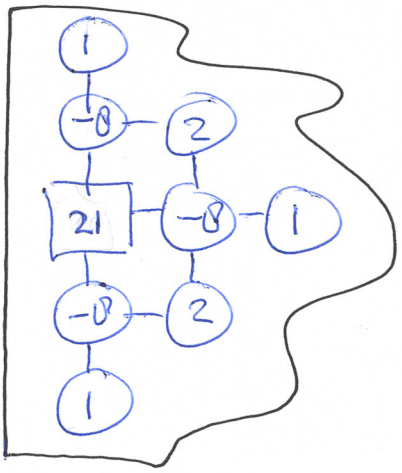
hinged edge molecules

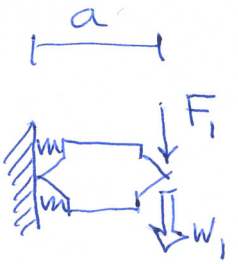




fixed edge molecules





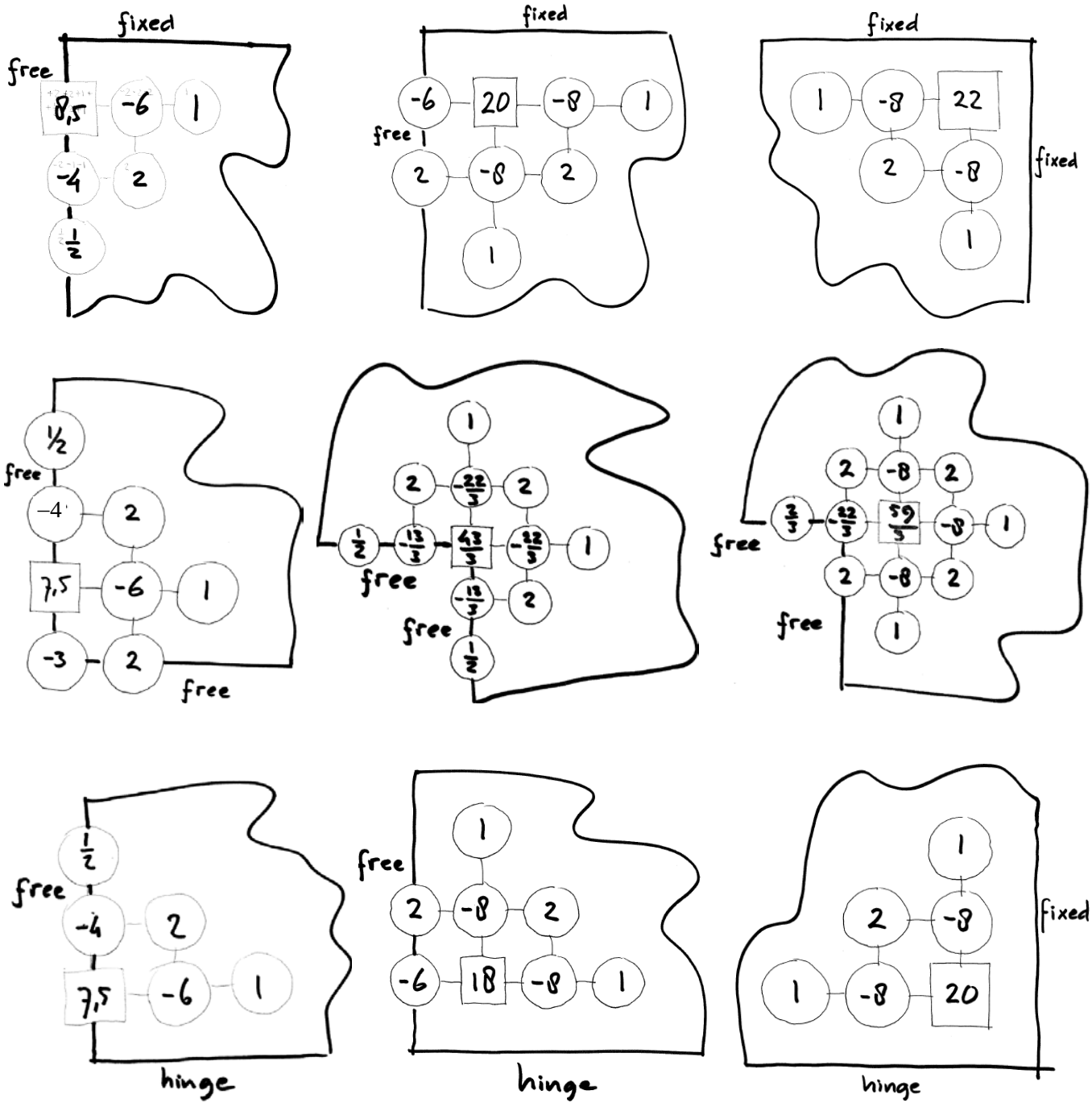


$$F_1 = D\frac{b}{a^2}2w_1$$

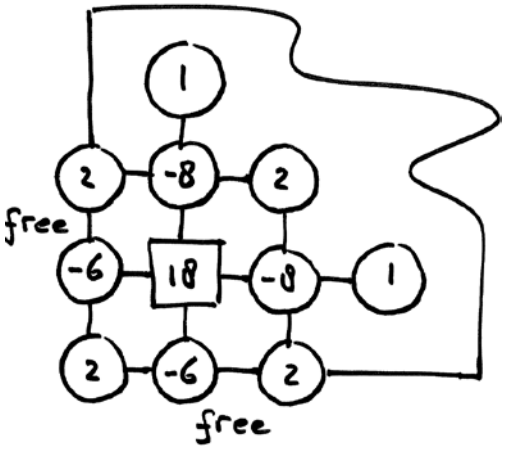
$$D = \frac{Et^3}{12(1-\nu^2)}$$

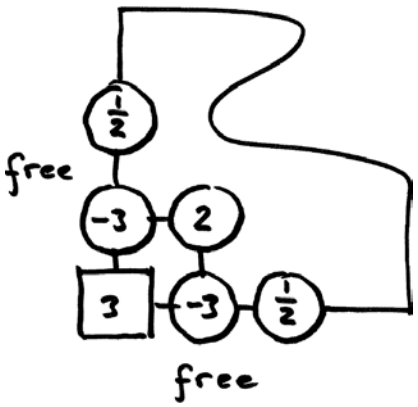
Plates loaded out of plane
Corner molecules

P.C.J. Hoogenboom, Delft 19 December 2019



An interior point has a load pa^2.
A point in the edge has a load ½ pa^2.
The re-entrant corner point has a load ¾ pa^2.
In this, p is the distributed load and a is the distance between grid lines.





Note that the hinge edge molecules and the fixed edge molecules can be obtained by making small adjustments to the free edge molecules.