Stress Trajectories

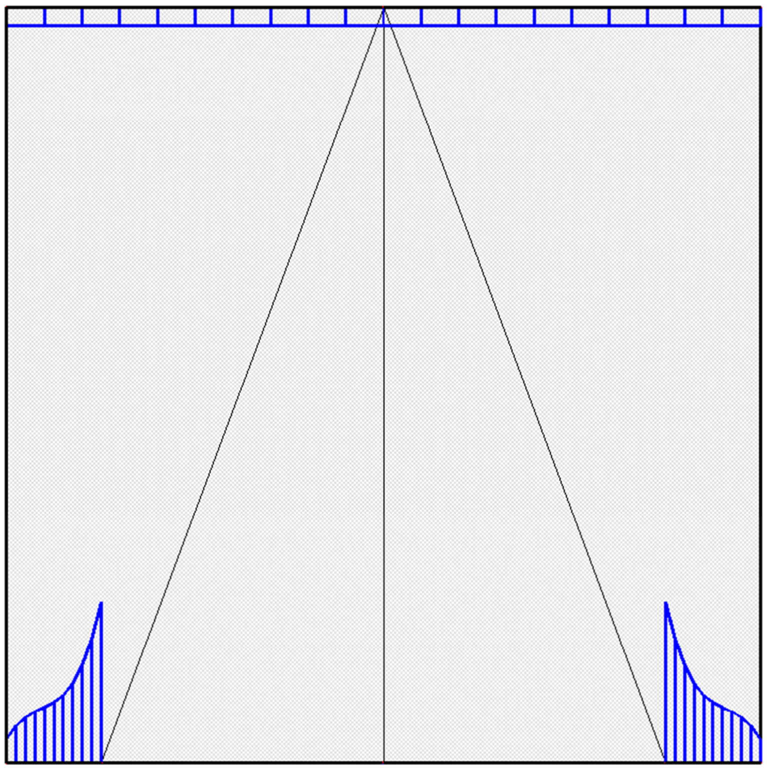
A trajectory is usually understood as the path that a moving object follows through space. In the context of vector fields a more general meaning for a trajectory is the path a point would follow if it moved in the local direction of the vector field. Stress trajectories refer to trajectories in a vector field of either a component of principal stress or resultant shear force. Trajectories begin from generatrix or seed points and end at the model boundary; special points such as isotropic points close by returning to the same point. In the case of principal stresses, if the trajectories from both components of principal stress are plotted they form a map of mutually orthogonal lines.

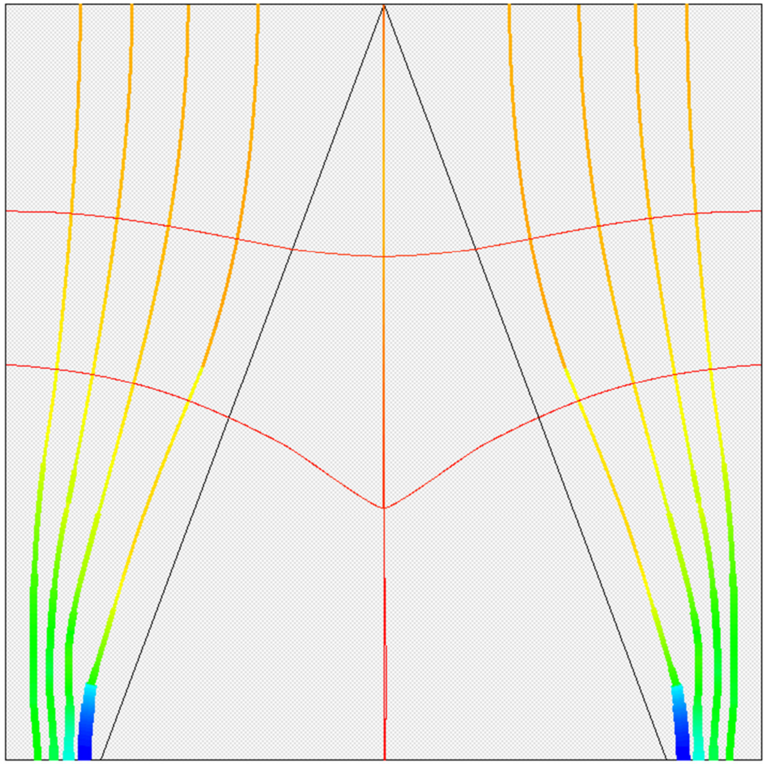
Stress trajectories indicate direction of principal stresses and the varying magnitude of the stress may be indicated by varying colour, thickness or both. They are useful to the engineer because they characterise, in a single figure, the detailed nature of the stress field. They indicate load paths through the structure and in the context of reinforced concrete may be used to identify the direction and amount of reinforcement required. For membrane problems they are used in the determination of strut and tie models of reinforcement.

The plotting of true stress trajectories is not common in proprietary finite element software. There are two possible reasons for this, firstly that the stress fields are generally poorly approximated in displacement based elements and are usually only stored at special point (nodes and/or integration points) and, secondly, that the potentially complex nature of stress trajectories is such that special algorithms and user controls need to be developed for reliable, accurate and computationally efficient plotting.

With the equilibrium elements used in EFE the first of these reasons is eliminated; the stress field is well approximated and is available throughout the model. The second reason has been overcome using carefully developed algorithms which allow for special points and user interaction in the seeding of models. The outcome of this is that with EFE the rich physical meaning of the stress field can be simply characterised in a single figure. The examples presented in this document were produced in EFE and hopefully show the value of stress trajectories to the practising engineer.

Membrane on Line Supports with UDL





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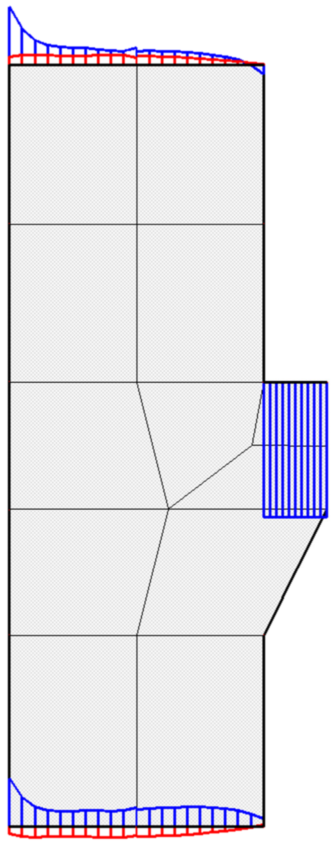
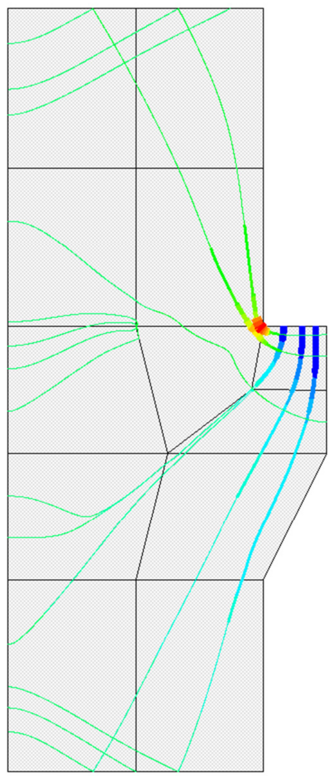
Trajectory Example Number 2

Membrane Corbel with Line Loading and Encastre Supports





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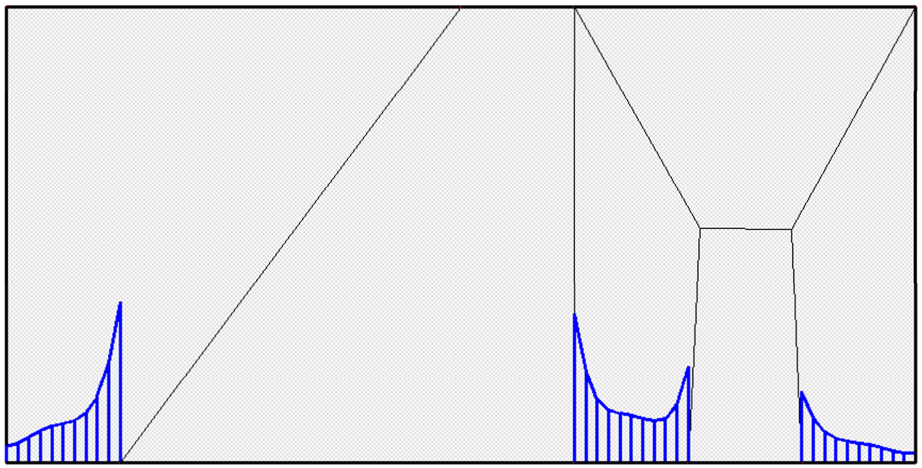
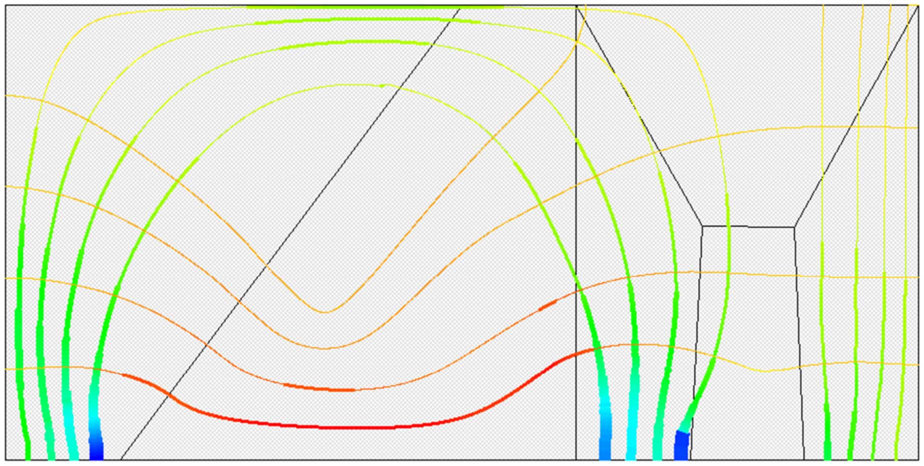
Trajectory Example Number 3

Membrane on Line Supports with Gravity Loading





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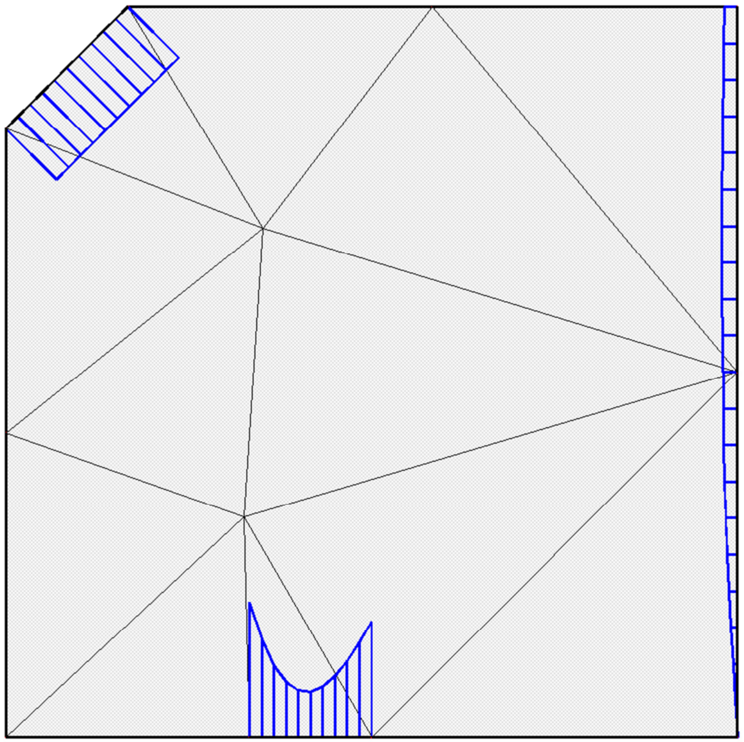
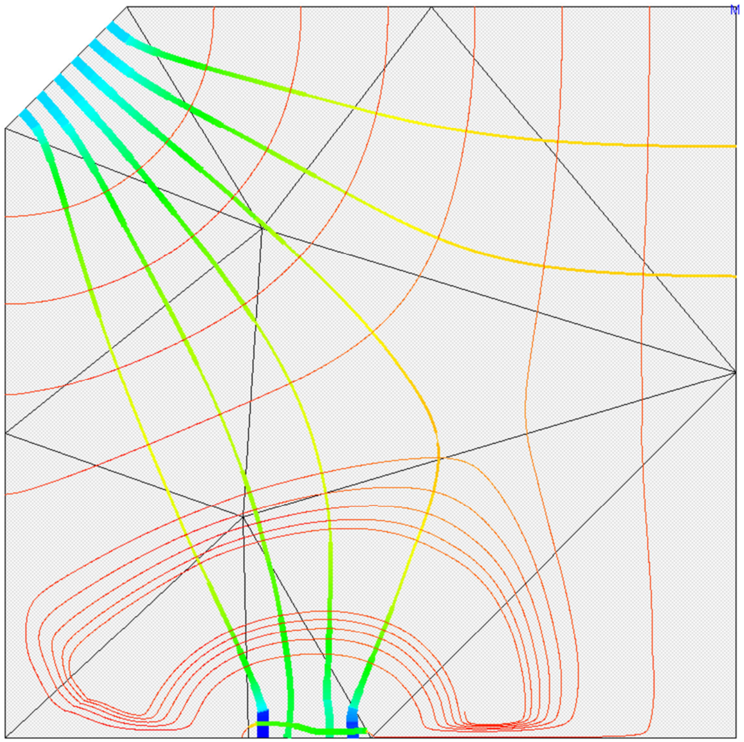
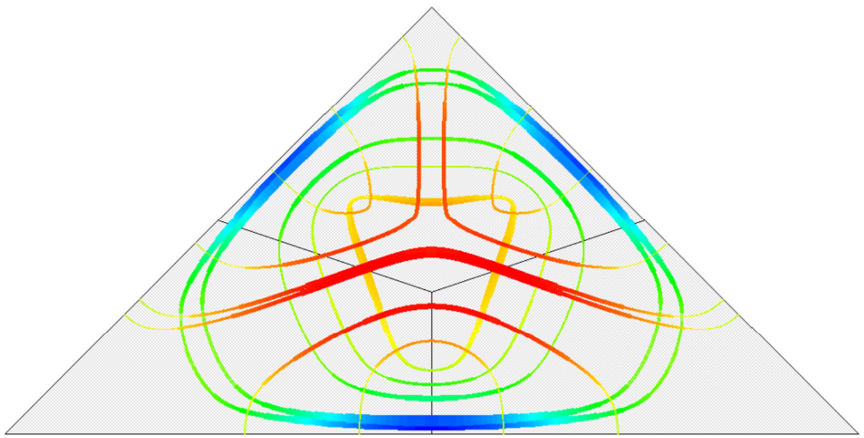
Trajectory Example Number 4

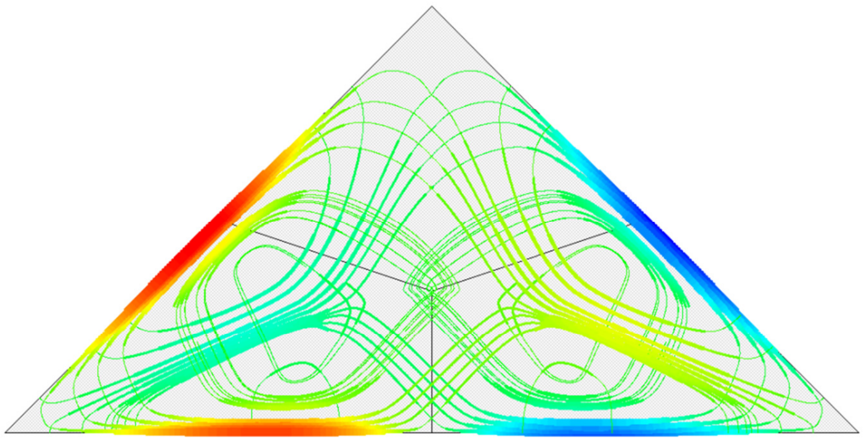
Membrane with Angled Line Loading, Line Support and Symmetry Edge





Membrane Triangles, Self-Loaded with Polynomial Temperature Fields





Simply Supported Plate with UDL