

# Failure analysis of composite structures – novel methods at MSC.Software

Per Nordlund  
MSC Software





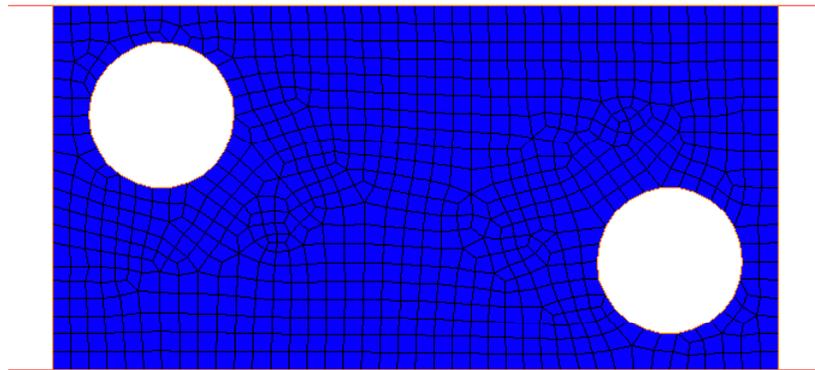
# Contents

- VCCT for crack propagation
- Mesh splitting for delamination
- Crack initiation
- Example



# VCCT for crack propagation in Marc

- Calculate energy release rate  $G$
- Modify FEM mesh to grow crack

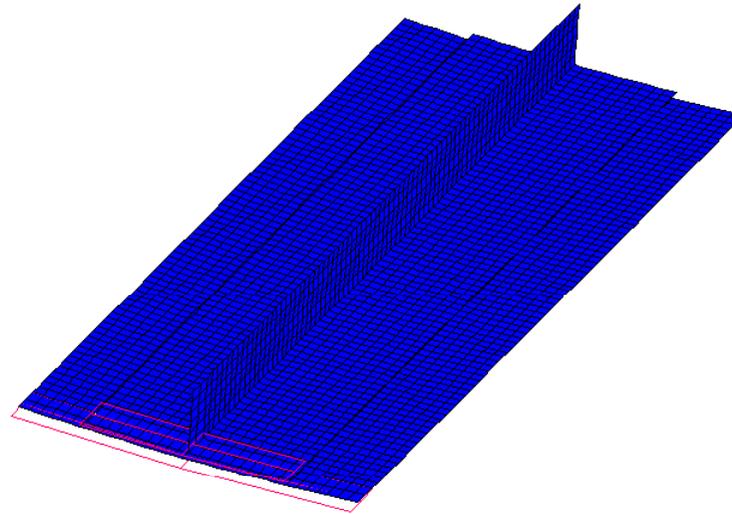


Global remeshing



# VCCT for crack propagation in Marc

- Calculate energy release rate  $G$
- Modify FEM mesh to grow crack

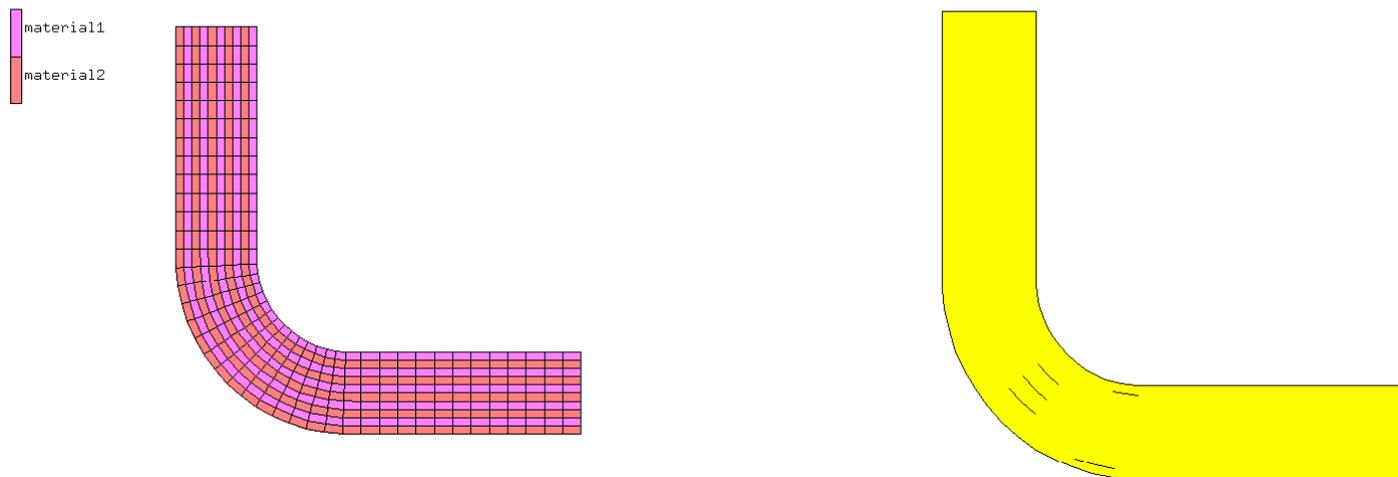


Release glued contact



# VCCT for crack propagation in Marc

- Calculate energy release rate  $G$
- Modify FEM mesh to grow crack



Grow along element edges



# Mesh splitting

- Delamination
  - Split up mesh when

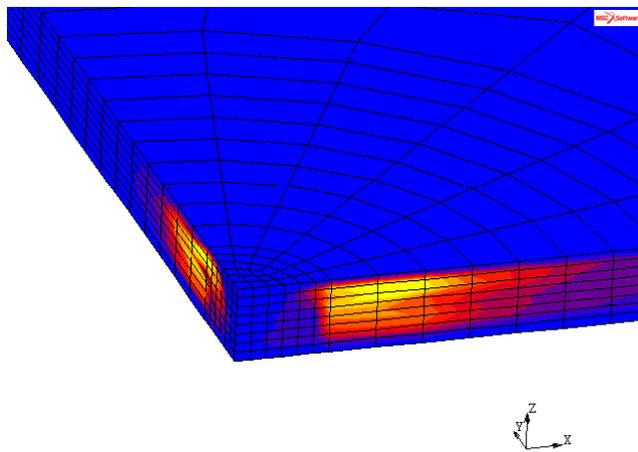
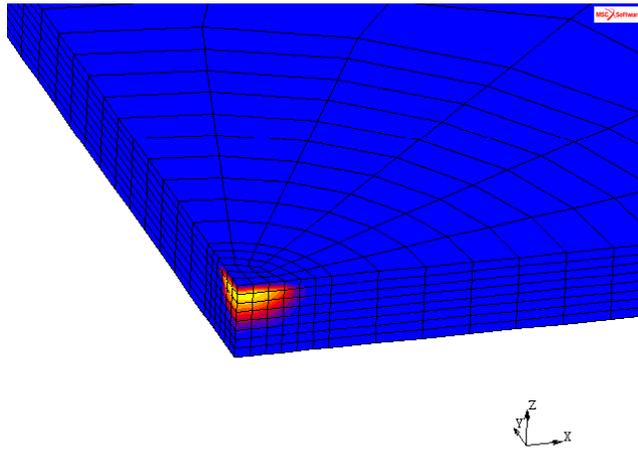
$$\left(\frac{\sigma_n}{S_n}\right)^m + \left(\frac{\tau}{S_t}\right)^n > 1$$

- Use normal and tangential stresses at element edges/faces
- For layered composites: split when all layers fail



# Mesh splitting

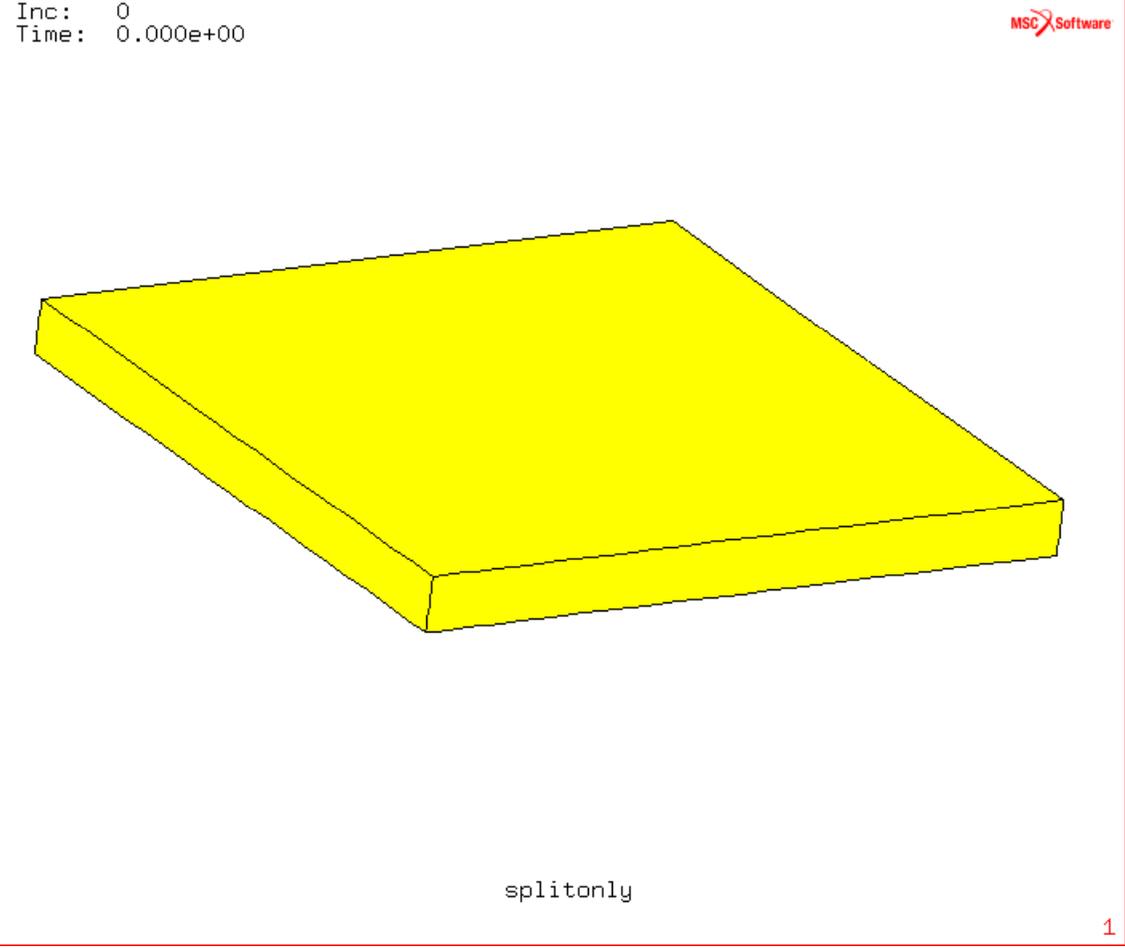
- Delamination



$$\left( \frac{\sigma_n}{S_n} \right)^m + \left( \frac{\tau}{S_t} \right)^n$$



# Mesh splitting





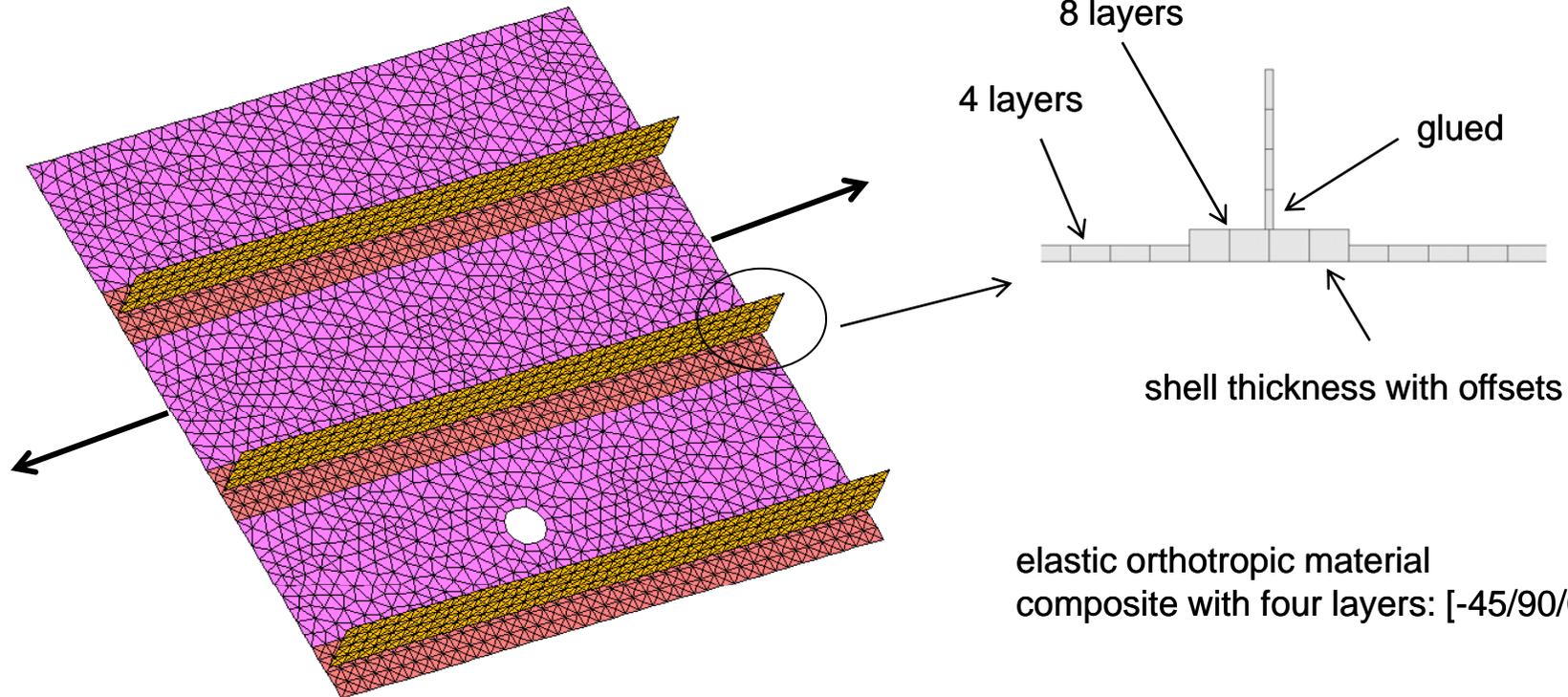
## Work in progress

- Crack initiation
  - Combine mesh splitting with VCCT
  - Where mesh is split, add cracks
  - Initiate crack with stress criterion, grow it with VCCT
- Crack bifurcation
  - Add new crack at intersecting shell



# Example

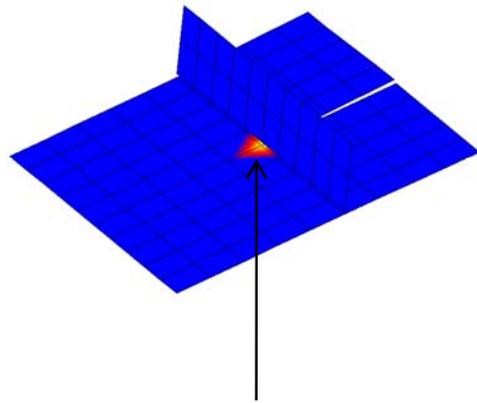
- Growth through composite skin with stiffeners



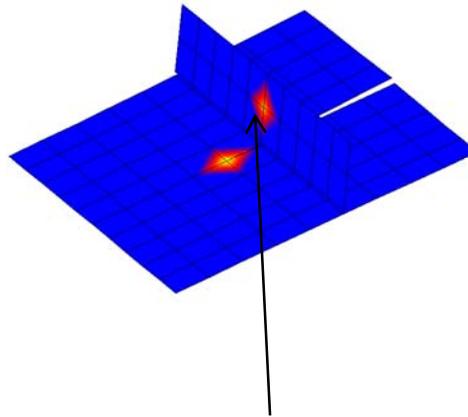


# Example

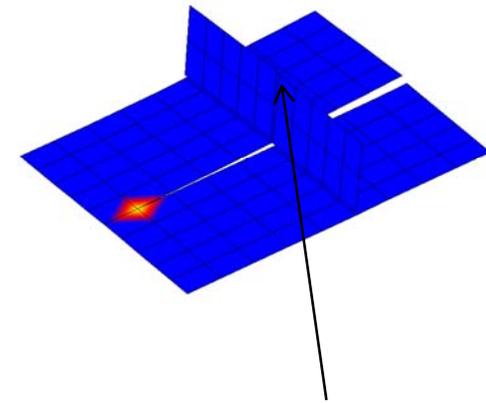
- Crack bifurcation



crack below stiffener



new crack created



new crack grows  
through stiffener

