Tech Tip: Plate Edge-to-Solid gluing in Femap with NX Nastran

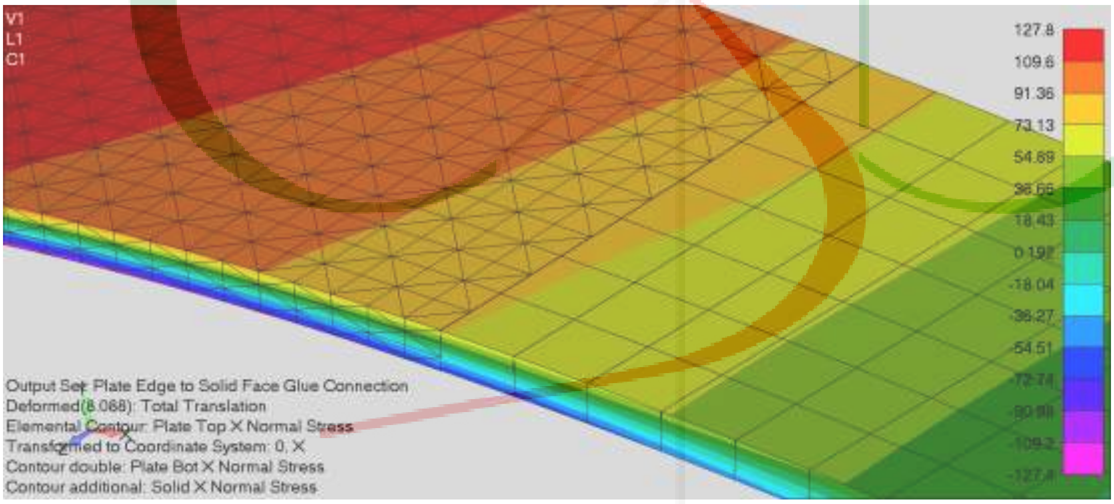
Regular FEA users will be familiar with practical industrial FEA situations where it may be useful to connect the edge of a plate mesh to the "edge face" of a solid mesh as a transition from a detailed area to non-detailed area of the structure. However, typical solid elements have 3 x stiffness Degrees of Freedom per node (rotational stiffness is missing), whilst typical plate elements have 5 x DoF per node (the drilling stiffness perpendicular to the "plane" of the plate is missing). Thus, in the absence of any special attention, a plate mesh connected directly to a solid mesh produces a "hinge", due to the lack of rotational stiffness in the nodes of the solid elements. There have always been varying ways to properly transfer the bending forces and stresses across this interface - ie. to overcome the hinge problem. In rough order of increasing rigour and difficulty, the typical methods have been: coat the face of the solid with standard plate mesh; mesh the plates "into" the solid elements; coat the face of the solid with "bending only" 2D elements; use special elements like RSSCON; connect an array of rigid elements from each plate edge nodes to corresponding adjacent nodes on the face of the solid. Edge glue saves a lot of time and effort, whilst doing an excellent job of accurately transmitting forces across the interface. Here's why:

(1) easy to create

(2) nodes of plate mesh do not need to match up with nodes of solid mesh (although stress continuity is best when the mesh sizing is close)

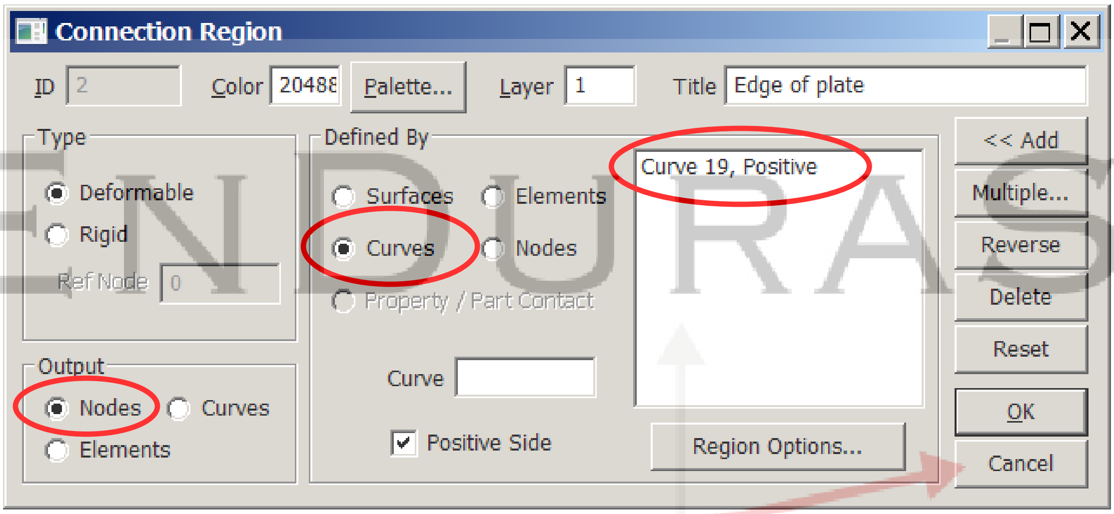
(3) doesn't matter if the solid mesh is brick or tetrahedral

Below is an image of a simple cantilever/twist case, showing X (global) direction stress at the junction between the plate and solid mesh. Plate element thickness is displayed with "double sided" stress contours on (ie. simultaneous display of top and bottom plate stress). Note that there is no mesh match-up at the solid/plate interface - there is 2:1 mesh sizing across the width, and there are 3 tetrahedral elements through the thickness - thus no line of solid corner nodes at the mid-plane location of the plates.

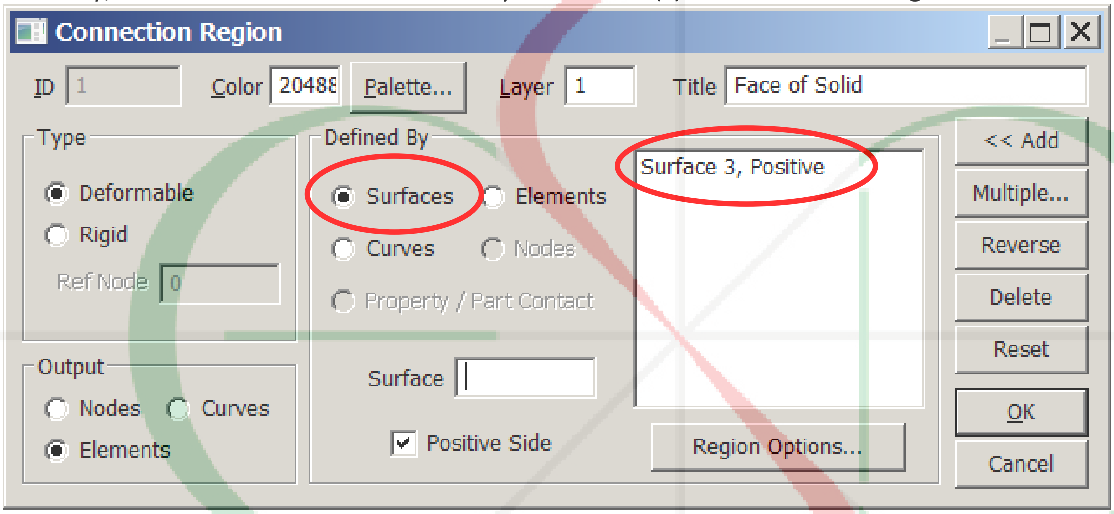


Setup of the glue regions is simple:

The edge of the plate is defined by the curve(s) that define the edge of the surface. If the mesh had come from an external source (and thus had no associated geometry), then the edge region would be defined by selecting the nodes on the edge of the plate.



Similarly, the face of the solid is defined by the surface(s) on the relevant edge face of the solid:



The "fully rigorous" method applied to this interface (perfectly matched mesh, and individual rigid elements transferring plate node rotation to adjacent solid node translations) produces the result in the image below. Note that there is a 0.07% variation in maximum deflection. The X stress (extreme fibre bending) developed in the solid elements varies by a maximum of 8.7% **at the plate/solid interface,** when comparing the mismatch mesh plate-tet glue case against the "rigorous" case. The bending stress variation between the glue case and the "rigorous" case reduces to a maximum of 0.3% when compared at only one element away from the plate/solid interface. This reconfirms general best practice that plate/solid transitions should be made slightly away (eg. 2-3 nominal thicknesses) from critical stress locations.