Nowadays codes use 32 bits and are therefore less sensitive to numerical problems. Nevertheless, as said, many companies in the aerospace sector require the filling of a real "check list" before the model can be used for the various analyses.

9.2.7 Visual checks

As we have already said, graphic post-processors today provide information in a very synthetic and immediate way. It is, for example, very useful to plot the contour of any tensor quantity (a stress or a strain) and to evaluate the discontinuities between one element and another, clearly without requiring the averaged calculation at the nodes. On this basis, with experience, it is possible to determine whether the mesh in the various zones of the model is adequate and has therefore produced a valid result, or whether it is necessary to proceed with refinements. Let's take the example, given in § 6.3, of the notched bar subjected to traction. Figures 9.1 and 9.2 show the longitudinal stress contour, un-averaged at the nodes, for the two different meshing densities already discussed in § 6.3.

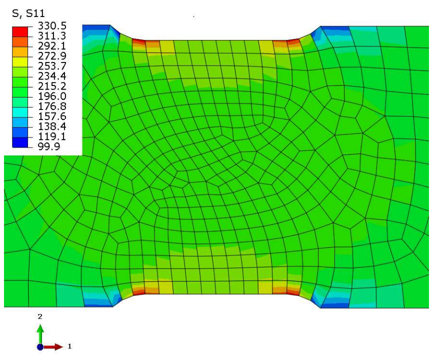

Figure 9.1. Unaveraged longitudinal stress for the fine mesh.

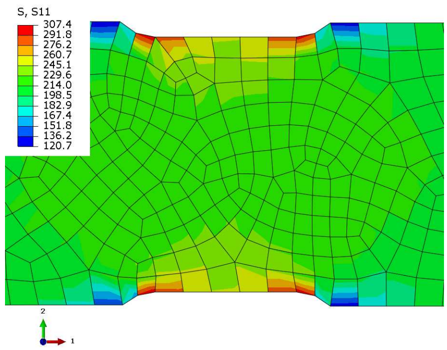

Figura 9.2. Unaveraged longitudinal stress for the coarse mesh.

It can be observed that in the case of coarse meshing (figure 9.2) the discontinuities are more pronounced than in the case with finer meshing (figure 9.1); from what was said in § 6.3 we know that the best agreement with the theoretical-experimental result is for the mesh of figure 9.1, confirming that this type of investigation helps in achieving reliable results.

It is necessary however to pay attention also to the type of element that is being used; in this case we are dealing with elements with bilinear shape functions, therefore capable of catching strain and therefore stress gradients in themselves: this fact translates into a chromatic variation also inside the element and not only between one element and another. If we execute the same un-averaged plotting on the model realized with triangular elements, these don't have color variations inside them because, due to their shape function, the strain (and stress) field is constant.We obtain Figure 9.3, where the discontinuity is such that the poor quality of the result, despite having used a mesh density similar to the model in figure 9.1, is such that no comment is needed.

9.3 Experimental validation

Experimentation on prototypes, possibly on the bench, is certainly the best way to verify the validity of a structural design. Obviously, the real conditions that the part will have to undergo during the operation for which it was designed must be respected as much as possible. There are different levels of "laboratory" tests that can be thought of and carried out, as we will see below.

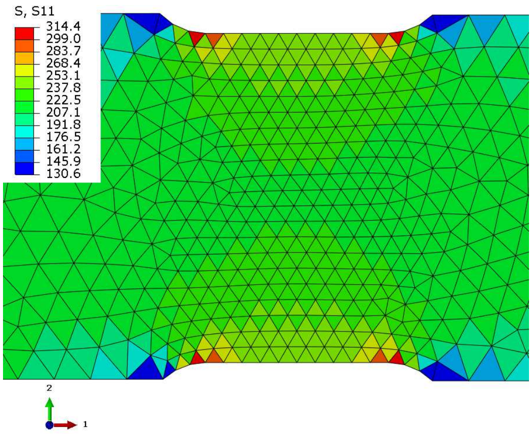

Figure 9.3. Un-averaged longitudinal stress for the mesh with triangular elements.

9.3.1 Load application without stress measurement

Certainly this is the simplest case; the structure under test is subjected to the action of loads, generally simulated with hydraulic cylinders, weights, pulleys and cables. No real time measurement of deformations or stresses is pursued; the structure is then disassembled and subjected to dimensional checks to verify that there have been no permanent deformations as a result of the application of loads. In the case of fatigue tests, appropriate checks are also carried out, such as x-rays (usually in welded joints) and dye penetrants.

In this simple case the finite element model was used to verify that there were not, at least theoretically, structural strength problems; this approach can be good for those components whose possible failure does not involve serious dangers, or for parts similar to others already calculated and tested.

9.3.2 Load application with strain gauge measurements

This case is similar to the previous one. The only difference is to apply, in precisely defined positions prior to testing, devices (usually strain gauges and strain gauge rosettes, illustrated in figure 9.4) that record the local strain that the structure undergoes during the application of the load. We are not going to discuss the technical aspects of strain gauging, because it is a methodology that presents several challenges; we will assume that strain gauges and strain gauge rosettes are applied to the structure in the correct way and that the connections of the various cables to the control unit are done in the best possible way.