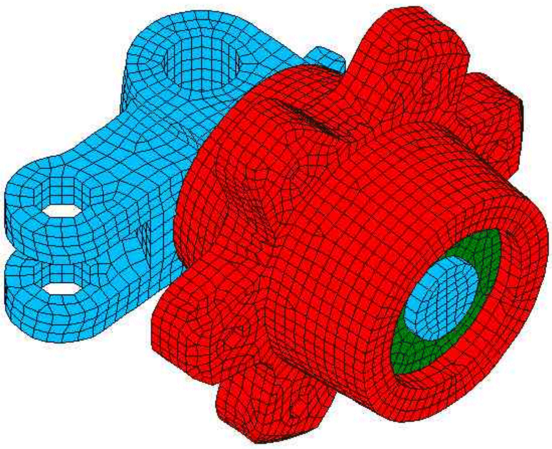

Figure 25. Hub and upright for a lift truck wheel group.

2.4 Modeling with shell elements

In a very simple way we could say that shell elements are a sort of hybrid elements between 2D and 3D elements, because they are used to model three dimensional structures but they are only able to represent plane stress conditions. Therefore, from what we said in § 2.2, structures that are classically modeled with shell elements are the ones with small thickness (a typical example are aircraft structures, but not only). A substantial difference with respect to 2D elements lays in the fact that shell elements can be clearly disposed along any plane arbitrarily oriented in the space; as a consequence of this no limitations exist for the directions of the forces that can load them. Beside the membrane status, the only possible for 2D elements, the bending status is present. Regardless this, however, the shell element is not able to calculate the τ_{xz} and τ_{yz} shears (if we assume that z is the axis normal to the element plane) that arise from shear forces acting orthogonally to the element plane. Just to find an analogy with the De Saint Venant beam, loaded by shear and bending, it is similar to calculate the normal stress due to the bending moment, neglecting the shear action.

The fields where it is necessary to use shell elements are various: aircraft (fuselages, wings, space modules), naval (hulls), rolling stock (bogie frames, body shells), automotive (body panels).

Also beam structures could be modeled with shell elements (let us think to the geometry of some complex section shapes), even if generally in these cases one-dimensional elements are used, as we will see in the next paragraph; we will come back to this point in Chapter 5.

From a practical point of view, constructing a shell element model does not present any particular problem if a modern interactive and graphical system is used. It is necessary, if a CAD geometry is not available, to build the surfaces (preferably in correspondence of the mid-plane of the sheets where they should be created) where to create the elements; attention must be paid to the intersections of the various surfaces, in order to be sure that the resulting elements are effectively connected where they should be.

On the other hand, if a 3D CAD file is available things are a little bit more complicated, because generally the designer produces the geometrical model in order to build the member and therefore all the sheets will have their correct thickness. In order to build the finite element model it is consequently necessary another phase: the one needed to prepare the geometry, extracting those surfaces that best suit structural analysis.

Figures from 26 to 28 show some examples of structures for which modeling by means of shell elements is the right choice seeking for results quality, low calculation times and low model construction times.

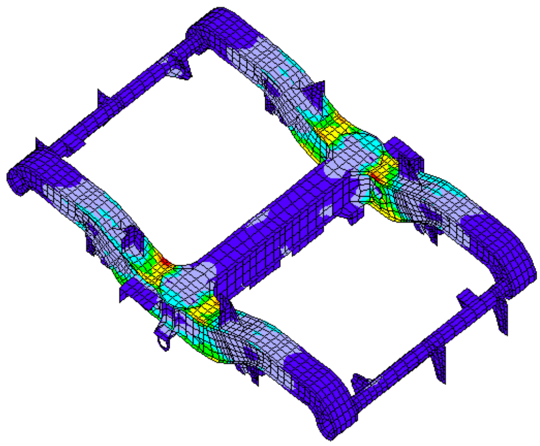

Figure 26. Railway motor bogie. The structure is obtained by steel plates cut and welded together.

Generally speaking, looking at the types of structures they represent, shell elements models have inside also some connection systems. For example the bogie shown in figure 26 is a box structure obtained by means of welded plates; the body shell shown in figure 27 is constituted by extruded beams and panels, riveted, bolted and welded together. It is therefore necessary to spend a few words on these kinds of connection.

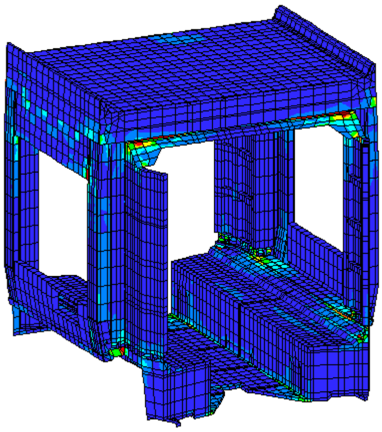

Figure 27. Central car body shell for a tramway vehicle. Aluminum extruded beams and panels bolted and riveted together.

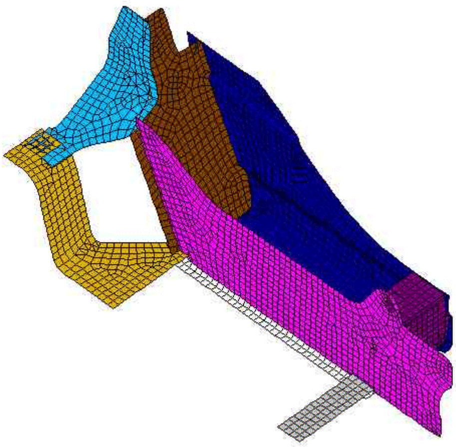

Figure 28. Lift truck frame (only a half is represented here): welded steel plates.

2.4.1 Considerations on welded joints

Concerning seam welding it is common practice to neglect, during the modeling phase, its presence. The various plates are considered as they would be continuous and the model is built in this very simple way. Only during the result interpretation procedure the presence of the weldings has to be taken into account.

Generally two distinct cases exist: 1) seam welding, which can be obtained by "preparing" (with chamfers) the edges to be joined; 2) bead welding. This is not the situation where to discuss which of the two systems presented above is the best, because