Finite Element Analysis

Modelling the tub.

For this component steps 1, 2 and 3 are relatively easy, even easier than for the wheel hub. Now though we're ready for step 4 - the modelling issues and assumptions. The tub is large, of a complex shape, and made of a material which is clearly not isotropic. It is "orthotropic." We'll let Lewis talk us through this step noting the assumptions he has made along the way. The material properties that we use for the chassis are ordinarily linear again, but the data source for that is slightly different because it's a bit more of a complex problem and there are many more different types of material. They're obviously not all isotropic they're all 2D orthotropic layers which come up to build a 2D orthotropic panel and all of these have different stiffness' depending on where they are in the car and how many layers of which material we use. So the constituative model we use is different to that of an isotropic material and we tend to use manufacturers data for that.

The material properties within the chassis are slightly different to most other components in that each of the layers if a 2D orthotropic material so that has a different sub-set within the model when you apply them. And each of the layers, because they can be orientated differently to one another, allows you to build up different stiffness' in different directions and that makes it more complex both from getting hold of the data we require and also actually validating that against test. So it's a little more complicated than isotropic material.
This is the input method that we use in this software for actually representing the material stack with all the different plies. So if you see the spreadsheet here there are, in this case nine different layers, within that you specify the thickness of each one and the orientation of each one and there's also a core material as well, which again is represented using a different kind of constituative kind of model. And the clever bit if you like is it goes and works out the stiffness of that and the strength of each of those plies individually when you actually apply loads to them.

For the load case we're considering for the chassis which was a torsion test, which is to try and measure the stiffness of the car under pure torque, we basically use the suspension components which you can see is the yellow, yellow sticks on the screen here and they're represented using extremely simplified versions of what is really on the car. But they still obviously apply the forces in the right positions under the chassis and from that the loads are carried in in the right correct manner and we try and do a verification test using this very same loading method. And we also only mesh half of the car, essentially because any asymmetry is fairly minimal in its impact on the overall results and it saves an awful lot of time for both simplification of the cad model and also just construction of the model itself. And also many of the load cases are applicable to just the half car so we tend to only run half of the model just to save on computing time.

A constraint case we have here is a little more complicated then just symmetry, it doesn't really represent doing the same thing on both sides which is what symmetry ordinarily is, in that it's actually trying to make the model do the opposite on one side to the other for a vertical load case. So it constrains out of the 6 degrees of freedom if you count 1, 2, 3 for the translational degrees of freedom and 4, 5 and 6 for the rotational ones, this actually constrains 1, 3 and 5. So in effect it tries to represent anti symmetry which is little complicated to explain in words but I can show you in the model later on with the displaced shape what it actually means and what it allows and disallows in terms of rotations and displacements at the centre line. It comes out within maybe 2% or 3% of what is known to be the case from a full model.

For the load case we're considering here the torsion test, no essentially the load is simply a vertical force applied at the contact patch here. And as you can see from there the load travels up through my representative wheel which is effectively just there for measuring displacements and applying the loads to the suspension members. Again these are just representative components which are very stiff; to make sure that the only variable within the model in terms of stiffness comes from the chassis itself, the main body. So that year on year we get a good comparison between the affect of that component only within the system. The constraints at the rear end of the car are simply the engine mounts which we showed a little bit earlier on across the road, on the real component and you can see there they are just constrained in all 3 displacement, displacement degrees of freedom. Any calculations that are made on those for strength are done using hand calculations rather than the FE model, so local stresses are ignored and the final thing is the anti symmetry constraint on the centre line. So as you can see this is trying to represent what happens to the overall car by just loading half of it and to do this it's effectively constrains of the 6 degrees of freedom. If 1, 2 and 3 were the translational X., Y and Z coordinates and 4, 5 and 6 were the rotational X, Y and Z it constrains the rear freedom 1, 3 and 5 and that is effectively the three that you wouldn't constrain if you were doing symmetry. It's the exact opposite, which is why we call it anti symmetry and that does fairly accurately represent what happens during this kind of loading.

It is the material behaviour that is probably the most different aspect with the chassis tub compared to the hub. The hub was made of steel, a linear, elastic, homogenous and isotropic material, requiring just a couple of numbers to be described. The material of the tub though has complicating features.