Validation of a constitutive law for bonded assemblies

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Aim of the study:
MP32 is a multi-partner project of Pays de la Loire's EMC2 competence pole. Its goal is to enhance local industry's knowledge in structural bonding. ENSMP and CETIM's role is to bring comprehension on multimaterial assemblies' mechanical behaviour, in order to optimise joints designs, gain weight and reliability. Final application is a nautical structure, employing fibreglass-polyester composite, multiply wood and polyurethane bond. Most of our concern is directed toward this last material's behaviour, because it's the main deformable part of the assembly.

Modelling bond behaviour:
Scanning electron microscopic observations revealed a bond structure made of calcium carbonates fillers and a polyurethane matrix. Uniaxial tensile tests have been made on dumb-bell specimens, showing a viscous behaviour. A device developed at the ENSMP to proceed to multiaxial tests on a bond joint has been used. With this device, depending on the direction of stress vector to the plane of the joint, a certain amount of hydrostatic pressure can be created within the material. These tests exhibited a yielding point depending on the inner hydrostatic pressure. FEM analysis allowed to find first and second invariants stress combinations occurring inside the joint and then to modify a Drucker-Prager plasticity criterion to fit the experiments. In association with a visco-elasto-plastic model, this formulation produced a new-found behaviour law [1], which has been transferred to the CETIM. Modelling and characterization have been validated on a special test device, made of four bond laps and aluminium substrates. A focus will be made on the detail of this dispositive, the instrumentation used and a comparison with a FEM analysis. Satisfying correlation between simulation and experiments enabled us to go on with structural applications.

Industrial applications:
A reduced-size of a marine structural assembly, referred as the « T » assembly, a multiply wood plate is joined with a composite laminate by the PU adhesive and submitted to uniaxial tension. This test has been performed and simulated by both ENSMP and CETIM. Correlating experiments and simulations results between laboratories allowed validating the mechanical constitutive law and its identification for the adhesive.
Then, the CETIM proceeded to simulations and tests on other joint designs with success. We are now able to optimize joints geometry and to advise the optimum assembly design for each purpose to our industrial partner.

References:
[1] Leroy M., Renard J., Thionnet A., Revue des Composites et Matériaux Avancés, volume 19 n°2/2009 p.127