

Modeling the damage of adhesives with high elongation: effect of confinement and loading conditions

Context:



Figure 1. Sealant application

In the field of building construction and renovation, bonding can be considered as a universal method due to the wide variety of materials and structures involved, but also quite complex regarding the polymer chemistries, interface properties and fracture mechanics. Indeed, the adhesives or sealants used in construction present a wide diversity of chemistries and formulations: silicones, acrylics, polyurethanes, hybrid polymers. Different substrates can be glued: metal, cement, ceramic, wood. The mechanical behavior of these sealants and adhesives differs greatly from those generally used for structural assemblies for which high reproducibility, rigidity and strong mechanical resistance are required. While silicone, polyurethane, etc. present a high elongation at break, a highly non-linear behavior and often as many elastomers, incompressible properties. In their specific field of application, they have numerous advantages, including tolerance to significant peeling stresses, the possibility of filling large gaps, and less sensitivity to the surface preparation. These interesting properties open the way to more demanding applications such as glazing or marine markets which require greater robustness of the assemblies. The aim of this project is therefore to identify the modeling tools necessary to understand the failure mechanisms on the adhesives with high elongation and at high thickness.

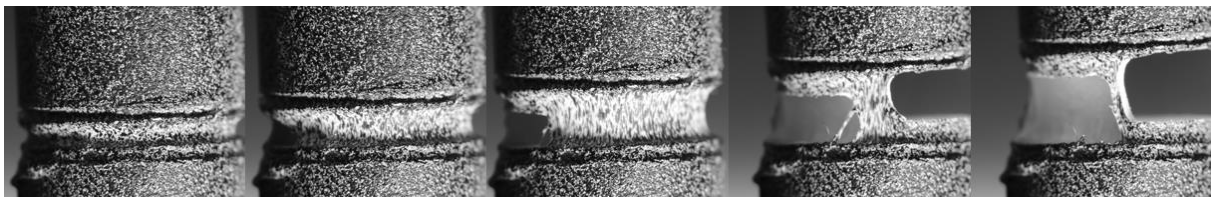


Figure 2. fibrillation or cavitation-like phenomenon occurring on butt joint test

Main objectives / scientific challenges:

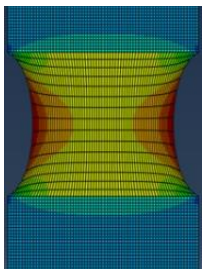


Figure 3. Butt joint simulation

The characterization and modeling works are well described regarding the mechanical behavior of materials with high elongation, nevertheless few studies focus specifically on the rupture behavior of these sealants used in confinement conditions. A significant challenge will be to introduce some damage law to integrate the change in volume for an hyperelastic material. To achieve a description of the assembly failure, the following work will be carried out:

- Mechanical characterization of bulk adhesives will be implemented to capture the mechanical response of the adhesives under multiaxial stress (simple tensile test, inflating bubble test, butt joint test, single lap shear test, dual cantilever beam test, etc.). It will allow to identify the typologies to integrate into subsequent modeling (hyperelasticity, plasticity, viscosity, damage). We will be particularly interested in the influence of hydrostatic confinement and therefore the incompressible nature of the material.
- Proposal of a behavior modeling of high elongation adhesive constructed in a rigorous thermodynamic framework predicting the results of structure tests.
- Behavior and modeling of assemblies, representative of industrial applications, will be studied via mechanical tests using adequate instrumentation (image correlation, acoustic emission, etc.) to observe damage in the presence of high deformation gradients. Numerical simulations of the response of the assembly will be carried out integrating the behavior model proposed for the adhesive but also the adhesion quality parameter.

Location:

The project was launched by Saint-Gobain Recherche Paris – Aubervilliers. This transversal research center develops key skills and technologies for the group, particularly in the field of soft matter. Through its R&D programs Saint-Gobain Research Paris (SGR Paris) develops reliable and efficient solutions that improve homes and daily life. The technical link with Saint-Gobain Research Paris will be regular and mainly remotely. Occasional stays will be scheduled to exchange and transfer the results of the work to the SGR Paris teams and to use experimental platforms for specific needs.

The work will be carried out at the Institut de Recherche Dupuy de Lome (IRDL – UMR CNRS 6027) on the École nationale supérieure de techniques avancées (ENSTA Bretagne / Brest). The IRDL conducts cutting-edge research activity both in the field of characterization and modeling of adhesives and bonded assemblies and in the field of the durability of elastomers and hyperelastic materials. In addition to monitoring by the SGR teams, the person recruited for this work will benefit from the supervision of three IRDL teacher-researchers requested for their different areas of expertise (modeling, bonding, characterization, etc.). For this work, the person in charge of the project will benefit from access to the MASMECA testing platform and the laboratory's analysis resources (DMA, DSC, microscopy, tomography, etc.).

Profile

The expected profile is research oriented M2 (Bac +5) or final year of engineering cycle. Strong skills in materials sciences, solid mechanics, rheology and mechanical behavior modeling are expected. Practical notions of finite element digital simulation and skills in mechanical experimentation are a plus.

Start: February / March 2024

Thesis scholarship: CIFRE Saint-Gobain Research Paris / IRDL

Location : Institut de Recherche Dupuy de Lome – Brest (29), France

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