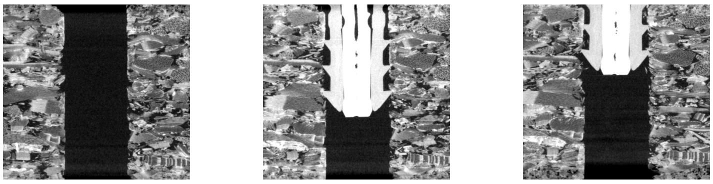
What keeps your furniture together and how?

What makes a piece of furniture feel sturdy and reliable? Surprisingly, the answer may depend on a small plastic component hidden inside the structure. Although rarely seen, this tiny connector plays an important role in keeping furniture together. In this thesis, X-ray imaging was used to reveal what happens inside such a connection as it is pulled out from the furniture component, as might happen under excessive loading or disassembly during house-moving.

Many furniture products are assembled using small connectors that become almost invisible once the furniture is put together. One example is the thermoplastic expander dowel. It works by first inserting the dowel into a furniture component and then pushing a pin into it, causing the dowel to expand. Small teeth on the surface of the dowel press into the surrounding material, helping to hold the furniture parts together.

Traditional mechanical testing can measure how much force is required to pull the dowel out of the furniture component. However, it cannot reveal why the connection behaves as it does, since the damage and deformation occur inside the particleboard, hidden from view.



(a) Before assembly. (b) After assembly. (c) After pull-out.

2D cross-sections through 3D X-ray µCT images of the furniture material and dowel.

To look inside the furniture connection without needing to destroy it, X-ray computed microtomography (µCT) was used. Similar to a medical CT scan, but at a much smaller scale, µCT provides three-dimensional (3D) images of the dowel and the particleboard around it. The image series above shows two-dimensional (2D) slices through 3D images of the expander dowel and surrounding material. The images were further analysed using digital volume correlation (DVC), a method that compares 3D scans taken at different loading stages. This made it possible to track tiny movements and changes within the material. By combining these measurements with the mechanical testing, the response could be linked to local deformation inside the board.

The results from the 3D analysis showed that the material did not deform uniformly. Instead, most of the movement and damage were concentrated in a cone-shaped region surrounding the dowel. The analysis further revealed that the dowel teeth play a key role in resisting pull-out and transferring load to the surrounding material. In addition, most of the material returned to its original shape after the dowel was removed, although small regions around the dowel teeth remained permanently damaged.

Together, µCT and DVC provide insights that cannot be obtained from mechanical testing alone. By revealing how damage develops inside furniture connections, these techniques help explain why some connections fail and how small design details influence strength and reliability. This knowledge can support the development of stronger, more durable furniture in the future.