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1 *Adhesively bonding: Small specimens are used for determining the wood strength, medium-sized lap shear specimens are used to select adhesives, and large specimens are used to verify the results on components.*
2 *Large specimens in the testing machine: the joint can withstand more than 3 metric tons.*

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INNOVATION - ADHESIVELY BONDED CONNECTIONS BUILDING INDUSTRY

Adhesively bonding – Joining technology for the building industry

Up until now the construction industry has essentially used two ways to join load bearing components together.

The first way relies mechanical fasteners; these are for example screws, nails, rivets, or dowels. They can be used for almost all materials but do weaken the materials, which is particularly unfavorable for fibrous materials such as wood, glass and carbon fiber reinforced plastics (GFRP, respectively CFRP). Due to the mechanical function of the fasteners, screwed or likewise joints are relatively weak and hence usually have a relatively low strength.

The alternative method for joining components is by welding them together. This results in much more rigid and stronger joints. This method can, however, only be used for certain materials which are resistant to the high welding temperatures, such as metals.

The use of adhesives to join components combines the advantages of the two aforementioned traditional joining methods: Adhesives are particularly suitable for joining fibrous materials such as wood or FRPs and this results in more rigid and usually stronger joints. Moreover, adhesives can be used to produce load bearing joints between wide ranges of different substrate materials.

Adhesively bonding – Joining technique for hybrid and multifunctional structures

Hybrid components or structures are combinations of expensive, high-performance materials, such as CFRP and steel, and relatively low-cost materials of generally inferior performance, such as concrete and wood. As these materials are usually fundamentally different, only adhesives allow effective,

strong, and durable joints to be manufactured. Wood-concrete systems are an example of such hybrid structures, and the materials can be joined together using adhesives for improved performance.

The next step when designing multifunctional hybrid structures is to not only use the different materials in a static way but rather to generate additional functions. For example, instead of subsequently introducing various structural-physical functions such as a building envelope, sealing, or heat insulation, the structural elements can be chosen, designed, and combined during the design phase such that from the outset they take on several functions. Examples of simple multifunctional structures are steel-glass respectively wood-glass systems whereby the glass acts as the transparent building envelope while fulfilling a static load-bearing function.

The principle of multifunctional load bearing structures can be expanded as desired. It leads not only to architecturally attractive designs, but also to more rational and more economical structures because the high-performance and in some cases expensive materials are assigned to multiple functions. As fundamentally different materials often have to be joined to create the multifunctional structures, adhesive bonding technology is often the only viable joining method.

Adhesively bonding – An effective joining method

In the building industry, bonded joints have often been met with certain skepticism. This is particularly true for bonded joints in load bearing elements. That having been said, on the other hand, adhesives have a long tradition in timber eneineering, where they provide the basis of plywood, "glued laminated beams" and nowadays cross laminated timber.

Despite the skepticism, a wide range of adhesives are available to meet almost any specific requirement, for example:

- Bonded joints of very high strength combined with long-term stability,
- Bonded joints that are resistant to extreme climatic conditions,
- Environmentally-friendly bonding processes.

Beside that, reliable methods are now available for dimensioning bonded structures and for experimentally determining relevant design parameters.

Range of services offered by Fraunhofer IFAM

- Counseling civil engineers, architects, and designers for material-specific concepts in the planning phase
- Advice about adhesive selection and the determination of all relevant design parameters
- Advice about using design methods for specific designs
- Development of customized production concepts for contractors for effective and economically viable realization of the desired structures
- Testing of materials and components, e. g. fatigue properties of bonded joints
- Development of special application techniques
- Quality assurance for bonding processes
- Employee training for adhesive bonding in the construction industry

3 *After the lap shear test: If adhesive is applied correctly, the bonded joint is stronger than the substrate material.*

4 *If the substrate material fails before the adhesive, then a good choice of adhesive has been made.*