Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 172 (2017) 186 – 193

Procedia Engineering

www.elsevier.com/locate/procedia

Modern Building Materials, Structures and Techniques, MBMST 2016

Adhesive bonding in steel construction - Challenge and innovation

Yvonne Ciupack[a]*, Hartmut Pasternak[a], Christoph Mette[b], Elisabeth Stammen[b], Klaus Dilger[b]

[a]*Chair of Steel and Timber Structures, BTU, Konrad-Wachmann-Allee 2, 03046 Cottbus, Germany*
[b]*Institute of Joining and Welding, Technische Universität Braunschweig, Langer Kamp 8, 38106 Braunschweig, Germany*

Abstract

Despite much advancement of typical joining techniques in steel construction, fundamental problems, like residual stresses for welds as well as weakening of the cross section for bolts and screws, still remain. The application of bonded joints could improve the situation. The automotive industry shows the potential of this certain joining technique since years. Even in civil engineering and especially in steel construction, researchers are continuously establishing the bonding technology as a structural element. On the one hand bonded joints mean a challenge, but on the other hand an innovation, what is shown in this paper.

Peer-review under responsibility of the organizing committee of MBMST 2016

Keywords: Adhesive; joining technology; steel structure.

1. Challenge

1.1. Design of bondline geometry

A great number of adhesives with different carrying and deformation behavior, as well as varying handling properties are available for the design of bonded structures. Due to a general lack of experience the selection of suitable adhesive systems is a difficult task for a civil engineer. General requirements for an adhesive are characterized by a specific viscosity for the manufacturing and a sufficient carrying and deformation capacity of the bondline. Despite these parameters the properties of the adherent surface play an important role for the compound.

* Corresponding author. Tel.: +49-355-69-2255; fax: +49-355-69-2144.
E-mail address: yvonne.ciupack@b-tu.de

Peer-review under responsibility of the organizing committee of MBMST 2016
doi:10.1016/j.proeng.2017.02.048

Thus, cleaning and degreasing of steel surfaces are essential during the bonding process. In addition, mechanical pre-treatments such as blasting can improve the adhesion properties.

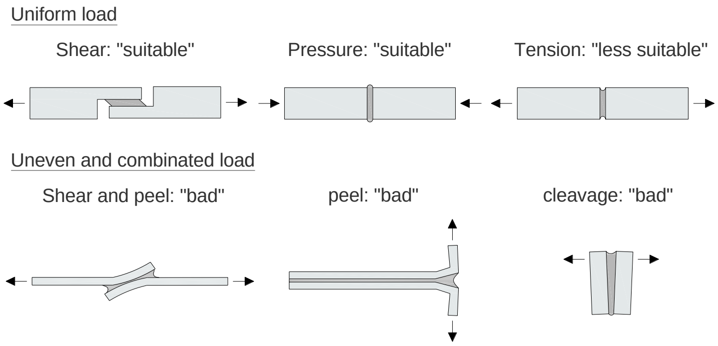

Fig. 1. Influence of geometric design and loading of a bondline.

Moreover, the kind of loading has a big influence on the carrying capacity of a bonded steel construction. Uneven and combined loads as well as peel stresses should be avoided, as shown in Fig. 1. But uniform distributed tension, pressure and shear impacts are suitable. By slopping the adherent ends stress peaks can be reduced, which increases the carrying capacity of the bonded connection.

1.2. Carrying and deformation behavior of bonded constructions

The carrying and deformation behavior of bondlines is nonlinear and time dependent. According to the kind of adhesive basis distinct creep and relaxation effects can be observed. The long-term mechanical behavior is influenced by environmental effects, e.g. temperature, UV-radiation and humidity. These impacts can lead to irreversible degradation of the mechanical bondline properties. Particular attention is paid to the temperature dependency, because adhesives are characterized by a so-called glass transition temperature. If a bondline is exposed to high thermal impacts, higher than the glass transition, it shows increased deformations and a decreased ultimate stress. Low temperatures lead to a high stiffness and an increased notch sensitivity of the bondline. These relations can be utilized in application, e.g. elastic adhesives and sealing materials are used for temperatures higher than the glass transition to avoid thermal residual stresses and compensate thermal strains.

Because of the complexity of the carrying and deformation behavior, an appropriate description of the stress distribution in a bondline means complex calculations, e.g. numeric simulations. Since simple and standardized concepts are necessary for the design in civil engineering, the development of suitable analytical models poses a special challenge.

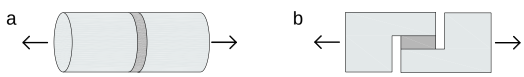

Fig. 2. (a) Butt joint test; (b) Lap shear test.

Another important challenge is the determination of characteristic material parameters for the design of bondlines. Whereas the temperature dependency of material properties for steel adherents need only to be considered for fire design, it is not sufficient for adhesives. The detection of time dependent material parameters, by consideration of damaging environment impacts, is imperative. But currently, only simple test methods are available, which exclute the implementation of suchlike influence factors. On the one hand the shear-stress to shear-strain relation can be described with shear lap tests according to DIN EN 14869-2 [1]. On the other hand evidence about the carrying behavior of bondlines under normal stress states can be obtained from butt joint tests according to DIN EN 15870 [2]. The specimens and loading situation for these experimental investigations are shown in Fig. 2.