Creep behaviour of flexible adhesives

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Abstract

Since flexible adhesives are used more and more in structural applications, designers should have a better understanding of its behaviour under various conditions as ultimate load, fatigue load, long-term load and environmental conditions. This paper focuses on long-term load conditions and its effect on flexible adhesives. The creep properties of both PU (PolyUrethane) and SMP (Silyl Modified Polymers) adhesives used for identical applications are considered. To investigate the creep behaviour tests under various conditions were done. The results of those tests are presented and compared. To evaluate these results an empirical method is proposed and discussed. An example illustrates the potential of this method. It is also shown that with use of a probabilistic calibration technique this method results into a simple rule, which can be used to calculate the creep for practical applications. For the studied adhesives, the creep performance of the SMP adhesive is shown to be of the same level or slightly better than of the two PU adhesives. In addition to this empirical method, the principles of a more complex theoretical based method are introduced. The potential of this method is illustrated and future research activities are drawn.

1 Introduction

During the last decade flexible adhesives are used more frequently as an alternative for traditional joining techniques like bolting, screwing, riveting and welding. Modern busses and trains are made of components bonded together, adhesively bonded sandwich panels are used as wall and roof structures of trailers and façades are bonded directly on the structure of a building without any mechanical support. An example of an application that makes use of flexible adhesives, is shown in figure 1. Most flexible adhesives are based on a chemical composition of PU (PolyUrethane) or SMP (Silyl Modified Polymers). The advantages of these adhesives are their large deformation capacity while keeping their strength properties, their ability to seal the joint, their ability to damp vibrations and their favourable long-term behaviour (environmental ageing, creep and fatigue). Flexible adhesives provide designers with the ability to realise new combinations of materials and other kinds of shaping, to realise weight reduction and to integrate various functions within one component. To optimise a design, designers should be aware of the behaviour of flexible adhesives under various conditions.
Figure 1 - Example of an application that make use of flexible adhesives

One of the main requirements in the design of adhesive bonded joints is the requirement that the strength and durability of the joint has to be guaranteed during its lifetime. To quantify this requirement, a designer does not only be able to calculate the stress state within the bondline, but he or she also has to be able to quantify the reliability (safety) of the design. Not only the strength of the joint for an ultimate load condition, but also its fatigue, creep and ageing behaviour have to be considered.

This paper focuses on the creep behaviour of flexible adhesives. Within the study performed by TNO BCR, a methodology is developed to predict the behaviour of flexible adhesive under long-term load conditions. This methodology makes use of experimental data, which is evaluated empirically. To guarantee the reliability of designs, probabilistic techniques are applied to draft a simple design rule. A disadvantage of the use of this empirical prediction model is that for every considered adhesive a set of experimental data has to be collected by performing an extended series of tests under various conditions. To limit the number of tests, a theoretical model based on springs and dampers is under development by TNO BCR.

2 Experimental investigation

To investigate the creep behaviour of both PU (PolyUrethane) and SMP (Silyl Modified Polymers) flexible adhesives, TNO BCR tested products from various suppliers. The double overlap joint geometry given in figure 2, was used within these tests. For the adherend an aluminium 6061-T6 alloy was selected. The nominal value of the bondline thickness is equal to 3 mm and the area of one bondline is equal to 20·25 = 500 mm². Compared to the mostly used single lap joint the selected geometry has several advantages. Due to its symmetry there is no non-linear bending effect as in most practical applications. The extended width of the specimen makes it possible to get the bondline thickness within a narrow scatterband. Another advantage of using this specimen for the creep tests is that four bondlines are tested instead of one; the creep results represent mean values.