WHITE PAPER

Peel Strength

Peel strength testing is carried out to assess the adhesion quality of the composite structure. A lack of adhesion strength between the face sheets and the core material can lead to unpredictable interface failure when in service.

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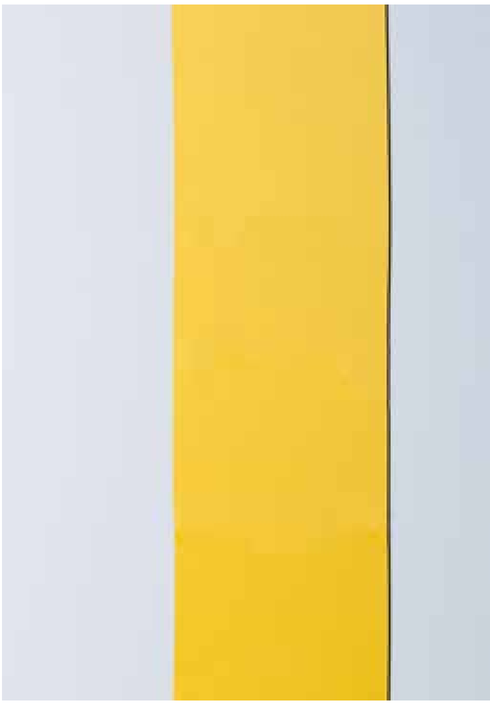

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ArmaPET®

ArmaPET® PEEL STRENGTH

INTRODUCTION

Composite sandwich structures consist of two thin, stiff and strong face sheets bonded to a relatively thick lightweight core to create a strong and stiff assembly with low weight. Composite sandwich structures are widely used in the wind energy, transport, marine and industrial markets due to the combination of high flexural rigidity, strength and low weight.

No matter what core material is used, there is a wide range of potential damage that could occur either during manufacture or in service. The most destructive failure is often delamination at the interface between the face sheet and the core, whereby the sandwich will rapidly lose stiffness and subsequently collapse.

TEST METHOD

There are several different test methods to assess the bond line strength between the face sheet and the core. Measuring the peel strength of the bond line gives a good indication of whether the sandwich can perform well during its lifetime and of its tolerance to minor damage during manufacture and in service. Different peel strength measurement methods are available, but results from the different methods cannot be readily compared and even small changes in the laminate used will give rise to big changes in the results.

Probably the most reproducible method is the Climbing Drum Peel (CDP) test, in accordance with the ASTM Standard D1781. The CDP test is relatively simple to perform but requires special testing equipment and relatively large test specimens. Also, the skins have to be thin if the results are to be compared to other sandwich configurations.

Other methods include the Cracked Sandwich Beam (CSB) and modified Double Cantilever Beam (DCB) tests. The advantages with these similar methods are that less testing equipment is required and smaller test specimens are used. The disadvantage is that only the exact same laminate thickness and lay-up can be used if results are to be comparable.

Figure 1: DCB samples ready for peel off test

Armacell's standard procedure for peel strength testing is similar to using a DCB type specimen, see Figure 2, and mode 1 fracture measurement, see Figure 3. Instead of calculating the fracture energy, however, we measure the load required to pull the skin of the specimen. This is sufficient for quality testing purposes and for comparing, for example, different core materials or different resins systems.

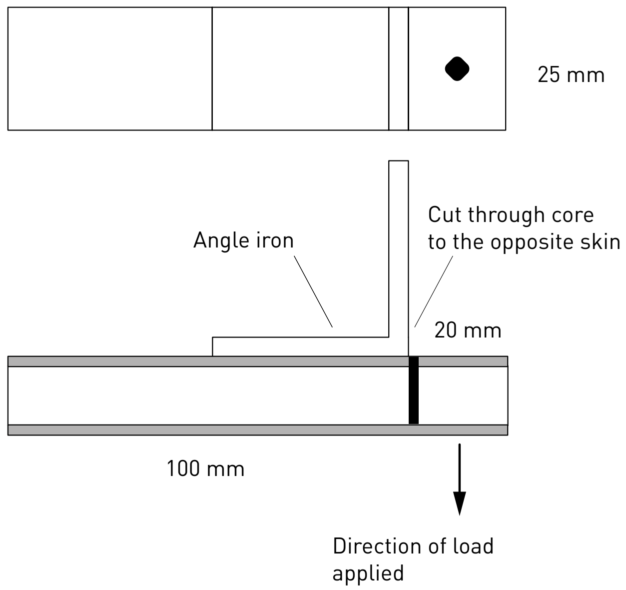


Figure 2: DCB samples set up

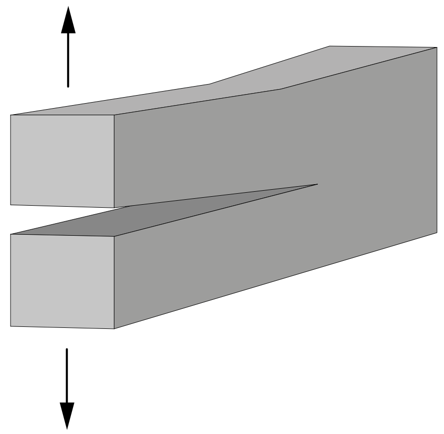


Figure 3: Mode 1 facture measurement

Double Cantilever Beam (DCB) Peel Testing

The set-up of the test is according to Figure 2, with specimen dimensions of 100 mm x 25 mm x thickness (typically 20 mm). One test batch should comprise at least five samples, as there is always some scatter in the results.

The samples for the test were prepared in the traditional way by infusing sandwich panels composed of a 20-mm-thick ArmaPET Struct foam core with densities of 70, 115 and 250 kg/m³ laminated on both sides with three layers of biaxial glass fabric (0/90°; 950g.m-2).

To determine the influence of the resin system, a polyester resin and an epoxy resin were used for these tests. The specimen dimensions were 100 × 25 × 20 mm (the core foam plus laminates result in a total thickness of around 24 mm).

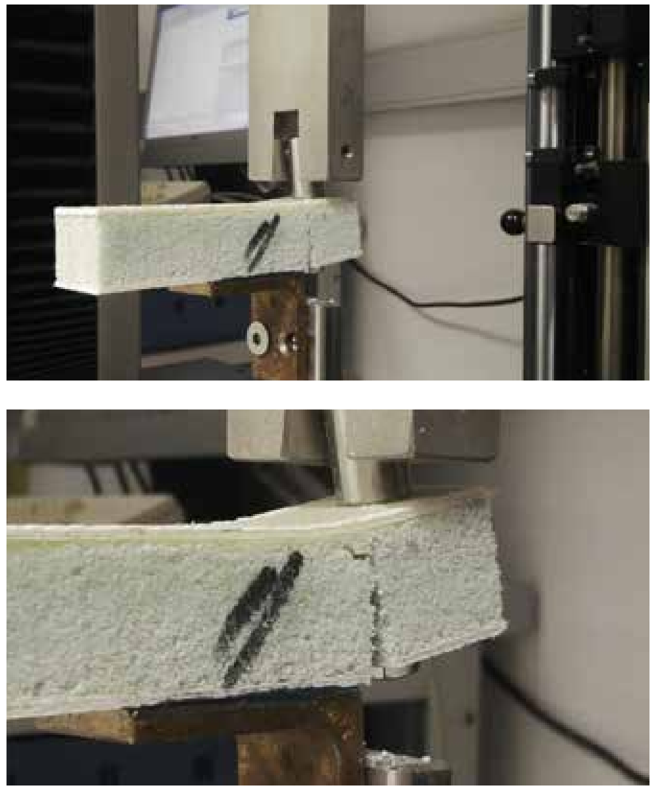


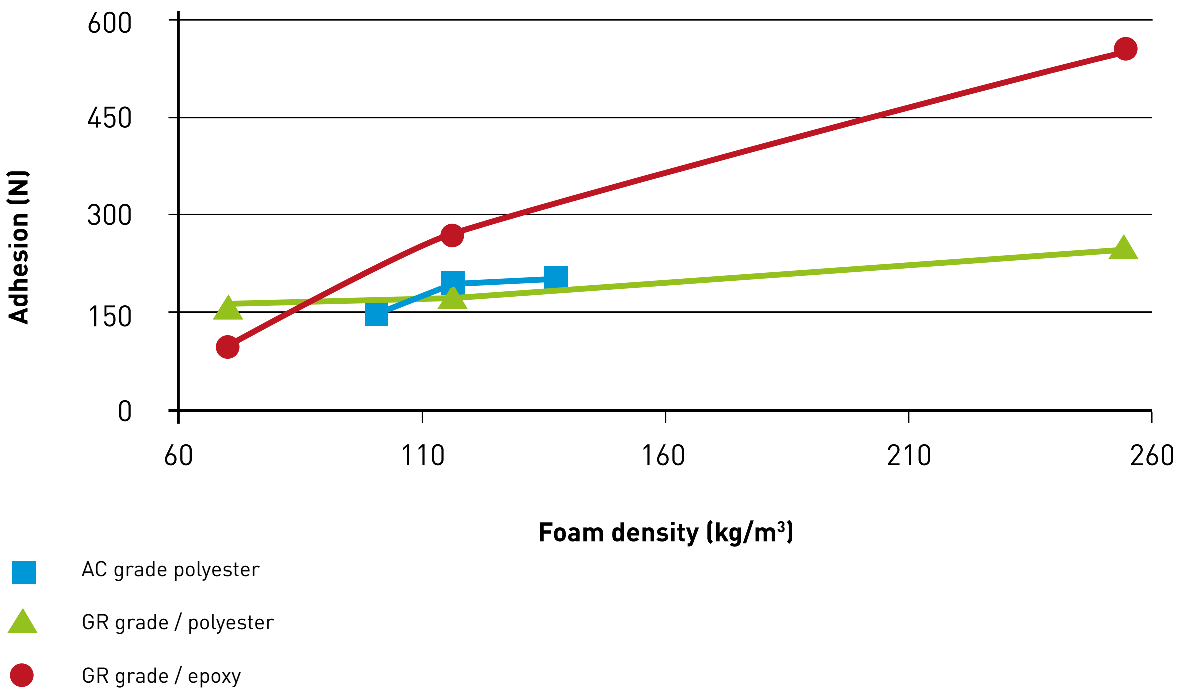
Figure 4: Peel off test on a sample

Usually the peel strength is slightly lower in the transverse direction (perpendicular to the extrusion direction) than in the longitudinal direction but can be assumed to be equal in order to simplify the calculations. In any case, a safety factor has to be used. This difference might be explained by the shape of the cells, since they do have an ovoid shape due to the extrusion/pulling process and this might influence the mechanical anchorage.

A significant increase in peel strength is observed with the use of epoxy, especially for high densities, where the peel strength is at least twice as high as for polyester. So, in cases where good adhesion is critical, it is advisable to use epoxy resins. However, the values obtained for low density samples infused with epoxy are lower than expected, since during previous tests epoxy always performed better than polyester regardless of the density. In all cases when peeling the skin, a thin layer of PET was observed on the inner side of the skins, which means that a cohesive failure of the substrate occurred and that the maximum strength of the substrate was reached.

Only limited data is available for the comparison between ArmaPET Struct based on virgin PET raw material, called AC grade, and today's ArmaPET Struct GR grade, based on 100% recycled PET. The AC grade infused with polyester resin shows results similar to those for the GR grade infused with the same kind of resin, whereas the GR grade infused with epoxy resin exhibits better adhesion.

PEEL STRENGTH WITH EPOXY AND POLYESTER RESINS



Summary

The Armacell DCB type peel strength method is presented. It can be used to check the peel strength properties of the core and laminated skin sheets and to evaluate different parameters such as core density or core type. However, the results are dependent not only on the core material used but also on the resin type, laminate thickness, fibre type etc. ArmaPET Struct shows excellent adhesion to the laminate with all standard laminating resin systems. Furthermore, it can be observed that the peel strength improves further with an increase in density of the core material.

ARMAPET USED IN VARIOUS SANDWICH CONSTRUCTIONS AROUND THE WORLD

// Five gilded domes of the Russian Orthodox Cathedral in Paris, France. The domes were manufactured off-site and it took 15 minutes to put the largest dome, spanning 12 metres in diameter, in place by crane.

// Façade cladding of King Abdullah KAFD World Trade Centre in Riyadh, Saudi Arabia. It covers a surfacearea of more than 40,000m². It isthe second tallest tower in the areawith an observation deck open forpublic at a height of 300 metres.

// Nose of the CRH3A bullet train that connects the 700km distant cities of Chengdu and Xi'an in Western China in less than four hours. The success of the CRH3A has put an end to flights between the two cities, thus reducing the carbon footprint on this route.

// PET foam house in Nova Scotia, Canada. The 186 m² prototype bungalow consists of 170 ArmaPET cored SIPs and was assembled in just 14 hours. 612,000 recycled PET bottles brought this eco house to life.

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ABOUT ARMACELL

As the inventors of flexible foam for equipment insulation and a leading provider of engineered foams, Armacell develops innovative and safe thermal, acoustic and mechanical solutions that create sustainable value for its customers. Armacell's products significantly contribute to global energy efficiency making a difference around the world every day. With more than 3,200 employees and 25 production plants in 17 countries, the company operates two main businesses, Advanced Insulation and Engineered Foams. Armacell focuses on insulation materials for technical equipment, high-performance foams for high-tech and lightweight applications and next generation aerogel blanket technology.

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