Chapter 1
Simple Lap Joint Geometry

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Abstract The chapter outlines the basic mechanics of adhesively bonded simple lap joints, focusing on the analytical solutions that have been developed. This can be viewed as foundational material for the chapters in this book that deal with numerical modelling of adhesive joints. It begins with a discussion of the shear-lag concept which governs the development of adhesive shear stresses arising from load transfer between substrates. From this starting point a number of design analysis approaches are outlined, all of which seek to provide easy access to adhesive stresses within joints under a range of service loading conditions. The chapter concludes by considering approaches that have been made to enhance the accuracy of the closed form analytical adhesive joint models. Although improving the accuracy, these developments also result in a considerable increase in complexity with the result that analytical solutions are more difficult to utilise.

1.1 Introduction

A large number of adhesively bonded joint configurations use an overlap in their construction. These are generically referred to as simple lap joint geometries. The most common of these simple lap joint geometries is the axially loaded single overlap joint (sometimes referred to simply as a single overlap joint). This chapter will consider the analytical stress analyses of the generic range of simple lap joints. Later chapters deal with the numerical modelling of such configurations.

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1.1.1 Limiting Joint Strengths

Adhesives are not generally as strong as the materials they join and hence use is often made of an overlap to increase the load carrying capacity of a joint. Generally, when designing a bonded joint, the ideal approach is to ensure that the bonded joint is stronger than the parts being jointed. However, it can be shown that the load carrying capacity of an overlap joint is not proportional to the length of the overlap. Consider the simple single overlap joint illustrated in Fig. 1.1.

The axial load is transferred from one substrate to the other through shear in the adhesive. This shear will only occur over a finite zone of the adhesive layer and any increase in overlap length beyond this maximum transfer zone length will not result in any increase in joint strength. Where load transfer beyond this limiting value is required (as in the case of very thick substrates) a different type of joint design will be required, such as the scarf or stepped lap joint, as shown in Fig. 1.2. In both these configurations the load is distributed more uniformly across the entire adhesive layer than in the single lap joint.

1.1.2 Load Transfer in Lap Joints

In some lap joints complete load transfer occurs from one set of substrates to another as shown in the joints in Figs. 1.1 and 1.2. In other configurations, such as that shown in Fig. 1.3, only partial load transfer occurs across the adhesive. However, even this partial load transfer may be sufficient to cause the bond line to fail and thus stresses and strains in the adhesive layer are required to assess the joint strength.