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# A nonlinear shear-lag model applied to chemical anchors subjected to a temperature distribution

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**Abstract**

Adhesive joints are increasingly used in bridges and buildings construction thanks to their high mechanical properties and their ease of implementation. However, the load transfer mechanism within adhesive joints is complex and has been the subject of several studies since 1938. Several models have been developed to quantify the stress distribution along bond joints. Nevertheless, very few models exist today to study the stress distribution in chemical anchors by taking into account the temperature effect. This paper presents a non-linear shear-lag model adapted to chemical anchors allowing predicting their stress distribution profiles and fire resistance duration for any temperature distribution. The model highlights the importance of the temperature distribution on the stress profile. The paper shows that when the anchor reaches its maximum axial force, all the elements composing the anchor provide their maximum performance at the same time.

***Keywords:*** *Chemical anchors, Shear-lag model, Temperature distribution, Load bearing capacity, Bond stress, Anchor slip, Fire resistance.*

## 1. Introduction

Over the years, the use of structural adhesive bonding techniques in concrete constructions is constantly increasing. Bonding techniques are employed for different applications such as cracks and joints filling, bonding concrete to concrete, metal to metal, steel to concrete and recently composite materials to timber or concrete. The main advantage of the use of bonding techniques in construction is that bond stresses are more uniformly distributed over the bonded surface area than with other conventional fastening methods such as bolts and rivets. This allows working with small bearing areas, and therefore leads to lighten the weight of the structure.

Adhesive joints ensure the load transfer from one adherent to another, essentially by shear stress. Nevertheless, the stress distribution along the bond joint is not usually uniform, and exhibit localized concentration in specific areas, which reduces the bond resistance and leads in the majority of cases to its failure. Several studies have been conducted and refined for more than seven decades in order to analyze the axial, shear and peel stress distribution along the bond joint. Volkersen was the first to propose a simple Shear-lag model in 1938, to predict the stress distribution along a mechanical joint with several fasteners. Later, the model was adapted for bonded lap joints but still ignoring the bending and the shear deformation of the adherents, in addition to ignoring the peel stress at the free ends of the joint. In 1944, Goland and Reissner improved the Volkersen model by considering the shear and normal transverse deformations of the bond. After that, the shear-lag model was enhanced by Oplinger by introducing a layered beam theory instead of the classical homogeneous beam model for single lap joints. The improvements made on the Volkersen model were continued with Hart-Smith