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Current design practice and research on stainless steel structures in Sweden

B. Johansson *, A. Olsson

Division of Steel Structures, Luleå University of Technology, Sweden

Abstract

The current design practice in Sweden is using codes for structural steel also when working with stainless steel. For load cases governed by instability this may produce non-conservative errors amounting to 10% while it may greatly underestimate the ultimate resistance in cases when instability is not governing. Three ongoing research projects are briefly described, one on weldbonding, one on plastic forming and one on the behaviour of structural components. A part of the latter concerns fundamental work regarding the material behaviour which in general is described using too simple models. This is presented in some detail and its results will be used to provide improved finite element simulations. © 2000 Published by Elsevier Science Ltd. All rights reserved.

Keywords: Stainless steel; Patch loading; Biaxial testing; Constitutive models; Plasticity

1. Introduction

The use of stainless steel in structural applications is quite low in Sweden but seems to be increasing. In this context, structural applications refer not only to buildings and civil engineering structures but any kind of structure or device for which the load carrying capacity is an important design requirement. Such structures are designed either by structural engineers or mechanical engineers and there is a wide difference between their design practices. This will be described in Section 2.

Moreover the research on stainless steel structures is quite limited in Sweden, which is of course a reflection of the limited use of stainless steel in structures. The projects presently carried out at universities will be described in Section 3. Further-

* Corresponding author. Tel.: +46-920-91344; fax: +46-920-91091.
E-mail address: bernt.johansson@ce.luth.se (B. Johansson).

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more, in Section 4 there is a summary of a project on material modelling that the authors are working on.

2. Current design practice

2.1. Buildings and civil engineering structures

Structural engineers are brought up to use codes for the design of structures. The level of safety of such structures is prescribed in codes together with verification methods usually based on calculations but with an option to test the resistance of components. The strong focus on codes may be an obstacle for development. The Swedish system has however changed in the last 10 years to become quite open and permissive. Design rules are mainly published as handbooks, sometimes by authorities and sometimes by private organisations. The handbooks have the status of representing one acceptable way of designing a structure. Other ways are also acceptable as long as the basic safety requirements are fulfilled. This possibility is not frequently used, but it is important that it exists.

The limited use of stainless steel has not justified the development of a separate code and designers are using the codes for structural steel. There is an old handbook on stainless steel [1], aimed at the construction industry giving basic information on material properties, available materials and products and related topics but no specific design rules. The design rules for structural steel are given in BSK [2], for normal steel structures and in StBK-NS [3], for cold formed thin walled structures. Specific rules for stainless steel structures are given in Eurocode 3-1-4 [4], which may be used in Sweden since last year when a NAD [5], was published. To the authors knowledge it has not been widely used.

The Eurocode gives some special rules for stainless steel but in most cases it refers back to the rules for structural steel. This practice of using design rules for structural steel is questionable in at least two respects. First, the yield strength is substituted by the 0.2% proof stress, which may cause errors of around 10% on the non-conservative side for e.g. column buckling and much greater errors on the conservative side when instability is not governing. Secondly, it does not account for the anisotropy of stainless steel especially in cold worked states. In this case, the errors are normally on the non-conservative side and some examples will be given in Section 4.

All the codes for structural design are based on limit state design. However, there is still some work to do on the definition of ultimate limit states. Gross section yielding is considered an ultimate limit state for structural steel, which may be rational as this implies about 3% strain. If we accept that this limitation is needed because it may cause a change in geometry big enough for the structure to fall off its support, it will also imply that we can use a much higher stress than the 0.2% proof stress for stainless steel. The condition here, is that instability does not occur at lower strains.

The use of stainless steel in buildings and civil engineering structures is normally