1 Introduction

Developments in the design, fabrication and erection of steel structures together with the introduction of new high performance materials have lead to significant changes in the design, buildability and performance of steel structures and in particular their connections. Early steel structures used riveted connections but following technological developments shop welded and site bolted connections are now common place. The introduction of high strength steels has increased the types and grades of bolt available to the designer. The range of bolts now includes ordinary strength steels bolts such as grades 4.5, 4.6 and 5.6 and high strength steel bolts such as grades 8.8, 10.9 and 12.9. Developments in automatic fabrication have seen a move away from manually produced drawings and setting out to sophisticated design software directly connected to numerically controlled machines for laser cutting, punching and drilling. The quality of welding has also improved with the introduction of continuous casting of steel and welding robots.

These changes and in particular the increase in the use of automated design and fabrication have lead to an increase in quality and standardization in comparison with other structural materials. Today steel connections are economical to fabricate and erect, have a high inherent level of safety and can help the architect produce elegant and practical structures.

To take advantage of the wide range of steel products and technological developments that exist within the different European countries, the European Union created a set of common design standards for the design, fabrication and construction of steel structures. These standards are called the Eurocodes and have been developed over many years to take advantages of the different techniques available within the different member states. At the time of writing the Eurocodes are still pre-standards [ENV 1992-1-1, 1992; ENV 1993-1-1, 1992; ENV 1999-2, 1999] but within one or two years they will be converted to full Euro-norms that will eventually replace the existing National codes [prNV 1992-1-1, 2003; prEN 1993-1-2, 2003; prEN 1993-1-8: 2003]. At the inception of the Eurocode for steel structures (Eurocode 3) the importance of structural connections was recognized and a specific standard for the design of steel connections was created. This standard is part of the main steel Eurocode and is called prEN1993-1-8 - Design of Joints.

As part of the development of the early versions of Eurocode 3, background documents were prepared summarizing best practice in the design and use of bolts and welds [see Snijder 6.01 and 6.05]. Furthermore, the design models for each of these components was validated against available test data before being included in the European standard.

Traditional design methods for connections were based on a series of capacity checks and did not include methods for calculating a connection's stiffness and rotational capacity. Over the last ten years our understanding of connection behaviour has improved and methods are now available for calculating the stiffness and rotational capacity of bolted and welded connections. prEN1993-1-8 takes advantage of these developments and includes a consistent approach for calculating the stiffness, strength and rotational capacity of a limited range of bolted and welded connections. The method given in prEN1993-1-8 is called the component approach and uses the behaviour of the individual components within a connection (bolts, welds, end-plate, Column flange etc.) to build a realistic picture of a connection's load-deformation characteristic. Using this information the designer is able to predict the behaviour of simple, continuous and semi-continuous steel frames. The component approach is based on Zoetemijer's work [Zoetemijer 1983] on flush and extended end-plate connections and has been extended to include joints with angle cleats [Jaspart, 1997], composite connections [Anderson, 1998; Huber, 1999, 2001] and column bases [Wald, 1998]. In addition to beam-to-column connections, prEN1993-1-8 also includes design methods for column bases with end-plate connections, new rules for the interaction of moment and axial force at the connection, new rules for calculating the bearing capacity of slotted holes, welded connections to rectangular tubes and improved serviceability limits for pins.

Following the Northridge and Kobe earthquakes a number of research initiatives were created to improve our understanding of the behaviour of steel connections subject to seismic events. One such initiative is the Copernicus project "Reliability of moment resistant connections of steel building frames in seismic areas" (RECOS). This project is still on-going and is continuing to contribute to our knowledge of how steel frames behave under seismic loads.

Education has always been seen as an essential part of the introduction and dissemination of new methods for the design of steel connections. One of the first educational packages on connections was produced by Owens and Cheal [Owens, 1988] who prepared educational material for structural connections. This material has been extended and is now incorporated into a European educational package called the European Steel Design Educational Programme (ESDEP). This programme is used today by educational establishments throughout Europe. Other educational packages which build on the work of ESDEP are available some of which include WIVISS, a set of lectures on CD, SteelCall, a virtual steel designers office, and SSEDTA which consists of a set of basic lectures on PowerPoint for the design of steel and composite elements.

For more that twenty year the European Convention for Constructional Steelwork's Technical committee for structural connections (ECCS TC10) has supported the development and implementation of a common set of design rules for steel connections. It is therefore not surprising to find that one of this committee's priorities is to facilitate the transition of prEN1993-1-8 from a European pre-standard to a full Euro-norm. A part of this activity is the development of the necessary educational material to encourage designers throughout Europe to adopt prEN1993-1-8. Consequently, a programme called 'Continuing Education in Structural Connections (CESTRUCO) was formed under the European Commission's Leonardo initiative to collect commonly asked questions on the background, implementation and use of prEN1993-1-8 and to publish expert answers to these questions. The CESTRUCTO project was developed from an idea by Mr. Marc Braham (Astron, Luxembourg), Mr. Jan Stark (TU Delft, The Netherlands) and Mr. Jouko Kouhi (VTT, Finland) to provide designers with more detailed information on the background and implementation of the design methods given in prEN1993-1-8. Since the start of this project 364 questions have been collected from the countries within Europe.

The purpose of this publication is to document each of these questions together with their answers. To facilitate easy of use this document is split into the following Chapters:

Chapter 1 - Introduction
Chapter 2 - Bolts
Chapter 3 - Welding
Chapter 4 - Structural Modelling
Chapter 5 - Simple Connections
Chapter 6 - Moment Connections
Chapter 7 - Column Bases
Chapter 8 - Seismic Design
Chapter 9 - Fire Design
Chapter 10 - Hollow Section Connections
Chapter 11 - Cold-Formed Connections
Chapter 12 - Aluminium Connections
Chapter 13 - Good and bad detailing

Each chapter starts with a brief over-view of the method use in prEN1993-1-8. This is followed by the commonly asked questions together with their answers. In due course the information contained within this document will be put on the Internet and will form part of an easily accessible Internet course for the design, fabrication and erection of structural steelwork connections.

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