ASI LIMIT STATE STEEL CONNECTION DESIGN SERIES – PART 1 – 2007
BACKGROUND AND SUMMARY DETAILS

by
T.J.HOGAN
Consultant & Former Director, SCP Consulting Pty Ltd, Sydney
and
S.A. MUNTER
National Structural Decking Manager, Bluescope Lysaght, Sydney

1. INTRODUCTION

This new Structural Steel Connection Design Series (the Connection Series), authored and published by the Australian Steel Institute (ASI) covers the theory for the design of connection parts including bolting and welding as well as individual connection types. Part 1 of this Connection Series details recommended design procedures and provides basic design capacity tables (DCTs) for simple connections including web side plate, flexible end plate and angle cleat. Detailing parameters are also provided for a range of these simple connections including seated connections commonly used for structural steel in Australia.

Connections have a major engineering and economic importance in steel structures influencing design, detailing, fabrication and erection costs. Standardisation of design approach integrated with industry detailing is the key to minimising costs at each stage. The Connection Series was first released in 1978 at which time connection design theories were developed for the purpose of generating and publishing connection capacity tables. The first three editions were released in permissible stress format. The fourth edition Design of Structural Connections (often referred to as the 'Green Book') was released in 1994 in limit state format but there was no subsequent release of a limit state companion document containing connection design capacity tables.

Part One of this new Connection Series in limit state format to the Australian Standard for Steel Structures AS 4100-1998 (Ref.1) separates the connection theory in Handbook 1 from the Design Guides for each individual connection type. The recommended design model for a connection model theory is referenced back to the Handbook for each type of connection formulated. Revision of the ASI connection detailing was based on surveys of best practice in the Australian steel industry.

2. BACKGROUND

The ASI was formed in 2002 through the merger of the Australian Institute of Steel Construction (AISC) and the Steel Institute of Australia (SIA). The former AISC published a design manual giving guidance on the design of structural connections in steelwork (Ref.2).

The ASI has been updating Reference 2 by way of this Connection Series dealing with individual connections for members of open sections. Part 1, as the first tranche of the series covers simple connections for this category of members. Part 2, as the second tranche will cover rigid connections and other connection types again for members of open sections.

The former AISC also published a manual containing standardised detailing for simple connections, accompanied by load tables (Ref.3). Each individual connection type in the Connection Series contains standardised detailing and design capacity tables for the connection covered by that publication as derived using the recommended design model in that publication. The connections dealt with are those presently in common use in Australia and reflect the types of connections covered within the earlier AISC Standardised Structural Connections (Ref.3).

3. PUBLICATIONS & SCOPE

The Connection Series is to be published in two tranches:

Part 1: Simple Connections – Open Sections, 2007, comprising:

Design capacity tables for structural steel, Volume 3: Simple connections – open sections (Ref.4)

Handbook 1: Design of structural steel connections (Ref.5)

Design Guide 1: Bolting in structural steel connections (Ref.6)

Design Guide 2: Welding in structural steel connections (Ref.7)

Design Guide 3: Web side plate connections (Ref.8)

Design Guide 4: Flexible end plate connections (Ref.9)

Design Guide 5: Angle cleat connections (Ref.10)

Design Guide 6: Seated connections (Ref.11)

4. CONSIDERATIONS IN CONNECTION DESIGN

In structural steel connections, there are two fundamental considerations:

- the connection designer requires a reasonable estimate of connection strength in order that a connection will be economical (not over-designed) and safe (design capacity exceeds design actions); and
- the connection must be detailed in such a way that it is economical to fabricate and erect, while recognising that the connection detailing may have an important impact on the strength of the connection.

Any design model for assessing the strength of a connection must take account of the following four elements:

- the strength of the fasteners (bolts and welds);
- the strength of the connection components (plates, flat bars, angles, gusset plates);
- the strength of the connected member in the vicinity of the connection; and
- the strength of the supporting member in the vicinity of the connection.

Codes for the design of steel structures primarily deal with member design as a whole, rather than specifically allowing for local effects and provide only the basic information on fastener design. No code specifies a detailed design procedure for any type of connection leaving the assessment of how a connection behaves and how its behaviour should be allowed for in design to the individual designer. This presents the designer with a substantial task considering the large number of different connection types that may be encountered, each requiring individual research and assessment. A connection series such as this seeks to assist the designer by providing guidance to reduce the task considerably.

In all types of structural steel, it is the structural steel connections which account for the greater part of the fabrication cost. It could therefore mistakenly lead to placing all the emphasis on minimising steel mass when the greatest potential for economy is in the rationalisation of the connection design and detailing.

The objective of the Connection Series is to provide such a rationalised approach to the design, detailing and fabrication of selected structural steel connections. The benefits of this approach are many, including:

- Providing the designer with a range of safe and economical connections accompanied by design capacity tables;
- Eliminating the need for repetitive computation by structural engineers;
- Allowing scope for the fabricator to produce connection components by production engineering methods and to develop standard jigs and fixtures for assembly;
- Advantages that can be expected to flow from industry rationalisation, such as better communication, better availability of materials and suitable components; and
- Most importantly, a considerable impetus towards improving the economy, and therefore the competitive position of structural steelwork in the Australian building industry.

There is no valid reason for diversity in detailing the selected connections contained in this Connection Series and one of the prime objectives of the ASI approach is to minimise variation by providing only selected connection configurations containing all essential elements for each connection type. The selected connection configurations provided should prove acceptable to designers, fabricators and erectors.

The design capacity tables presented in this Simple Connections DCTs V3 have been developed by adopting selected connection configurations involving:

- steel grade
- connection components
- welds
- bolts
- hole geometry
- bolt pitches
- bolt gauge lines

When using the connection design capacity tables for a selected connection configuration, tedious design calculations are eliminated to a large extent. Certain design checks which relate to the supporting member or to general frame design may still be required.

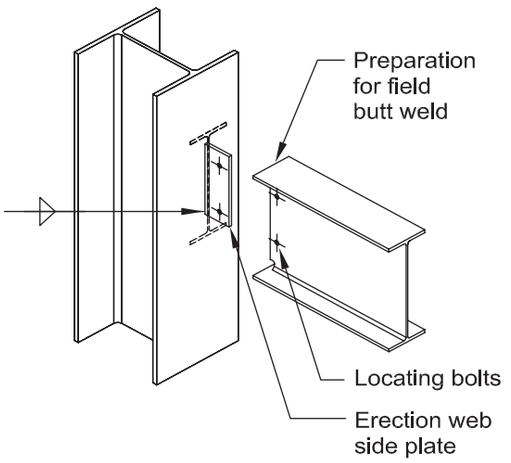
The design capacity tables apply to structural steelwork connections that are essentially statically loaded. Connections subject to dynamic loads or subject to fatigue require additional considerations.

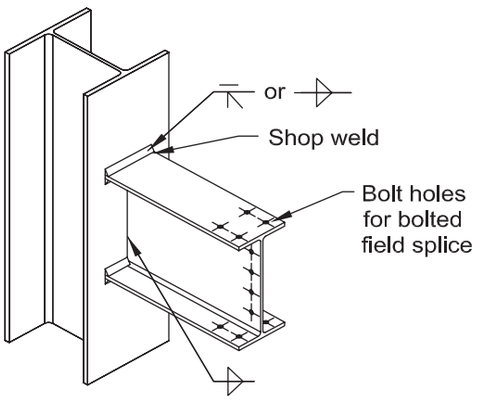
The following connection types have been included in this Simple Connections DCTs, V3 (Fig. 1):

- Web side plate connection (refer Design Guide 3, Ref.8)
- Flexible end plate connection (refer Design Guide 4, Ref.9)

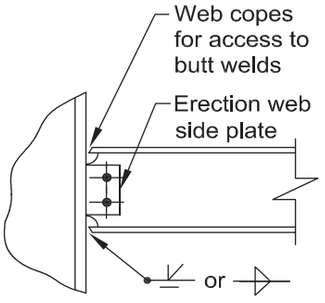
demonstrated experimentally. The connection is then required to be considered as subject to reaction shear forces acting at any eccentricity appropriate to the connection detailing. Examples of simple connections provided in the design capacity tables (Ref.4) include (Fig.1):

Part 2 of the Connection Series will include, amongst other connections those for rigid construction where the connections are assumed to have sufficient rigidity to hold the original angles between the members unchanged. The joint deformations must be such that they have no significant influence on the distribution of the action effects nor on the overall deformation of the frame. Examples of rigid connections to be included in design capacity tables (Ref.5) include (Fig.2.):



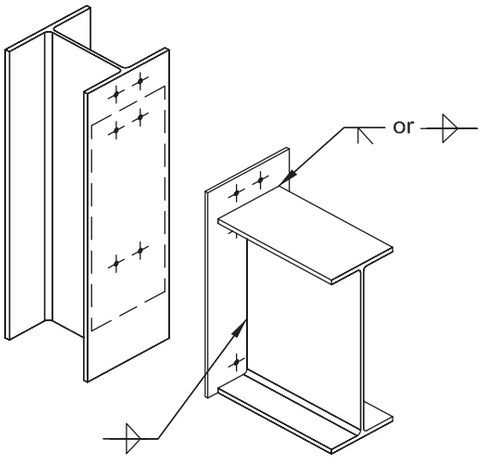


(b) Shop welded stub girder plus bolted field splice



(a) Field welded moment connection

Note:
Erection web side plate - Single side shop fillet
Web of beam - Field butt weld using web side plate as backing plate
Alternatively - Can use double sided shop fillet to web side plate in lieu of web beam field weld



(c) Bolted moment end plate

FIGURE 2. RIGID CONNECTIONS

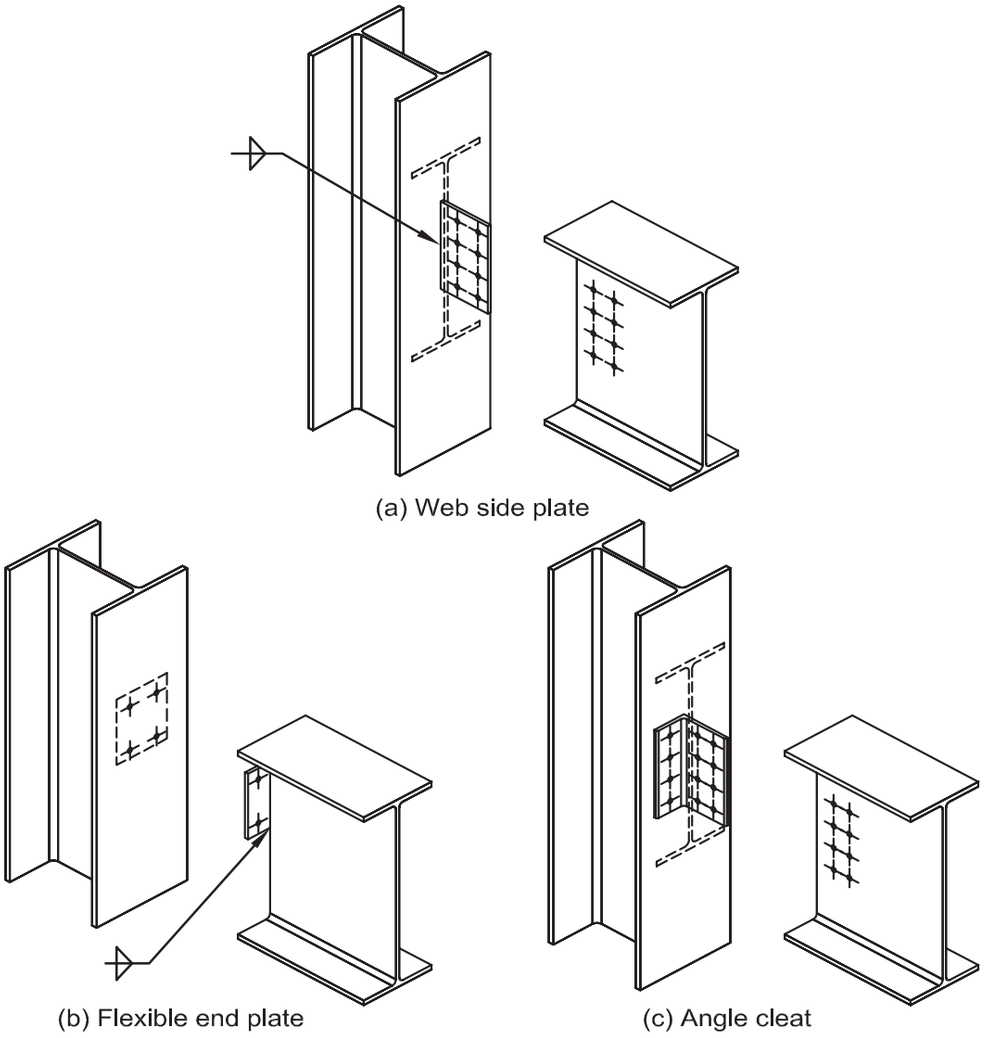


FIGURE 1. SIMPLE CONNECTIONS

Part 2: Rigid & Other Connections – Open Sections will comprise design capacity tables for structural steel - Volume 4: Rigid connections – open sections; Design guides for welded beam to column connections; Bolted moment end plate – beam splice connections; Bolted moment end plate – beam to column connections; as well as Beam splices and Column base plates.

The Connection Series comprises specialist publications devoted to the design of connections in structural steel in accordance with current Australian codes of practice while incorporating the current state of international knowledge of connection behaviour from test results. In some instances, the test evidence is sparse and in other instances the evidence is contradictory or clouded. Each design guide for an individual connection type has been written by weighing the evidence to provide a recommended design model based in part on the design procedures used in equivalent international publications and/or published papers.

Each individual connection type is intended to provide a design model which gives a reasonable estimate of connection design capacity and effort has been expended in researching and developing design models which can be justified on the basis of the available research and current design practice. It is to be emphasised that the design model presented is not the only possible model and attention is drawn to the disclaimer at the beginning of each publication as to its applicability and use.

Part 1 of the Connection Series is for simple construction where the connections at the ends of members are assumed not to develop bending moments. Connections between members in simple construction must be capable of deforming to provide the required rotation at the connection and are required to not develop a level of restraining bending moment which adversely affects any part of the structure. The rotation capacity of the connection must be provided by the detailing of the connection and must have been

- Angle cleat connection (refer Design Guide 5, Ref.10)

All these connections fall into the SIMPLE CONSTRUCTION form of construction permitted by AS 4100 (Ref.1).

GEOMETRIC PARAMETERS

Standard Parameters

STEEL GRADES	
(A) SUPPORTED MEMBERS	GRADE 300 TO AS 3679 (REF.12)
(B) ANGLE COMPONENTS	GRADE 300 TO AS 3679 (REF.12)
(C) FLAT BAR STRIP COMPONENTS	GRADE 300 TO AS 3679 (REF.12)
(D) PLATE COMPONENTS	GRADE 250 TO AS 3678 (REF.13)

Standardised Structural Connections

Bolts

20mm high strength structural bolts to AS 1252 (Ref.14)

22mm diameter holes

Welds

6mm or 8mm fillet welds

E48XX or W50X welding electrodes to the rel evant Australian Standard (Refs 15, 16, 17, 18)

Hole geometry

Bolt pitch	70mm
Bolt gauge	Either 70mm, 90mm or 140mm as required

Other

Several other geometrical aspects. such as cope sizes and edge distances have been standardised. These are detailed in the following tables.

TABLE 1

CONNECTION COMPONENTS ADOPTED

Connection	Component type	Size	Figure	Hole dia. (mm)	Edge distance (mm)
Web side plate	Flat bar or plate	90 x 8 90 x 10 180 x 10	3 3 4	22 22 22	55/35 55/35 55
Flexible end plate	Flat bar or plate	200 x 10 150 x 10	5 5	22 22	30 30
Angle cleat	Equal angle Unequal angle	100 x 100 x 8 EA 150 x 100 x 10 UA	6 7	22 22	35 35

TABLE 2

ADDITIONAL DETAILS OF COMPONENTS

Type	Size	Mass per metre (kg/m)	Actual thickness	Yield stress (MPa)	Tensile strength MPa
Flat bar	90 x 8 90 x 10 180 x 10	5.65 7.06 14.1	8 10 10	320 320 320	440 440 440
Angle	100 x 100 x 8 EA 150 x 100 x 10 UA	11.8 18.0	7.8 9.5	320 320	440 440
Plate	90 x 8 90 x 10 180 x 10	5.65 7.06 14.1	8 10 10	280 260 260	410 410 410