DESIGN GUIDE 11

Welded beam to column moment connections

by

T.J. Hogan

contributing author

N. van der Kreek

first edition-2009



AUSTRALIAN STEEL INSTITUTE (ABN)/ACN (94) 000 973 839

Design Guide 11 Welded beam to column moment connections

Copyright © 2009 by AUSTRALIAN STEEL INSTITUTE

Published by: AUSTRALIAN STEEL INSTITUTE

All rights reserved. This book or any part thereof must not be reproduced in any form without the written permission of Australian Steel Institute.

Note to commercial software developers: Copyright of the information contained within this publication is held by Australian Steel Institute (ASI). Written permission must be obtained from ASI for the use of any information contained herein which is subsequently used in any commercially available software package.

FIRST EDITION 2009 (LIMIT STATES)

National Library of Australia Cataloguing-in-Publication entry:

Hogan, T.J. Design Guide 11: Welded beam to column moment connections

1st ed. Bibliography. ISBN 978 1 921476 12 9 (pbk.). ISBN 978 1 921476 13 6 (pdf.).

- 1. Steel, Structural—Standards Australia.
- 2. Steel, Structural—Specifications Australia.
- 3. Joints, (Engineering)—Design and construction.
- I. van der Kreek, N.
- II. Australian Steel Institute.
- III. Title

(Series: Structural steel connection series).

Also in this series:

Handbook 1: Design of structural steel connections

- Design Guide 1: Bolting in structural steel connections
- Design Guide 2: Welding in structural steel connections
- Design Guide 3: Web side plate connections
- Design Guide 4: Flexible end plate connections

Design Guide 5: Angle cleat connections

Design Guide 6: Seated connections

Design Guide 10: Bolted moment end plate beam splice connections

Design Guide 12: Bolted end plate beam to column moment connections

Design Guide 13: Splice connections

Disclaimer: The information presented by the Australian Steel Institute in this publication has been prepared for general information only and does not in any way constitute recommendations or professional advice. While every effort has been made and all reasonable care taken to ensure the accuracy of the information contained in this publication, this information should not be used or relied upon for any specific application without investigation and verification as to its accuracy, suitability and applicability by a competent professional person in this regard. The Australian Steel Institute, its officers and employees and the authors of this publication do not give any warranties or make any representations in relation to the information provided herein and to the extent permitted by law (a) will not be held liable or responsible in any way; and (b) expressly disclaim any liability or responsibility for any loss or damage costs or expenses incurred in connection with this publication by any person, whether that person is the purchaser of this publication or not. Without limitation, this includes loss, damage, costs and expenses incurred as a result of the negligence of the authors or publishers.

The information in this publication should not be relied upon as a substitute for independent due diligence, professional or legal advice and in this regards the services of a competent professional person or persons should be sought.

This publication originated as part of Design of structural connections First edition 1978 Second edition 1981 Third edition 1988 Fourth edition 1994

ii

CONTENTS

Page

List of figuresivList of tablesvPrefaceviAbout the authorviiAbout the contributing authorviiAcknowledgementsviii			
1	CON0 1.1	CEPT OF DESIGN GUIDES Background	1 1
2	DESC	RIPTION OF CONNECTION	2
3	TYPIC	CAL DETAILING OF CONNECTION	5
4	DETA	ILING CONSIDERATIONS	8
5	AS 41	00 REQUIREMENTS	10
6	BASIS	S OF DESIGN MODEL	11
7	CALC	ULATION OF DESIGN ACTIONS	12
8	RECC SUMN	OMMENDED DESIGN MODEL— MARY OF DESIGN CHECKS	16
9	RECC BEAM 9.1 9.2	DMMENDED DESIGN MODEL— 1 WELDS DESIGN CHECK NO. 1—Design capacity of flange welds to beam DESIGN CHECK NO. 2—Design	19 19
		capacity of web welds to beam	20
10	RECC UNST 10.1	OMMENDED DESIGN MODEL— IFFENED COLUMN DESIGN CHECK NO. 3—Local bending of column flange at beam	22
	10.2	tension flange DESIGN CHECK NO. 4—Local vielding of column web at beam	22
	10.3	tension flange DESIGN CHECK NO. 5—Local yielding of column web at beam	23
	10.4	compression flange DESIGN CHECK NO. 6— Column web crippling at beam	25
	10.5	compression flange DESIGN CHECK NO. 7— Column web compression	26
	10.6	buckling DESIGN CHECK NO. 8— Column web panel in shear	28 29
11	RECO COLU 11.1	DMMENDED DESIGN MODEL— JMNS WITH DOUBLER PLATES DESIGN CHECK NO. 9—Local bending of column flange with flange doubler plates at beam tension flange	30 30

		Page
11.2	DESIGN CHECK NO. 10—Local yielding at beam tension flange of	:
11.3	DESIGN CHECK NO. 11—Local yielding at beam compression	31
11.4	doubler plate(s) DESIGN CHECK NO. 12— Crippling of column web with	32
11.5	doubler plate(s) at beam compression flange DESIGN CHECK NO. 13—	34
11.6	Compression buckling of column web with doubler plate(s) DESIGN CHECK NO 14-	36
11.0	Shear on column web panel with doubler plate(s)	38
12 RECO	DMMENDED DESIGN MODEL	
STIFF 12.1	ENERS DESIGN CHECK NO. 15—	40
12.2	stiffeners at tension flange DESIGN CHECK NO. 16—	40
12.3	column with transverse stiffeners at compression flange DESIGN CHECK NO. 17—	42
	Column with transverse diagonal shear stiffeners	44
13 ADDI	TIONAL CONSIDERATIONS	46
14 ECO	NOMICAL CONSIDERATIONS	47
15 DESI 15.1	GN EXAMPLES Design example 1—Beam on	48
15.2	one side of column Design example 2—Beams on	48
	both sides of column	54
16 REFE	RENCES	58
17 DESI 17.1	GN CAPACITY TABLES Configuration A—Full penetration	59
17.2	butt welds to flanges and webs Configuration B—Fillet welds required to develop section	60
17.3	moment capacity Configuration C–Fillet welds to flanges and web	62 64
A B	Limcon software ASI Design Guide 9	66



comment form

iii

73

LIST OF FIGURES

Page

Figure 1	Typical welded beam to column moment connection 2
Figure 2	Alternative arrangements for welded beam to column connections
Figure 3	Arrangement with shop welded beams and column splices
Figure 4	Possible configurations of the welded moment beam to column connection
Figure 5	Stub girder connection, fully shop welded beam stub, beam spliced on site
Figure 6	Field welded moment connection— including erection cleat
Figure 7	Column doubler plate types and column flange replacement alternative
Figure 8	Column stiffener types7
Figure 9	Stiffener detailing
Figure 10	Design actions on beam at column 12
Figure 11	Calculation of flange forces due to bending moment and axial force— Beam at right angles to column 13
Figure 12	Calculation of forces on column elements where beam is inclined upwards at column
Figure 13	Alternative stress distributions in beam due to design bending moment
Figure 14	Column and beam dimensions used in design model 17
Figure 15	Stiff bearing dimension <i>b</i> _{sc} used in design model
Figure 16	Summary of DESIGN CHECK locations on column
Figure 17	Flange weld design actions 19
Figure 18	Web weld design actions 21
Figure 19	Application of <i>c</i> _t term—Local bending at tension flange
Figure 20	Application of c_t term—Column web yielding at beam tension flange 23
Figure 21	Angle of dispersion used in DESIGN CHECK NO. 4 and NO. 5 24

	Page
Figure 22	Dispersion arrangement used in DESIGN CHECK NO. 724
Figure 23	Application of <i>c</i> _t term—Column web yielding at beam compression flange
Figure 24	Case I arrangement
Figure 25	Case II and Case III arrangement27
Figure 26	Examples of web panel shear conditions
Figure 27	Column flange doubler plate details at beam tension flange30
Figure 28	Column web doubler plate details at beam tension flange31
Figure 29	Column web doubler plate detail at beam compression flange.32
Figure 30	Web doubler plate—Welds to column flange
Figure 31	Case I arrangement34
Figure 32	Case II and Case III arrangement34
Figure 33	Column web doubler plate details at beam compression flange35
Figure 34	Column web doubler plate details for compression buckling37
Figure 35	Column web doubler plate details for shear
Figure 36	Tension stiffener arrangement40
Figure 37	Compression stiffener details42
Figure 38	Diagonal shear stiffener arrangements45
Figure 39	Transverse stiffener options when beam flanges are offset due to unequal beam depths46
Figure 40	Design example no. 1—Beam on one side of column
Figure 41	Shear stiffener geometry52
Figure 42	Design example no. 1—Beam on one side of column—Alternative detailing to Figure 4053
Figure 43	Design example no. 2—Beams on both sides of column54
Figure 44	Stress distribution in beam #2 due to 180 kNm55



iv

LIST OF TABLES

Page

Table 1	Equations to be applied for different configurations and connection elements
Table 2	Stiffener material design strengths 41
Table 3	Universal beams Grade 300— Design section moment and
	web capacities
Table 4	Welded beams Grade 300— Design section moment and web capacities
Table 5	Universal beams Grade 300— Weld configurations to achieve design section moment
	capacity \$\phi_s\$

	Page
Table 6	Welded beams Grade 300— Weld configurations to achieve design section moment capacity ϕM_s 63
Table 7	Universal beams Grade 300— Design moment capacity of welded connection with 10 mm flange fillet welds and 8 mm web welds
Table 8	Universal beams Grade 300— Design moment capacity of welded connection with8 mm flange fillet welds and 6 mm web welds



v V

PREFACE

This new series of connection publications by the Australian Steel Institute (ASI) covering capacity tables, theory and design of individual rigid connections will be known as the Structural Steel Connections Series, Part 2: 1st ed. 2009 ('Connection Series, Part 2'). This Connection Series, Part 2 details the method of design and provides capacity tables and detailing parameters for a range of rigid 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 minimum costs at each stage. This Connections Series, Part 2 in conjunction with the Connection Series, Part 1 for simple connections (collectively the Structural Steel Connections Series or 'Connection Series') replaces and enhances an ASI flagship publication first released in 1978 at which time connection design theories were developed for the purpose of generating and releasing 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.

This Design Guide is intended to provide a recommended design model for the welded moment connection, which is a rigid connection in terms of AS 4100 provisions. In general, most design models for this connection in the technical literature are similar, any notable differences revolving around the design of the column stiffening.

The recommended design model is based extensively on the American Institute of Steel Construction Steel Design Guide 13 'Stiffening of wide-flange columns at moment connections : Wind and seismic applications'.

The new Connections Series format with separate design guides for individual connection types is intended to facilitate addition to or revision of connection model theory using relevant new local or international research as deemed appropriate by the ASI. Connection models developed using the Handbook 1 theory follow a stylised page format with a numbered DESIGN CHECK procedure to simplify connection capacity assessment.

Engineering Systems has worked closely with the Australian Steel Institute to further develop Limcon as the companion program for this new Connection Design Guide Series. The latest version of Limcon fully implements the new connection design models and it was employed in checking the design tables. The Limcon output for the worked examples is included in an appendix to each Design Guide. The program is an efficient tool covering the full range of structural connections, including those beyond the scope of the Design Guide capacity tables.

An appendix to each Design Guide also contains an ASI comment form. Users of this publication are encouraged to photocopy this one page form and forward any suggested improvements which may be incorporated into future editions.

T.J. Hogan N. van der Kreek



vi

ABOUT THE AUTHOR

Tim Hogan is Consultant to and Retired Director of SCP Consulting Pty Ltd. His academic achievements include a Bachelor of Engineering from the University of NSW with 1st Class Honours and the University Medal. Post graduate qualifications include a Master of Engineering Science and a Master of Business Administration. Tim is a Member of the Institution of Engineers Australia with CPEng and FIE Aust. status.

His early experience was on bridge design and construction with the NSW Public Works Department and subsequently as Development Engineer and then Engineering Manager with the Australian Institute of Steel Construction until 1980. Consulting experience with SCP Consulting since 1980 has included design and supervision of large steel framed buildings, industrial buildings, mill buildings, retail developments, defense infrastructure and composite steel-concrete buildings. His published works deal primarily with the areas of composite construction, steel connections, fabrication and erection of steel structures and he was a major contributor and editor of the Commentary to AS 4100. He is a member of a number of Standards Australia Committees dealing with steel and composite structures and is currently Chairman of Committee BD-001 Steel Structures and BD-032 Composite Construction. He received an award from Standards Australia for his contributions to writing of Australian Standards.

ABOUT THE CONTRIBUTING AUTHOR

Nick van der Kreek is OneSteel Manufacturing's Technical Development Manager and has held various technical and marketing roles during his 22 years with OneSteel (BHP Steel prior to 2000). Nick's activities included engineering development and design support associated with composite and steel framed building solutions—either of a generic nature or specific designs for many notable Australian multi-storey buildings. Nick is the principal author of the OneSteel composite software.

Nick has a BE from the University of Queensland and a Graduate Diploma in Computing from the University of Melbourne.



ACKNOWLEDGEMENTS

This publication is an Australian Government funded initiative under the Industry Cooperative Innovation Program.

The author would like to extend special thanks to:

The ASI Connections steering committee consisting of Richard Collins (Engineering Systems), Nick van der Kreek and Anthony Ng (OneSteel Market Mills), Arun Syam (Australian Tube Mills) for their respective contributions with the development and review of the technical and editorial content of the revised ASI Connection Manual.

Significant contributions were made by:

- Richard Collins—Engineering Systems in the development and upgrade of the Limcon software code in parallel with the design theory and aiding in the editing and validation of the revised models.
- Biometrical Data Processing for technical typesetting expertise.
- Whizzcad Pty Ltd with drafting and graphics for publishing.
- ASI State Engineering & Construction special Sub-Committees for progressive engineering and industry review of manuscripts.

Together with support of:

• All facets of the ASI membership including design engineers, steelwork detailers and fabricators in contributing industry best practice and standards through ASI surveys and direct consultation to establish the theory and geometry in this new ASI Connection Manual.

