

Design Guide 7
Pinned base plate connections for columns
by

T.J. Hogan

first edition—2011



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

Design Guide 7
Pinned base plate connections for columns

Copyright © 2011 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 2011 (LIMIT STATES)

National Library of Australia Cataloguing-in-Publication entry:

Hogan, T.J.

Design Guide 7: Pinned base plate connections

1st ed.

Includes bibliographic references.

ISBN 978 1 9214762 4 2 (pbk.).

Steel, Structural—Standards – Australia.

Steel, Structural—Specifications – Australia.

Joints (Engineering)—Design and construction.

Australian Steel Institute.

(Series: Structural steel connections series).

This publication originated as part of

Design of structural connections

First edition 1978

Second edition 1981

Third edition 1988

Fourth edition 1994

Also in this series:

Design capacity tables for structural steel. Volume 3: Simple connections—Open sections

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 11: Welded beam to column moment connections

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

Design Guide 13: Splice connections

Design capacity tables for structural steel. Volume 4: Rigid connections—Open sections

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 and editors 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, editors 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 regard the services of a competent professional person or persons should be sought.



CONTENTS

	<i>Page</i>		<i>Page</i>
List of figures	iv	9.4 DESIGN CHECK NO. 4—Design capacity for horizontal shear transfer by friction at base plate/concrete interface	35
List of tables	v	9.5 DESIGN CHECK NO. 5—Design capacity for horizontal shear transfer by bearing of embedded steel column	36
Preface	vi	9.6 DESIGN CHECK NO. 6—Design capacity for horizontal shear transfer through shear key	38
About the author	vii	9.7 DESIGN CHECK NO. 7—Design capacity for horizontal shear transfer through anchor bolts	40
Acknowledgements	viii		
1 CONCEPT OF DESIGN GUIDES.....	1	10 RECOMMENDED DESIGN MODEL—	
1.1 Background	1	AXIAL TENSION AND SHEAR.....	43
2 DESCRIPTION OF CONNECTION	2	10.1 DESIGN CHECK NO. 8—Design capacity of steel base plate	43
3 TYPICAL DETAILING OF CONNECTION..	4	10.2 DESIGN CHECK NO. 9—Design capacity of weld at column base	51
4 DETAILING CONSIDERATIONS.....	6	10.3 DESIGN CHECK NO. 10—Design capacity of anchor bolts in tension	52
4.1 Base plate dimensions for open sections	6	10.4 DESIGN CHECK NO. 5	56
4.2 Base plate detailing	8	10.5 DESIGN CHECK NO. 6	56
4.3 Anchor bolt detailing	11	10.6 DESIGN CHECK NO. 7	56
5 CODE REQUIREMENTS	14	10.7 DESIGN CHECK NO. 11—Design capacity for horizontal shear and tension applied to anchor bolts	57
6 BASIS OF DESIGN MODEL.....	15	11 DESIGN EXAMPLES	58
6.1 Axial compression	15	11.1 Axial compression and shear—Design Example No. 1	58
6.2 Horizontal shear	17	11.2 Axial compression or axial tension and shear—Design Example No. 2	62
6.3 Anchor bolts in shear	19	12 REFERENCES.....	67
6.4 Axial tension	21	APPENDICES	
6.5 Anchor bolts in tension	24	A Limcon software	69
6.6 Anchor bolts subject to tension and shear simultaneously	26	B ASI Design Guide 13 comment form	76
7 CALCULATION OF DESIGN ACTIONS ...	27		
8 RECOMMENDED DESIGN MODEL—SUMMARY OF DESIGN CHECKS.....	28		
9 RECOMMENDED DESIGN MODEL—AXIAL COMPRESSON AND SHEAR	29		
9.1 DESIGN CHECK NO. 1—Design capacity for bearing on concrete support	29		
9.2 DESIGN CHECK NO. 2—Design capacity of steel base plate	32		
9.3 DESIGN CHECK NO. 3—Design capacity of weld at column base	34		



LIST OF FIGURES

	<i>Page</i>		<i>Page</i>
Figure 1	Typical pinned column base plates..... 2	Figure 22	Effective tensile areas to free edges37
Figure 2	Typical detailing of pinned column base plates for open sections..... 4	Figure 23	Shear key detail.....39
Figure 3	Typical detailing of pinned column base plates for hollow sections..... 5	Figure 24	Dimensions of shear key39
Figure 4	Use of steel shims 9	Figure 25	Shear key to resist shear force in two directions39
Figure 5	Shear key details 9	Figure 26	Break-out cone assumptions41
Figure 6	Tolerances permitted by AS 4100 in anchor bolt location 10	Figure 27	Reinforcement to failure cone of anchor bolt subject to shear force42
Figure 7	Varieties of cast-in anchor bolts.... 12	Figure 28	Yield line layout near the bolt hole.....46
Figure 8	Caged anchor bolt arrangement ... 13	Figure 29	Geometry for RHS/SHS base plate bolts on two sides only.....47
Figure 9	Cored hole detail around anchor bolt..... 13	Figure 30	Geometry for RHS/SHS base plate bolts on four sides48
Figure 10	Assumed loaded area for base plate subject to axial compression—cantilever method.. 16	Figure 31	Geometry for RHS/SHS base plate bolts in four corners only.....49
Figure 11	Assumed loaded area for Murray-Stockwell Method 16	Figure 32	Geometry for circular CHS base plate50
Figure 12	Stress distribution on shear key.... 18	Figure 33	Concrete breakout cone for single anchor bolt53
Figure 13	Effective width of base plate resisting bending 21	Figure 34	Concrete breakout cone for anchor bolt group54
Figure 14	Murray yield line approach..... 22	Figure 35	Concrete breakout cone for anchor bolt near edge54
Figure 15	Failure plane for anchor bolt pull-out used in references 2 and 8 24	Figure 36	Lateral bursting force for anchor bolts subject to tension and near an edge55
Figure 16	Anchor bolt failure surfaces—bolt subject to tension 25	Figure 37	Steel reinforcement to anchor bolts subject to tension55
Figure 17	Design actions on column bases .. 27	Figure 38	Design example 1 axial compression and shear58
Figure 18	Base plate dimensions and assumed loaded area of base plate (shown shaded) for open sections—Cantilever method..... 29	Figure 39	Concrete pier tie reinforcement61
Figure 19	Base plate dimensions and assumed loaded area of base plate (shown shaded) for closed sections—Cantilever method..... 30	Figure 40	Design example 2 axial compression or axial tension and shear62
Figure 20	Murray-Stockwell model—assumed shape of pressure distribution 31	Figure 41	Concrete breakout cone for single anchor bolt66
Figure 21	Column embedment detail 36	Figure 42	Concrete breakout cones for anchor bolt group66



LIST OF TABLES

		<i>Page</i>			<i>Page</i>
Table 1	Base plate dimensions universal beam and column sections	6	Table 7	Design variables for axial compression	33
Table 2	Base plate dimensions parallel flange channel sections	7	Table 8	Minimum concrete edge distances Grade 4.6 bolts/ Grade 250 rods	41
Table 3	Base plate dimensions welded beam and column sections	7	Table 9	Design parameters—I-section with 2 bolts	43
Table 4	Recommended sizes of anchor bolt holes and washers in base plates	10	Table 10	Design parameters—I-section with 4 bolts	44
Table 5	Strength of plate to AS 3678 Grade 250	32	Table 11	Design parameters—PFC section with 2 bolts	45
Table 6	Design dimensions for axial compression	32			



PREFACE

Design Guide 7 forms part of a series of connection publications by the Australian Steel Institute (ASI) covering capacity tables, theory and design of individual simple connections, known as the Structural Steel Connections Series, Part 1, Simple Connections: 1st ed. 2007 ('Simple Connection Series'). This series details the method of design and provides capacity tables and detailing parameters for a range of simple connections commonly used for structural steel in Australia. Connections have a major engineering and economic importance in steel structures influencing design, detailing, fabricating and erection costs. Standardisation of design approach integrated with industry detailing is the key to minimum costs at each stage. The Simple Connections Series, in conjunction with the Structural Steel Connection Series, Part 2, Rigid 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.

The current 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.

DESIGN GUIDE 7 covers the pinned column base plate connection. The recommended design model draws extensively on the American Institute of Steel Construction Steel Design Guide 1 '*Base plate and anchor rod design*' Second Edition and on the Australian Steel Institute publication Steel Construction Vol. 36 No. 2, September 2002, '*Design of pinned column base plates*'.

It is to be emphasised that the recommended design model is considered the most representative of the behaviour of the connection in the opinion of ASI. It is not intended to suggest that other design models may not result in adequate connection capacity.

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. The Limcon output for one or more of 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



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 (Ret.) and FIEAust 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 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.

