

**Tubular Design Guide 20:  
Background and design basis**

**by**

**P.W. Key**

**and**

**A.A. Syam**

**first edition - 2014**



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

**Tubular Design Guide 20:  
Background and design basis**

Copyright © 2014 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 2014 (LIMIT STATES)

National Library of Australia Cataloguing-in-Publication entry:

Key, Peter W.

Tubular Design Guide 20: Background and design basis / Peter W. Key, Arun A. Syam

ISBN 978 1 921476 29 7 (pbk.).

Series: Structural tubular connection series.

Includes bibliographical references.

Steel, Structural—Standards - Australia.

Structural engineering.

Syam, Arun A.

Australian Steel Institute.

624.1821021894

Also in this series:

Tubular Design Guide 21: Bolted bracing connections

Tubular Design Guide 22: Bolted bracing cleats

Tubular Design Guide 23: Plate fitments

Tubular Design Guide 24: Bolted planar connections

Tubular Design Guide 25: Fully welded – Simple planar connections

Tubular Design Guide 26: Fully welded – Gap planar connections

Tubular Design Guide 27: Fully welded – Overlap planar 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 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 regards the services of a competent professional person or persons should be sought.



# CONTENTS

	<i>Page</i>		
<i>List of figures</i>	<i>iv</i>	4.4.2 Flat bar material	27
<i>List of tables</i>	<i>v</i>	4.4.3 Design yield stress for Australian produced plate material	27
<i>Preface</i>	<i>vi</i>	4.5 Bolt types and bolting categories	28
<i>About the authors</i>	<i>vii</i>	4.6 Properties of bolts	29
<i>Acknowledgements</i>	<i>viii</i>	4.7 Weld types	31
1 CONCEPT OF DESIGN GUIDES	1	4.8 Properties of welds	33
1.1 Background	1	4.9 International material sourcing	36
2 BASIS OF SSHS CONNECTION DESIGN TO AS 4100	2	4.9.1 Background	36
2.1 General considerations	2	4.9.2 Material perspectives	36
2.2 Forms of construction	3	4.9.3 Product perspectives	37
2.3 Connection design models	5	4.9.4 Bolt sourcing	37
2.4 Connection characteristics	6	4.9.5 Welding consumables	38
2.5 Connection terminology	9	4.9.6 Product compliance	38
2.6 Fatigue considerations	10	4.9.7 Sample tests of imported product	39
2.7 Seismic considerations	11	4.9.8 Third-party product certification	40
3 BACKGROUND TO SSHS IMPLEMENTATION	12	5 DESIGN CAPACITIES	42
3.1 Advantages of SSHS for construction	12	5.1 Bolt design capacity	42
3.2 Australian production	13	5.2 Weld design capacity–Fillet welds	44
3.2.1 Background	13	5.3 Weld design capacity – Pre-engineered welds	47
3.2.2 Cold-formed manufacturing process	13	5.3.1 Stress distribution in profiled fully welded SSHS connections	47
3.2.3 Section availability	14	5.3.2 Prequalified fillet weld throat thickness	47
3.2.4 Material properties	14	5.3.3 Weld matching	49
3.3 International design context	15	5.4 Other connector types	54
3.4 Australian design context	16	5.5 Section design capacity	56
3.5 International research	17	5.5.1 Design section capacity in axial tension	56
3.6 Books and design manuals	18	5.5.2 Design section capacity in axial compression	56
4 MATERIAL AND SECTION PROPERTIES	19	5.5.3 Design section moment capacity	57
4.1 Properties of Australian SSHS	19	5.5.4 Design shear capacity of a web	57
4.1.1 Applicable standards	19	5.6 Component design capacities	59
4.1.2 Material properties	19	5.6.1 General	59
4.2 Australian SSHS section sizes	20	5.6.2 Design capacity in axial tension for rectangular component	59
4.3 Design aspects related to Australian SSHS	21	5.6.3 Design shear capacity of rectangular component	60
4.3.1 Influence of higher strength steel on SSHS connection design	21	5.6.4 Design moment capacity of rectangular component	60
4.3.2 Influence of yield to ultimate tensile strength ratio on SSHS connection design	21	5.6.5 Design capacity in axial compression for rectangular component	61
4.3.3 Design yield stress for Australian produced SSHS	22	5.6.6 Design capacity against rupture due to block shear failure for rectangular component	62
4.3.4 Section classification	23		
4.4 Properties of plate materials	26		
4.4.1 Plate material	26		



	<i>Page</i>		<i>Page</i>
6 DESIGN ACTIONS	65	8.4 Truss design	81
6.1 Minimum design actions	65	8.4.1 Effective length for compression members	81
7 DETAILING AND STANDARDISATION	67	8.4.2 Guidance on member selection	81
7.1 Detailing of SSHS connections	67	8.4.3 Suggested truss design procedure	82
7.1.1 Drainage and corrosion	67	8.5 Truss deflections	84
7.1.2 Galvanizing	68	8.5.1 Truss deflections	84
7.1.3 Recommended weld details	68	9 FUTURE DESIGN GUIDES	85
7.1.4 General design considerations	69	9.1 Planned future design guides	85
7.2 Tolerances	71	10 REFERENCES	86
7.3 Standardisation and rationalisation	72	11 NOTATION AND ABBREVIATIONS	90
8 TRUSS DESIGN CONSIDERATIONS	74	APPENDICES	
8.1 Context	74	A SSHS section sizes	100
8.1.1 Scope	74	B Limcon software	114
8.2 Classification of connections	75	C ASI Design Guide comment form	115
8.2.1 Connection classification	75		
8.3 Truss analysis	79		
8.3.1 Analysis model configuration	79		

## LIST OF FIGURES

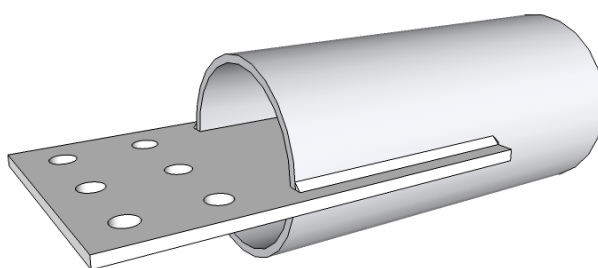
	<i>Page</i>		<i>Page</i>
Figure 2.1 Typical rigid connections	4	Figure 5.8 Rectangular connection component geometry	59
Figure 2.2 Typical semi-rigid connections	4	Figure 5.9 Rectangular component bent about major axis	61
Figure 2.3 Typical simple connections	4	Figure 5.10 Rectangular component bent about minor axis	61
Figure 2.4 Moment-rotation characteristics of typical connections	6	Figure 5.11 Examples of block shear failure in components	62
Figure 2.5 Boundaries for stiffness calculation for beam-to- column connections	7	Figure 5.12 Block shear area in components	63
Figure 2.6 Definition of connection elements	9	Figure 5.13 Block shear failure planes inclined to the direction of the applied load	64
Figure 3.1 Typical cold-formed SSHS manufacturing process	14	Figure 7.1 Detailing of open and sealed connections	67
Figure 4.1 Definition of element width for RHS flanges	25	Figure 7.2 Recommended weld details	69
Figure 4.2 Common structural weld types in AS 4100	31	Figure 7.3 Definition of gap and overlap connections	70
Figure 5.1 Design throat thickness of fillet welds	46	Figure 7.4 Definition of bolt hole detailing dimensions	72
Figure 5.2 Non-uniform stress distribution around connected face of SSHS brace member	47	Figure 8.1 Various types of truss configuration	74
Figure 5.3 Resolution of forces on throat of fillet weld	48	Figure 8.2 Various connection types	75
Figure 5.4 Connection configurations for checking weld matching	51	Figure 8.3 Examples of connection classification	77
Figure 5.5 Lindapter hollobolt configuration	54	Figure 8.4 Classification of KT connections	78
Figure 5.6 Huck ultra-twist process	54	Figure 8.5 Planar truss connection modelling assumptions	80
Figure 5.7 Flowdrill process	55	Figure 8.6 Limits of noding eccentricity	80



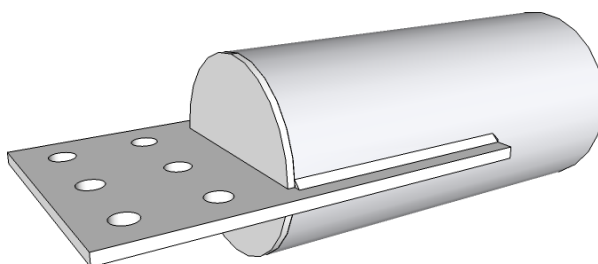
**7.1.1 Drainage and corrosion**

The interior of hollow section members may be either fully sealed by the connection details or by purpose configured seal plates, or may be left open. Both scenarios are illustrated in Figure 7.1 for the case of a slotted SSHS end connection. The decision as to the appropriate solution is influenced by a number of factors, including the intended environment for the finished member:

1. Fully (i.e. hermetically) sealed members ensure that the environment inside the SSHS member remains benign, precluding the supply of fresh oxygen that is required for continuing corrosion. However, the sealing must be effective, otherwise small holes and cracks can allow surprisingly large amounts of water to enter the SSHS member. In particular in cold and wet environments where freezing is likely, the SSHS may be split at the corners by the pressure of freezing water. A solution is to place a minimum nominal 10 mm diameter hole in a location that allows water to drain. The small amount of oxygen replenishment in these cases results in only a small amount of oxidation internally.
2. SSHS members with purpose open ends, such as shown in Fig. 7.1(a) may be used in benign internal environments where only very nominal internal corrosion would be expected.



(a) Section with open end



(b) Section with sealed end

**FIGURE 7.1 DETAILING OF OPEN AND SEALED CONNECTIONS**

### 7.1.2 Galvanizing

During galvanizing, fabricated steel members and assemblies are dipped into a molten zinc bath that is at an approximate temperature of 450°C for about 5 minutes. SSHS members which would otherwise have internal volumes that are sealed must have specific vent and draining holes detailed to ensure heated expanding air can escape and with a sufficient hole size for the molten zinc to drain. Hole size is based on the sectional size of the member, with suggested sizes given in Table 7.1, rationalised from galvanizer recommendation to hard metric sizes (Ref. 58). CIDECT Design Guide 7 (Ref. 65) also provides some guidance on preparation for galvanizing. Further information can also be obtained from the Galvanizer Association of Australia ([www.gaa.com.au](http://www.gaa.com.au)) and the Galvanizing Association of New Zealand ([www.galvanizing.org.nz](http://www.galvanizing.org.nz)).

**TABLE 7.1**  
**SIZE OF VENT AND DRAIN HOLES FOR GALVANIZING SSHS MEMBERS**

CHS nominal bore (mm)	RHS size (mm)	SHS size (mm)	Vent hole diameter (mm)	
			Single hole	Double hole
50			12	2 x 10
65	50 x 20	50 x 50	16	2 x 12
80	75 x 50	65 x 65	20	2 x 14
100	100 x 50	75 x 75	25	2 x 18
125	125 x 75	100 x 100	32	2 x 22
150	150 x 100	125 x 125	38	2 x 27
200	200 x 100	150 x 150	50	2 x 35
250	250 x 150	200 x 200	63	2 x 45
300	300 x 200	250 x 250	75	2 x 54
350	350 x 250	300 x 300	88	2 x 63
400	400 x 300	350 x 350	100	2 x 70

NOTE: For member sizes smaller than listed, use a minimum 10 mm diameter vent hole.

### 7.1.3 Recommended weld details

Figure 7.2 illustrates a range of recommended weld details for various locations on different connection configurations. Note the limitation on the minimum angle between the brace and chord member. Clause 4.5 of AS/NZS 1554.1 (Ref. 33) provides further guidance on prequalified joint preparations, including specific requirements for hollow section members.

