



# Architecture and Construction in Steel

Edited by Alan Blanc,  
Michael McEvoy  
and Roger Plank

The  
Steel Construction  
Institute



**E & FN SPON**  
An Imprint of Chapman & Hall

**Published by**  
**E & FN Spon, an imprint of Chapman & Hall, 2-6 Boundary Row,**  
**London SE1 8HN**

---

Chapman & Hall, 2-6 Boundary Row, London SE1 8HN, UK

Blackie Academic & Professional, Wester Cleddens Road, Bishopriggs,  
Glasgow G64 2NZ, UK

Chapman & Hall Inc., One Penn Plaza, 41st Floor, New York, NY 10119,  
USA

Chapman & Hall Japan, Thomson Publishing Japan, Hirakawacho Nemoto  
Building, 6F, 1-7-11 Hirakawa-cho, Chiyoda-ku, Tokyo 102, Japan

Chapman & Hall Australia, Thomas Nelson Australia, 102 Dodds Street,  
South Melbourne, Victoria 3205, Australia

Chapman & Hall India, R. Seshadri, 32 Second Main Road, CIT East,  
Madras 600 035, India

---

First edition 1993

©1993 The Steel Construction Institute

Typeset in 9/11pt Bembo by Type Study, Scarborough, North Yorkshire  
Printed and bound in Great Britain at the University Press, Cambridge

ISBN 0 419 17660 8

Apart from any fair dealing for the purposes of research or private study, or criticism or review, as permitted under the UK Copyright Designs and Patents Act, 1988, this publication may not be reproduced, stored, or transmitted, in any form or by any means, without the prior permission in writing of the publishers, or in the case of reprographic reproduction only in accordance with the terms of the licences issued by the Copyright Licensing Agency in the UK, or in accordance with the terms of licences issued by the appropriate Reproduction Rights Organization outside the UK. Enquiries concerning reproduction outside the terms stated here should be sent to the publishers at the London address printed on this page.

The publisher makes no representation, express or implied, with regard to the accuracy of the information contained in this book and cannot accept any legal responsibility or liability for any errors or omissions that may be made.

A catalogue record for this book is available from the British Library

#### **Library of Congress Cataloging-in-Publication data**

Architecture and construction in steel/edited by A. Blanc, M.  
McEvoy, R. Plank.

p. cm.

Includes bibliographical references and indexes.

ISBN 0-419-17660-8

I. Building, Iron and steel. 2. Building, Iron and steel—case studies. I. Blanc, A. (Alan) II. McEvoy, M. (Michael)

III. Plank, R. (Roger)

TH1611.A73 1992

691'.7—dc20

92-6490

CIP

# Contents

<b>List of contributors</b>	<b>xi</b>	3.3 Specifications for structural steels	
<b>Preface</b>	<b>xv</b>	3.4 Cold worked steels	
<b>Acknowledgements</b>	<b>xvii</b>	3.5 Heat treated steels	
<b>Introduction</b>		3.6 Welding	
<i>Derek Sugden</i>	<b>1</b>	3.7 Bolting	
		3.8 Miscellaneous properties of steel	
 		<b>4 Structural steel components for buildings</b>	<b>57</b>
<b>Part One</b>		<i>Keith Moores</i>	
<b>History of Iron and Steel Construction</b>		4.1 Introduction to shaping steel	
		4.2 Manufacturing methods	
<b>1 The 19th century</b>	<b>15</b>	4.3 Tubular sections	
<i>Dennis Sharp</i>		4.4 Cables, ropes and couplings	
1.1 Introduction		<b>5 Sheet and strip</b>	<b>67</b>
1.2 Cast and wrought iron		<i>Eric Hindhaugh</i>	
1.3 Forth Railway Bridge: first steel structure		5.1 Introduction	
1.4 Mill buildings in Britain		5.2 Historical review	
1.5 Chicago style		5.3 Manufacture of steel sheeting	
1.6 Iron's great symbol: the Eiffel Tower		5.4 Metallic coatings	
1.7 Kings Cross/St Pancras stations		5.5 Organic coatings	
1.8 European pioneer ironwork		5.6 Making profiled sheet	
1.9 The Crystal Palace and its significance		5.7 Durability and maintenance	
<b>2 The 20th century</b>	<b>33</b>	5.8 Other applications	
<i>Dennis Sharp</i>		<b>6 Stainless and related steels</b>	<b>77</b>
2.1 Introduction		<i>D. J. Cochrane</i>	
2.2 Mechanization and nature		6.1 Introduction	
		6.2 Applications	
<b>Part Two</b>		6.3 Material grades	
<b>Materials</b>		6.4 Surface finishes	
<b>3 Properties of steel</b>	<b>47</b>	6.5 Corrosion resistance of stainless steel	
<i>W. D. Biggs</i>		6.6 Maintenance	
3.1 Introduction		6.7 Summary	
3.2 Mechanical properties		<b>7 Nature of corrosion</b>	<b>91</b>
		<i>Yvonne Dean</i>	
		7.1 Introduction	
		7.2 World economic factors	

- 7.3 The effects of corrosion
- 7.4 Chemistry of corrosion
- 7.5 Exposure problems
- 8 Anti-corrosion measures**  
*K. A. Chandler (with contribution on weathering steels by Keith Moores)* 97
- 8.1 Introduction
- 8.2 Design
- 8.3 Surface preparation of steel
- 8.4 Paint coatings
- 8.5 Metal coatings
- 8.6 Other coatings
- 8.7 Performance and weathering
- 8.8 Costs
- 8.9 Maintenance
- 8.10 Selection of coating systems
- 8.11 Weathering steels *A. Keith Moore*
- 9 Fire protection**  
*J. T. Robinson* 107
- 9.1 Introduction
- 9.2 Building regulations
- 9.3 Protection of structural members
- 9.4 Design for fire resistance
- 9.5 Tubular structures (with filled tubes, water or concrete)
- 9.6 External frames
- 9.7 Fire engineering  
 Appendix
- Part Three**  
**Principles of Steel Framing**
- 10 The architecture of steel**  
*Patrick Morreau* 121
- 10.1 Introduction
- 10.2 Structural steel and architectural design
- 10.3 Functional advantages
- 10.4 Economic considerations
- 10.5 Designing for steel
- 11 Basic theory of framing**  
*John Le Good (with contributions by David Harriss)* 131
- 11.1 Introduction
- 11.2 General strategy
- 11.3 Environmental factors
- 11.4 Plan variations
- 11.5 Roofs and roofing
- 11.6 Structural loading
- 11.7 Structural design sequence for a framed building
- 11.8 Structural principles related to steelwork
- 11.9 Structural systems for single storey flat-roofed sheds
- 11.10 Pitched and other roof forms
- 11.11 Relationship between plan and roof form
- 11.12 Adaptability and additivity
- 11.13 Guide to steelwork economics
- 11.14 Design life
- 12 Multiple bay single storey buildings**  
*Roger Plank (with contributions by Peter Brett and David Harriss)* 155
- 12.1 Introduction
- 12.2 Multi-bay pitched truss and column construction
- 12.3 Multi-bay pitched roof portal frames
- 12.4 Multi-bay flat roof structures
- 12.5 Multi-span structures
- 12.6 Conclusion
- 13 Floor framing and services above and below floors**  
*Tom Schollar and Anthony Gregson* 181
- 13.1 Introduction
- 13.2 Structural floor systems
- 13.3 Floor beam systems
- 13.4 Planning modules and service grids
- 13.5 Secondary floor systems (false or raised floors)
- 13.6 Other access systems
- 13.7 Suspended ceilings
- 13.8 Services

13.9	Vertical service distribution	
13.10	Fireproofing	
13.11	Transmission of sound through raised floors	
<b>14</b>	<b>Multi-storey frames</b>	<b>197</b>
	<i>Bjorn Watson</i>	
14.1	Introduction	
14.2	Factors affecting choice of structural system	
14.3	Structural principles	
14.4	Robustness	
14.5	Common floor systems	
14.6	Alternative floor framing systems	
14.7	Vertical bracing systems	
14.8	Case study: Whitefriars Development, Fleet Street, London	
14.9	Conclusion	
<b>15</b>	<b>Tall structures</b>	<b>215</b>
	<i>Hal Iyengar</i>	
15.1	Introduction	
15.2	Development of lateral systems	
15.3	The systems evolution	
15.4	The 'shear frame' system	
15.5	Shear truss and frame systems	
15.6	Frames with vertical, belt and outrigger trusses	
15.7	The framed tube	
15.8	Bundled tube or modular tube system	
15.9	The diagonalized tube	
15.10	Form and structural system	
15.11	Seismic design considerations	
15.12	The design process	
15.13	Current state of the art	
<b>16</b>	<b>Composite floors and structures</b>	<b>235</b>
	<i>Roger Plank and Anthony Gregson</i>	
16.1	Introduction	
16.2	Composite construction for beams and slabs	
16.3	The principles of composite action	
16.4	Alternative forms of construction	
16.5	Composite steel deck floors	
16.6	Introduction to composite building structures	
16.7	RC core or shear walls and steel frames	
16.8	RC construction to podium with steel frame above	
16.9	Steel frame to lower storeys, RC cross-wall construction above	
16.10	RC columns or loadbearing masonry with steelwork	
16.11	Suspended structures	
<b>17</b>	<b>Transfer structures</b>	<b>253</b>
	<i>Bryn Bird</i>	
17.1	Introduction	
17.2	Alternative forms	
17.3	Design principles	
17.4	Avoiding progressive collapse	
17.5	Examples of transfer structures	
17.6	Conclusion	
<b>18</b>	<b>Foundation structures</b>	<b>263</b>
	<i>Stefan Tietz</i>	
18.1	Introduction	
18.2	Sheet piling	
18.3	Bearing piles	
18.4	Tension piles	
18.5	Effective life and corrosion protection	
<b>19</b>	<b>Atria</b>	<b>271</b>
	<i>Richard Saxon</i>	
19.1	Introduction	
19.2	Design criteria	
19.3	Examples of roof forms	
19.4	Wallforms	
19.5	Other steel structures in atria	
<b>20</b>	<b>Tensile structures</b>	<b>289</b>
	<i>John Thornton and Ian Liddell</i>	
20.1	Introduction to tension structures	
20.2	Historical review	
20.3	Reasons for tension structures	
20.4	General technical considerations	
20.5	Primary technical considerations for cable-stayed systems	
20.6	Secondary technical considerations for cable-stayed systems	
20.7	Detailing for cable-stayed systems	

- 20.8 Economic factors related to cable-stayed structures
- 20.9 Introduction to suspension forms
- 20.10 Elementary cable mathematics
- 20.11 Structural form for two-dimensional suspension forms
- 20.12 Structural form for three-dimensional structures (two-way spanning)
- 20.13 Surface stressed structures
- 20.14 Equilibrium equations
- 20.15 Form finding of stressed surfaces
- 20.16 Detailed consideration of structural form
- 20.17 Boundary conditions
- 20.18 Construction and detailing
- 20.19 Structural fabrics and foils

## **Part Four**

### **Steel Construction**

#### **21 Structural connections for steelwork** 321

*Tom Schollar*

- 21.1 Introduction
- 21.2 Classification of connections
- 21.3 Bolting versus welding
- 21.4 Advantages and disadvantages of commonly used connections
- 21.5 Finishes and corrosion protection

#### **22 Fabrication and erection** 335

*R. Taggart*

- 22.1 Introduction to fabrication
- 22.2 Principles of fabrication
- 22.3 Economic factors concerned with fabrication
- 22.4 Selection of a fabricator
- 22.5 Introduction to erection
- 22.6 Site planning
- 22.7 Site organization
- 22.8 Setting out
- 22.9 Erection operations
- 22.10 Erection methods
- 22.11 Speed of erection
- 22.12 Site painting
- 22.13 Conclusion

#### **23 Tolerances and movements in building frames** 345

*Julian Ryder-Richardson (with contributions from Michael McEvoy)*

- 23.1 Introduction
- 23.2 Dimensional strategies
- 23.3 Loose-fit interface
- 23.4 National Building Specification and BS 5606: 1990
- 23.5 Sample specification
- 23.6 Construction management
- 23.7 Conclusion

#### **24 Insertion and strengthening of frames and upgrading facades** 357

*Peter Wright and Alan Blanc*

- 24.1 Introduction
- 24.2 Load assessment
- 24.3 Upgrading loadbearing structures
- 24.4 Strengthening iron and steel framed buildings
- 24.5 New building frames behind existing facades
- 24.6 Lift wells and staircase cores
- 24.7 Strengthening work

## **Part Five**

### **Secondary Steel Elements**

#### **25 Principles of cladding** 373

*Alan Blanc*

- 25.1 Introduction
- 25.2 Alternative relationships of frame and enclosure
- 25.3 Cladding materials
- 25.4 Guide to dry lightweight cladding
- 25.5 Heavyweight (precast or 'traditional') cladding
- 25.6 Conclusion

#### **26 Lightweight and heavyweight cladding** 391

*Alan Blanc*

- 26.1 Introduction
- 26.2 A guide to lightweight cladding
- 26.3 Guide to heavyweight cladding

**27 Window walls and rain-screen facades**

- Alan Blanc* 411
- 27.1 Introduction
  - 27.2 Design trends today
  - 27.3 Response to energy saving in facade construction
  - 27.4 Basic forms of window wall
  - 27.5 Case studies
  - 27.6 Rain-screen facades
  - 27.7 Recent developments – the design of trussed elevational units
  - 27.9 Conclusion

**28 Decking and built up roofing**

- Alan Blanc* 429
- 28.1 Background
  - 28.2 Roof decking and fixing: structural considerations
  - 28.3 Design for thermal insulation, movement and the control of condensation
  - 28.4 Rainwater disposal

**29 Fastenings**

- Alan Blanc* 437
- 29.1 Nails
  - 29.2 Screws
  - 29.3 Rivets
  - 29.4 Other light fastenings
  - 29.5 Heavy masonry fixings
  - 29.6 Other fittings

**30 Metal studwork and lath**

- Alan Blanc* 445
- 30.1 Introduction
  - 30.2 Partitions
  - 30.3 External studwork
  - 30.4 Metal framed housing
  - 30.5 Metal lathing
  - 30.6 Conclusion

**31 Metal windows and louvres, sills and lintels**

- Alan Blanc* 455
- 31.1 Historical review
  - 31.2 Metal windows, sections and sizes

- 31.3 Patent glazing
- 31.4 Louvres
- 31.5 Sills and lintels

**32 Metal door frames, screens and security**

- Alan Blanc* 473
- 32.1 Background
  - 32.2 Security against intruders
  - 32.3 Security against fire

**33 Staircases and balustrades**

- Alan Blanc* 479
- 33.1 Design codes
  - 33.2 Fabrication
  - 33.3 Components and finishes
  - 33.4 Case studies

**34 Gutters, downpipes and overflows**

- Alan Blanc* 497
- 34.1 Gutters
  - 34.2 Downpipes

**35 Decorative iron and steel**

- Alan Blanc* 503
- 35.1 Introduction
  - 35.2 Modern cast iron
  - 35.3 Forged steel as an art form compared with wrought iron
  - 35.4 Artist blacksmiths
  - 35.5 Materials, techniques, equipment and finishes

**Part Six****Outstanding Contemporary Steel Architecture****36 The last 25 years**

- Dennis Sharp* 515
- 36.1 Preamble
  - 36.2 Residential buildings
  - 36.3 Education buildings
  - 36.4 Civic and cultural buildings
  - 36.5 Commercial buildings

**37 Structural Steel Design****Awards***Alan Blanc*

569

- 37.1 Introduction
- 37.2 Draught Beer Department for Greene King and Sons Ltd, Bury St. Edmunds (1980)
- 37.3 The Humber Bridge (1982)
- 37.4 Thames Barrier Rising Sector Gates for the Greater London Council (1983)
- 37.5 The Liverpool International Garden Festival Exhibition Building (1984)
- 37.6 The Renault Centre, Swindon (1984)
- 37.7 No. 1 Finsbury Avenue, London, for Rosehaugh Greycoat Estates Ltd (1985)
- 37.8 New HQ for Hongkong and Shanghai Banking Corporation (1986)
- 37.9 Princess of Wales Conservatory, Kew Gardens (1986)
- 37.10 Western Riverside Solid Waste Transfer Station (1987)
- 37.11 Fleet Velmead Infants School for Hants County Council (1988)
- 37.12 Broadgate (phases 1-4) for Rosehaugh Stanhope Developments

plc in partnership with British Rail Property Board (1988)

- 37.13 Stansted Maintenance Facility for FFV Aerotech Ltd (1989)

**38 Futures***Mark Whitby and Alan Blanc*

589

- 38.1 Introduction
- 38.2 20th century developments
- 38.3 Trends into the 21st century
- 38.4 The influence of computers
- 38.5 Design legislation
- 38.6 Steel architecture for the next epoch
- 38.7 The new revolution
- 38.8 Mechanization takes command
- 38.9 The future of the past
- 38.10 Optimism for the future

**Appendix A Relevant codes, standards and general publications** 595

**Appendix B Advisory services for the steel construction industry** 597

**Index of architects and engineers** 601

**Index of buildings** 605

**Subject index** 609