

4.5.6 IMPACT OF EMERGING TECHNOLOGIES ON STEEL FABRICATION FOR THE CONSTRUCTION INDUSTRY

By Sandy Longworth

For The Warren Centre

Introduction

The use of steel in high-rise building construction in Australia is low compared with some other developed markets, such as the UK. This paper examines the fabricating processes used in building construction, particularly new and emerging technologies. Its aim is to promote awareness of the potential economic benefits from adopting new technologies and to identify some of the barriers in realising these benefits.

STEEL FABRICATING PROCESSES FOR BUILDING CONSTRUCTION

The major processes are:

- **cleaning:** typically by some form of blasting, which may be done before or after most of the other processes depending on the extent of work being done on that component.
- **cutting and profiling:** sawing is the most commonly used method for cut-to-length beams and columns. Oxy cutting and plasma cutting are both widely used for cutting plates for welded beam webs and flanges, and profiling the end of beams (also known as coping).
- **bending/forming:** bending presses to produce a camber are sometimes incorporated into beam lines. Roll forming is also commonly used for lighter sections.
- **drilling/punching:** holes for bolted connections are usually made by drilling, but occasionally punching is found to be more efficient.
- **welding:** fully automated welding is used for the production of beams and columns fabricated from three plates, usually with the submerged arc welding process. Most other welding is done with hand-held, semi-automatic gas metal arc welding (GMAW).
- **machining:** load-bearing end faces of columns are often machined by milling to achieve the desired tolerances.
- **Protecting:** steelwork is spray-painted or metal-sprayed for corrosion, and usually with intumescent paint for fire protection.

- **handling:** although this is a non-value-adding process, the awkwardness of handling large steel components and the importance of timely supply to site demand that close attention be paid at the time of design to component or module size, erection handling and sequence.



Figure 1: FICEP beam with in-line drill and sawing (Photo courtesy Brian Mahony)



Figure 2: Identification engraved on beam (Photo courtesy Brian Mahony)

Existing commonly used technology

Beam lines are designed for processing columns and beams. In Australia there are an estimated 40 beam lines, with 14 on order. The vast majority of beam lines have a saw for cut-to-length, including a mitre capability, and hole drilling or punching capability. It is common to have dedicated in-line blasting facilities for cleaning of regular shapes, while cleaning of irregular shapes and coating are manual operations.

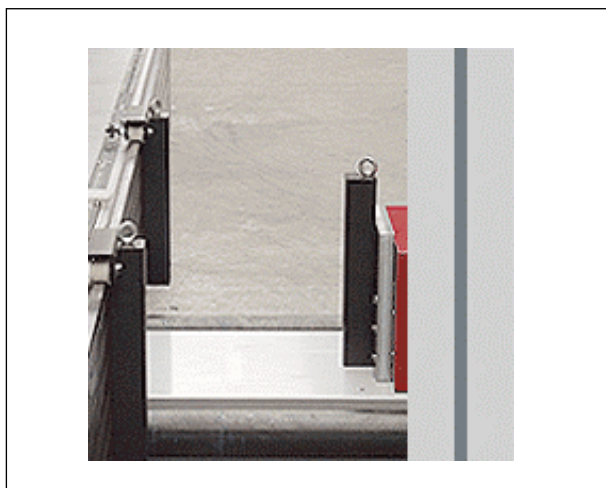


Figure 3: In-line horizontal beam cambering machine developed for cambering steel profiles (Photo courtesy www.FICEP.it)

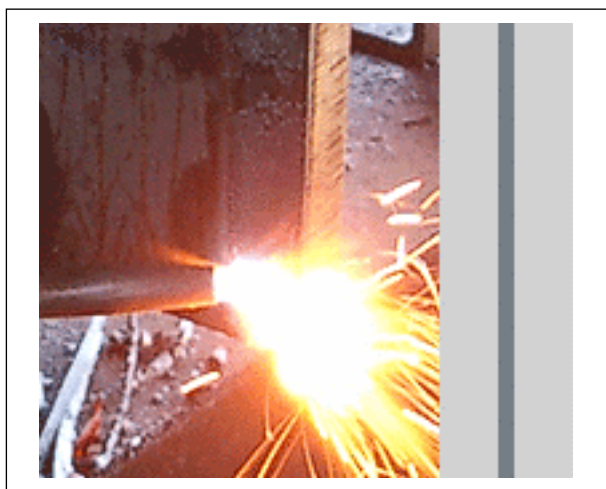


Figure 4: 5-axes Oxyfuel beam coping machine designed for cutting I-beams, H-beams, channel, angle, rectangular tubes and flat-bars (Photo courtesy www.FICEP.it)

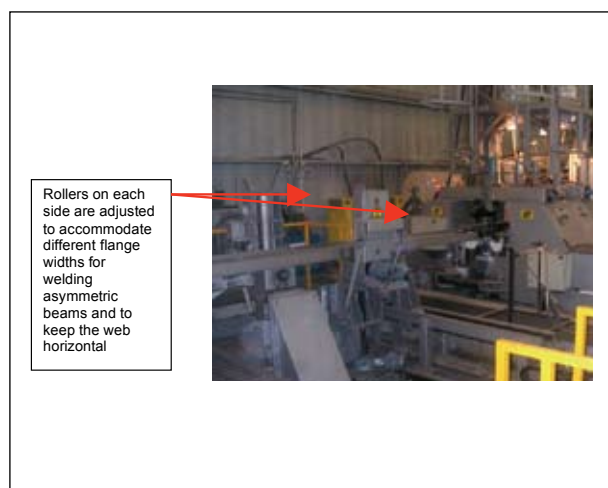


Figure 5: Welded beam line in the UK set up for welding asymmetric sections (Photo courtesy Brian Mahony)

Several beam lines include oxy or plasma cutting for coping (profiling) the ends of the beams.

Markings are also mechanically engraved on the beams for identification and traceability.

Whilst the majority of these beam lines do have CNC capability, the machine controls do not generally provide for download of data from steel design packages at present.

There are at least three beam lines in Australia for production of beams by welding three plates. One of these, at BlueScope Steel in Unanderra, welds one side of the web to both flanges using two tandem submerged arc heads at one station. The web is in the flat position. The beams are then turned over, and the other side of the web-to-flange joins are made in a second identical station. While very productive, this configuration is not set up for the production of asymmetrical beams.

The other two beam lines make both fillet welds between one flange and the web in one pass. The second flange is welded in another pass, and it is therefore relatively easy to make an asymmetric section in these lines.

The welded beam lines are typically partial penetration welds. That is, the fillet welds on either side do not penetrate the full thickness of the web, leaving the surface between the web and the flange unwelded at the centre of the web.

The major market for all this equipment in Australia has been for infrastructure projects rather than building construction. Innovative building design incorporating slim-floor construction, chilled beams and large spans could change this.

Virtually all other components, such as cleats and stiffeners, are welded with hand-held, semi-automatic GMAW processes.

The majority of beam lines are with fabricators, but some steel distributors have also installed beam lines to provide partial pre-fabrication.

Emerging technologies

Hole-drilling

New designs of low-vibration machine tools and advancement in drill design have resulted in major reductions in drilling time, to the point where a 26mm diameter hole can be drilled in 12mm plate literally in seconds. As a result, CNC single tool drilling stations

are replacing gang drilling in some applications because of the greater flexibility offered.

New welding power source inverter

Inverter technology development has reached the point where high power (1000amp+) welding power sources are now readily commercially available. As well as much more efficient transformation of high voltage mains supply to low voltage welding current, with more than 95 per cent power factor, these new inverters allow much greater flexibility in the welding current waveform. Until now, submerged arc welding processes commonly used tandem arc for greater welding speeds. The lead wire was supplied with DC power, while the trailing wire was AC to avoid electrical interference between the two arcs. Additional wires can be fed into the weld pool but it is difficult to achieve stable conditions.

With the advent of new waveform control, new configurations are possible which may allow full penetration welds to be achieved in welded beam fabrication, and require smaller external fillets with proportional increases in welding speeds. The result should be higher quality welded beams at lower cost due to less wire being used and lower power consumption.

Laser and high-definition plasma cutting

Laser technology continues to advance rapidly, but is a major capital expense. The energy conversion is also quite poor. Despite these disadvantages, laser cutting is finding more and more application in metal fabrication due to the very rapid and precise parallel-sided cut that can be achieved with very high surface finish.

In the automotive industry, laser cutting has displaced press trimming and punching in many applications due to the flexibility with which shapes can be produced. Could there be similar potential for building construction?

Due to the energy demand, most applications have been for light gauge metals, but laser cutting is now being used in shipbuilding in Europe for cutting steel up to 20mm thick.

Plasma cutting, where an arc is used to remove metal rather than weld it, has been a popular alternative to the more traditional oxy-cutting process. But like oxy cutting, plasma cutting has had the disadvantage of producing a wedge-shaped cut, and a surface finish similar to oxy cutting.

High-definition plasma cutting, where the two cut surfaces are much closer to parallel, improves the

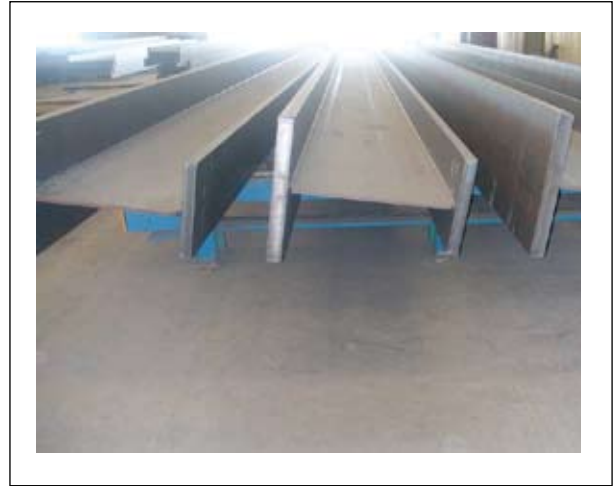


Figure 6: Asymmetric welded beams (Photo courtesy Brian Mahony)

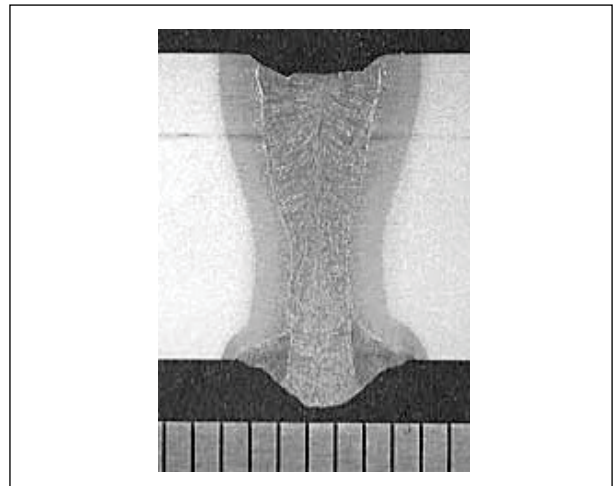


Figure 7: Macro of a hybrid Nd:YAG laser/MAG full penetration weld in 11mm steel section (Source: Dolby RE 2003)

precision of the cut and the surface quality. Although still not as precise as laser cutting, it is a much more economical process and arguably superior to oxy cutting at higher speeds.

Laser/laser hybrid welding

Laser welding allows deep penetration and very precise welds, and the heat source can be directed into tight area locations. These advantages have allowed joint configurations not possible before. However, a weld requiring 4kW requires an input power of approximately 340kW with a Nd:YAG laser, compared with approximately 4.2kW with arc welding. Laser welding also requires very precise fit-up as no filler material is added and the weld pool is small.

Laser hybrid welding, where a laser is used in conjunction with an arc weld, overcomes some of these



STEEL – FRAMING THE FUTURE



The University of Sydney

Project Report

Co-published by
The Warren Centre for Advanced Engineering
Engineering Link Building J13,
University of Sydney NSW 2006 Australia
www.warren.usyd.edu.au

SYDNEY UNIVERSITY PRESS

University of Sydney Library
www.sup.usyd.edu.au

© 2007, The Warren Centre for Advanced Engineering
(text)

The ideas and assertions put forward here are those of the members of the *Steel – Framing the Future* project teams as interpreted by the authors of the individual papers or those of the authors of the individual papers. It is not the intention of The Warren Centre or its management or the Centre's many sponsors, to present a formal Warren Centre, the University of Sydney or sponsor view of any of the matters presented.

© 2007 Sydney University Press

Reproduction and Communication for other purposes
Except as permitted under the Act, no part of this edition may be reproduced, stored in a retrieval system, or communicated in any form or by any means without prior written permission. All requests for reproduction or communication should be made to Sydney University Press at the address below:

Sydney University Press
Fisher Library F03
University of Sydney
NSW 2006 AUSTRALIA
Email: info@sup.usyd.edu.au

ISBN13 978-1-920898-45-8

Printed in Australia at the University Publishing
Service, the University of Sydney

ACKNOWLEDGEMENTS

This project received substantial funding from:

- AusIndustry's Industry Co-operative Innovation Program
- BlueScope Steel
- OneSteel

And tangible in-kind support from:

- Lucis
- The Australian Steel Institute
- Minter Ellison Lawyers
- Evans and Peck

The project was only possible due to the commitment of a number of individuals and organisations in particular:

- Sandy Longworth, Project Champion
- Peter Thompson, Visiting Fellow
- Richard Barrett, Visiting Fellow
- Brian Mahony, Project Manager
- Geoff Winter, Project Initiator

Members of the project management team and team leaders:

David Ansley	Robert Mitchell
Trevor Gore	Aruna Pavithran
Reg Hobbs	Dick Prince
Chris Humphries	David Ryan
Andrew Marjoribanks	



An Australian Government Initiative



CONTENTS

Executive summary.....	1
1.0 Introduction	7
1.1 Background	
By Sandy Longworth.....	7
1.2 Situation Analysis	
By Anthony Ng.....	9
1.3 Skills Deficiency – A Changing Scene	
By Sandy Longworth.....	11
1.4 Contrasting the Steel Construction Industry in the UK and Australia	
By Richard B Barrett	12
1.5 Steel and Concrete Alternatives	
By Peter Thompson	18
1.6 Sustainability – Overview	
By Sandy Longworth.....	19
2.0 Recommendations	
By David Ansley.....	23
3.0 Issues Group Summaries.....	29
3.1 Leadership	
By Reg Hobbs.....	29
3.2 Value Chain	
By Aruna Pavithran.....	31
3.3 Costing	
By Andrew Marjoribanks.....	32
3.4 Technology	
By Sandy Longworth.....	36
3.5 Relative Value Proposition Summary	
By David Ryan	38
4.0 Issues Group Reports	41
4.2 Leadership report	
By Reg Hobbs and Andrew Marjoribanks.....	41
4.3 Value Chain Issue Group	
By Aruna Pavithran.....	48
4.4 Costing in Steel Fabrication for Construction	
By Andrew Marjoribanks.....	59
4.5.2 New generation practice in delivering steel-framed structures in Australia	
By John Hainsworth and Stuart Bull	60
4.5.3 Design and construction of steel-concrete composite building structures: Australian practice	
By Emil Zyhajlo	70
4.5.4 Fire and Steel Regulations	
By Ian D Bennetts.....	76
4.5.5 Fire Engineering	
By Ben Ferguson.....	79
4.5.6 Impact of emerging technologies on steel fabrication for the construction industry	
By Sandy Longworth	85
4.5.7 History of off-site modular construction trends	
By Michael Gallagher.....	91
4.5.8 A glimpse to the future – BIM – the new Building Information Model paradigm	
By John Hainsworth.....	95
4.5.9 FRAMEquick: A key to modern fabrication	
By Peter Farley.....	97
4.5.10 What does the future hold	
By John Hainsworth, Peter Farley and Sandy Longworth	102
4.6 Relative Value Proposition	
By Brian Mahony	108

STEEL – FRAMING THE FUTURE

5.0	Project management issues.....	115
5.1	Methodology By Robert Mitchell	115
5.2	Linking the Issue Groups to 3Cs framework By David Ansley.....	121
5.3	Key Personnel By Brian Mahony	121
5.4	Resourcing and funding the project By Robert Mitchell	124
5.5	ASI and the ICIP Program	124
5.6	Primary Information Sources	128
6.0	Bibliography.....	133
Appendix A1 Australian Steel Statistics		136
Appendix A2 The Three ‘C’s: Communicate, Collaborate & Capabilities’		138
A2.2	The Need to Communicate By Andrew Marjoribanks.....	138
A2.3	Collaborate to Succeed By Andrew Marjoribanks..... By Sandy Longworth..... By David Ryan	143 144 146
A2.4	Capability By Brian Mahony	147
Appendix A3 Leadership Issues By Reg Hobbs.....		149
Appendix A4 Notes accompanying Value Chain Paper		156
Appendix A5 Note on contractual models for steel frame delivery By David Fabian.....		158
Appendix 6 Summary report on visit to NZ SCNZ, HERA and NZ fabricators By David Ryan		160
Appendix A7 ASI Survey Results		162
Appendix A8 UK Steel Fabrication - An External Viewpoint		172
By Brian Mahony		172
Appendix A9 Building Assemblies Scorecard		181
Appendix A10 ASI Life Cycle Performance of Steel in the Built Environment.....		182
Appendix A11 Sustainability and the Steel Industry.....		184
Appendix A12 Tech Update Survey.....		187
Appendix B – Case Study Descriptions.....		190
Appendix B1: Latitude Project at World Square - Sydney		191
Appendix B2: BMW Building and BHP Billiton Building - Melbourne.....		194
Appendix B3: Brisbane Airport Carpark Extensions		196
Appendix B4 : Carrington House - Sydney.....		197
Appendix B5: Sacrificial Formwork for Structural Walls		199
Appendix B6: Rhodes Project - Sydney.....		201
Appendix B7 : Flinders Link - Adelaide.....		203
Appendix B8 : 50 Lonsdale St - Melbourne.....		204
Appendix B9 : Southern Cross office complex - Melbourne		206
Appendix B10: Adelaide airport - new terminal		208
APPENDIX C Project Authors		210

ABOUT THE WARREN CENTRE FOR ADVANCED ENGINEERING

The Warren Centre for Advanced Engineering is the leading Australian forum for advanced engineering issues, recognised for its inclusive, forward-looking approach and the wide impact of its many achievements.

The Centre is a self-funding, independent, not-for-profit institute operating within the Faculty of Engineering at the University of Sydney, controlled by representatives from industry and elected by the University's Senate.

It has three principal objectives:

- to stimulate the application and further development of new engineering technology.
- to encourage the integration of innovation and engineering technology into the development of Australia's public policy and wealth creation.
- to provide independent comment and advice to government and industry on these and related issues.

The Warren Centre:

- identifies and supports major projects that bring together people at the leading edge in selected fields of engineering technology to develop new technical insights and knowledge in those technologies and accelerate their application in Australian industry.
- holds industry forums for companies in specific industry segments to explore opportunities of common or joint interest that will accelerate the development and/or exploitation of technology.
- organises events such as seminars, lectures and conferences that explore contemporary technology issues and disseminates the results of the Centre's activities.
- produces electronic and printed material to promote discussion and build awareness of contemporary, advanced engineering issues.
- recognises people and projects that make a unique contribution to encouraging excellence and innovation in all fields of advanced engineering.

Since opening in 1983, the Centre has gained wide recognition for its unique approach and its achievements in diverse fields of engineering technology and industry development.

THE **Warren** CENTRE
FOR ADVANCED ENGINEERING



Engineering Link Building J13
Sydney University NSW 2006
Telephone: +61 2 9351 3752
Facsimile: +61 2 9351 2012
Internet: www.warren.usyd.edu.au
E-Mail: warrenc@eng.usyd.edu.au