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

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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.

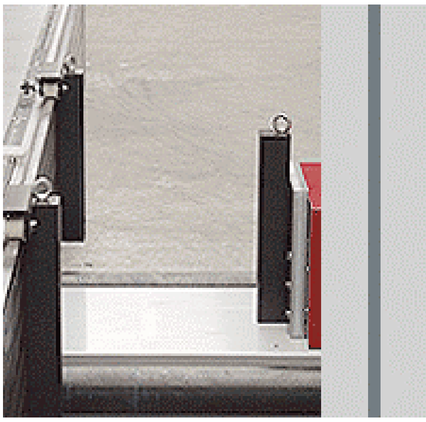

Figure 3: In-line horizontal beam cambering machine developed for cambering steel profiles *(Photo courtesy www.FICEP.it)*

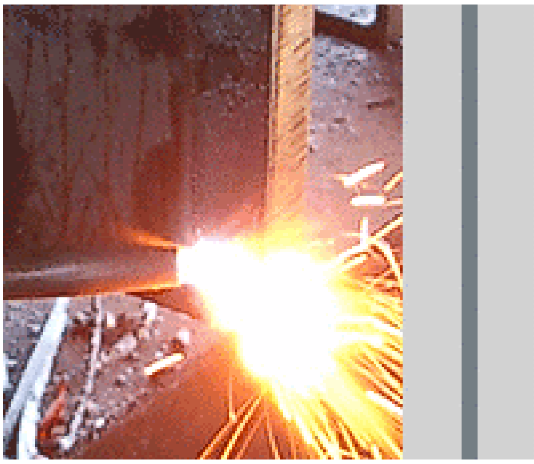

Figure 4: 5-axes Oxyfuel beam coping machine designed for cutting I-beams, H-beams, channel, angle, rectangular tubes and flat-bars *(Photo courtesy www.FICEP.it)*

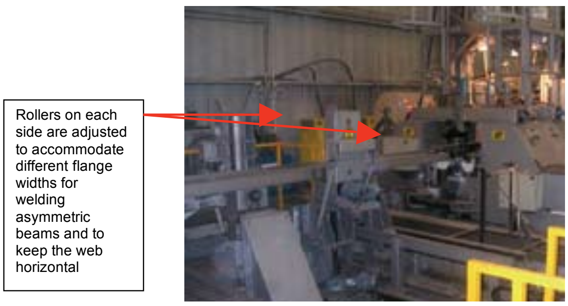

Figure 5: Welded beam line in the UK set up for welding asymmetric sections (*Photo courtesy Brian Mahony*)

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 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.

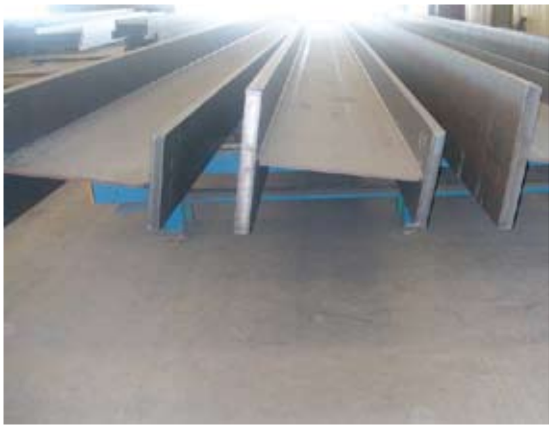

Figure 6: Asymmetric welded beams (*Photo courtesy Brian Mahony*)

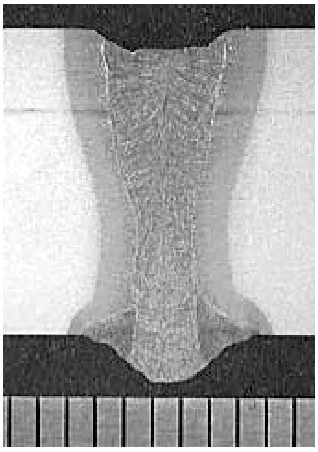

Figure 7: Macro of a hybrid Nd:YAG laser/MAG full penetration weld in 11mm steel section *(Source: Dolby RE 2003)*

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

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It has three principal objectives:

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