LASTEICON – Laser Technology for Innovative Connections in Steel Construction

Summary

Modern laser tube cutting machines are capable of making any type of cut on steel tubes, in entirely automatic, programmed cycles. CAD programming and the laser beam eliminate the traditional fixed costs determined by punches, clamps, tools, templates and dies, Figure 1. The laser cutting technology (LCT) has so far generated significant benefits in both processing and cost terms, for a wide range of applications. ADIGESYS reports that their customers obtained production improvements in the range from 70 to 80% through LCT, with respect to conventional processes. This was mainly thanks to more stringent machining tolerances resulting in improved quality of joints, fittings, easier fastenings, process efficiency and vast flexibility.

Figure 1. An example to the automated laser cutting process.

Circular hollow sections (CHS) have excellent properties with high compression, tension and bending resistance in all directions, thanks to their inherent shape and geometrical properties. Structures produced using tubular sections have lighter overall weights in the order of 40%, and they require smaller volume of fire protection material than their equivalent H section. Indeed, CHS columns can be designed to have a fire resistance up to 120 minutes, without using fire protection. Moreover, tubular profiles also have reduced transport costs. They are also architecturally very appealing offering more space, and freedom to the designers (Figure 2).

Figure 2. Example hollow section joints with stiffeners and welding.

However, these profiles have complex detailing, fabrication and erection requirements for their connections, always requiring stiffeners and gusset plates. From an extensive literature study including the largest steel users in the world construction market such as Europe, United States, and Japan, it is seen that most common types of I-beams-to-CHS columns connections are directly welded, or diaphragm connections. Both solutions include vast amount of welded local stiffeners or gusset plates, which makes the design and construction of these joints complicated and expensive, slow down the design and construction process and spoil the aesthetics of the design.

LASTEICON proposes using LCT in the fabrication of I-beam-to-CHS-column joints. This can drastically reduce fabrication costs, as well as meeting the structural requirements, expanding also the freedom of architects and engineers when developing new projects. Figure 3 shows a prototype of laser-cut joint compared with a typical diaphragm joint.

Figure 3. Traditional joint and LASTEICON solution.

Although the proposal intends to promote hollow section profiles in building frames, extendibility of LCT for other structural systems will be demonstrated by studying truss girders. In this case, the use of LCT (due to the cut edge quality and reduced tolerances) may lead to promising intersections and joints between the structural elements composing the truss girders, reducing eccentricities and avoiding the use of gusset plates. A prototype of open-section joint and preliminary renders of closed-section truss girder joints are presented in Figure 4. In the case of open sections, it is evident how LCT allows to connect truss members directly to the web of the top and bottom chords. In the case of hollow sections, thanks to the high precision cut obtained by LCT, it is possible to reduce welding and avoid gusset plates in the joints.

CERIS Civil Engineering Research and Innovation for Sustainability

LASTEICON
LASER TECHNOLOGY FOR INNOVATIVE CONNECTIONS IN STEEL CONSTRUCTION

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Leading Institution

Fincon Consulting Italia Srl (Italy)

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UNIPI – Università di Pisa (Italy), INSA Rennes – Institut National des Sciences Appliquées de Rennes (France), RWTH Aachen – Rheinisch-Westfaelische Technische Hochschule Aachen (Germany), ADIGE-SYS SPA (Italy), Officina Carpenteria Metallica Srl, (Italy), VAD GMBH – Vallourec Deutschland GmbH (Germany)

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www.lasteicon.eu

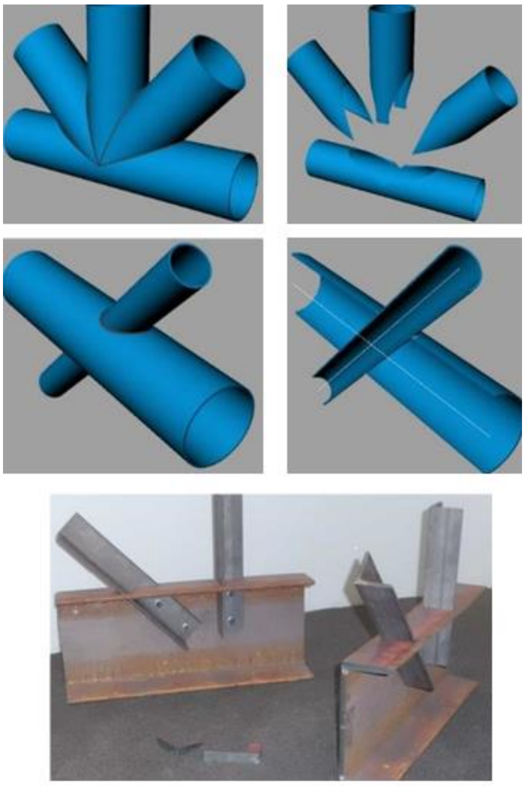

Figure 4. Prototype of truss girder specimens obtained by LCT.

Specifically, LASTEICON proposes the following benefits to what has already been achieved to date:

- Joint fabrication with high precision, increased quality and reduced costs.
- High structural performance with simpler joint configurations:
  - avoiding directly welding the beams on the column surface, which causes flange fractures and local distortion problems;
  - decreasing heat-affected zones, more predictable mechanical behaviour, reduced risk of fractures;
  - reducing eccentricities between structural elements composing the truss girders;
- Increased reliability with less parts with different material properties, less human-induced errors.
- Energy efficient and sustainable joint fabrication through:
  - less welding material and related man-hours;
  - shorter overall construction schedules;
  - significantly reduced number of parts and components;
- Eco-friendly joint fabrication thanks to:
  - much less welding, and eventual release of slag during joint fabrication;
  - easier demountability and re-use of steel components;
- Safer workplace:
  - less manual work and more computer programmed automation;
  - increased degree of prefabrication, less works on site;
- Contribution to Eurocodes, allowing new connection types with hollow sections.
- Better market position for hollow sections.