TATA STEEL

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Colin Smart: Structural Advisory Service

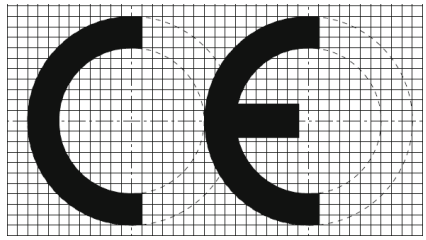
Steel specification and design

Together we make the difference

Contents

CE Marking: Introduction

The Construction Products Regulation (CPR): 1st July 2013



CE Marking

- Is a requirement of the CPR
- Demonstrates compliance with the appropriate manufacturing standard
- Places new legal obligations on the construction supply chain
- Applies to all construction products where a harmonised standard or ETA is in force
- Applies to fabricated structural steelwork too

Harmonised standards

CE Marking is mandatory NOW for

- Open sections & plates: BS EN 10025-1
- Hollow sections
  - Hot finished: BS EN 10210-1
  - Cold formed welded: BS EN 10219-1
- Structural bolts
  - Non-preloaded structural bolting assemblies: BS EN 15048-1
  - High strength structural bolting assemblies for preloading: BS EN 14399-1
- Mandatory for fabricated steelwork delivered to site on or after 1st July 2014

CE Marking of fabricated structural steelwork

Specifications

Contracts for fabricated structural steelwork to be delivered to site on or after 1 July 2014 should include the following specifications, which incorporate the obligations of BS EN 1090-1 and BS EN 1090-2 on the steelwork contractor:

Buildings

- National Structural Steelwork Specification (NSSS) for Building Construction 5th Edition CE Marking Version

Bridges

- Model Project Specification for the Execution of Steelwork in Bridge Structures (SCI Guide P382) revised January 2012

Harmonised standard

- BS EN 1090: Execution of steel structures and aluminium structures
  - Part 1: Conformity assessment
  - Part 2: Technical requirements
- BS EN 1090-1
  - mandatory on 1 July 2014
- CE Marking compliance will be a condition of membership of the BCSA from 1 July 2014.

Contents

CE Marking – The Engineer's responsibility

- To specify required quality of fabrication or Execution Class
- Execution Class to be specified for
  - the works as whole
  - an individual component
  - a detail of a component
- Procedure for determining Execution Class
  - Determine the Consequence Class
  - Define the Service Category and the Production Category
  - Derive the Execution Class
- Execution Class 2 (EXC2) will cover the vast majority of buildings in the UK. (EXC2 is default to BS EN 1090-2: Cl. 4.1.2)

Step 1: Determine the Consequence Class

BS EN 1990-1: Table B1

Table B1	Definition of Consequence Classes	
Consequence Class	Description	Examples of buildings and civil engineering works
CC3	**High** consequence for loss of human life ***or*** economic, social or environmental consequences **very great**	Grandstands, public buildings where consequences of failure are high (eg a concert hall)
CC2	**Medium** consequence for loss of human life; economic, social or environmental consequences **considerable**	Residential and office buildings, public buildings where consequences of failure are medium (eg an office building)
CC1	**Low** consequence for loss of human life ***and*** economic, social or environmental consequences **small** or **negligible**	Agricultural buildings where people do not normally enter (eg storage buildings), greenhouses

Step 1: Determine the Consequence Class

BS EN 1991-1-7: Table A1

Table A.1	Categorisation of Consequence Classes
Consequence Class	**Example of categorisation of building type and occupancy**
1	Single occupancy house not exceeding 4 storeys. Agricultural buildings. Buildings into which people rarely go, provided no part of the building is closer to another building, or area where people do go, than a distance 1½ times the building height
2a Lower Risk Group	5 storey single occupancy houses. Hotels not exceeding 4 storeys. Flats, apartments and other residential buildings not exceeding 4 storeys. Offices not exceeding 4 storeys. Industrial buildings not exceeding 3 storeys. Retailing premises not exceeding 3 storeys or less than 1,000m² floor area in each storey. Single storey educational buildings. All buildings not exceeding 2 storeys to which the public are admitted and which contain floor areas not exceeding 2,000m² at each storey.
2b Upper Risk Group	Hotels, flats, apartments and other residential buildings greater than 4 storeys but not exceeding 15 storeys. Educational buildings greater than a single storey but not exceeding 15 storeys. Retailing premises greater than 3 storeys but not exceeding 15 storeys. Hospitals not exceeding 3 storeys. Offices greater than 4 storeys but not exceeding 15 storeys. All buildings to which the public are admitted and which contain floor areas exceeding 2,000m² but not exceeding 5,000m² at each storey. Car parking not exceeding 6 storeys.
3	All buildings defined above as Class 2 Lower and Upper Consequence Class that exceed the limits on area and number of storeys. All buildings to which members of the public are admitted in significant numbers. Stadia accommodating more than 5,000 spectators. Buildings containing hazardous substances and/or processes.

Notes:
1. For buildings intended for more than one type of use the 'Consequence Class' should be that relating to the most onerous type.
2. In determining the number of storeys, basement storeys may be excluded provided such basement storeys fulfil the requirements of 'Consequences Class 2b Upper Risk Group'
3. UK Building Regulations Approved Document A contains a similar table to A.1 of EN 1991-1-7 which may also be used to determine the Consequence Class.

Step 2: Define the Service Category

BS EN 1090-2: Table B.1

Table B.1	Suggested Criteria for Service Categories
Categories	**Criteria**
SC1	• Buildings and components designed for quasi static actions only (Example: Buildings) • Structures and components with their connections designed for seismic actions in regions with low seismic activity and in DCL* • Structures and components designed for fatigue actions from cranes (class S_0)**
SC2	• Structures and components designed for fatigue actions according to EN 1993. (Examples: Road and railway bridges, cranes (class S_1 to S_9)**, structures susceptible to vibrations caused by wind, crowd or rotating machinery.) • Structures and components with their connections designed for seismic actions in regions with medium or high seismic activity and in DCM* and DCH*.

Notes:
* DCL, DCM, DCH: ductility classes according to EN 1998-1.
** For classification of fatigue actions from cranes, see EN 1991-3 and EN 13001-1.

Step 3: Define the Production Category

BS EN 1090-2: Table B.2

Table B.2	Suggested Criteria for Production Categories
Categories	**Criteria**
PC1	• Non welded components manufactured from any steel grade products • Welded components manufactured from steel grade products below S355
PC2	• Welded components manufactured from steel grade products from S355 and above • Components essential for structural integrity that are assembled by welding on construction site • Components with hot forming manufacturing or receiving thermic treatment during manufacturing • Components of CHS lattice girders requiring end profile cuts

Step 4: Derive the Execution Class

BS EN 1090-2: Table B.3

Table B.3		Recommended Matrix for Determination of Execution Classes					
Consequence classes		**CC1**		**CC2**		**CC3**	
Service categories		SC1	SC2	SC1	SC2	SC1	SC2
Production categories	PC1	EXC1	EXC2	EXC2	EXC3	EXC3 [a]	EXC3 [a]
	PC2	EXC2	EXC2	EXC2	EXC3	EXC3 [a]	EXC4

[a] EXC4 should be applied to special structures or structures with extreme consequences of a structural failure as required by national provisions

Note:
Annex B of BS EN 1090-2 is classed as 'informative'. Therefore the approach described is not mandatory and the engineer can base the selection of Execution Class on experience provided they can support their decision.

- Both NSSS 5th Edition CE Marking Version and BS EN 1090-2 default to EXC2 if no execution class is specified.

Steelwork contractor requirements

Declare performance to the System 2+ level in Annex V of the CPR

Steelwork contractor requirements for CE Marking

In order to be able to CE Mark the fabricated structural steelwork that they produce, steelwork contractors are required to declare performance to the System 2+ level of assessment (as described in Annex V of the CPR). This requires them to undertake:

- initial type-testing of the product
- Factory Production Control (FPC), which will include
  - implementation of FPC system procedures
  - appointment of a responsible welding coordinator (RWC)
  - implementation of welding quality management system (WQMS) procedures
- further testing of samples taken at the factory in accordance with the prescribed test plan

They must also be assessed by a notified body that will carry out:

- initial inspection of the manufacturing plant
- initial inspection of the FPC
- continuous surveillance, assessment and approval of the FPC, which will typically include:
  - an annual audit to ensure continued competence to the declared Execution Class (Table B.3 of BS EN 1090-1 sets out minimum levels for the routine surveillance intervals)

The notified body will then issue a FPC certificate and Welding Certificate identifying the Execution Class that the steelwork contractor has achieved.

Undertake

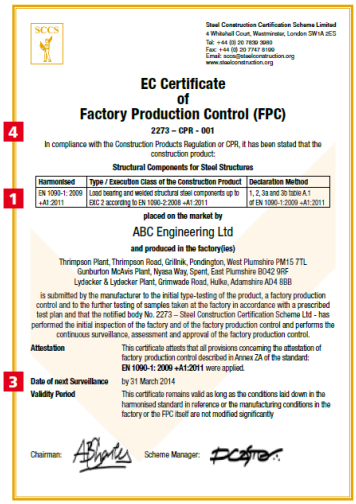
- Initial type testing
- Factory Production Control (FPC)
  - Implementation of FPC system procedures
  - Appointment of RWC
  - Implementation of a welding quality management system (WQMS) procedures
- Further testing of samples in accordance with the test plan

Client and/or main contractor's responsibility

The legal requirement comes into force on 1 July 2014

- Client/MC should appoint a steelwork contractor with an Execution Class equal or greater than that required by specification
- For steelwork due on site on or after 1 July 2014, only award contract to a steelwork contractor who has already achieved CE Marking accreditation
- CE Marking compliance will be a condition of BCSA membership
- Contract documentation should be updated to refer to
  - NSSS 5th Edition (CE Marking Version)
- If a non-EU steelwork contractor is used, the CPR puts liability on the client/main contractor (classed as importer)

Checking compliance



Steel Construction Certification Scheme Limited
4 Whitehall Court, Westminster, London SW1A 2ES
Tel: +44 (0) 20 7839 3680
Fax: +44 (0) 20 7747 8100
Email: scos@steelconstruction.org
www.steelconstruction.org

EC Certificate of Factory Production Control (FPC)

4 **2273 – CPR - 001**

In compliance with the Construction Products Regulation or CPR, it has been statad that the construction product:

Structural Components for Steel Structures

Harmonised	Type / Execution Class of the Construction Product	Declaration Method
EN 1090-1: 2009 +A1:2011	Load bearing and welded structural steel components up to EXC 2 according to EN 1090-2:2008 +A1:2011	1, 2, 3a and 3b Table A.1 of EN 1090-1:2009 +A1:2011

1

placed on the market by

ABC Engineering Ltd

and produced in the factory(ies)

Thrimpson Plant, Thrimpson Road, Grillnik, Pondington, West Plumshire PM15 7TL
Gunburton McAvis Plant, Nyasa Way, Spent, East Plumshire BO42 9RF
Lydacker & Lydacker Plant, Grimwade Road, Hulke, Adamshire AD4 8BB

is submitted by the manufacturer to the initial type-testing of the product, a factory production control and to the further testing of samples taken at the factory in accordance with a prescribed test plan and that the notified body No. 2273 – Steel Construction Certification Scheme Ltd – has performed the initial inspection of the factory and of the factory production control and performs the continuous surveillance, assessment and approval of the factory production control.

Attestation This certificate attests that all provisions concerning the attestation of factory production control described in Annex ZA of the standard: **EN 1090-1: 2009 +A1:2011** were applied.

3 **Date of next Surveillance** by 31 March 2014

Validity Period This certificate remains valid as long as the conditions laid down in the harmonised standard in reference or the manufacturing conditions in the factory or the FPC itself are not modified significantly

Chairman: Scheme Manager:

Steel Construction Certification Scheme Limited
4 Whitehall Court, Westminster, London SW1A 2ES
Tel: +44 (0) 20 7839 3680
Fax: +44 (0) 20 7747 8100
Email: scos@steelconstruction.org
www.steelconstruction.org

Welding Certificate 9809 – CPR - 001

4 In compliance with EN 1090-1:2009, table B.1, the following has been stated:
This Welding Certificate is an annex to
the EC-Certificate of the Factory Production Control (FPC) 9809 – CPR - 001.
This Welding Certificate is only valid in conjunction with the aforementioned EC-Certificate in the scope of the Construction Products Regulation or CPR.

Manufacturer ABC Engineering Ltd

Facilities of the Manufacturer Thrimpson Plant, Thrimpson Road, Grillnik, Pondington, West Plumshire PM15 7TL
Gunburton McAvis Plant, Nyasa Way, Spent, East Plumshire BO42 9RF
Lydecker & Lydecker Plant, Grimwade.Road, Hulke, Adamshire AD4.8BB

Standard EN 1090-2: 2008 +A1:2011

1 **Execution Class** up to EXC 2 according EN 1090-2:2008 +A1:2011

Welding Process(es) 111 – Manual metal arc
121 – Submerged metal arc

2 **Base Material(s)** S235, S275, S355 according to EN 10025-2

Responsible Welding Coordinator Mr L Drogheda

Substitute None

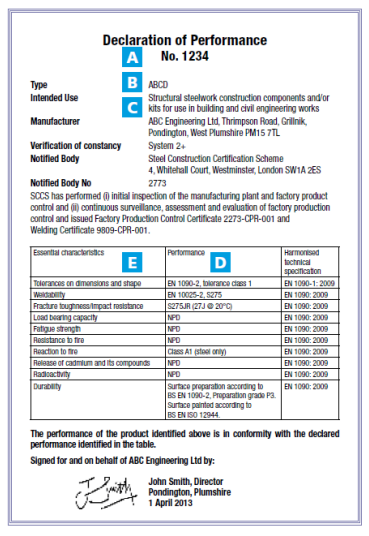
Attestation This certificate attests that all procedures for the execution and surveillance of welding works are implemented.

3 **Date of next Surveillance** 31 March 2014

Validity Period This certificate remains valid as long as the conditions laid down in the technical specification in reference (in connection with EN 1090-1:2009 +A1:2011) or the manufacturing conditions in the factory or the FPC itself are not modified significantly.

Chairman: Scheme Manager:

Checking compliance



Declaration of Performance

A **No. 1234**

Type	B	ABCD
Intended Use	C	Structural steelwork construction components and/or kits for use in building and civil engineering works
Manufacturer		ABC Engineering Ltd, Thrimpson Road, Grillnik, Pondington, West Plumshire PM15 7TL
Verification of constancy		System 2+
Notified Body		Steel Construction Certification Scheme 4, Whitehall Court, Westminster, London SW1A 2ES
Notified Body No		2773

SCCS has performed (i) initial inspection of the manufacturing plant and factory product control and (ii) continuous surveillance, assessment and evaluation of factory production control and issued Factory Production Control Certificate 2273-CPR-001 and Welding Certificate 9809-CPR-001.

Essential characteristics E	Performance D	Harmonised technical specification
Tolerances on dimensions and shape	EN 1090-2, tolerance class 1	EN 1090-1: 2009
Weldability	EN 10025-2, S275	EN 1090: 2009
Fracture toughness/Impact resistance	S275JR (27J @ 20°C)	EN 1090: 2009
Load bearing capacity	NPD	EN 1090: 2009
Fatigue strength	NPD	EN 1090: 2009
Resistance to fire	NPD	EN 1090: 2009
Reaction to fire	Class A1 (steel only)	EN 1090: 2009
Release of cadmium and its compounds	NPD	EN 1090: 2009
Radioactivity	NPD	EN 1090: 2009
Durability	Surface preparation according to BS EN 1090-2, Preparation grade P3. Surface painted according to BS EN ISO 12944.	EN 1090: 2009

The performance of the product identified above is in conformity with the declared performance identified in the table.

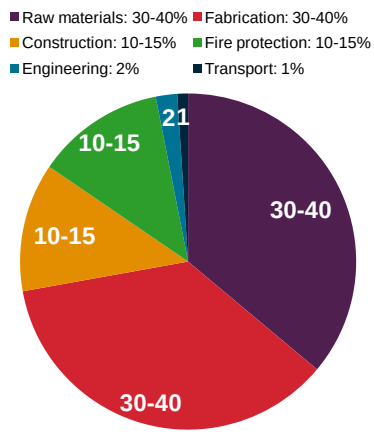
Signed for and on behalf of ABC Engineering Ltd by:

John Smith, Director
Pondington, Plumshire
1 April 2013

- **A** Steelwork contractor's unique DoP Certificate identification number.
- **B** Steelwork contractor defined (may be omitted if not relevant).
- **C** Brief description of use, which may include project name and location.
- **D** Check that notified body and level of assessment declared is consistent with the FPC and Welding Certificates where appropriate.
- **E** Steelwork Contractors are not required to declare performance against all of the performance characteristics in Table ZA.1 of BS EN 1090-1 +A1:2011, but only those that are appropriate and for which they are responsible.

Contents

Total cost of structural steelwork



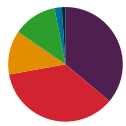
Custom and practice

- Traditionally, the Engineer's measure of efficient design is steel intensity (kg/m2)
- This only considers one aspect of total cost of structural steelwork

Sample estimate on 1500t steel frame

Includes off-site applied fire protection

▪ 1500t of raw material @ say £800/t	: £ 1,200,000	(41%)
▪ 1500t of fabrication @ say £500/t	: £ 750,000	(26%)
▪ 12 week construction programme @ say £35k/wk	: £ 420,000	(14%)
▪ 20,000 m^2 of fire protection @ say £22/m^2	: £ 440,000	(15%)
▪ 1500t transportation costs @ say £30/t	: £ 45,000	(1%)
▪ 3000 Engineering hours @ say £30/hr	: £ 90,000	(3%)
Total	**: £ 2,945,000 or**	
	: £ 1963/t	



Sample estimate on 1500t steel frame

Includes off-site applied fire protection

▪ 1550t of raw material @ say £800/t	: £ 1,240,000	(45%)
▪ 1550t of fabrication @ say £400/t	: £ 620,000	(23%)
▪ 12 week construction programme @ say £35k/wk	: £ 420,000	(15%)
▪ 20,000 m^2 of fire protection @ say £15/m^2	: £ 300,000	(11%)
▪ 1550t transportation costs @ say £30/t	: £ 46,500	(2%)
▪ 3200 Engineering hours @ say £30/hr	: £ 90,000	(4%)
Total	**: £ 2,722,500 or**	
	: £ 1756/t	

Fabrication

Not all steel fabrication is the same

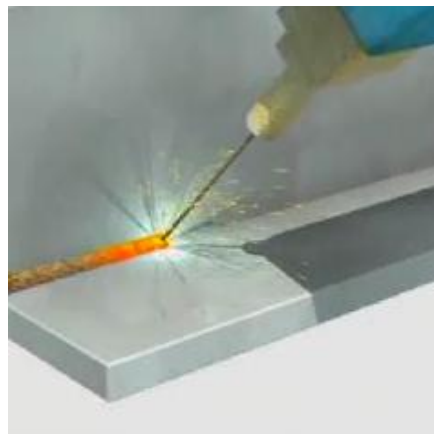
- Modern high volume fabrication shop
- Low weld content
- Low man hours/t

- Specialist plate girder facility
- High weld content
- Automated
- Low man hours/t

- Specialist piece
- High weld content
- Manual
- High man hours/t

Assessing the impact of fabrication

Optimising weld content

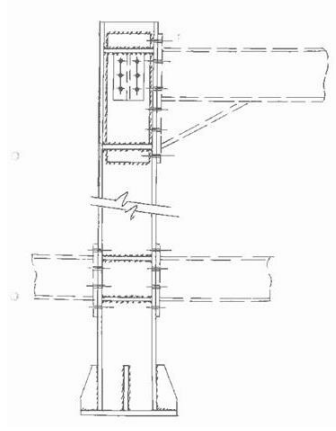


The cost of welding

- It takes 20 minutes to lay 1m of 6mm single run fillet weld (including set-up, cleaning, testing and inspection)
- In cost terms 20 hours of fabrication time is equivalent to 1t of steel
  - or 60m of 6mm fw = 1t steel
  - or 60mm of 6mm fw = 1kg steel

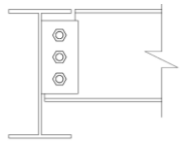
Assessing the impact of fabrication

An example from the industry

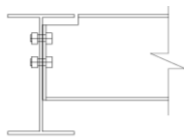


Quantities		
305 UKC 118 x 14m	= 1652	kg
Base plts & stiffeners	= 160	kg
Connection stiffeners	= 115	kg
Total	**= 1927**	**kg**
Length of welds (avg 6mm FW)	= 55	m
(55m ≡ 18.3 fab hrs ≡ 915 kg steel)		
Equivalent cost	**= 2842**	**kg**
Alternatives		
305 UKC 137 x 14m	= 1918	kg
305 UKC 158 x 14m	= 2212	kg

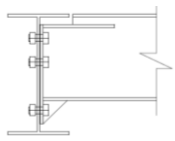
Cost of different connection details



- Endplate connection
  - +2% more Material
  - +14% more Labour
  - +5% Overall Cost



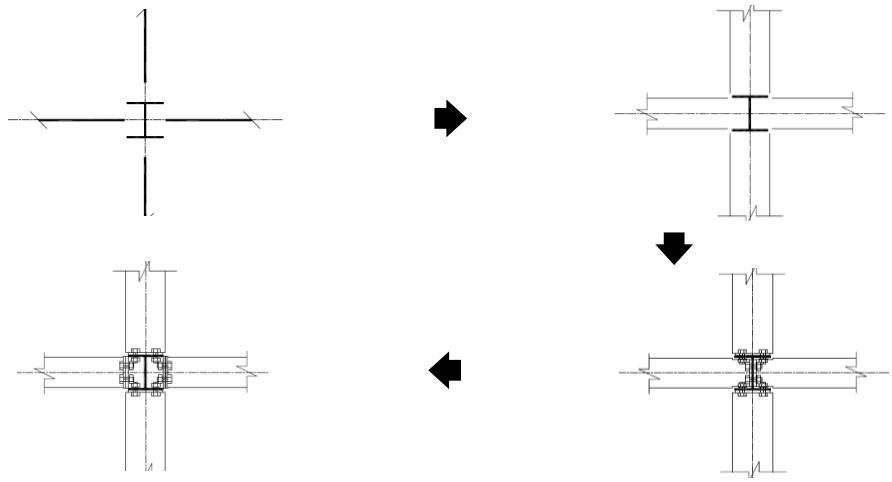
- Stiffened endplate
  - v's fin plate connection
    - +5% more Material
    - +49% more Labour
    - +15% Overall Cost.



- v's endplate connection
  - +3% more Material
  - +31% more Labour
  - +10% Overall Cost

Identifying fabrication complexity

Placeholder for your own sub headline (Arial 20p)

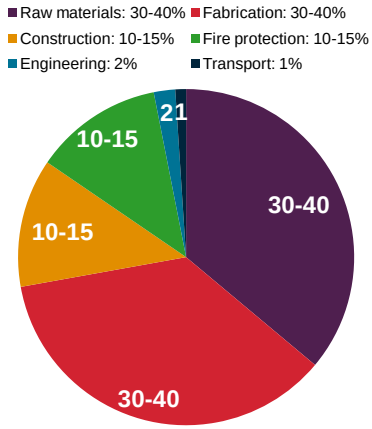


Introducing fabrication cost

Make decisions based on engineering calculation

- Don’t change connection details to suit personal preference/ experience
- Try not to specify minimum weld sizes and/or butt welds based on uncertainty or conservatism
- Do not add connection stiffening or reinforcement plates when not required by calculation
- Frame assemblies (bolted v welded)
- Geometry, e.g. skewed or bevelled cuts
- Standardisation of section sizes for structure

Assessing the impact of erection

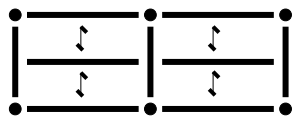


Steel erection

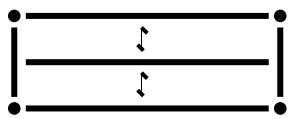
- Not as significant as material and fabrication costs
- Potential to add value

Impact of erection

Piece count



- Short span layout
  - Beam intensity : 20 kg/m^2
  - No. of beams : 9
  - No. of columns : 6
  - Total No. of pieces : 15

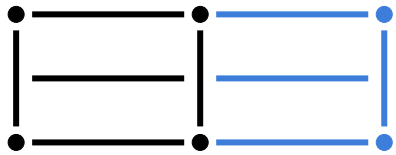


- Clear span layout
  - Beam intensity : 32 kg/m^2
  - No. of beams : 5
  - No. of columns : 4
  - Total No. of pieces : 9

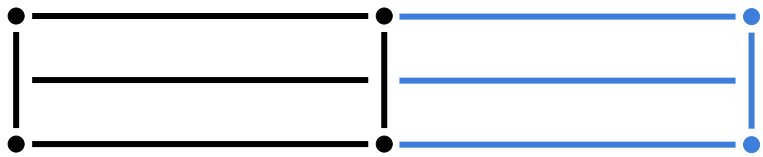
Impact of erection

Piece count

Short span layout

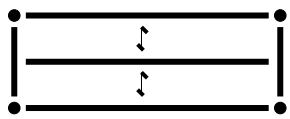


Clear span secondary layout

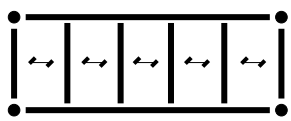


Impact of erection

Clear span layouts



- Clear span secondary layout
  - Beam intensity : 32 kg/m^2
  - No. of beams : 5
  - No. of columns : 4
  - Total No. of pieces : 9



- Clear span layout
  - Beam intensity : 30 kg/m^2
  - No. of beams : 8
  - No. of columns : 4
  - Total No. of pieces : 12

Contents

Conclusions

- CE Marking
  - All fabricated structural steelwork on site after 1 July 2014 must be CE Marked
  - It is the Engineer's responsibility to specify the Execution Class
  - Either
    - Use a BCSA member or
    - Check Factory Production Control Certificate / Welding Certificate / Declaration of Performance (project specific)
- Practical design considers
  - Fabrication : optimum weight to minimise workshop hours
  - Erection : simple details aligned with the design philosophy
  - Economy : shedding lbs doesn't = Less £'s

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Thank you …