BCSA Code of Practice for Erection of Multi-Storey Buildings

BCSA Publication No 42/06

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BCSA is the national organisation for the Steel Construction Industry: its Member companies undertake the design, fabrication and erection of steelwork for all forms of construction in building and civil engineering. Associate Members are those principal companies involved in the purchase, design or supply of components, materials, services etc., related to the industry. The principal objectives of the Association are to promote the use of structural steelwork: to assist specifiers and clients: to ensure that the capabilities and activities of the industry are widely understood and to provide members with professional services in technical, commercial, contractual and quality assurance matters.

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SUMMARY

This document is a code of practice for Steelwork Contractors erecting multi-storey steel-framed buildings. The principles included also apply to high-rise structures generally, such as those used to support industrial process plant.

The code also provides guidance to Clients, Planning Supervisors, Principal Contractors and Designers. It describes the management procedures and methods to be adopted and is intended to serve as a standard reference when drafting site- and project-specific Erection Method Statements.

Multi-storey buildings are defined as those structures that cannot be wholly accessed using mobile elevating work platforms [MEWPs] working from site ground level. Generally these structures require columns to be spliced, and it is often necessary to use tower cranes for erection.

The document contains advice on the safety aspects of site management; site preparation; delivery, stacking and storage of materials; structural stability; holding down and locating arrangements for columns; lifting and handling; and interconnection of components.

The document is intended to aid compliance with the *Health and Safety at Work etc Act*, and with the relevant specific requirements of applicable regulations and approved codes of practice issued by the Health & Safety Executive.

If the Steelwork Contractor appoints a specialist erection subcontractor, then some obligations defined in the code of practice may inevitably devolve to the erection subcontractor (eg where these relate to the direct employer of the erectors), but the Steelwork Contractor should still ensure that the code of practice is being followed properly by agreeing the allocation of responsibilities in advance.

ENDORSEMENT

The Health & Safety Executive welcomes this BCSA *Code of Practice for Erection of Multi-Storey Buildings* and considers it as an important document in supporting the effective management of health and safety risk. It is a clear example of industry "self regulation", as the direct involvement of experienced and professional practitioners ensures that such guidance will be both relevant and authoritative.

The British Constructional Steelwork Association understands the importance of self regulation and over the years has been proactive and not simply reactive in reducing risks and accidents. The HSE welcomes working in partnership with BCSA because its positive approach has enabled steelwork erection to be undertaken both imaginatively and with increased safely.

This code can also serve, in part, to replace the withdrawn HSE publication entitled GS 28 *Safe erection of structures.*

Multi-storey erection can use 35m MEWPs that reach the eighth level

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1 INTRODUCTION

1.1 SAFETY OBJECTIVES

The principal safety objectives when erecting steelwork are:

- Stability of the part-erected structure;
- Safe lifting and placing of steel components;
- Safe access and working positions.

The most serious accidents that occur during the erection of structures are generally caused by falls from height, either from working positions or while gaining access to them. Other serious accidents can occur because of structural instability during erection and while handling, lifting and transporting materials. Failure to establish safe erection procedures and to implement them through effective site management can create unnecessary hazards, leading to risks being taken and hence to accidents.

1.2 COMPETENCE AND SUPERVISION

The single most important step that contributes towards safe practice is to ensure that competent persons are mobilised. This is because such persons will observe the following precautions concerning the work in general and tasks in particular:

PRECAUTIONS

Do not commence work until it is clear what needs to be done.

Do not undertake work outside the limits of your competence.

Do not undertake tasks without the necessary tools and equipment.

Be clear about the arrangements for supervision in terms of the chain of command.

Do not deviate from what has been planned without checking with those in the chain of command.

Ensure that the area around the worksite is kept clear of hazards.

Watch out for hazardous activities being undertaken by other operatives, including others in your own gang.

Ensure that others not involved in the task do not encroach into an exclusion zone around the worksite.

Selection of a competent Steelwork Contractor is a necessary precondition towards ensuring that competent persons are mobilised to undertake the steel erection – whether these be employed by the Steelwork Contractor directly or by a specialist steel erection subcontractor. The Steelwork Contractor must observe the following preconditions:

PRECONDITIONS

Ensure that the scope of work is within the limits of competence of the firm.

Develop suitable method statements for the erection work in general and for specific tasks as necessary.

Agree the chain of command for site work with the Principal Contractor.

Provide appropriate supervision to manage the work on site.

Provide the necessary resources of manpower, plant and equipment.

Agree how exclusion zones should be operated to keep others away from hazards arising from steel erection.

The BCSA's *Guidance Notes on the Safer Erection of Steel-Framed Buildings* define activities that Steelwork Contractors should be able to undertake within their scope of competence (see the Appendix to this code of practice).

Work should be supervised by persons who are suitably trained and experienced in the type and size of structure being erected and their authority should be made known to all concerned, possibly by means of an organisation chart. The arrangements for supervision of work on site during erection can vary as follows:

- The Steelwork Contractor must identify a manager in overall charge of the work being undertaken, and the personnel and resources mobilised. Often this person, such as a contracts manager, will be in charge of work on more than one site and will thus not be on site continuously.
- Individuals sent to site to work alone must be assessed as capable of self-supervision, and they must report regularly to the Principal Contractor's site manager.
- When work is in gangs, each gang requires a chargehand to be identified.
- A site foreman, often being the most senior chargehand, would often be in continuous charge of day-to-day site operations on smaller sites.
- If several gangs are working on site simultaneously with more than one foreman, it may be necessary for the Steelwork Contractor to maintain the continuous on-site presence of an overall site supervisor.

At all times whilst erection activity is taking place, it must be made clear to both the erectors and to the Principal Contractor's management who is in direct supervisory control of those activities. The identity of the responsible erection supervisor may change over the period of a contract.

1.3 TRAINING AND QUALIFICATIONS

The Steelwork Contractor should be satisfied that those employed are fit enough to carry out the work required, have the necessary experience and have received the necessary training to carry out the work safely and without risk to health.

Experienced workers may generally be assessed as being competent to undertake steel erection based on their record of work. New entrants will require a more detailed record of training and assessment in a suitable National Vocational Qualification at Level 2 as a minimum. All persons employed on site need to produce evidence of having passed an appropriate Health & Safety Test. Advice on the specific NVQs and H&S Tests that are appropriate is available from the BCSA.

The Steelwork Contractor should ensure that training and qualifications meet that required by the Principal Contractor (eg those of the Major Contractors Group [MCG]). Minimum training and qualification requirements are as follows:

Managers and Supervisors	CSCS Manager or Supervisor Cards
Foremen and Chargehands	As erectors with: Crane supervision training Rescue training
Erectors	CSCS Erector Card Health & Safety awareness training Work at height awareness training Certificated slinger/signaller training CPCS Card or IPAF training for operation of MEWP
Welders	CSCS Fabricator Card Welder qualification suited to task in hand

Equivalent training and qualification schemes are operated in the petrochemical and other specialist sectors.

1.4 BRIEFING AND INDUCTION

All erectors should be issued with a copy of the BCSA Erectors' Manual and be familiar with its contents. Erectors should also be properly briefed about the tasks in hand using on-the-job instruction.

Before beginning work on site, all workers should attend a site induction which should include making workers aware of special site restrictions or any specific hazards on site. Site inductions should be organised by the Steelwork Contractor in accordance with the Principal Contractor's arrangements for site inductions. If workers are involved in the main work of steel erection, their induction should include a briefing conducted by the Steelwork Contractor based on the Erection Method Statement for the work. They should countersign a document that confirms that they have received and understood the site induction.

Erectors should continue to be briefed on the safe method of work to be employed on each particular job as the work progresses using regular toolbox talks that:

- Familiarise erectors with the development of the work in accordance with the Erection Method Statement;
- Brief them on changes to methods and Addendum Method Statements as necessary;
- Explain the content of any Task Specific Method Statements;
- Discuss other topics relevant to site conditions (eg developing weather conditions);
- Focus on problems identified from "walk round" risk assessments;
- Ensure that their equipment, training and certification are up-to-date.

1.5 PLANNING, PROGRAMMING AND COORDINATION

Safe working methods and practices on site require:

- Appreciation of the implications of design risk assessments;
- The preparation and use of detailed method statements;
- Thorough and active contract co-ordination both on and off site;
- The implementation and maintenance of effective communications;
- Realistic and effective methods of programming and progressing;
- The organisation of work, which takes into account adverse weather conditions;
- The provision of competent staff, as noted above;
- The provision of the necessary resources including protective equipment appropriate for the work.

Co-ordination and liaison should be planned before the job starts. Depending upon the size and complexity of the job, the Steelwork Contractor should identify a line manager responsible for erection and/or a manager with overall responsibility for the contract. The role of the person, or persons, responsible for co-ordination and liaison should be clearly defined and their authority made known to others involved.

Before implementing any procedures or changes in previously agreed procedures, the procedures must be verified as being safe by the person responsible for co-ordination. Safety must be assessed in terms of the safety objectives defined above – stability, lifting and access.

If procedures or changes affect structural stability, they should be checked with the Designers or by a suitably qualified person who has knowledge of the structural scheme and of design risk assessments provided by the Designers, who would include the designer of the structural frame, and may also include those who have detailed the structural connections. Occasionally it could include other Designers, such as those with responsibility for the design of specialist components such as light gauge members or precast elements.

The coordination necessary for safe erection includes ensuring:

- That liaison has taken place on the sequence of operations, the arrangements for delivery, stacking and storage on the ground or on previously erected steelwork, and the provision of suitable access and hard standings for off-loading.
- That liaison has take place on the arrangements for the provision of suitable hard standings for cranes, and/or for sharing craneage if necessary.
- The availability of the necessary information including sufficient detailed drawings available in time to allow effective forward planning for safe construction: these drawings may be from the frame designer, the detailer or the manufacturer.
- The manufacturer has adequate information (including any dimensions which can only be obtained from site once construction has started) and is manufacturing to specification and according to programme.
- That the supply of materials/components is as specified: generally all steel components should comply with the BCSA “Black Book” National Structural Steelwork Specification for Building Construction [NSSS]. A copy of the NSSS should be made available on site.

- That the correct components are delivered to site in the required order: if incorrect or insufficient or non-conforming components are delivered to site, the consequences should be reviewed and the effect on the erection sequence taken into account in any subsequent action.
- The availability of resources of manpower, plant and equipment.

Irrespective of the employment status of the site erectors, arrangements should be made to ensure that erectors know who to contact if the work cannot proceed as planned. When erecting, communications should be clear and unambiguous and use of on-site radio contact may be essential in the case of very tall structures.

Erection progress should be recorded to help ensure that the correct components are available when required to enable the job to proceed according to the agreed sequence in the erection method statement. This may be by means of an easily read system of graphical representation to record progress. The system chosen should reflect the magnitude and type of job, and could be illustrated by bar charts, marked-up drawings or by more sophisticated computerised reviewing techniques.

1.6 WEATHER CONDITIONS

As weather conditions can change from hour to hour, and as not all erection activities are similarly affected by weather changes, persons in charge of supervising erection work on site should regularly monitor weather conditions, and take appropriate decisions. Weather conditions that could have an adverse effect on erection work include:

- Rain or dew that leaves the steel wet;
- High winds that may cause light components to blow about, suspended loads to swing or part-erected structures to become unstable;
- Frost, ice or snow that can result in slippery surfaces and endanger personal health;
- Fog, mist or glare that may impair visibility.

On most high rise structures, it will be necessary to undertake a particular assessment of how wind might affect the proposed erection method in terms of stability, craneage and access equipment. BCSA *Guide to Steel Erection in Windy Conditions* and any guidance given by the manufacture or supplier of the plant in use should be followed.

If a decision is made to stop work, then measures should be taken to ensure the maintenance of stability of the remaining part-erected structure. If the wind is increasing sharply, it may be necessary to guy columns or even to dismantle them as a precaution. If the wind increases in strength more quickly than anticipated, such that it is no longer possible to operate safely but components have been left in a potentially dangerous condition, the designation and strict operation of an absolute exclusion zone will be necessary. Later, the stability of the previously erected components must be reassessed before work is restarted.

1.7 METHOD STATEMENTS

Employers must ensure, as far as is reasonably practicable, the provision of a safe system of work. The preparation of an erection method statement setting out the proposed erection scheme is an important part of planning for such a safe system of work. The extent of detail in a method statement will depend upon the size and/or complexity of the work. Simple jobs may only require a simple method statement and repetitive tasks may be covered by standard sheets. With this in mind, the BCSA has published a proforma suitable for use in preparing Task Specific Method Statements [see the Appendix to this code of practice].

For all but the most straightforward of structures, it is preferable that the frame designer identifies how the stability of the structure is to be developed by defining a safe design erection sequence. For complex structures it is essential that a more detailed design-basis method of erection is provided. It can also be the case that stability during erection is affected by the nature of the connections selected by the detailer. The BCSA's *Guidance Notes on the Safer Erection of Steel-Framed Buildings* give additional guidance on:

- How erection method statements should be prepared;
- Items to be considered in developing the erection method statement;
- How the design of connections can affect safe erection;
- Stability and temporary bracing.

Note that in this document terms are used in the following way:

- **Erection sequence.** The order in which components are lifted and placed into position; often this will be provided by a suitably qualified person who clearly understands design implications, and it does not need to be presented graphically.
- **Erection scheme.** The erection sequence presented graphically in the form of drawings.
- **Erection procedure.** An extension of the erection scheme or sequence that includes information about the location and movement of plant such as cranes; often this will be initially defined in the tender by a specialist in erection techniques.
- **Erection method statement.** This comprises what is needed for planning and control of the site operations; this document will add more detail to the erection procedure to ensure that it is comprehensive in coverage. Often this is based on a generic method statement but should always be developed into a site specific method statement by or with the collaboration of the person with primary line responsibility for supervising the work on the site. It is a "live document" that should be reviewed and updated if site circumstances dictate. It should then be distributed to all those concerned with the supervision of erection.
- **Addendum method statements.** These are often needed if a change takes place that affects the previously agreed method significantly.

1.8 REGULATIONS AND DOCUMENTATION

There are many regulations that affect site erection of steelwork, and it is the responsibility of management to be both familiar with the regulatory requirements and to ensure that relevant requirements are observed. Generally, the most practical way of doing this is to follow the approved codes of practice and guidance notes that have been prepared for this purpose by the Health & Safety Executive [HSE]. The person named in the Company's H&S Policy as having primary responsibility for health and safety is responsible for ensuring that line managers have copies of the latest relevant HSE documents.

Where directly relevant, copies of useful documents (such as the HSE's Construction Information Sheets [CISs]) should be issued to those directly responsible for the supervision of site operations. Site supervisors can then use the codes and guidance issued to brief site erectors as necessary. Supervisors should not rely solely on issuing paperwork to those undertaking the actual work on site; instead key abstracts should be used to brief the site team.

The BCSA *Guidance Notes on the Safer Erection of Steel-Framed Buildings* incorporate many of the most important points flowing from the regulations. The Steelwork Contractor should ensure that those with overall responsibility for steel erection are familiar with this document.

Currently the regulations of most importance to steel erection are:

- *Construction (Design & Management) Regulations* [CDM Regs]
- *Construction (Head Protection) Regulations*
- *Construction (Health, Safety & Welfare) Regulations* [CHSW Regs]
- *Control of Substances Hazardous to Health Regulations* [COSHH Regs]
- *Control of Vibration at Work Regulations*
- *Electricity at Work Regulations*
- *Health and Safety (First Aid) Regulations*
- *Health and Safety at Work, etc Act* [HSW Act]
- *Highly Flammable Liquids and Liquefied Petroleum Gases Regulations*
- *Lifting Operations and Lifting Equipment Regulations* [LOLER]
- *Management of Health & Safety at Work Regulations* [MHSW Regs]
- *Manual Handling Operations Regulations*
- *Noise at Work Regulations*
- *Personal Protective Equipment at Work Regulations* [PPE Regs]
- *Provision and Use of Work Equipment Regulations* [PUWER]
- *Reporting of Injuries, Diseases and Dangerous Occurrences Regulations* [RIDDOR]
- *Workplace (Health, Safety & Welfare) Regulations*
- *Work at Height Regulations*

BS 5531 *Safety in erecting structural frames* is a code of practice that is still current in terms of all its technical advice including especially that concerning how to ensure stability during erection.

Note that for many years steel erectors relied on the guidance given in a general series guidance note issued by the HSE in four parts entitled GS 28 *Safe erection of structures.* This guidance note was withdrawn by the HSE and has not been replaced as some of its advice has been outdated by more recent regulatory changes. Part 3 *Working places and access* and Part 4 *Legislation and training* of GS 28 were most affected by the subsequent changes, whereas most of the guidance in GS 28 Part 1 *Initial planning and design* and Part 2 *Site management and procedures* remains sound background advice. The Steelwork Contractor should ensure that those with overall responsibility for steel erection are familiar with BS 5531 and have reviewed for themselves what was in GS 28 Parts 1 and 2.

1.9 RISK ASSESSMENT

Employers must identify and assess hazards and risks that apply to their undertakings, and state the measures to be taken to eliminate, reduce or control those hazards. Such assessments should be in writing. The following steps should be followed:

- Operations or tasks that are or could be performed on site should be identified. Hazards that might arise from those activities are then listed. As these steps are generally common to steel erection operations on most construction sites irrespective of size and complexity, generic lists of activities and hazards may be prepared.
- The risk assessment then consists of evaluating the extent or degree of risk that could arise from each hazard. The ability to avoid, reduce or control risks arising from these hazards can be taken into account in order to reduce risks arising to an acceptable level, provided that the controls etc are managed. For instance, the risk of laceration from sharp edged steel components can be managed by the supply and enforced use of suitable gloves as personal protective equipment appropriate to the job in hand.
- Importantly, there is always the possibility that each new project may give rise to new hazards as each project is different. For this reason, the generic risk assessments associated with generic methods should always be reviewed alongside the implications of the site-specific method statement. If the design of the structure gives rise to special hazards, these should be identified in a design risk assessment issued as part of the Pre-Tender Health & Safety Plan and carried forward for action in the Construction Health & Safety Plan. The opportunity should be taken to consider whether some risks could be avoided by re-design.
- During the progress of the work on site situations may arise that require a review of methods and/or a re-assessment of risks. There may be the necessity to alter the sequence of work, to undertake variations to the work content, or a "walk round" the site may identify unanticipated or poorly controlled hazards. In all these circumstances, the BCSA's *Task Specific Method Statement* provides a proforma for additional hazard identification and risk assessment associated with specific situations.

2 DESIGN ISSUES

2.1 GENERAL

There is an obligation on Designers to have adequate regard to:

- Avoiding risks to health and safety;
- Tackling the causes of risks at source;
- Reducing and controlling the effects of risks by means aimed at protecting anyone at work (ie general protection is preferable to providing personnel protection for individuals);
- Providing information to contractors about significant residual risks occasioned by the design;
- Establishing at least one safe sequence of erection for the structure.

When providing information about erection to others, Designers should concentrate on items whose importance for safety would not be evident to persons without a detailed knowledge of the design and design practice. Generally, these residual risks will be identified in the *Pre-Tender Health & Safety Plan* or on the drawings. However, as the distinctive role of the Designer may be less clear if the work is being undertaken on a design-and-build basis, the Steelwork Contractor should ensure that in-house Designers are aware that they carry the same obligations defined above.

With respect to the erection of the steel structures of multi-storey buildings, the most important design considerations arise from the need to ensure stability of the part-erected structure. The design erection sequence will generally require an understanding of structural concepts that a Designer would have but which those responsible for supervising erection may well not have. This places a special obligation on the Designer to ensure that others without specialist knowledge are clearly informed about what might otherwise be latent hazards arising from the design concept. On more complex structures it may be necessary for the person drafting the Erection Method Statement to enter into a dialogue with the Designer. The NSSS requires that erection shall not commence until the method statement is accepted by the person responsible for the structural design.

2.2 STRUCTURAL LAYOUT

With multi-storey structures, the most important design issues affecting stability are:

- **Securing of single columns against toppling.** Before they are tied into other structural members, columns at foundation level may require guying if stability cannot be ensured by using suitable holding down [HD] bolt arrangements combined with wedging. Often the base details will be decided by the connection designer, and the wind speed used to review the stability of a single column (with wedges as appropriate) should be clearly communicated. Reference should be made to the BCSA *Guide to Steel Erection in Windy Conditions* when carrying out such a review.
- **Column splices.** Similar stability considerations occur where upper shafts are connected at column splice positions. Whilst the details will again often be decided by the connection designer, the shaft lengths and splice locations will generally be decided by the frame designer. The location of the splice needs to be at least 1100mm above finished floor level if it is to be used for securing temporary edge protection. As above, the limiting wind speed should be clearly communicated and reference should be made to the BCSA Guide noting that typical wind speeds for a site rise with height.

- **The condition of the foundations.** Erection is often started as soon as the foundations are complete and before they achieve their full design strength. The forces arising in the holding down bolts from, say, single erected columns may place significant loads on the foundation that might not be sustainable in the part-cured condition.
- **Pin bases.** Often column bases are designed as pinned connections. In such cases, the erectors need to be warned that it would not be safe to leave the columns un-guyed unless an assessment showed that the "pin" base does nevertheless provide sufficient moment capacity to achieve adequate resistance to transient horizontal loads applied to the column.
- **Overall stability.** During the part-erected condition, multi-storey structures need to resist horizontal loads applied to them by wind or due to practical imperfections such as lack of verticality. Many multi-storey building structures resist horizontal loads by means of the floors – normally in-situ or precast concrete slabs – acting as stiff diaphragms spanning horizontally between bays of vertical bracing. The vertical braced bays may comprise diagonal bracing members, or be rigid moment frames or cores from concrete or steel (as illustrated). In the permanent condition, there is a clear load path for the horizontal loads applied at the floor levels which are distributed horizontally through the floor plate to the braced bays and then down to foundation level through the vertical bracing. In the part-erected condition, all or a significant amount of the erection needs to take place prior to the construction of the permanent floor plate. The erection sequence needs to address this issue by ensuring that stability of the columns which are not aligned with permanent bays of vertical bracing can be ensured by other means – generally by a contribution to sway frame action from the beam-to-column connections or otherwise by temporary bracing (see below). Even if the steel frame is designed with beam-to-column connections which are assumed to be pinned in theory, they are likely to have a degree of moment capacity but this should be verified.

Corefast© steel core

- **Temporary bracing.** The temporary stability of multi-storey structures should be assessed by a suitably qualified person and, if necessary, temporary bracing should be designed and incorporated into the structure as erection proceeds. This may comprise additional bays of vertical bracing to stabilise columns which are intermediate between permanent braced bays or plan bracing to temporarily carry out the function of the floor plates before they are constructed. Design loads on temporary bracing should be appropriate to the actions on the structure during the transient construction phase. The BCSA *Guide to Steel Erection in Windy Conditions* provides useful references when designing for transient conditions. For taller structures it is likely that construction of floor plates will immediately follow the frame erection thus limiting the number of storeys subject to temporary instability effects above the highest completed floor. It is essential that the planned safe erection sequence is clearly understood by the person making the temporary stability assessment. To ensure that this sequence is adhered to during the execution of the works, the erection method statement must clearly state the conditions for removal of the temporary bracing. It is likely that a number of stability assessments will need to be made to consider different stages of erection. It may be possible for temporary bracing to be removed from lower levels and relocated further up the building as construction proceeds.

- **Temporary stability of beams.** In the permanent condition beams may be laterally restrained by the floor or roof construction. During construction there will almost certainly be a temporary condition where the beam is required to carry some load in an unrestrained condition. Long span roof members, composite floor beams or other members such as cellular beams that would be susceptible to instability should be identified by the frame designer, and a suitably qualified person should define the necessary restrictions for the erection method statement.
- **Beam end connections.** When two beams have a back-to-back connection to the web of a column or the web of a transverse beam it should be possible for the first beam be fixed and freed from the crane before the second is erected. The connection should be detailed with at least one or two bolts which are not shared by both beams and which can be inserted and tightened when the first beam is erected independently of the fixing of the second beam.
- **Precast concrete units.** Planks and staircases made of precast concrete can impose significant local loads that can de-stabilise the steel frame before the work is completed (eg by the use of in situ topping or grout). A particular case of temporary instability of beams may occur when they either support precast concrete floor units on a shelf angle or on the bottom flange as in the case of a Slimflor type beam. When one or more units are erected on only one side of the beam, torsional twisting of the beam may occur due to the eccentricity of the applied load leading to instability. The erection sequence should be planned to minimise such effects but the design of such beams and their end connections should consider temporary torsional effects likely to arise during construction. If such effects cannot be designed out, appropriate temporary propping will need to be designed and specified. The guidance issued by the Precast Flooring Federation on the safe erection of precast elements should be followed.

2.3 HANDOVER CRITERIA

With multi-storey structures, there are also design issues that affect the safe handover of the structure to following trades:

- **Grouting.** Until the bases are grouted, the structure does not possess the full stiffness and stability intended by design. It may be necessary to ensure that the grout is sufficiently cured before the structure is ready to receive other construction loads. Decisions on whether the grout is suitably cured should be taken in consultation.
- **Decking.** The locations where packs of decking can be safely positioned may need to be determined by the frame designer. Fixing of decking or sheeting should not commence until the structure has been aligned.
- **Handrails and netting.** It is common for handrail edge protection and netting to be fixed to the steel structure to ensure safe access for following trades such as deckers and cladders. However, over-tensioned netting can distort steel members and fixing handrails to edge beams and requires care to ensure the members are not distorted.
- **Concreting.** Usually concreting is not undertaken by the Steelwork Contractor. Hence, the use of decking prior to concreting and the conditions necessary to ensure stability during concreting will need to be discussed between the relevant contractor, the Principal Contractor and the Designer.

3 MANUFACTURE AND DELIVERY

3.1 FABRICATION

Fabrication of steel components for the most common form of multi-storey structures is generally semi-automated nowadays, such that errors are few and trial assembly is unnecessary.

Drilled holes in columns allow for the provision of anchor points for fall arrest systems and running lines during the erection stage. Drilled holes in beams or welded attachments can be provided for fixing of proprietary or custom edge protection systems. Drilled holes may also be required for attachment of positive lifting devices.

Positive lifting device

3.2 DELIVERY

Except perhaps in the case of main columns, it is generally the case that steel components used in multi-storey structures can be delivered without the need of an escort. The Steelwork Contractor's primary concerns during delivery are to load the components so that they are not distorted and that any surface coatings are not damaged. Surface coatings applied to internal steelwork are generally more for reasons of visual appearance than corrosion protection.

It is also important to ensure that they arrive in due time and in a manner that permits them to be easily unloaded to meet the requirements for site progress. On most confined inner city sites lay-down areas are often restricted. In order to reduce the disruption to local traffic it is also common to have delivery time restrictions placed on the site thus rendering "straight from the trailer" erection difficult. In such circumstances the Steelwork Contractor may consider the use of storage platforms. These platforms are steelwork frames that can be lifted on to the structure and secured to allow materials to be delivered above structurally completed floor levels. The platform is provided with edge protection and toe boards along its perimeter and can be re-located as the structure develops.

High level storage platform located onto the steelwork for use where there is insufficient storage at ground level

4 SITE ACCEPTANCE

4.1 PRINCIPAL CONTRACTOR'S RESPONSIBILITY

It is the responsibility of the Principal Contractor to provide a site that is suitable for erection to proceed safely. Prior to commencement of work on site, the Steelwork Contractor needs to clarify that site conditions provided by the Principal Contractor are safe for erection. The BCSA's *Safe Site Handover Certificate* [SSHC] should be used to ensure that the key issues affecting safety are addressed.

In completing the SSHC, the Principal Contractor also has the opportunity to identify any special conditions that may exist, such as shared use of access, fall protection or other provisions.

Often the Steelwork Contractor will have based the preliminary scheme for steel erection on the *Pre-Tender Health & Safety Plan.* The Principal Contractor is responsible for developing the *Construction Health & Safety Plan.* In developing this, the Principal Contractor should clarify any special requirements that may affect steel erection, such as special restrictions on hours of work, noise levels and timing of deliveries to site.

4.2 SAFE SITE HANDOVER CERTIFICATE

The *Safe Site Handover Certificate* has been developed to:

- Facilitate the safe erection of steelwork, with the risks arising from poor site conditions removed, avoided or reduced.
- Assist Clients, Principal Contractors and Steelwork Contractors alike to meet their respective responsibilities under health and safety regulations eg *CDM Regulations.*
- Provide criteria stipulating safe site conditions as an inherent part of the steelwork tender offer, and as an agreed basis for the commencement of steelwork delivery and erection on site.
- Provide a consistent approach to safe site conditions.

The SSHC provides a checklist approach to key areas of safety related to site conditions. In some cases, brief descriptions of the checklist items are given to maintain consistency of interpretation of terms and of specific requirements.

Commencement of site delivery and erection shall be contingent upon the completed and signed certificate being received by the Steelwork Contractor SEVEN DAYS before an agreed commencement date. Subject to agreement with the Steelwork Contractor, survey of the position and condition of column foundations may proceed prior to the acceptance of the site as safe for the main erection activities.

This seven-day period should allow the Steelwork Contractor to ascertain whether adequate conditions have been provided and, subject to that provision, to sign and return a copy of the SSHC to the Principal Contractor signifying that the steelwork delivery/erection can commence on the agreed date.

It is assumed that the site conditions will be maintained at a proper level, and the SSHC checklist provides the means for monitoring conditions throughout the programme of steel erection.

Similarly, where the contract involves phasing, the SSHC can be used as a means of either:

- Providing a single certificate with a condition that subsequent areas/phases will be provided to the same standards, or
- Providing multiple certificates, one for each phase.

When assessing site conditions and completing the SSHC, the following issues will need to be given due consideration: access for delivery; hardstanding; craneage; electric power lines; delivery, loading and off-loading on site; and attendances.

4.2.1 Access for delivery

The Principal Contractor should provide satisfactory means of access to the site so that delivery vehicles can reach the correct unloading point. Suitable unloading facilities should be available and the ground should be capable of withstanding the wheel loads of the delivery vehicles as well as any mobile plant used for unloading. Sufficient storage area should be designated and made available before deliveries of components take place.The Principal Contractor should ensure that there are clear points of access, free of all obstructions, to allow passage of vehicles carrying the steelwork on to the site. No obstructions should prevent the access of vehicles with high loads, or the movement of cranes and lifting gear in the erection area. If there are obstructions, the Principal Contractor should provide sufficient and adequate warning that such hazards or restrictions exist prior to commencement of work on site.

Generally, the arrangements for deliveries will be contained within a site specific traffic management plan provided by the Principal Contractor. For certain sites, such as congested city centre sites where delivery lorries waiting to be unloaded need to be held off site on the public highway, such a plan is essential.

When any vehicle is reversed, a banksman must be in attendance.

4.2.2 Hardstanding

The Principal Contractor should ensure that rolled and consolidated hardstanding is provided everywhere that either mobile cranes or MEWPs are to be used.

Care must be taken to ensure that plant (for lifting, handling or access) is located on properly prepared ground. Outriggers should be well supported with no possibility of ground slippage. The Principal Contractor is responsible for notifying the Steelwork Contractor of the allowable ground bearing pressure of the made-up sub-base. The Steelwork Contractor should then calculate the requirements for outrigger pads, wheels or tracks as appropriate based on data from the plant manufacturer or supplier.

4.2.3 Craneage and powered plant

The most common types of plant used for steel erection of multi-storey structures are tower cranes and mobile elevating work platforms [MEWPs]. For medium rise structures up to about 20m it may be possible to access the steelwork using MEWPs operating from ground level, provided there is sufficient room beyond the footprint of the structure for the MEWPs to operate. As described further below, for high rise structures it may be possible to arrange access using MEWPs working off the structure – either mounted on frames (sometimes termed “skids”) or by operating over the floor slab.

The Steelwork Contractor should ensure that only trained and competent persons operate powered plant except when persons are being trained under the direct supervision of a competent person.

The tower crane is usually provided by the Principal Contractor inclusive of a competent driver. When utilising tower cranes the following should be considered:

Tower crane located centrally within atrium

- Once provided, the capacity (number of hooks, coverage, lift, radius and lifting rate) of the tower crane(s) cannot be changed. Furthermore, several contractors on site will require use of the crane(s). Arrangements for periods of exclusive or shared use must be agreed at the outset and carefully linked to the number and types of lift (single or multiple component) required by the erection sequence and programme.
- Tower cranes are usually capable of lifting light loads over a large area. Often the key lift is off-loading the lower shaft columns from the perimeter of the site at the crane's maximum radius, rather than where the column needs to be landed within the site. This may then determine where steel columns need to be spliced.
- The wide slewing area of the tower crane increases the risk of collision with adjacent structures, buildings or other site craneage.
- Tall tower cranes must be provided with aircraft warning lights if situated near flight paths.
- Material slinging routes should be established to avoid passing over occupied premises, public roads or thoroughfares. The routes should take into account any slewing restrictions on the crane.
- Clear lines of communication must be established between crane driver and slinger. The most effective method is to use radios.
- Slingers should wear a designated coloured hard hat and high visibility clothing in order to be easily identified by the crane driver.
- Weather conditions such as high winds and poor visibility can affect the operation of the tower crane. Advice is given in the BCSA *Guide to Steel Erection in Windy Conditions* which also provides other references.

4.2.4 Delivery, loading and off-loading on site

Special care is necessary in the delivery, storage and handling of components on site as unloading facilities may be less satisfactory than when loading at the fabrication works. The general means of unloading on confined sites is by means of the primary craneage. The Steelwork Contractor should ensure that:

- Deliveries are planned to coincide with the availability on site of personnel and plant adequate to deal with the work.

- Drivers and/or passengers are in possession of safety helmets for use when delivering to site and they do not remain in the cab of the vehicle during any loading/off loading operation.
- Special care is taken in loading the components at the fabrication works. They should be loaded in such a way (eg using timbers) so the slings may be placed easily for off-loading.
- Guidance issued by the BCSA on safe access onto trailers to sling components for unloading is followed.
- If part-loads are to be moved on site, the load is secure and that the vehicle has stability while it is being moved, and that the driver has checked the position of the load and its fastenings before taking a vehicle onto the public highway.
- As far as possible, components that are of such a shape or weight as to involve difficulty in handling should be in a position from which they can be lifted directly without adjustment of their position before slinging.
- If an area at ground level is available, steelwork that is to be stacked and stored should be laid on suitable timber packers, not directly onto the ground. It should be stacked in a manner and position that will avoid any risk of stack collapse or component distortion.
- If ground level storage is not available or restricted, and erection cannot be undertaken straight off the delivery trailer, then the Steelwork Contractor will need to make arrangements for storage of steel (and decking) components aloft. "Shake-out" areas should be identified and the implications of the imposed construction loads evaluated by a competent design engineer.

If materials are to be loaded out onto metal decking it is important that the following precautions are followed:

- Ensure that the decking contractor has completed the works, including shot firing the decking into position and side lap stitching the decking as necessary. Wherever possible, enough time should be given for the shear studs to be through deck welded as the welding after loading of materials is problematic.
- Care must be taken to ensure that materials are loaded out so that the weight is safely transferred to the supporting beams without damaging the profile of the decking sheets.

The recommendations given in the BCSA *Guide to Loading and Unloading of Steelwork* should be followed, and it may be necessary to prepare a site specific *Task Specific Method Statement* for off-loading if site circumstances dictate.

4.2.5 Attendances

Unless agreed otherwise, the Principal Contractor should provide:

- Off-loading and hoisting for items other than steelwork components;
- Access to working levels;
- Perimeter edge protection;
- Skips for waste;
- Welfare facilities;
- 110V power as required;
- First aid facilities.

4.3 FINALISATION OF ERECTION METHODS

Before work is commenced on site, the Steelwork Contractor should ensure that agreement has been reached with the Principal Contractor:

- That the erection sequence included in the method statement has been accepted as safe by the Designers, and is in accordance with the *Construction Health & Safety Plan;*
- That adequate resources have been committed to the tasks;
- That competent personnel are available to undertake the tasks;
- That a chain of command has been established from the site erectors through to the Principal Contractor's senior agent on site.

Often it is necessary to change the method of working because of change orders/variations, or changed circumstances that arise. In such cases, it is the responsibility of the Steelwork Contractor to decide any changes to the sequence of work, to notify the Principal Contractor accordingly, and to brief the erection personnel about changes. For significant alterations, an addendum to the method statement should be produced.

4.4 BEARINGS AND FOUNDATION SUPPORTS

To permit safe and speedy erection of columns, tolerances are required between the prescribed level of concrete and the level of the underside of the column baseplates to allow for discrepancies in the level of the concrete. The permitted deviations for foundations, walls and foundation bolts are specified in the NSSS.

The common method of adjusting the level is by the use of packing plates. Generally these are placed in a single central pile. For larger columns, such as those needed at the base of tall multi-storey structures, it may be necessary to use four piles of packs or to use pairs of folding wedges instead, as illustrated in BS 5531.

The method to be used should be stated in the erection method statement so that the location where the packs will be positioned is known in advance. This is important as the concrete surface around that location needs to be generally level and smooth. Otherwise this would jeopardise the ability to provide a stable surface on top of the packing plates for the safe positioning of the column.

The Principal Contractor should ensure that foundations meet the requirements explained above and that the HD bolts are clean with free running nuts to permit proper tightening without overloading.

In addition to vertical support at foundation level, multi-storey structures often require horizontal support by fixing to concrete cores. Two methods are generally used:

- Steel plates cast into the concrete, which is the preferable method for all major connections. The subsequent connection of the steelwork is then a steel-to-steel connection under the control of the Steelwork Contractor. In order to allow sufficient adjustment to accommodate the tolerances, slotted connections and/or site welding of the final connection may be needed. In such cases it is important to ensure that the connection can provide sufficient vertical and horizontal support in its intermediate partially completed condition.

- Resin or spit-fix anchors site drilled into the concrete, which is generally only suitable for secondary connections (eg trimmer beams). The responsibility for setting out the locations for the holes needs to be agreed in advance, bearing in mind that the exact required location is often uncertain until the adjacent steel structure is erected. If the anchors are to be relied upon to stabilise the steelwork during erection, it is important that the period for them to reach the required capacity is properly evaluated. If site drilling of concrete is required for such connections, then a *Task Specific Method Statement* should be prepared.

5 SITE PRACTICE

5.1 ACCESS AND WORKING PLACES

5.1.1 Temporary access during construction

The Steelwork Contractor must ensure that method statements and their associated risk assessments address the need to provide safe access and working positions. Installation of the permanent or temporary stair systems as soon as possible helps to eliminate some of the risks associated with temporary access. To avoid access restrictions, temporary stair systems, such as *Haki* stairs, can be hung on the frame outside of the building footprint.

Multi-storey and other high rise structures are characterised by the fact that it is not always practicable to meet these requirements without the need for access over the steelwork using "beam straddling". The use of beam straddling should be avoided where the use of one of the following methods is practicable:

- Using telescopic boom MEWPs ("cherry pickers") for both access and working positions: this method is preferred where it is practicable; however, even if access around the site footprint is suitable, it can only be used for the lower floor levels up to, say, 20m – ie around the first splice level.
- In some circumstances it is possible to use small boom MEWPs or "spiders" for access and working positions: these can be temporarily positioned on the structure using support frames which can be re-located as the high rise building sequence develops. When determining whether MEWPs can be used on upper floor levels the Steelwork Contractor must arrange for an engineer to evaluate the additional imposed loadings during the construction phase.
- In other cases it may be possible to use such "spiders" or alternatively scissor-lift MEWPs ("flying carpets") traversing the floor slab for both access and working positions. However, this would generally require the permanent works designer to have anticipated such construction loads in the initial design of the floor slab, and may result in operational restrictions that need to be defined in the erection method statement and closely controlled during erection. Generally scissor-lifts are only suitable for later operations such as bolting up or painting.
- Using crane-mounted cradles or "man baskets": this is an alternative method of access to and for work on steelwork where MEWPs cannot reach; however, this method is often restricted by the availability of or access for suitable craneage. The use of man baskets on high rise structures is also more likely to be restricted by the wind conditions. As is often the case, if man baskets are specified for use in emergency recovery procedures, then a suitable basket needs to be available on site at all times.
- When using MEWPs or baskets on site all contractors should ensure their operators are secured to the anchorage point of the MEWP basket using safety harness and lanyard. It should be noted that the anchorage point on most types of MEWP are not designed for shock loading, therefore lanyards are provided as a fall restraint only. In general it is therefore recommended that MEWP restraint lanyards are no longer than 1.5m long, but the use of any type of platform needs to be assessed for particular risks associated with its design (eg anchor point locations) to determine the appropriate lanyard.

- Using mobile access towers [MATs]: this is another method sometimes suitable for later operations if sporadic tasks need to be undertaken. MATs must be constructed with due regard to stability and may be used only on a firm base. MATs can only be mounted directly on top of metal decking if suitable load spreaders (or "elephant's feet") are used. If the MAT has wheels, they must be secured against movement when a person is working on the tower and movement of the tower must be only from the base. *The Operator's Code of Practice* published by the Prefabricated Access Suppliers and Manufacturers Association provides benchmark training standards and other recommendations that should be followed in addition to manufacturer's recommendations.
- Using scaffolding with suitable edge protection: this is rarely practicable or justified for steel erection when the "risk transfer" implications are considered. However, the use of scaffolding may be practicable and justifiable in special situations, such access to high level elevations using scaffolds cantilevered out from structurally finished floor levels. Another situation envisaged would be where a working platform is needed for, say, a later site welding task; then the steel component can be "dressed" with a suitable scaffold platform and access ladder before it is lifted. Employers are responsible for ensuring that scaffold is safe to use and complies with the regulations. Only competent persons may erect, alter or dismantle scaffolding, and a competent person must also inspect the work regularly.
- Using a *Spandek* system or similar span deck platforms for access: these are often used in the erection of multi-storey structures in conjunction with ladders whereby the span deck platform acts as a landing platform. The platforms are secured on the open steelwork, and as erection progresses they can be more readily relocated than scaffold platforms. This advantage enables them to keep pace with the erection in a way that reduces risk by shortening the length of beam-straddling routes. As with scaffold platforms, span deck platforms must be provided with edge protection and toe boards.
- Using ladders for access to working positions on the steelwork: this is a very common method where MEWPs and man baskets are impracticable. Ladders must be properly positioned and tied, and they need to extend 1m above the supporting steelwork. Landing platforms must be provided where access extends further than 9m. Special care needs to be taken where ladders are positioned onto metal decking, as the surface of the decking has a low friction coefficient and is also profiled such that secure and even bearing may prove difficult to achieve. In such circumstances, the ladder should be footed by another worker or provided with a stability device whilst in use. Often the positions where ladders can be installed will nowadays be restricted by safety netting.
- Using ladders for working positions: this is only justified for short duration tasks of less than 30 minutes in one location and for work that permits the user to have a minimum of three points of contact. Working off ladders should only be carried out if they are of suitable type, strength and length for the operation being carried out. Before work commences the ladders should be suitably tied at the top (or footed at all times during use where this is not practicable and the ladder does not exceed 4.6m in length). Erectors must be instructed that, having used a ladder to reach a working position, they must immediately clip on to a suitable anchorage point on the steelwork before any work is commenced.

If preferred methods are identified, it is recommended that a generic *Task Specific Method Statement* be prepared based on the recommendations above concerning methods for gaining access and using working positions at height (eg use of man baskets, span deck platforms, ladders or MATs).

5.1.2 Beam straddling

MEWP operating over slab

Scaffolded working positions attached to high level beams before erection

This means of access may be used by the Steelwork Contractor where there is no other practicable means of access, or a working position, other than by using the steelwork itself.

Methods that rely on gaining access over the steel structure itself must be justified by the Steelwork Contractor. In this instance the following considerations must be addressed:

- A *Task Specific Method Statement* should be developed with an accompanying risk assessment.
- The controls and briefing needed to reduce the risk as far as possible (e.g. instruction on the need for double lanyards to provide fall arrest at all times and how these should be attached and re-located).
- The training and experience of the persons being asked to undertake the task.
- Recovery of persons should a fall occur. The recovery procedures should be communicated to the erectors and through the chain of command to the Principal Contractor prior to any work activity being undertaken at height. See below for rescue and recovery techniques.

The *Task Specific Method Statement* needs to include the following:

- The means of access to the beam at height. Depending on the circumstances, this may be by using ladders and span deck platforms (see above) or by using mobile platforms or baskets. As, generally, erectors working from mobile platforms or baskets are instructed not to climb out, special instructions will be needed for this activity.
- The method of straddling the beam for access. At no time should erectors be allowed to "walk" beam top flanges. Where access is required beams should be crossed by "straddling". Straddling involves the worker sitting on the top flange, using the bottom flange for a foothold and using both hands to grip the top flange in transit. Workers move along the beams with feet on the inside of the bottom flange, hands on the top flange of the section. Straddling may only be undertaken if the depth of section is suitable (normally for UBs between 356mm and 610mm deep).
- Fall arrest during access. The use of beam gliders or girder trolleys allows the erector to traverse a beam up to 380mm wide whilst being secured to the structure. Otherwise a "double lanyards" system would be needed. As an example, *Dover Clamps* are proprietary items that are secured to and run along the flange of a beam. Such devices are unsuited for use on the top flange of a beam with shear studs fitted to the top flange. If used

on the bottom flange, they are well suited to work taking place below beam level, such as rigging of safety nets.

- The method of straddling the beam as a working position. A method is needed by which the erector is tied on during the work. Generally this will be by clipping on to a local hole provided in the column and/or beams with a lanyard equipped with a *Manlok* connector.
- If safety nets are rigged to the bottom flange of the steelwork the erectors should take additional care when straddling steelwork to ensure that the net attachment devices are not dislodged.

Beam glider

5.1.3 Floors and stairs

Floors for multi-storey buildings are generally constructed using either precast concrete planks (usually only for lower rise buildings) or metal decking (for nearly all high rise buildings). If precast planks are to be erected by the Steelwork Contractor, the guidance given by the Precast Flooring Federation (see *PFF Code of practice for the safe erection of precast concrete flooring and associated components*) should be developed into a *Task Specific Method Statement.*

For metal decking, the guidance given in the BCSA *Code of Practice for Metal Decking and Stud Welding* should be followed. The code has wider implications for high rise construction as follows:

- A distinction between access to the working level and at the working level that becomes relevant as portions of the floor are completed. This has general relevance to the provision of edge protection as considered in the code and below.
- Whilst fall arrest suited at one time for everyone is preferable to the provision of individual fall arrest equipment, the common systems of providing such fall arrest - netting, air mats and air cushions or bags - do not provide suitable means of providing fall arrest during steel erection. The general applicability of such methods for operations after steel erection is described in the code.
- The need to protect against materials or personnel falling through voids and openings in floors if these need to be provided at an early stage rather than being cut later when exact locations can be more readily established.

Staircases are generally prefabricated off site as precast units or steel stair flights. As special considerations apply in each case, it is recommended that a suitable *Task Specific Method Statement* be prepared.

5.1.4 Exclusion zones and safe access routes

The Steelwork Contractor should try to ensure that others do not enter a hazardous area where steel erection work is taking place. Where reasonably practicable, the hazardous area should be established by the Principal Contractor as an exclusion zone within which only steel erection activity should be allowed.

For high rise multi-storey structures, it is often impracticable to designate an exclusion zone solely in terms of a section of the building's plan area. Then, an additional segregation method is needed in terms of the building's height. This can be arranged if there are sufficient floors to act as a suitable safety barrier from falling materials between the erection activity and the following trades working below. With respect to falls of smaller objects, staggered construction sequences enable following trades to commence work activities under the protection of two structurally complete metal decked floors known as "crash decks". Fully concreted levels can be designed both to serve as "crash decks" and to provide access for MEWPs operating over the slab.

Care is still needed with respect to material slinging routes to minimise the need to traverse areas of work below. In some cases, where there is no sufficient "crash deck" in between, control of the lift and traverse routes may be the only way to control the risks to others working on site. As such restrictions have a major impact on the number and positioning of tower cranes, and the sequence of erection and other work, it is important that these issues are resolved as early as possible – preferably during the development of the *Pre-Tender Health & Safety Plan.*

If unauthorised entry is made to an exclusion zone, hazardous work should cease and a report should be made immediately to the Principal Contractor. Work should not be restarted until the situation has been resolved.

Objects falling from above are a hazard on construction sites; therefore, it is important that warning signs indicating overhead work should be posted by the Principal Contractor. The areas where work is permitted below crash decks should be clearly cordoned off by the Principal Contractor with tape, bunting or barriers and, where necessary, moved with the work as it progresses.

If the work is on a constricted site and an exclusion zone around the perimeter cannot be arranged, the Principal Contractor will need to provide debris netting and protective fans at various heights around the structure. With careful planning, these can be fixed to the steel edge beams before they are erected.

Debris netting can also be installed throughout the construction sequence to provide additional protection to site workers at risk below from falling hand tools and small materials. It should be noted that debris netting will not provide suitable protection from large steelwork, precast concrete and metal decking components.

Debris netting fixed to perimeter beam before erection

The Principal Contractor should warn the Steelwork Contractor about exclusion zones operated on behalf of other contractors (eg where cementitious sprays are being applied). In addition, the Steelwork Contractor needs to ensure that all erection personnel remain alert to the possibility of hazards arising on site that are outside of their control. If these arise, they should be reported to the Principal Contractor and personnel should not enter the hazardous areas until the danger has been eliminated.

In addition to exclusion zones the Principal Contractor should clearly identify pedestrian and vehicular access routes at ground level, and safe routes to gain access to working levels aloft. Where appropriate, fire escape routes are also to be identified by the Principal Contractor. These routes should be protected with appropriate guard railing. Access to temporary laydown areas must also be provided with edge protection.

As noted above for operations after steel erection, partially or fully completed floors will generally be used for access routes above ground level. If free standing scaffold is used it must be placed a minimum of 2m back from the leading edge of the decking. Temporary toeboards may also be required where there is no decking edge trims in place and there is a risk of materials falling. Temporary scaffold staircases may be needed until the permanent access stairways are completed. These access stairways should be provided with edge protection, handrails, toeboards and adequate lighting by the Principal Contractor.

5.2 FALL PREVENTION AND ARREST

5.2.1 Fall protection

Falling from height is one of the most critical site hazards that the Steelwork Contractor has to address. If a person falls from a height, the resulting impact will generally result in a major or fatal injury. The only practical way to reduce the risk of falling from height is by risk control using fall protection. This protection can either be provided as:

- Fall prevention – which prevents a person from getting into a position from which they could fall, for example using guard rails, barriers and edge protection systems.
- Fall restraint – which restrains a worker from moving too far towards a position from which they could fall, for example using a system of fall-restraint lanyards attached to wires. The term “fall restraint” used in the context of steel erection is a particular application of the term “work restraint” used in HSE terminology.
- Fall arrest – which, should a person fall, “arrests” the fall to limit its extent, for example using safety nets or a fall-arrest lanyard attached to a safe anchorage.

Fall arrest and fall restraint systems are designed by proprietary manufacturers to provide a safe and ergonomic connection between the worker and the anchorage on the structure. Before purchasing or hiring the equipment, the Steelwork Contractor should check that the manufacturer has declared compliance with the relevant standards. (BS ENs 353, 354, 355, 358, 360, 361, 362, 363, 364 and 365 may be relevant depending on whether the system provides fall arrest or fall restraint.)

5.2.2 Fall prevention

Fall prevention by means of edge protection should always be provided where practicable. The edge protection will protect all workers and it facilitates mobility because there is no connection between workers and hand railing. The necessary provisions are set out in BS EN 13374.

Subject to practicability, the general hierarchy endorsed by the Major Contractors Group for providing edge protection using perimeter guardrails is as follows:

- Guardrails to be fitted at ground level.
- Guardrails to be fitted aloft after steel erection before decking or concrete planks, with preparatory work (eg sockets) undertaken at ground level.
- Work aloft to fit guardrails to be from a working platform (MEWP, MAT, man basket, scaffold) in preference to using steelwork itself.

Unauthorised attempts to lean over or through the edge protection rails to gain access need to be prevented as these would involve a risk of falling. Provided it is allowed explicitly in the method statement and precautions against falling materials are taken, access through the edge protection to fix edge trims can be authorised.

As with debris nets and scaffold fans, where practicable the Steelwork Contractor should install integral edge protection to the steelwork at ground level and lift as one item. Installing the edge protection at ground level reduces the risk of workers working at height during its installation.

The use of proprietary edge protection is often preferred by the Principal Contractor due to the additional protection provided by the mesh panels. The means for securing the edge protection system to the steelwork is system-specific. Some systems use clamps that can be secured either in position or at ground level prior to the beam being installed. Others rely on spigots welded to the steelwork that are later buried in the concrete slab. Others rely on a specific pattern of holes pre-drilled in the steel component during manufacture – which clearly requires an early decision on which system to employ. The Edge Protection Federation is expected to publish generic guidance shortly.

Use of the 'easi-edge' proprietary edge protection system

5.2.3 Fall restraint

By tethering the worker to the workplace structure, fall-restraint systems prevent the worker from getting into a position from which they could fall. However, mobility is restricted to the length of the lanyard around the position of the anchorage point. This would be the case when erectors are working in a MEWP or man basket to prevent them from leaning over the hand rails.

5.2.4 Fall arrest

Wherever fixed barriers or fall restraint is not provided, the Steelwork Contractor must consider how to provide fall arrest. During steel erection the only practicable method relies on harnesses with shock-absorbing lanyards attached directly or through a running line to suitable anchorage(s). If a fall should occur, the equipment automatically arrests the worker by a braking means, which minimises the fall distance and limits the arresting force.

5.2.5 Harnesses and lanyards

The Steelwork Contractor should ensure that, where harnesses and lanyards are in use for fall arrest or fall restraint, erectors are instructed on how to check their equipment and what attachment anchorages are suitable. The procedures for safe use (with running lines and/or *Spanset* type safety lines if appropriate) should be clearly defined by the Steelwork Contractor in a *Task Specific Method Statement* that also includes a plan for the safe recovery of those who might fall.

The simplest system consists of a full-body safety harness, which a worker puts on prior to attaching to the system. This safety lanyard is the flexible link between the harness and the anchorage. The anchorage is then connected to the structure. The Steelwork Contractor should ensure all workers working at height have double lanyards attached to their safety harnesses. This is to ensure they can transfer across steelwork without being unattached at any time.

All users of safety harnesses must be given training on the safe use, care, inspection and maintenance of the equipment.

On multi-storey buildings it is imperative that the Steelwork Contractor provides lanyards that ensure that the fall height predicted for the equipment used is less than the actual height between working levels and any steelwork or other obstruction below. The lanyard shock absorber extension must also be taken into consideration when determining the safe fall distance.

5.2.6 Fall arrest blocks and running lines

Retractable lifelines (also known as fall-arrest blocks) give more mobility than connecting directly to anchorage points. Anchored above the worker they have a spring-tensioned cable which is paid out and retracted under the normal movement of the worker, but a braking mechanism automatically locks the cable in response to the sudden jerk of a fall, in a similar fashion to a car seat belt.

The use of running lines as a means to attach safety harnesses allows wider lateral mobility. The manufacturer's guidance should be followed concerning the strength of the line and how to anchor it securely with minimum slack to anchorages that are sufficiently strong.

5.2.7 Anchorage points

In terms of anchorages, for fall restraint purposes the loads are relatively low, and attachment points are provided on MEWPs etc. If it is necessary to use harnesses with fall arrest lanyards attached to running lines or directly to the steelwork, the shock load can be significant. It is important to ensure that the anchorage point can withstand the forces applied in a fall with an adequate safety factor. The Steelwork Contractor should ensure that the advice of a suitably qualified person has been sought concerning the suitability of attachment points and that enough holes are pre-drilled during manufacture.

The capacity of the holes to serve as anchorages will be determined by their diameter and edge distance, and these will also need to match the requirements of the eyebolt, *Manlok* device or running line as appropriate. Where possible, attachment point should be positioned above the worker to minimise the falling distance, and sufficient space needs to exist beneath the worker so that the length of the fall does not exceed that which is available on site.

Securing of lanyards with a bight by "looping round" is not the preferred method as pre-drilled holes for attachment of anchor clips are better. There are special lanyards available with additional loops to allow a bight to be used. If looping round is necessary, it should only be permitted where there are no sharp edges to abrade the lanyard. In any case, working aloft requires secure and appropriate tying on at all times.

5.2.8 Safety nets and bags

Safety nets also facilitate mobility because they provide general fall arrest with no specific connection required for the worker. However, it is not possible to use nets to assist with fall arrest during primary steelwork erection as nets must be installed as close to the working level as possible to minimise the fall distance – generally this will be around 2m with the maximum permitted being 6m. Debris nets installed by the Principal Contractor around the perimeter help during erection by catching falling objects such as bolts.

The fixing of safety nets also entails hazards and must only be undertaken by competent personnel with suitable fall protection. The issues concerned with the use of nets are considered in the BCSA *Code of Practice for Metal Decking and Stud Welding* as they are widely used as primary fall protection during such operations.

Safety bags (filled with air or compressible material) are also worth considering for certain applications, although they are rarely used on multi-storey structures as they can be cumbersome to install above ground level.

5.3 HEALTH HAZARDS

5.3.1 Housekeeping and waste

Unwanted materials should be kept to a minimum on site. The Steelwork Contractor should ensure that waste materials are disposed of as soon as possible and do not accumulate on the ground. The Principal Contractor should provide skips or other waste disposal facilities with the type of waste permitted designated on each skip. The most practical method will involve providing skips at higher levels. The usual lifting provisions will apply to the skip itself or a skip cradle if used.

When not required for immediate use, the Steelwork Contractor should ensure that loose materials arising from steel erection activities should be placed where they will not restrict unduly the passage of any person, and that the working area is cleared daily of any hazardous waste materials.

5.3.2 Manual handling

The Steelwork Contractor should provide lifting equipment on site, such as telehandlers or fork-lifts for off-loading and distribution, to minimise the amount of manual handling that is needed.

There are circumstances that require manual handling of significantly heavy pieces (possibly with the aid of chain blocks or other lightweight device), particularly during refurbishment work on multi-storey buildings where lifting equipment cannot be manoeuvred to the workface. The Steelwork Contractor should use the BCSA's *Task Specific Method Statement* to define procedures for such tasks.

5.3.3 Noise and hand-arm vibration

Pneumatic nut runners and other equipment used for erection can be the source of noise and vibration. In such cases, the Steelwork Contractor should use the BCSA's *Task Specific Method Statement* to develop safe procedures for using such equipment that meet the regulatory requirements for noise limitation and reduction of risk of hand-arm vibration syndrome [HAVS] (also known as "vibration white finger" [VWF]).

5.3.4 Hazardous substances

Under the *Control of Substances Hazardous to Health* [COSHH] Regulations, no substance should be permitted to be used unless a suitable assessment of the risks involved has been made and the steps needed to eliminate or minimise the risk have been taken. Examples of substances used during steel construction that may come under COSHH are gases, most liquids other than water and the residues from consumable products used in welding, painting etc.

If such substances are to be used, the Steelwork Contractor should use the BCSA's *Task Specific Method Statement* to develop safe procedures. In all cases, data sheets on the materials and antidotes should be provided on site, records of use must be kept, and such records should be available on site.

Hazardous waste must not be placed in mixed waste skips as it must be disposed of in accordance with the *Hazardous Waste Regulations.*

5.4 Fire precautions

Rubbish fires should not be allowed on site unless specifically permitted by the Principal Contractor. Where "hot work" operations are to take place, appropriate fire extinguishers and other agreed precautions must be provided.

Site accommodation should be sited in a safe place by agreement with the Principal Contractor. The Steelwork Contractor should provide each unit with at least one extinguisher appropriate to the fire risk involved and for the size of unit.

The Steelwork Contractor should ensure that:

- The relevant recommendations of HSE publication HSG 168 *Fire safety in construction work* are followed.
- Gas bottles, flammable liquids, paint and fuel are stored in accordance with regulations.
- *Task Specific Method Statements* are developed for welding and burning operations that could create fire hazards that include the consideration of whether a fire watcher needs to be appointed during these operations.
- Only sufficient gas bottles for the operation in progress are kept at the place of work: all others should be kept in a secure safe place.

6 TOOLS AND EQUIPMENT

6.1 LIFTING EQUIPMENT

The Steelwork Contractor must ensure that cranes are appropriate to the maximum weight they will be expected to lift and the 'reach' they will be expected to need. This should be done by identifying the necessary craneage in the erection method statement, which should also state the locations where cranes will need to operate. It is a sound precaution for the Steelwork Contractor to check these items even if craneage is provided by others (eg the Principal Contractor or an erection subcontractor).

In practice many multi-storey structures are built on congested city centre sites, where tower cranes are the only possible choice. The provision of such cranes for steel erection and all other lifting operations is nearly always undertaken by the Principal Contractor, who then carries the primary responsibility for ensuring that the crane is being used in accordance with the *Lifting Operations and Lifting Equipment Regulations* [LOLER]. The regulatory requirements for the provision and use of lifting equipment require that:

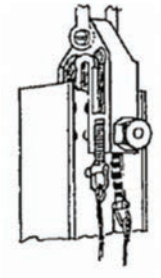
- Valid test certificates for cranes must be available at all times.
- Lifting equipment is thoroughly examined every six months in the case of equipment used for lifting people, or every 12 months in the case of other equipment – but in either case in accordance with an examination scheme as, where there is significant risk, weekly or daily inspection may be necessary. Note that even plans for only emergency use of the crane for lifting a man basket during rescue and recovery could determine a six monthly examination scheme.
- All chains, slings, shackles and other lifting tackle must be tested and certificated before being brought into use.
- Six monthly examinations of chains etc must be undertaken and the records kept.
- All lifting equipment must be marked with its lifting capacity [eg SWL] and identification reference.

Even where the Principal Contractor provides a tower crane, the provision of some lifting tackle may be the responsibility of the Steelwork Contractor. Thus the requirement for testing and certification of lifting tackle applies to special rigging devices manufactured by the Steelwork Contractor for use on a one-off basis. It does not apply to temporary cleats attached to the permanent steelwork for attaching lifting equipment, which should, however, be designed by a suitably qualified person.

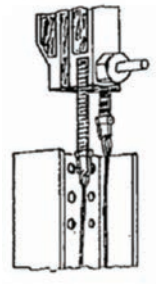
The Steelwork Contractor should also ensure that:

- All crane hooks are of an approved design.
- Damaged equipment is discarded and replaced to prevent it remaining in use.

If MEWP is used for access to unshackle a column this facilitates the simultaneous installation of other members to tie the column in as soon as possible. Otherwise, the Steelwork Contractor should use quick release shackles, *Dawson Shackles* or similar, as they eliminate the risk associated with climbing to the top of a newly erected column in order to detach the crane hook. The column shackle is released by pulling the release ropes. The ratchet action withdraws the pin allowing the shackle to be lifted clear of the column after it has been secured in position.



During Lift



After Lift

Dawson shackle in use

6.2 PERSONAL PROTECTIVE EQUIPMENT

The Steelwork Contractor must ensure that personal protective equipment PPE is provided in accordance with the needs of the task and as defined in the associated method statement and/or risk assessment. If individuals assume the responsibility for providing PPE for their own use (eg abseilers) this must be specifically agreed in advance and in writing.

The Steelwork Contractor should manage the provision and proper use of PPE by ensuring that:

- Users check the adequacy of their PPE daily, and are instructed to bring any possible deficiencies to the attention of their supervisor.
- The issue of specialist equipment, such as harnesses/lanyards, is recorded so that it can be replaced or inspected by a competent person at the necessary intervals.
- Where equipment is issued for the first time, the user is instructed on its proper use and care.
- As the *Construction (Head Protection) Regulations* require that safety helmets are used on all sites, everyone is instructed that safety helmets MUST BE WORN AT ALL TIMES IN ALL AREAS, except where management have agreed dispensation (eg mess rooms).
- Safety harnesses are worn and used as required by the safe system of work.
- Safety harnesses with fall restraint lanyards are worn and suitably clipped on whenever MEWPS are being operated.
- If used as fall arrest protection, safety harnesses are used with suitable shock absorbing devices and users are instructed on what attachment methods and locations are suitable. As noted above, suitably located holes in steel components may need to be provided for this purpose.
- A competent person regularly inspects safety harnesses for suitability/damage.
- If work is carried out involving risk of eye injury, appropriate eye protection is made available and the wearing of it enforced.

- If noise above permitted levels is likely to be produced by any erection activities or adjacent activities, appropriate ear defenders are provided.
- All those working on or visiting construction sites wear high visibility vests or jackets.
- Erectors are issued with suitable safety boots and gloves.

The Steelwork Contractor should ensure that clothing used does not have flaps that could get trapped and is suitable for the weather conditions. Warm, water-proof outer garments will generally be needed in winter. In sunny weather, shirts should be worn and sun-screen cream used to protect skin from UV radiation. Foul weather clothing should be issued and used when necessary.

6.3 ACCESS EQUIPMENT

6.3.1 MEWPs

In order to ensure safe operation of MEWPs, the Steelwork Contractor should ensure the following:

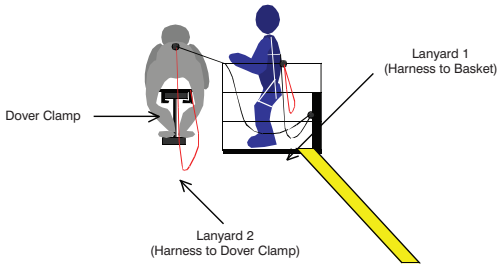
- MEWPs must only be driven and operated by trained and authorised persons.
- Before operating a MEWP the operator should check that a competent person has inspected the MEWP within the last six months and a current inspection report is available.
- MEWPs should be positioned on suitable hard and level ground. Unless approved by the Principal Contractor, drainage or manhole covers should not be traversed as these can collapse and cause the MEWP to topple.
- MEWPs must not be operated in strong winds. The BCSA *Guide to Steel Erection in Windy Conditions* recommends that a general operating limit of 12.0 m/s (27 mph) as the "safe gust wind speed" should be observed in the absence of manufacturer's guidance.
- The maximum capacity of the MEWP must not be exceeded in use in terms of weight personnel and equipment combined.
- Workers travelling in a MEWP basket must wear safety harnesses, clipped on to a suitable anchorage point within the platform and also wear safety headgear and footwear.
- Unless it has been specially designed and tested for this purpose and is marked with the safe working load, loads must not be suspended from the work platform and the MEWP should not be used as a crane.

If "spider" MEWPs or scissor lifts are to be mounted aloft on support frames or on completed floor slabs, it is recommended that specific procedures for use are set out in a *Task Specific Method Statement*, as particular hazards need to be addressed – such as potential over-running close to the edge. In such cases an edge barrier should be provided using, say, timber sleepers.

In certain circumstances, where access options to steelwork are extremely limited, it may be necessary for the worker to leave the MEWP basket to access the steelwork. Where this is the case it is recommended that a *Task Specific Method Statement* be prepared based on the following procedures to ensure that at no time is the worker unclipped from both the structure and the MEWP anchorage point:

- Workers must be equipped with double lanyards (one of which must be long enough to allow access onto the steelwork).
- Whilst still attached to the anchorage point of the basket using the fall-restraint lanyard provided for work in the MEWP, the second fall-arrest lanyard attached to the worker's harness is then attached to a *Dover Clamp* on the beam or by *Manlok* to the steelwork.
- The first lanyard can then be detached allowing the worker to leave the confines of the MEWP basket and to straddle the steelwork.
- Re-entry into the MEWP basket is achieved by reversal of the above method (ie not detaching the lanyard from the steelwork until in the basket with the second lanyard attached to it).

6.3.2 Man baskets



There are circumstances where access to a specific location on the structure may only be by means of a man basket suspended from either a mobile or tower crane. The man basket itself must be constructed with fixed rigid toe boards and guard rails and must be provided in compliance with the *Lifting Operations and Lifting Equipment Regulations.* The basket must be clearly marked with the safe working limit and the permissible number of persons to be carried.

It is essential that clear lines of communication are established between the workers riding in the basket and the crane driver.

When in the confines of the basket workers should be attached to a suitable anchorage point (this is usually the hook of the crane). The crane that is being used to lift the man basket must be provided with an automatic braking device to prevent uncontrolled descent of the basket. In order to prevent the basket from spinning it is good practice to attach a stability line to the crane rope.

Man basket in use

6.4 ERECTION EQUIPMENT

6.4.1 Mobile plant

In addition to the craneage used for lifting and placing the steelwork into position, other lifting equipment may be needed on site for off-loading, storage and distribution of the steel components. Fork lifts, side loaders and telehandlers are the most common. The Steelwork Contractor should ensure that the use of such equipment is limited to those erectors with appropriate training in accordance with CPCS or IPAF criteria.

The Steelwork Contractor should ensure that MEWPs are appropriate for the job in hand. The relevant test certificates and inspection records must be available at all times.

6.4.2 Handtools

Three types of handtool are in common use for bolting:

- The podger spanner which has a tapered end to assist with aligning bolt holes in different plies;
- Club hammers to assist with aligning the steel locally taking care to avoid distortion;
- Socket spanners and ratchets to then tighten up the bolt assembly.

The Steelwork Contractor should ensure that:

- All erectors are fully familiar with how to use these tools.
- Tool belts are provided to reduce the risk that these tools are dropped.
- The tool belts are also suitable for carrying bags of the bolts needed for the connection being assembled.
- The necessary tools are provided and are fit for purpose, and not adapted to unintended uses or made from scrap materials available on site.

Occasionally it is necessary to install proprietary fasteners (such as tension control bolts [TCBs]), or to use torque wrenches or other devices to ensure that bolts are preloaded. In such cases, the BCSA's *Task Specific Method Statement* should be used to define methods of use. Erectors should be briefed on such special methods and may need to undertake trials under supervision before being allowed to work alone. Tools should be fit for purpose and Survey equipment, such as laser sights, may require special care in use.

6.4.3 Survey and alignment

Alignment of the permanent works is generally undertaken by applying forces using *Tirfor* wires or pull-lifts. The Steelwork Contractor should ensure that the use of such equipment is properly supervised and that the supervisor is aware of precautions to take to avoid overloading the tackle and to avoid distorting or over-stressing the permanent works when using such equipment.

6.5 SPECIAL WORK EQUIPMENT

Where the work requires the use of special equipment – such as portable power tools, grinders, burning equipment, welding equipment, drills or reamers – the BCSA's *Task Specific Method Statement* should be used to develop safe methods of operation.

6.5.1 Portable power tools

Nut-runners and other portable power tools are in common use by steel erectors. The Steelwork Contractor should ensure that:

- All tools and equipment are suitable for the job or process in hand and are in good condition. Use of the "wrong tool for the job" is to be avoided.
- Low Voltage (110V) or rechargeable battery powered tools are used wherever possible. Such tools and any associated equipment comply with current standards for electrical equipment.
- If a portable generator or mobile compressor is used to provide power for small tools or welding, it is kept in good condition.
- All tools are tested for electrical safety in accordance with PAT procedures (Portable Appliance Testing).

6.5.2 Grinders

If abrasive wheels and cutting discs are used, the Steelwork Contractor must ensure that users are competent and the equipment provided meets the requirements of the *Provision and Use of Work Equipment Regulations* [PUWER]. Wheels should only be mounted by a competent person.

6.5.3 Burning equipment

If burning is to be undertaken, the Steelwork Contractor should ensure that:

- The gas bottles are safely handled and stored.
- Gas valves and nozzles are in good condition.
- Flash back arrestors are used.
- Burning operations can be damaging to the eyes; not only for those carrying out the operation, but also to others working nearby; hence, if such a risk exists, screens should be used or an exclusion zone operated.
- Suitable fire precautions are taken and "hot work" procedures operated if necessary.

6.5.4 Welding equipment

If electric arc welding is to be undertaken, the Steelwork Contractor should ensure that:

- The voltage should be as low as possible and consistent with requirements.
- Leads and return cables should be of equal length and in good condition.
- Welding operations can be damaging to the eyes; not only for those carrying out the operation, but also to others working nearby; hence, if such a risk exists, screens should be used or an exclusion zone operated. Weather protection may also be needed.
- Suitable fire precautions are taken and "hot work" procedures operated if necessary.

During welding, the provision of temporary means of support and stability may be needed to secure the joint in the correct position for welding.

6.5.5 Drills and reamers

Site drilling is generally undertaken using a *Rotabroach* bit in a drill with a magnetic stand. Precautions are needed to ensure that, if the power supply to the magnet is lost during use, the drill is restrained by a chain from falling too far. Reaming may be undertaken using a hand reamer or a mechanical reamer for larger holes.

7 ERECTION

7.1 PRE-ASSEMBLY

In accordance with the provisions of the Work at Height Regulations, the Steelwork Contractor must give consideration when developing the erection method statement as to whether it is reasonably practicable to undertake some pre-assembly of steelwork at a lower level, bearing in mind that even lower level work may present fall hazards. For multi-storey buildings, some gains may be possible from "dressing" larger components with smaller items before lifting, such as adding splice plates to columns and connection cleats to beams.

Another example is the possibility of adding debris fans or edge protection barriers prior to lifting edge beams (as illustrated). Even if the sequence of work militates against full installation of such items at ground level, the provision of suitable attachment points at ground level that facilitate easier and quicker fixing aloft should be considered.

Roof steelwork assembled at low level and lifted to height using jacking towers

Beam dressed with 'easi-edge' protection

7.2 MAINTAINING STABILITY

7.2.1 Bracing systems

Before erection is commenced, the Steelwork Contractor must ensure that the sequence included in the erection method statement has been reviewed by a suitably competent structural engineer who understands the means by which structural stability is achieved in the permanent works design. The engineer will also need to decide on the extent of any temporary bracing required and to design it for the interim loading conditions. The BCSA *Guide to Steel Erection in Windy Conditions* provides recommendations for assessing the capacity of permanent or temporary bracing in terms of the wind loads to consider and the effect of column lack of verticality during erection.

The stability of multi-storey structures when completed is particularly affected by wind. The permanent works design will include a system by which wind loads are taken to the foundations. Generally this will be by using the floors as horizontal diaphragms to take the wind loads back to a vertical bracing system. This system will often be stair/lift cores of either concrete or steel. The ability of floors to act as diaphragms requires careful assessment as, for instance, precast planks may not be fully secured by grout immediately after installation and this could allow some adverse movement. In such cases temporary plan bracing or additional panels of temporary vertical bracing may need to be installed.

In the case of concrete cores, they need to be complete to the necessary number of floor levels before steel erection commences. The key issue is then to ensure that the connections between the steelwork and the concrete core are completed soon enough to be able to take the wind forces on the part-erected structure. In cases where the final connection is to be site welded, a "temporary fix" will be needed prior to alignment of the steelwork.

In the case of steel vertical bracing systems, these can only be erected as the steel erection progresses generally. The key issue is then to ensure that the bracings are installed as soon as possible to be able to take the wind forces on the part-erected structure. Essentially this means that the steel in a braced core area should be erected first so that it can act as a stable "box" to provide lateral support for subsequent erection. The stable box created needs to be able to provide lateral support in two orthogonal directions, which is more difficult to achieve if the vertical bracing panels are distributed around the building rather than being localised in core areas. In such cases, additional temporary bracing may be required to act as either vertical or horizontal bracing until the permanent works are complete.

In terms of permanent horizontal bracing, generally the floors will be either precast concrete planks or in situ concrete cast on metal decking. However, prior to placing of the precast planks or fixing of the metal decking, wind pressure acting directly on steel columns and beams can be taken straight into other steel members that frame into them. Hence, problems usually only occur where members are not framed in two directions – for example, where a column is supported by a single beam.

If temporary bracing or temporary fixings are needed, they need to be retained until the permanent works are sufficiently complete – for example until after concrete floors are cast – to ensure that the frame remains both stable and held in position against movement under construction loads.

7.2.2 Columns

In the part-erected condition, the Steelwork Contractor must ensure that columns are stable against wind forces and the lack of verticality prior to alignment. Unless explicitly allowed in the erection method, columns will need to be tied in two directions within a working shift during which wind will be monitored. This means that the stability of a single "flagpole" column may well be more influenced by its initial lack of verticality, and that:

- The bottom lift of column is designed with the base plate adequately sized to allow free-standing of the column until it is tied in.
- Column splices are adequately designed to allow the upper shaft to be erected safety until it is tied in.

The splice locations should be determined on three criteria as follows:

- Subject to stability during erection, longer shafts with fewer splices are preferred. This often means that columns can be spliced every three floor levels.
- Access methods for securing beams may limit the column shaft lengths to two levels. This depends on whether access is from the ground or from previously erected steelwork, by MEWP or ladder – as ladder access is limited to 9m and MEWPs mounted aloft are often too small to be able to reach more than two levels.
- To facilitate access to secure the splice during bolting up, the precise location should generally be 1100mm above local finished floor level (ie about 1300mm above any metal decking).

7.2.3 Typical sequence

By observing the following sequence, the Steelwork Contractor can generally ensure stability is maintained during erection:

- Erection should always commence from a braced bay (or a suitable structural core).
- A bay of steelwork should be erected including all floor members (up to first splice level – generally two or three floor levels) and bracings, ensuring that the structure is braced in both directions (using permanent and temporary bracing as necessary).
- Prior to the continued erection of the frame, the initial bay of steel should be fully lined, levelled, plumbed and bolted up to ensure a rigid structure is achieved as a "stable box".
- The remaining steelwork in the footprint area of the whole structure should then be erected to first splice. The steel should then be fully lined, levelled, plumbed and bolted up.
- On completion of the above, the bases of the columns should be grouted prior to commencement of steel erection for the next lift.
- Ensure all permanent/temporary bracing has been installed.
- Subsequent horizontal "slices" of the structure are erected similarly, completing each up to the next column splice level before proceeding above.

In the case of multi-storey buildings with large plan areas and multiple cores, it may be possible to work on a series of areas divided vertically, especially if there are expansion joints between. Erection then proceeds as a "carousel" whereby other trades such as decking and concreting follow round in sequence. This sequence will require additional temporary edge protection to phase edges.

7.3 LIFTING AND POSITIONING

7.3.1 Lifting

In all cases each lift should be controlled by a competent person. In most cases this will the gang chargehand acting in the role of slinger/banksman whilst the other erectors in the gang are guiding the steel component into position (on the ground or aloft) and then securing it in position with bolts. As a slinger the chargehand attaches the load to the crane, as a banksman (or signaller) the chargehand dictates the movement of the crane hook.

Immediately after any component is lifted clear of the round, and whilst it is still close to the ground, its trim should be checked by the slinger to ensure that it is still safely secured and it is taking the right attitude to enable it to be place in position as safely and easily as possible.

In those cases where special or complex lifts are required, a specific lifting plan will be required and the conduct of the lift will need to be under the control of an appointed person, such as the site supervisor or the Steelwork Contractor's erection manager. It may be necessary to draft a *Task Specific Method Statement* in such cases.

The BCSA plans to provide additional guidance on good lifting practice in due course.

7.3.2 Slinging

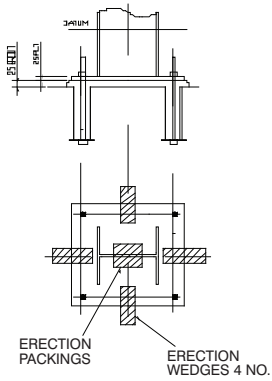
The Steelwork Contractor should ensure that erectors know that during slinging:

- Chains are generally preferable to slings for steel erection. Bundles of decking edge trims and ancillary items should also be slung using chains.
- Slings, chains, clamps and shackles should be checked that they are properly and safely fitted.
- Multi-legged slings/chains, beam clamps, lifting beams or cradles, etc should be used to keep components in a horizontal attitude.
- Slings/chains should not be allowed to be trapped by steel loads. Trapping can either cut or damage the sling to a point where it would no longer be safe to use
- Chain slings should not be wrapped under the load round the crane hook; the rings at the ends of the sling should be used instead.
- Chain slings and strops must only be used with a moused hook or one having a spring-loaded safety catch to prevent the load shedding if the chain goes slack.
- Single wrapped chains/strops may be used for off-loading, but double wrapped chains/strops must be used during erection.
- A positive method is needed (such as a connection cleat) to secure chains around components slung in a vertical orientation (such as columns). Reliance on friction to prevent slipping between the chains and the component (even using a wooden block) is too hazardous. Properly rigged "choke hitches" can be used to lift columns although the practice does require care and proper training in its use. Increasingly, devices that offer "positive" attachment are becoming the preferred method as endorsed by the Major Contractors Group.
- The load should be fully supported in the bowl of the hook and not on the tip.
- Snatch or sudden loads should be avoided.
- Where practicable, sections that are lifted horizontally should be controlled by a tail-line fixed to one end and held by a man on the ground.

7.3.3 First lift columns

In order to erect steelwork it is necessary at some stage that single columns are stood upright. Ensuring that single columns do not topple before they can be tied in to form a stable box is sufficiently important that it is recommended that the Steelwork Contractor describes this in a *Task Specific Method Statement.* The principles are as follows:

- Before works starts, ensure that all the necessary equipment for erection of steelwork is on site.
- Place separate items (columns and the rafters or beams to be used to tie in) close to where they are to be finally erected.



- Ensure that the holding down bolts are, cleaned and nuts free running.
- Packs are placed prior to erection of the columns, recording the amount placed at each base for checking when the column is erected on the base.

The most common arrangement is as illustrated with the baseplate supported on a single central pile of packs and four wedges inserted around the perimeter of the plate.

- The packs are set at the required level or 3mm high to allow for any compression or to assist in beam level surveys at a later date.
- The column is lifted onto the foundation and the pile of packs, and aligned to position on the centre lines as closely as possible, using position points and marks previously scribed on the concrete base.
- The HD bolts are tightened.
- The column is checked for plumb – with a spirit level.
- With part of the column weight on the central packs (say 1 tonne of a 3 tonne column), the column is plumbed using the HD bolts.
- When the column is 'near-enough' (bubble within the lines) all HD bolts are tightened.
- Then the wedges are driven in. This assumes that access is readily available around the baseplate, and special considerations might apply if the column base is set in a pocket or positioned on top of a narrow wall.
- The bolts are rechecked again for tightness.
- The column is released from the crane. Wherever possible, holes should be provided in columns to facilitate the use of quick release shackles. If not provided, suitably secured chain slings may be used.
- Progressive adjustment of the wedges and HD bolt tensions may be required to enable the other steel components to be installed that tie the column in initially – although this needs careful control.
- When the column is fully tied in with other steelwork, the wedges will be removed to allow alignment of the structure. The column can rock on the central pack to permit alignment of the structure and to achieve the tolerances stated in NSSS.

For larger columns (eg heavy columns with large baseplates) it may be necessary to use four piles of packs (or to use pairs of folding wedges instead), as illustrated in BS 5531. In this method the following procedure is followed:

- Four sets of laminated packs are set to exactly the same level and rechecked.
- The column is landed and aligned against the centre lines.
- The HD bolts are fully tightened.
- The column is checked for plumb with a spirit level.
- Plumbing of the column can only be achieved by adding or removing packs but this requires lifting of the column, and probably means that the baseplate has not been welded perpendicular to the column shaft. HD bolts would then be retightened.
- The column is released from the crane.

This method is rarely used as to align the column and plumb [to NSSS] is very hard work. The column is not plumbed to NSSS when on the crane as it would be too time-consuming, so alignment is done using wedges and a heavy hammer. This introduces an additional risk from injury whilst swinging the hammer. Also, it is difficult to install further pieces, as the column is rigid. This may also introduce additional hazards and hold up progress.

7.3.4 Beams

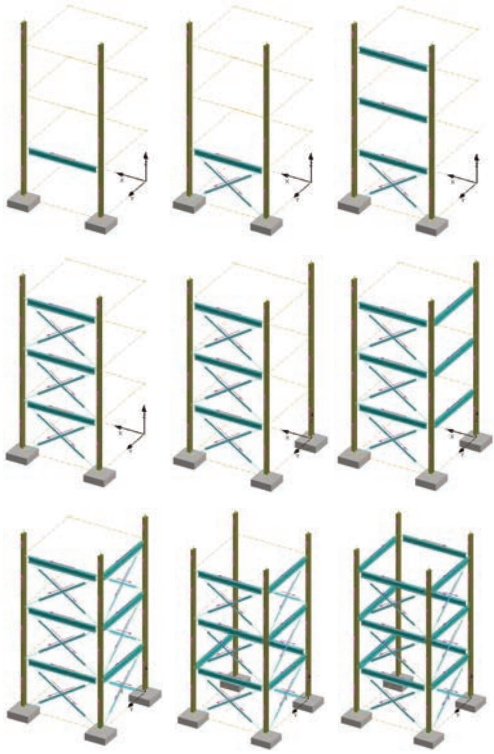
The Steelwork Contractor should generally observe the following practice:

- Beams should normally be lifted at the point of balance as most beams are finally fixed horizontally. If, for a particular beam, the angle with the vertical is different from 90°, then an adjustment in the slinging leg lengths by a proprietary-shortening device should be made.
- A tail line should always be attached to prevent the beam spinning in the wind. Special care may be needed when erecting on a site surrounded by other buildings as beams may leave the lee of a sheltered zone and suddenly enter a zone exposed to much higher wind speeds.

7.3.5 Stable box

Illustration of a typical sequence to erect enough steelwork to form a stable box is as follows:

The illustrations here show how the risk of column toppling may be reduced by tying in and bracing the columns as soon as possible after erection. Once they form a suitably complete "box" they are stable enough to await grouting which should be undertaken together for a wholly aligned zone of steelwork ready for handover to other trades.



7.3.6 Column splices

In order to erect multi-storey steelwork it is necessary at some stage that upper lift shafts of columns are stood upright onto completed lower columns. Ensuring that single column shafts do not topple before they can be tied in to form a stable box is sufficiently important that it is recommended that the Steelwork Contractor describes this in a *Task Specific Method Statement.* The principles will depend on the Steelwork Contractor's preferred connection splice design. These can be of three types:

- Bearing splices: if the close fit-up required of such splices has been checked by trial assembly in the works, this will facilitate safe and speedy erection. The upper shaft should mate readily with the lower shaft to achieve the full contact bearing required, which will provide a stable base to support and align the upper shaft.
- Non-bearing splices: these connections rely wholly on the bolts and stability of the upper shaft relies on enough bolts being inserted to secure and align the upper shaft. The splice plates will already be fixed to the lower shaft, but the bolts cannot be fully tightened until the upper shaft is engaged.
- Cap and base splices: these connections are easy to assemble, but have very limited capacity to resist toppling of the shaft induced by wind or lack of verticality. Hence, temporary guys are more likely to be needed.

The robustness requirements applicable to the permanent works design case generally dictate that non-bearing splices are used. These can be readily engineered to accommodate the wind forces acting on the upper shaft provided that due account is taken of any dynamic forces that can occur on slender shafts. The BCSA *Guide to Steel Erection in Windy Conditions* provides guidance on this.

Splices may be designed to be secured using general grade ordinary bolts, countersunk bolts or preloaded fastener assemblies (eg tension control bolts [TCBs]). Countersunk bolts are less tolerant of any lack of fit that ordinary bolts. TCBs and other preloaded bolts are good at accommodating tolerances, but they cannot be properly tightened until the alignment is finalised as they cannot be untightened and re-used. In such cases it may be necessary to use temporary bolts to secure the upper shaft initially until other steelwork has been completed and alignment is finalised.

7.3.7 Further erection

Typically, the Steelwork Contractor should observe the following practice:

- On completion of the erection to first splice the steel should be fully lined, levelled and bolts fully tightened. All necessary permanent and temporary bracing should be installed. The underside of the column bases should be grouted.
- If the plan area of the building is more than approximately 1000m^2, it can be split into two zones to allow metal decking installation to commence below the splice level in one half of the building while steel erection continues above splice level in the other half.
- Whilst metal decking can be installed by manual labour (once packs are lifted to level), the laying of precast concrete planks requires craneage. Thus the overlapping of trades working in two zones would thus require a building plan serviced by at least two cranes.
- During work on metal decking up to splice level, the uppermost level of the decking should not be studwelded until it has been used for access and steel storage for the next lift.
- Steel for the next lift of steel should be loaded out on storage platforms which are positioned over the floor beams and packed up over the decking troughs.
- The upper column shafts should be lifted using quick release shackles to avoid the need for erectors to climb columns using pole ladders.

- The next erected vertical portion of steelwork should be able to form a stable box. It should be erected as previously and safe access to the beam connection locations should be arranged. This may be achieved using pole ladders and span deck platforms, or, dependent upon the loading criteria and layout of the steel beams, it may be achieved by scissor lifts or "spider" MEWPs supported off the steelwork (using temporary support frames or the previously completed floor slab).
- The remainder of the steel in this lift should be erected in the same sequence and manner.
- The staircases should be erected in the same sequence as the main frame to facilitate safe access for all trades to the upper levels.
- Further lifts would continue in a similar manner, bearing in mind the need for "crash decks" to be in place before following trades can be permitted to work below a zone where steel is being erected above.

Concerning the metal deck, this should be stud welded as soon as possible following deck installation as:

- Water will get underneath the decking and sit between the deck and the steel which can affect the quality of the stud weld.
- Foot traffic and materials placed on the decking leaves contamination which can again affect the weld quality.
- Dependant on the volume of traffic over the deck the ends of the sheets tend to lift slightly which will leave an air gap between the deck and the beam leading to additional problems.
- Although the decking is pinned down prior to welding, it is more secure and therefore safer for loading and working from once anchored by the studs.
- It is therefore best if studs are always fixed prior to use for access, and especially if it is to be used as a loading platform.
- Where materials are loaded onto decks care must be taken so that there are clear walkways around the work zones and to adjacent work zones.

7.4 BOLTING-UP

The Steelwork Contractor should ensure that the maximum number of joints is made at ground level.

The erector should be instructed:

- To take sufficient bolts, nuts and washers to the connection in a tool belt or using a bag slung on the beam itself before lifting.
- To ensure that the spanners required to secure the bolts are of the correct size and of adequate length to achieve the required tightness of the bolts.
- Never to allow tools, fasteners etc to be thrown up to or down from persons working aloft.
- To ensure that the ground below is clear of persons who may be injured by falling bolts or spanners.

8 COMPLETION

8.1 ALIGNMENT

Unless specifically forbidden in the Steelwork Contractor's erection method statement, installation and removal of temporary ties (eg *Tirfor* wires or pull-lifts) used to assist with the alignment of the structure may be added and removed at the discretion of the erection supervisor.

8.2 HANDOVER

Prior to withdrawing labour, plant and equipment from site, the Steelwork Contractor should ensure that the steelwork is handed over to the Principal Contractor in accordance with the specification and in a safe condition, and that this handover is recorded. The assessment of whether the steel structure is complete and stable is the responsibility of the Steelwork Contractor. It is the Principal Contractor's responsibility to assess whether the structure is safe for the use of following trades. This assessment should also take into consideration the condition of edge/void protection. The column bases should be fully grouted before other trades are permitted to have access to work on the structure unless authorised by the Designer or a suitably qualified person.

If the Steelwork Contractor is asked to omit or remove components of the permanent works to permit access for others, this request should be referred to the Designer or a suitably qualified person for agreement to check whether the action could endanger structural stability.

Similar disciplines are needed when phased or partial handovers are necessary, but with additional attention to the fact that steel erection will be continuing in close proximity to the following trades working on the steelwork already handed over.

Steelwork ready for handover

8.3 SITE CLEARANCE

The Steelwork Contractor is responsible for ensuring that all his equipment brought on to site has been safely removed.

Temporary bracing and other temporary works should only be removed with the consent of the person who has specified what temporary works shall be used. Generally, the timing for removal will be specified in the erection method statement based on the erection sequence developed by the Steelwork Contractor and reviewed by the Designer.

9 ACCIDENTS

9.1 LOG/DIARY

In addition to any arrangements made by the Principal Contractor, the Steelwork Contractor should ensure that the person on site identified as being in direct control of erection maintains a personal log/diary and keeps it with them at all times in case an accident or emergency arises. It should record the significant events concerning:

- Weather and site conditions.
- Drawings and amendments issued
- Plant resources and manpower on site.
- Toolbox briefings given.
- Deliveries received.
- Progress with erection, alignment and handovers.
- Health and safety issues.
- Problems encountered.
- Liaison with the Principal Contractor and site instructions received.

Entries in the log should be summarised in the form of a short daily report for issue to the Steelwork Contractor's manager in charge.

9.2 RESCUE AND RECOVERY

The Steelwork Contractor should review with the Principal Contractor what emergency rescue equipment should be available in case of accidents at heights. In particular, if MEWPs cannot be used for erection in certain locations on multi-storey structures, then they will not be able to facilitate rescue and recovery in those locations either.

Training for rescue should be undertaken in accordance with BS 8454, which recommends that a rescue plan be included in the method statement for the work. It may be best, therefore, to prepare a *Task Specific Method Statement* to deal with emergency rescue and recovery in general or in specific circumstances. This should deal, in particular, with how to recover an unconscious person in a safe and timely way.

The options available to the Steelwork Contractor very much depend on the structure configuration and the severity of the person requiring emergency rescue. The following recovery methods should be considered prior to any erection work commencing on site:

- Provision of a designated rescue man basket that can be suspended underneath the casualty. This method is only appropriate if there is a crane on site already that is rated and inspected with a suitable capacity to lift and recover the manned basket.
- Provision of a MEWP (mounted on the ground or aloft) that can be elevated underneath the suspended casualty. This method is only appropriate if the MEWP has un-obstructed access to the casualty.

- Provision of an emergency rescue harness. The trained rescuer suspended from the rescue harness connects a line onto the casualty's harness, then by cutting the casualty's lanyard lowers both parties to a safe floor level.
- Provision of a rescue stretcher. This equipment is again lowered down to a suspended casualty by a trained rescuer.
- Provision of a tied ladder lowered down to a suspended casualty. This method is only appropriate if the casualty is conscious.
- Provision of a rescue hook from the crane lowered down and attached to the casualty's harness.

Liaison with the public Fire and Rescue Service may also be necessary although reliance on the public emergency services is not acceptable.

9.3 FIRST AID

Provision of first aid should be coordinated by the Principal Contractor. This includes identification of who are the designated first-aiders and where the first aid facilities and resources are located.

The Steelwork Contractor has a special responsibility to ensure that specific situations that might possibly occur during steel erection are adequately covered. These include: trauma from falls in harnesses, trapping of limbs by heavy components and exposure of eyes to dust and grit.

9.4 ACCIDENT REPORTING

The Steelwork Contractor must make arrangements to ensure that ALL accidents are recorded in the accident book kept on site.

The Steelwork Contractor should also ensure that any accidents are reported to the Principal Contractor and that the Company Safety Officer is informed so that follow-up investigations and reporting can be undertaken.

It should be noted that:

- It is the responsibility of the employer of any injured person to report all major injuries, reportable diseases and dangerous occurrences (see RIDDOR for definitions) to the enforcing authority usually the HSE national reporting centre, details on riddor@natbrit.com) by the quickest means available (ie telephone). Generally the employer would be the Steelwork Contractor or their specialist erection subcontractor.
- It is the responsibility of the employer of any injured person to report all injuries involving absence of more than three days to the enforcing authority within ten days.
- In such cases, a copy of the report should also be forwarded to the Principal Contractor.

Thorough follow-up of any recorded dangerous occurrences should be used to provide the necessary impetus to improving safety standards. It should be noted that failure of load-bearing parts such as lifting equipment is classified as a dangerous occurrence – as well as more obvious unintended collapse of a structure under construction.

REFERENCES

Publications produced by the BCSA:

Code of Practice for Metal Decking and Stud Welding

Erectors' Manual

Guidance Notes on the Safer Erection of Steel-Framed Buildings

Health & Safety Guide for Sites

National Structural Steelwork Specification for Building Construction

Safe Site Handover Certificate

Guide to Steel Erection in Windy Conditions

Guide to Loading and Unloading of Steelwork

Task Specific Method Statement

Other publications:

BS 5531 *Code of practice for safety in erecting structural frames*

BS 8454 *Code of practice for the delivery of training and education for work at height and rescue*

BS EN 13374 T*emporary edge protection systems – Product specification, test methods*

PASMA *Operator's Code of Practice*

PFF *Code of practice for the safe erection of precast concrete flooring and associated components*

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APPENDIX: Task Specific Method Statements

For ease of reference, this code recommends that a *Task Specific Method Statement* may be needed for the following tasks or situations:

Task or Situation	Type
Issue of variations or site instructions	Site specific
Alterations to the erection sequence to cope with circumstances arising	Site specific
Coping with unanticipated hazards arising on site	Site specific
Off-loading of steelwork	Site specific
Operating MEWPs on support frames or over floor slabs	Site specific
Use of man baskets, span deck platforms, ladders or MATs	Generic
Beam straddling	Generic
Use of harnesses, lanyards, fall arrest blocks and running lines and attachment to anchorages	Generic
Use of double lanyards for exiting a MEWP basket onto the steelwork	Generic
Manual handling of heavy pieces (including using chain blocks or other lightweight device)	Generic
Placing precast flooring	Generic
Erection of steel stair flights or placing of precast staircases	Generic
Using equipment that causes noise or vibration (including abrasive wheels)	Generic
Coping with substances hazardous to health (including fuels and gases)	Generic
Site welding	Generic
Burning	Generic
Use of equipment for tightening preloaded fasteners	Generic
Site drilling steelwork	Generic
Reaming	Generic
Drilling concrete	Generic
Erection and stabilisation of a single column including packing, wedging and tightening of HD bolts	Generic
Column splices	Generic
Special or complex lifts requiring an appointed person to control	Site specific
Emergency rescue and recovery	Generic or Site specific

Based on the activities defined in the Scope of Competence listed in BCSA's *Guidance Notes on the Safer Erection of Steel-Framed Buildings*, the following tasks or situations may also demand the preparation of a *Task Specific Method Statement*:

Task or Situation	**Type**
NORMAL SCOPE OF COMPETENCE	
Jacking	Site specific
Hot work (including work on previously painted surfaces)	Generic
Site painting or "touch up" (including application of intumescent paint)	Generic
Fixing of metalwork items	Generic
Installing expanding/chemical anchors	Generic
Work on a contoured site	Site specific
Connection to an existing structure (including dismantling)	Site specific
SPECIAL SCOPE OF COMPETENCE	
Grouting bases	Generic
Placing movement bearings	Generic
Installing a scaffold platform	Generic
Assisting external inspectors	Generic
Use of special fasteners of fixing proprietary items	Site specific
Work in artificial light	Generic
Lateral movement of heavy loads (eg using winches)	Site specific
Work in confined spaces	Generic
Work over or alongside water or in contact with polluted water	Site specific
Work over a railway or airside at an airport	Site specific
Work alongside a trafficked road or during a possession	Site specific
OTHER ACTIVITIES	
Arrangements for radiographic inspection	Site specific
Site blasting	Generic
Fixing pre-glazed frameworks	Site specific
Using bonded adhesives	Generic

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