HSE
Health G Safety Executive

Guidance Note GS28/2 from the Health and Safety Executive

Safe erection of structures. Part 2: site management and procedures

General Series 28 Part 2 (January 1985, reprinted November 1991)

These Guidance Notes are published under five subject headings: Medical, Environmental Hygiene, Chemical Safety, Plant and Machinery and General

BACKGROUND

1 This is the second Guidance Note in a series of four dealing with the safe erection of structures, and gives advice on safety aspects of erection procedures and site management. It forms part of the Health and Safety Executive's response to public comments, and the Construction Industry Advisory Committee's* advice to the Health and Safety Commission following publication of the report *Safety in steeL erection.* + As a result of consultation with industry, however, the scope of the notes has been widened so that they apply also to the erection of structures in other materials.

2 The other three Guidance Notes in the series provide advice on initial planning and design to aid safe erection, working places, access and egress, and legal requirements. Further details are given in Appendix A.

INTRODUCTION

Objectives

3 The guidance in this note is primarily intended for those involved with and responsible for the erection of structures, including those who plan, design, detail, manufacture and fabricate components. However, clients, together with their professional design advisers, such as engineers and architects, should find the advice useful. The note 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 and panels; lifting and handling; and interconnection of components.

4 The advice given can form the basis for safe working on all types and sizes of site. The planning and management aspects covered concentrate on work about to start, or already started, on site. The note is intended to aid compliance with the Health and Safety at Work etc Act 1974 (HSW Act) and with the relevant specific requirements of applicable codes of regulations. In particular, the note should assist in the preparation and implementation of method statements (see para 7).

The problem

5 Many accidents occur during the erection of structures, and the principal cause of both serious and fatal accidents is falls from heights, either from, working positions or while gaining access to them. Other accidents 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 lead to risks being taken and hence to accidents.

MANAGING FOR SAFE ERECTION

6 Safe working methods and practices on site should be encouraged by:

(a) the preparation and use of a detailed method statement;

(b) thorough and active contract coordination both on and off site;

(c) the implementation and maintenance of effective communications;

(d) realistic and effective methods of programming and progressing;

(e) the organisation of work which takes into account adverse weather conditions;

(f) the provision of suitable staff;

*The Construction Industry Advisory Committee (CONIAC) was established by the Health and Safety Commission in 1978 to consider and advise the Commission on: the protection of people at work from hazards to health and safety arising from their occupation within the building, civil engineering and engineering construction industty; on the protection of the public from related hazards arising from such activities; associated matters referred to them by the Commission or the Health and Safety Executive.

+ The report Safety in steel erection (ISBN 011 833 2417) was published in 1979 and is available from HMSO. It was prepared by a sub-committee of the Joint Advisory Committee on Safety and Health in the Construction Industries with the following terms of reference: "to consider the dangers in the erection of structural steelwork with particular regard to the safety of workers; to make recommendations on safety precautions and on the competency and raining of those involved in supervising and carrying out such work".

(g) the provision of protective equipment which is necessary and appropriate for the work, eg safety helmets, safety harnesses, gloves, bad weather clothing and eye protection, together with arrangements for employees to obtain safety footwear; some of these are mandatory and further advice is provided in the fourth note* in this series.

Method statements

7 Section 2 of the HSW Act requires employers to ensure, so far as is reasonably practicable, the provision of a safe system of work. The preparation of a method statement setting out, inter alias, 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, with a simple job requiring a simple method statement and repetitive tasks being covered by standard sheets. Guidance on the layout and format of a method statement is given in Appendix B, and advice on features that should be included can be found in the first note + in this series.

8 Before work starts on site, outline proposals produced at the tender stage should be developed into a method statement which should include a detailed erection scheme. The whole method statement should be reviewed and updated as necessary so that it remains current. It should be distributed to all those concerned with the supervision of erection.

Staffing and training

9 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 organisational chart.

10 Those erecting the structure should be suitably trained as well as supervised. Training* should be a continuing process with on-the-job instruction and formal training sessions provided as appropriate.

Contract coordination

11 Coordination and liaison between different parties should be planned before the job starts. This may be undertaken by the line management responsible for the erection, depending upon the size and complexity of the job. The role of the person, or persons, responsible for coordination should be clearly defined and their authority made known to those involved.

12 Any changes in previously agreed procedures must be verified by the person responsible for coordination as being safe betore they are implemented. Where these may affect structural integrity, reference should be made to the designers.

13 Matters which, if coordinated, will contribute to safe erection on site include the availability of information, plant and manpower (as required), and the quality and supply of materials. Those coordinating construction activities should ensure that:

(a) there is liaison on site, especially on the sequence of operations, arrangements for stacking and provision of suitable access and hard standings;

(b) sufficient detailed drawings are available in time to allow for effective forward planning and safe construction: these drawings may be from the designer, the detailer or the manufacturer/ fabricator;

(c) the manufacturer/fabricator 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;

(d) the correct components are delivered to site in the required order;

(e) if incorrect or inadequate components are delivered to site, the consequences are thoroughly analysed and the effect on the erection sequence taken into account in any subsequent action.

Communications

14 To ensure that precautions for safe erection outlined in the method statement are followed, lines of communication should be clearly designated, with the responsibility for implementing the method statement well defined. Lines of communication can be incorporated into an organisational chart which should include the management links between contractors and sub-contractors and their clients or representatives.

15 Arrangements should be made to ensure that erectors and other operatives are familiar with the requirements of the erection scheme before erection starts and that they know whom 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 appropriate in some cases.

Programming and progressing

16 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 erection sequence in the method statement.

17 It is often valuable to use 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, coloured drawings or by more

+ HSE Guidance Note GS 28/1 Safe erection of *structures Part 1: Initial planning and management*

* HSE **Guidance** Note GS 28/4 *Safe erection of structures. Part 4: Legislation and training* **(in preparation)**

sophisticated computerised reviewing techniques. For some jobs progress could be shown combined with a diagram depicting the erection sequence.

Weather

18 Weather conditions should be constantly monitored by the person responsible for the erection work on site. Reference to weather forecasting facilities should be made in advance: *Weather services for builders,* published by the Meteorological Office, will be of use.

19 Weather conditions that could have an adverse effect on erection work include:

(a) rain or dew;

(b) high wind*;

(c) frost, ice or snow;

(d) those which cause poor visibility, such as fog, mist or glare.

20 If a decision is made to stop work, then measures should be taken to ensure the maintenance of stability. The stability of previously erected material should be reassessed before work is restarted.

PREPARING THE SITE

Access on to the site

21 Although the site should have been surveyed + at the forward planning stage, contractors should undertake their own site check for hazards and special features, ensuring that:

(a) suitable unobstructed safe access with good all round visibility is provided for delivery vehicles, cranes and other plant;

(b) any delivery requirements which may pose access problems, because of the curvature and gradients of roadways, are taken into account;

(c) the structural stability of adjacent buildings will not be affected;

(d) there will be no risk of contact with overhead services;

(e) underground services will not suffer damage.

Movement on the site

22 The planning and preparation for movement about the site at ground level should take account of:

(a) the need to provide good pedestrian access, e.g. by providing clear and clean access ways, thereby avoiding tripping hazards and slippery foot ways;

(b) the need to exclude personnel from areas where they would be at risk due to work in progress overhead;

(c) the likely movement patterns and working locations of lorries and plant, particularly heavy equipment such as cranes, where stability is vital;

(d) the projected use of access equipment, which could include power-operated mobile work platforms, tower scaffolds and "ladders;

(e) the need to ensure that access routes are not impeded by other site activities such as the excavation of trenches.

23 The ground conditions should be capable of remaining sound even after bad weather and sustained heavy traffic, and if the ground is particularly poor it may be necessary to make provisions for specially constructed well drained and durable temporary roadways and hard standings. Consideration should be given to the construction of permanent roadways and hard standings prior to erection.

Storage areas

24 Areas should be allocated for the stacking and storing of components and should be clearly shown on site plans. These areas should be:

(a) clear of obstructions, reasonably level, and of adequate size;

(b) on ground which is capable of withstanding the loads imposed by the stored materials and plant used in the area (investigation should include a check for the presence of underground services in order to prevent damage from imposed loads);

(c) sited away from hazards such as overhead power lines *;

(d) arranged so that clear access and sight lines are provided and maintained between stacks of components;

(e) provided with artificial lighting and weather protection where appropriate, to aid handling.

25 If on-site manufacture, fabrication, modification or repair work is to be undertaken additional areas may be needed with facilities similar to those of storage areas. In addition, contingency plans should be made to provide an area for a buffer store in case it becomes necessary to store more material than originally planned.

***** National Federation of Roofing Contractors *Roofing and cladding in windy conditions* 1982

+ HSE Guidance Note GS 28/1 Safe *erection of structures. Part 1: Initial planning and design*

•HSE Guidance Note GS *6 Avoidance of danger from overhead electric lines*

DELIVERY, STACKING AND STORING

Planning

26 The delivery of materials to site should be planned:

(a) so that arrival times coincide with site requirements;

(b) to coincide with the availability of sufficient numbers of personnel and suitable cranes to ensure safe unloading;

(c) so that arrangements are made to safeguard the public if access to site is impracticable and delivery vehicles have to be unloaded from the highway;

(d) to allow for components to be erected directly from the delivery lorry, where appropriate, and particularly if site storage space is limited;

(e) to cater for the possible need to store extra imaterial on site in a buffer store.

27 Multiple handling can be avoided by loading the lorry at, for instance, the fabrication shop or casting yard in the same order as erection to facilitate stacking in the correct order.

28 When organizing the stacking area account should be taken of site suitability, including ground stability (see paras 24 and 25).

Unloading

29 Special care should be taken when unloading delivery vehicles to ensure that:

(a) they are stable at all times;

(b) components have not been damaged during transportation to the site;

(c) all components, loose fittings, erection packs and fasteners shown on the loading lists are present;

(d) adequate lighting is available, especially deliveries may be made when there is insufficient daylight;

(e) lifting or slinging points are present and correctly marked, particularly for unusually shaped components, heavy components or sub-assemblies: special lifting attachments or brackets may be required;

(f) the weights are clearly marked on all members, bundles of components and sub-assemblies of one tonne or over;

(9) unwanted rotational movement of long components or sub-assemblies is prevented by using hand lines fixed near the ends of the load.

30 At the time of unloading any damaged or incorrectly manufactured components or omissions from the loading lists should be identified and the person responsible for coordination informed to avoid any adverse effects on safe erection.

31 Paragraphs 62 to 69 below give further guidance on lifting and handling.

Storing

32 To enable components to be readily accessible for erection in accordance with the erection scheme, consideration should be given to:

(a) whether they are required for immediate use or have to be stored for future use;

(b) a method of storage to be adopted which allows for retrieval in the order required;

(c) the provision of clearly designated storage areas from which components required for stability purposes, e.g. bracing, can be retrieved readily;

(d) the provision of a separate area for the storage of components which can be handled manually.

33 Arrangements should take account of the possible need to retrieve components for activities prior to erection such as:

(a) connecting together at ground level to form sub-assemblies;

(b) planned on-site preparation such as surface treatment or adding connectors;

(c) remedial work following damage or on-site modifications:

(d) quality control inspection.

Stacking and restacking

34 Any stack of materials, whatever its size, should be made in such a way that' it can be destacked safely. Matters which should be taken into account when stacking or restacking * components include:

(a) stacking in a way which will ensure that there is no risk of collapse, sliding or distortion;

(b) enhancing stability of the stack by ensuring the supply and use of adequate numbers of timber packing pieces, battens and wedges, which should be of suitable size and strength and positioned in lines vertically throughout the stack;

(c) the safety of personnel on the stack by ensuring that if access at height is required (e.g. to fix or remove lifting slings), operatives are provided with a safe means of access and safe places of work;

(d) avoiding injury due to trapping when handling (see para 69).

35 To aid erection, components should be stacked on suitable timber battens and packing pieces so that:

* General advice is given in Health and Safety at Work Booklet 47 Safety in the *stacking of rnaterials* (to be revised)

(a) they are not brought into contact with the ground, thereby preventing mud deposits which could present a slipping hazard;

(b) damage to projections, such as nibs and brackets, is minimised;

(c) slings can be positioned easily around components for later handling.

36 Having considered the general requirements for safe stacking, restacking and storing, there may be advantages in using specialised devices such as mobile or transportable storage racks or platforms, particularly for small or common components (Fig 1). Such racks or platforms should be designed to be stable when some or all of the components are removed. They should be clearly marked with the safe working load and self weight.

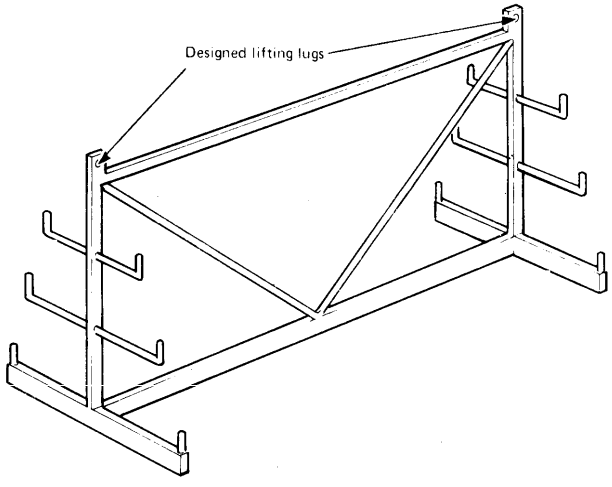


Fig 1 Example of transportable storage rack

STRUCTURAL STABILITY

37 Planned systems for achieving and maintaining stability at all times during construction should be fully detailed in the method statement which should contain precise step-by-step instructions. These should be indicated on the detailed working drawings and given to the erection gang.

38 Any special or unusual features of the structural design which may affect stability during erection should be highlighted and emphasised on drawings which form part of the method statement.

Assessing the disturbing forces

39 Instability can be caused by a number of factors, some of which are difficult for the designer to predict and assess accurately. These factors could include the springing of members into position, members becoming jammed during positioning, temporary eccentricities occurring during erection and the effect of parts of the frame being struck by a crane jib or slung loads. Particular attention should be paid to the effect of the force imposed by ladders on the stability of single columns or light structures.

40 Loadings which should be considered as possibly producing disturbing forces and thus instability (depending upon circumstances) are listed in Appendix C. Means of providing stability during erection should be able to resist likely disturbing forces. Additionally, the structural members should be capable of withstanding any forces induced by the methods chosen for providing stability.

Principles of stable erection

41 Erection should start at a location where it is possible to construct an inherently stable and self-supporting rigid 'box' with internal or in-built restraints. This applies to most types of structure of whatever size, including rectilinear frames, portal frames, preformed panel buildings, towers, masts and bridges. The box should be started at a braced or, stiff bay. Until the self supporting stage is reached some temporary support will be required.

42 On long, tall or irregularly shaped structures further rigid boxes may be required as erection progresses. This may also apply to phased work, where construction or movement joints occur, and separate buildings.

43 Special care is required to ensure that those structures are identified which act in a fundamentally different way in their temporarily erected state to when the erection is completed. In addition, identification should be made of those members in a structure, such as cold rolled purlins, which may appear to give a degree of rigidity but in fact cannot be relied upon. These points emphasise the need for the erection techniques to be devised by a person competent to recognise how the imposed loads are distributed and the way in which the structure acts.

44 Erection of any element or sub-assembly should start only if all the necessary equipment and tackle is on site to enable stability to be maintained at all times. Stability should be reassessed at the beginning of each shift, before further erection starts.

Methods of support for providing stability

45 Methods of supporting different structural members or assemblies, together with advice for ensuring stability during erection, are given in Table 1.

46 Applications for different methods of providing stability are shown in Table 2. The different methods shown can be applied in different combinations to individual members and sub-assemblies as well as to the erected or partially erected structure.

Table 1 Alternative types of support for structural elements during erection

Structural element member or assembly	Alternative types of support (see Table 2 for advice on use)	Comments
Columns - single	Guying and propping (B)	Temporary supports (Fig 3) should be provided unless the holding down system has been proved able to resist the overturning moment.
	Embedded anchorages and Column bases (D)	Where only two holding down bolts are used, the column should be propped or guyed. A minimum of four erection packs should be positioned to enhance stability (Fig 2).
Columns - pairs Single bays	Bracing (A) Guying and propping (B) Permanent connections (C) Embedded anchorages and column bases (D) Shear resisting elements and panels (E) Temporary structures (F)	To be made stiff as soon as possible, and before a second bay is erected (Figs 4, 5 and 6).
Structural panels	Bracing (A) Guying and propping (B) Permanent connections (C) Embedded anchorages and column bases (D) Shear resisting elements and panels (E) Temporary structures (F)	Temporary support will invariably be required (Fig 10)
Lattice girders Slender beams Roof trusses - single	Guying and propping (B) Temporary structures (F)	Lattice girders (Fig 7), slender beams and roof trusses have little lateral stiffness and resistance to both toppling and bending should be provided. Erection may be with the aid of strong backs or lifting beams - this lifting gear should not be removed until satisfactory stability has been achieved with suitable connections to the supporters.
Lattice girders Slender beams Roof trusses - pairs and groups	Bracing (A) Guying and propping (B)	Pair of rafter beams require plan bracing (Fig 6b and 8). Roof trusses may be erected in groups with a designed lifting beam; plan bracing is usually required (Fig 9)
Sub-assemblies	Guying and propping (B) Permanent connections (C) Temporary structures (F)	It is often better to create as many sub-assemblies as possible so that there is inherent stability and connections made at height are reduced. Towers and masts could be included in this category. During assembly adequate support of individual pieces is required and care must be taken to recognise and counter any possible imbalance when further pieces are connected. These supports should be stable and based on good foundations.

Note: The types of support listed in the middle column indicate the most appropriate alternatives.

Table 2 Types of support for providing stability, and their applications

Types of support	Possible applications	Requirements for effectiveness	Advantages	Disadvantages	Other considerations
A Bracing (permanent and/ or temporary) including both plan and vertical	Pair of columns Group of columns Stiff bay Rigid box Providing transverse support to pairs of horizontal or sloping members such as in roofs and floors	Rigidly fixed connections Accurately designed and manufactured/ fabricated components	Contained within structure grid lines and less likely to be accidentally removed or hit Can form part of the permanent structure to obviate removal problems later	**Permanent:** Induced construction loads may be greater than when completed and a check is required Temporary: Removal of high level cleats and brackets may be required when bracing is no longer necessary	When possible, erection should start in bays where permanent bracing is provided. If not, temporary supports should be provided unless proved to be unnecessary High level brackets should be left in whenever possible
B Guying and propping	Single column Pair of columns Group of columns Stiff bay Rigid box Structural panel Slender beams and trusses (lateral support)	Suitable and adequate strength of fixing positions on components Secure fixing to component to prevent accidental displacement Adequate anchorage at base location to cater for tension and compression as required, and in all weathers Ability to vary and maintain force on component safely	**Readily obtainable** **Commonly known method**	**Can obstruct access ways** **Subject to accidental** impact damage May have special fixings to be removed at height when no longer required Sometimes difficult to make and sustain secure fixings	**Some supports act only in tension (e.g. guys) or** in compression (e.g. non push-pull props) Guys should be of suitable wire rope
C Permanent connections (load bearing and moment resisting)	Stiff bay Rigid box Structural panel Permanent rigidity of structure	Tight and secure fixings	No extraneous parts or tackle Would usually form part of permanent structure	Erection stresses may exceed permanent case Not always practicable to effect final alignment and tightening at an early stage	Check on continuing adequacy may be required Temporary support may be required until final connection made

Table 2 (contd)

Types of support	Possible applications	Requirements for effectiveness	Advantages	Disadvantages	Other considerations
D Embedded anchorages and column bases	Single column Portal frame Structural panels	Tight and secure fixings and wedges Symmetrical and stable packs under bases Securely embedded fixings resistant to displacement once fixed	No extraneous fittings to obstruct other activities	Adequacy of constructed fixings cannot be checked readily Pull-out of bolts may be a problem if not properly fixed and pull-out values may have to be tested High degree of accuracy in setting out required	Often the construction of these anchorages is by organisations other than the erection contractor and requires planning, coordinating and checking to help minimise difficulties
E Shear resisting elements and panels (e.g. walls, floors and roofs)	Stiff bay Rigid box Permanent rigidity of completed portion of frame	Adequately developed strength, including mortar, concrete and fastenings, where appropriate Temporary supports required until strength developed	Forms part of permanent structure Extraneous fixings may not be required Extra or temporary equipment may not be required Temporary supports can be released for other work	Delay while strength of mortars and concrete develops Would depend on other trades for construction	A clear system of responsibility would have to be established to permit the removal of the temporary supports Requires careful planning and coordinating
F Temporary structures (purpose built)	Any individual member, assembly or group	Sufficiently strong temporary structure to withstand forces Adequate distribution of forces within temporary structure Adequate local strength for fixings Effective connections	Can be designed to avoid the need for other support systems which may hinder the erection process	Purpose built temporary supporting structure has to be designed and erected May require special foundations	A clear system of responsibility would have to be established to permit removal of the temporary structure Requires careful planning and coordinating

Table 2
(continued)

Notes

Points to be considered when selecting methods of support include:

(a) Some-supports will provide restraint either in tension only or in compression only. This can depend (either) upon the support itself or the type of end connection. Care must be taken to identify this in the type of restraint chosen.

(b) To give effective support in more than one direction it is usually necessary to provide restraints at, for example, 90° to each other.

(c) When using external supports excessive force should not be used as this could itself induce instability.

(d) A distinction must be made between supports which are to be provided to resist loads and those such as jacking which are intended to aid erection by deliberately moving the structure or a component part, as this can adversely effect the structure, means of support or fixings.

(e) Where an existing structure is to be relied upon to provide support, it should be capable of resisting the imposed loads.

(f) Where temporary supports could be mistaken for part of the permanent structure, painting in a different and distinctive colour will aid identification. This will help to avoid the removal of permanent components by mistake when the temporary supports are removed.

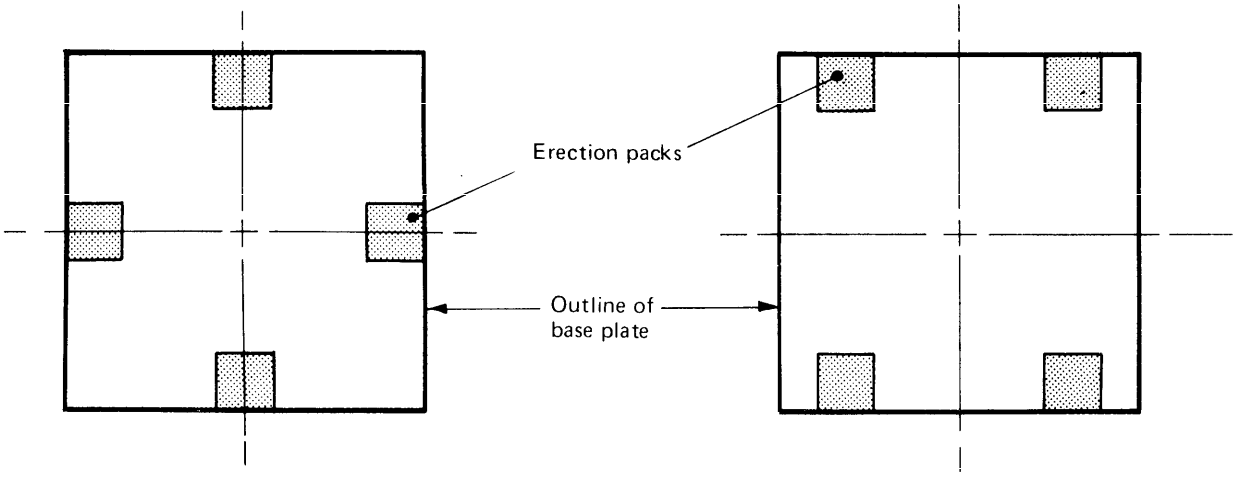
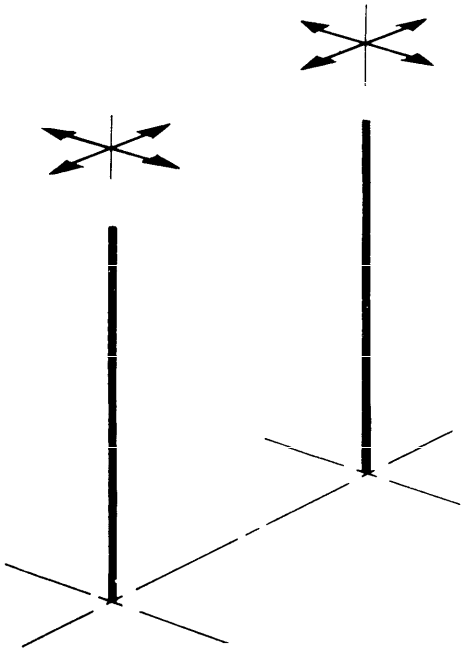
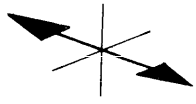


Fig 2 Erection packs under base plates (showing preferred positions to enhance stability)





Indicates direction in which temporary supports are required unless base arrangements have been proved able to resist the overturning moment before erection

Fig 3 Stability of single columns (diagrammatic representation)

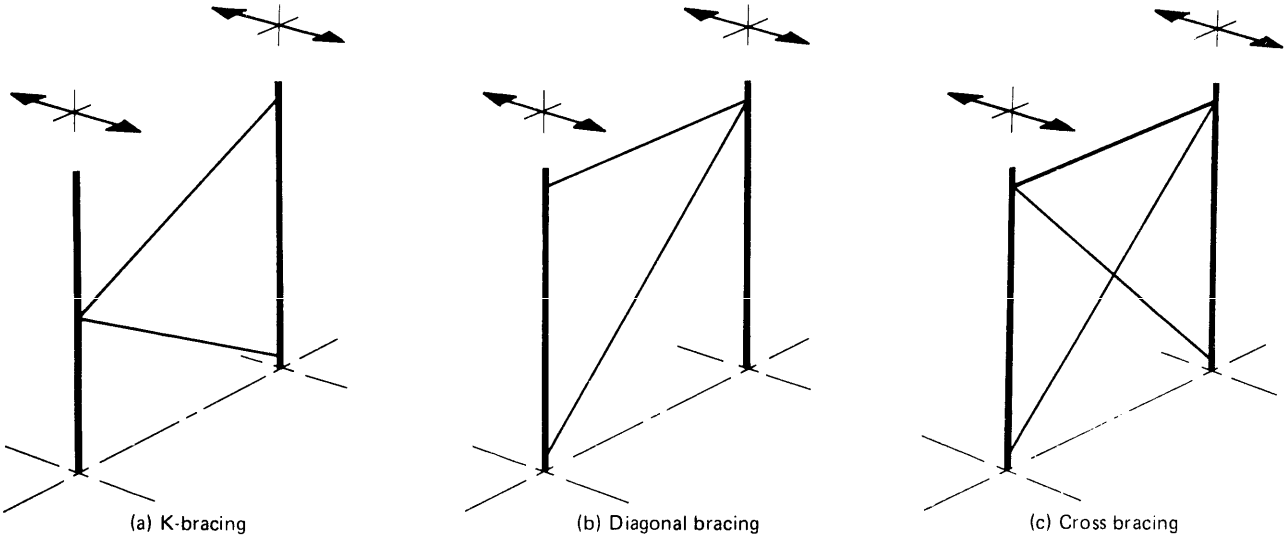
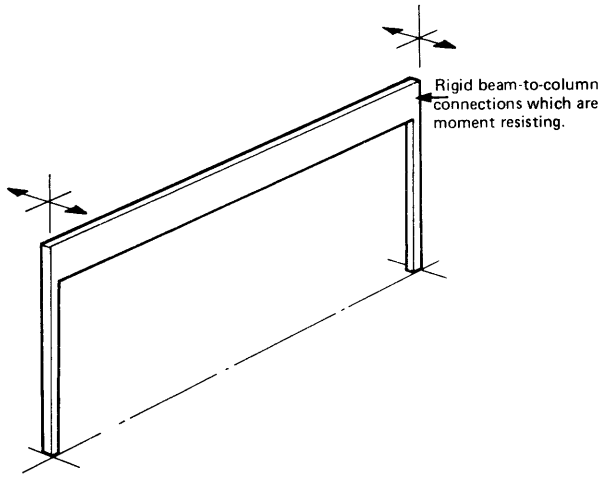
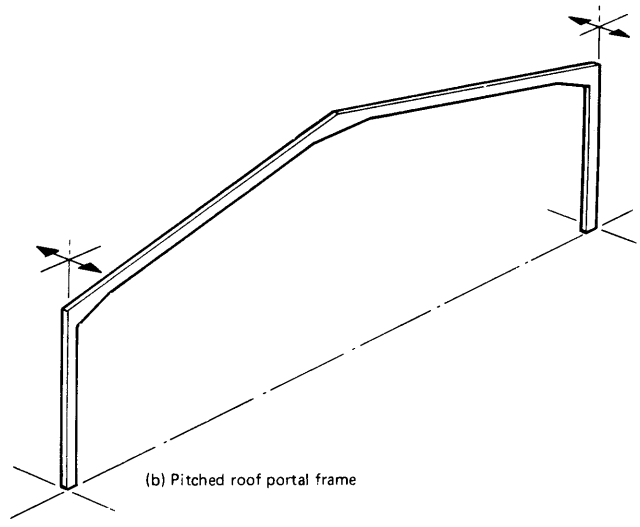


Fig 4 Stability of single bays — braced (diagrammatic representation)



(a) Rectangular portal frame (which may be part of a multistorey multi-bay structure)



(b) Pitched roof portal frame

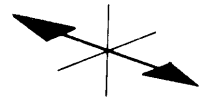
Notes

1 To be made rigid as soon as possible and before further components are erected.

2 Any side of a rigid box formed by a single bay that is not Inherently stable, may require external support such as guying or propping.

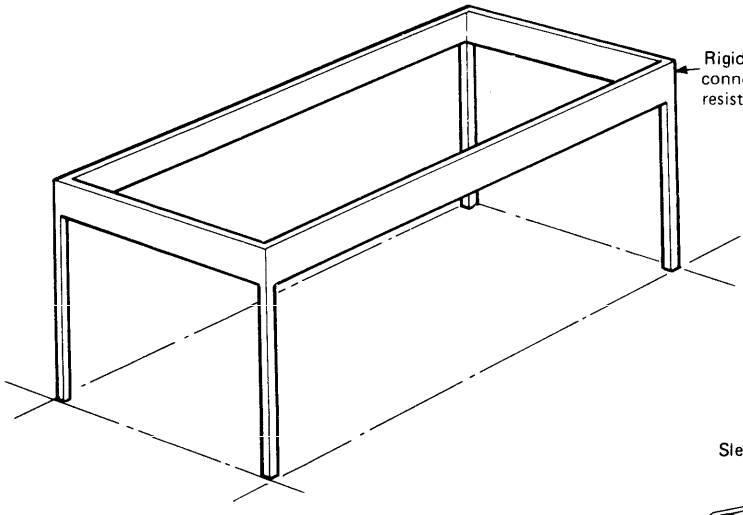
3 Rigidity of base may be important to achieve stability.

4 Further information is given in Tables 1 and 2



Indicates direction in which temporary supports are required unless base arrangements have been proved able to resist the overturning moment before erection

Fig 5 Stability of single bays – unbraced



(a) Rectilinear frame

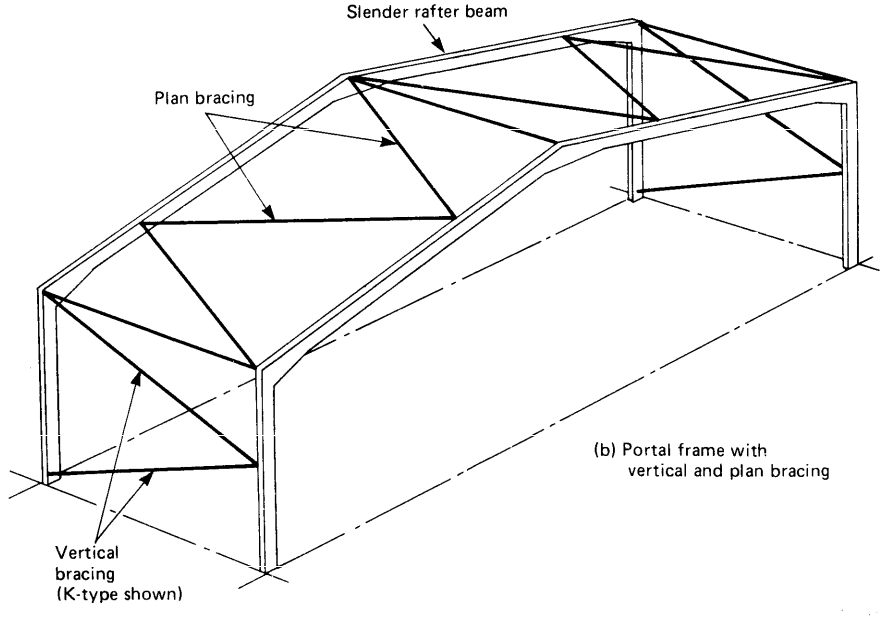
Notes

1 To be made rigid as soon as possible and before further components are erected.

2 Any side of a rigid box formed by a single bay(see Fig 4 and 5) that is not inherently stable may require external support such as guying or propping.

3 Rigidity of base may be important to achieve stability.

4 Further information is given in Tables 1 and 2



(b) Portal frame with vertical and plan bracing

Fig 6 Stability of rigid boxes

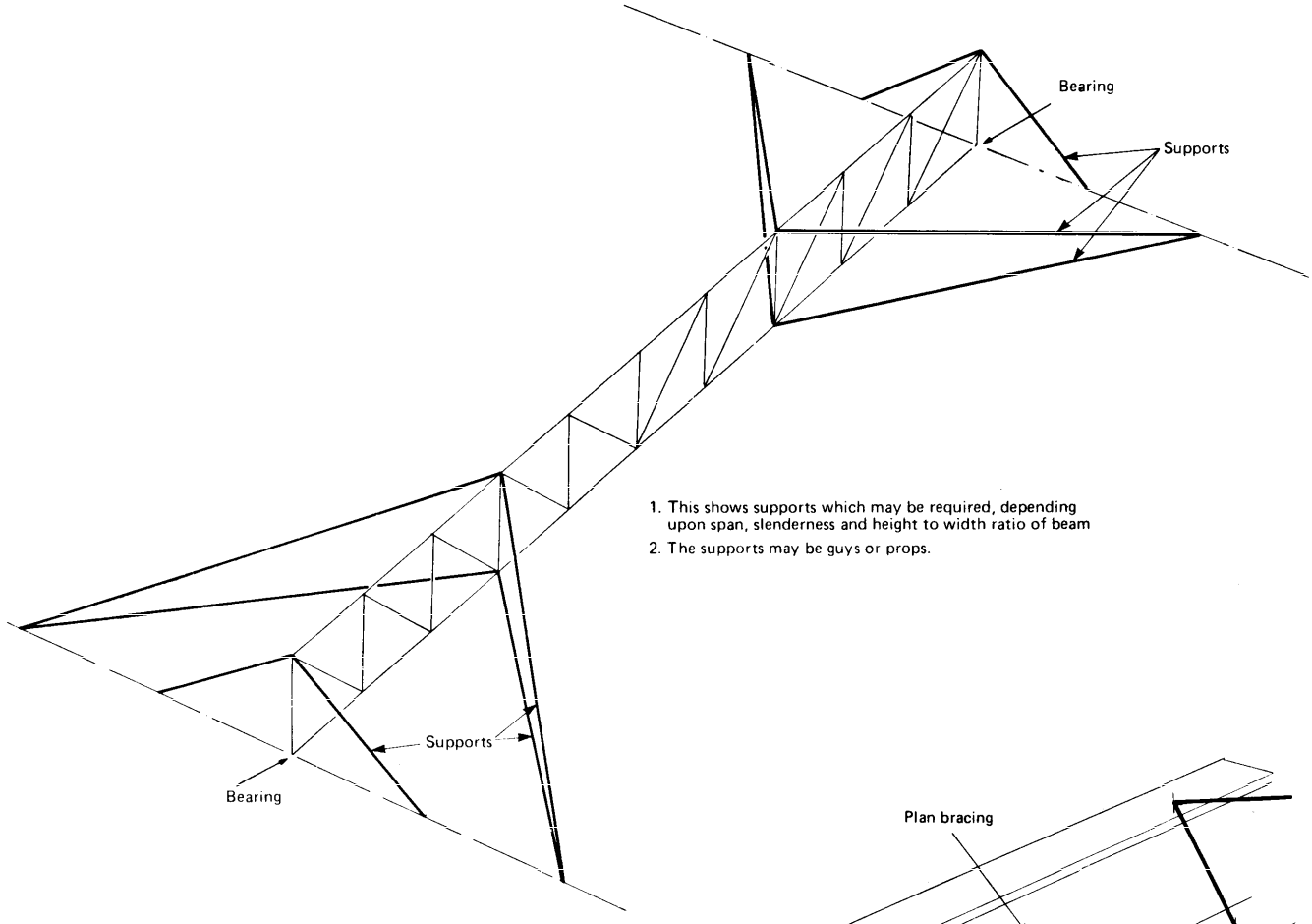
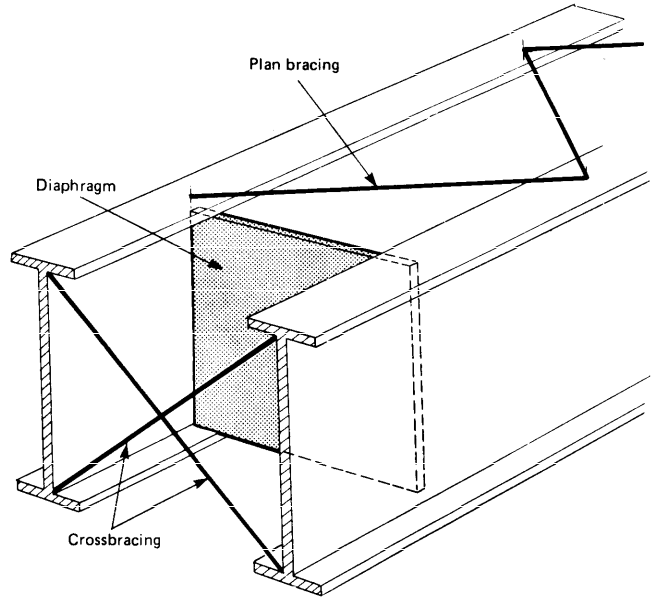


Fig 7 Stability of single slender beam or truss



Notes: 1 Alternative types of support are shown
2 Further information is given in Tables 1 and 2

Fig 8 Stability of pair of slender beams or trusses

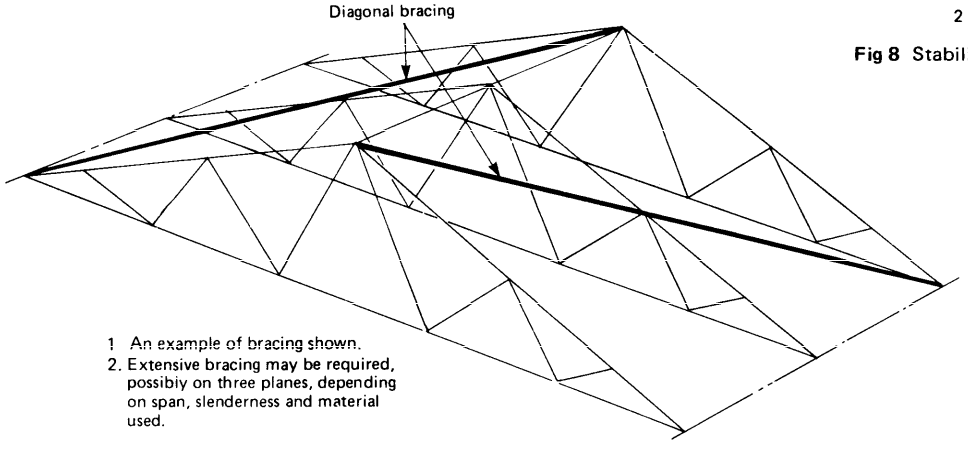


Fig 9 Stability of roof trusses

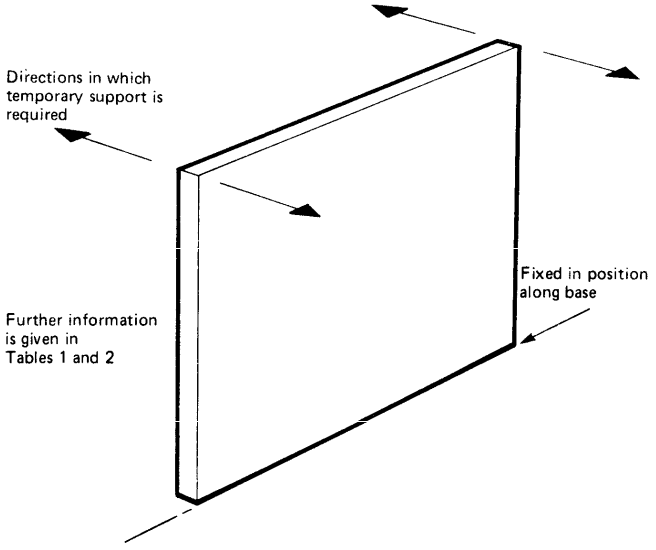


Fig 10 Stability of rigid structural panel

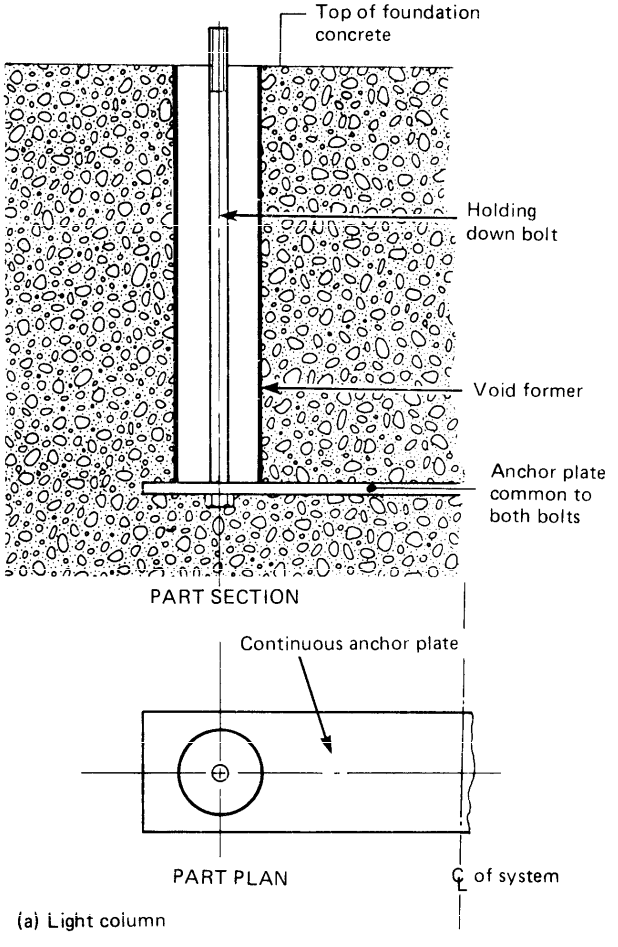


Fig 11 Example of cast-in holding down bolt arrangements for light column

BASE FIXINGS

Initial considerations

47 Holding down and locating systems may be required to perform under two entirely separate service conditions. These are:

(a) permanent loadings, where the system transmits the varying vertical loads and shear forces from structures via individual columns or structural panels to the foundations;

(b) *temporary erection loadings,* where the system may be required to provide stability for columns or panels and possibly other parts of the structure, if no other means of resistance to overturning is provided.

48 As erection conditions often impose greater forces on the holding down or locating system than the completed structure, no such system should be relied upon to provide stability for even a single column unless calculations have proved that it is capable of doing so. In all other cases, some form of temporary support, such as those described in paras 37 to 46, should be used.

49 Parameters and assumptions used in the design should be fully detailed on the drawings as an aid to calculating resistance to overturning and hence the degree of stability. Sufficient comprehensive information should be given to avoid errors and misunderstandings both when making those calculations and during construction,

50 As the design of the foundations and of the holding down or locating system is often divided between two offices which are sometimes in different organisations, there should be liaison between all the parties concerned to minimise erection difficulties. When construction is being undertaken by separate contractors, further coordination is required. The parties concerned may include the scheme designer, the erection contractor, the foundations contractor and the main contractor.

Setting out and pre-erection survey

51 The accuracy of the setting out of the foundations should be checked, as errors can be difficult to correct and can cause delay and subsequent erection problems.

52 The erection contractor should survey the foundations before erection starts to ensure that the foundations and holding down or locating systems are positioned accurately and at the correct levels. Where holding down bolts are to be used, a check should be made to ensure that enough thread is available to provide a secure fixing for each nut.

53 If any errors such as misplaced holding down bolts or oversized or incorrectly located pockets are detected the necessary remedial work should be agreed and coordinated between the various parties involved. The survey should be scheduled to allow time for any remedial work to be completed before erection starts.

Holding down and locating systems

54 Holding down and locating systems for use with materials such as steel, precast concrete and

timber (provided that there are adequate base details) may make use of:

(a) holding down bolts, which may be either cast-in or drilled and fixed;

(b) recessed bases, where the column or structural panel is set into a pocket or recess; or

(c) specialist fixings or anchorages.

55 Features common to all types of systems and which should be considered at both design and construction stages include:

(a) setting out by skilled personnel;

(b) reinforcing steel in the foundation to be placed accurately;

(c) checking the installation prior to concreting to ensure compliance with the design;

(d) concrete which is adequately compacted to ensure that no voids remain;

(e) concrete which has reached sufficient strength before being loaded;

(f) adequate supervision to ensure the foregoing.

56 Holding down bolts*, whether cast-in or drilled and fixed, should provide adequate pull-out. Any proposed use of drilled and fixed bolts should be considered carefully if they are expected to contribute to the stability of a structure as there may be difficulties in providing sufficient resistance to overturning of columns or panels during erection.

57 Where cast-in holding down bolts are to be used:

(a) it is preferable that steel channels, angles or plates are used as anchors to join more than one bolt head, instead of individual anchor plates (Fig 11);

(b) the plan shape of the anchor plates (if individual plates are specified) should be the same as the plan shape of the void formers to facilitate an adequate and equal bearing on the concrete;

(c) the installations should be fixed so that they will not move during concreting.

58 Where drilled or fixed bolts are to be used:

(a) holes should not be drilled oversize nor through reinforcing steel;

(b) all holes must be clean with scarified sides;

(c) the manufacturer's instructions should be followed implicitly with reference made to the manufacturer where difficulties arise;

(d) there may be a need for pull-out tests before reliance is placed upon them.

*BBS 8/80 *Holding down systems for steel stanchions*

59 To aid the location of the bases of components on holding down bolts in general:

(a) consideration should be given to the use of templates to enhance accuracy when positioning or marking the positions for bolts;

(b) the provision of bolts of different lengths should enable them to be fed through the base plate holes in succession;

(c) cast-in bolts should have shanks which are free to allow some lateral deflection.

60 Where recessed bases are used for columns **or** structural panels, they should be wedged in position and temporarily supported * during erection by means of props, guys or, in the case of large structural panels, purpose-built temporary structures.

61 When special fixings are used, the manufacturer's instructions should be followed. Any uncertainties in the use or applications of any product should be clarified with the supplier or manufacturer.

LIFTING AND HANDLING

Planning

62 Safety during lifting and handling requires careful consideration of all aspects of the methods and systems to be used. Advice on such aspects as the use of cranes and derricks, safe slinging practices, manual handling and training is available in a number of publications (see Bibliography), including British Standards and those of trade associations.

Use of cranes and derricks

63 Factors specifically relating to the use of cranes and which should be coordinated include:

(a) organizing the appropriate number and type of cranes, bearing in mind that the choice could be limited if cranes are to be hired locally;

(b) confirming that the designated siting positions for cranes can be achieved with suitable hard standings provided;

(c) checking for the presence of hazards or developments which may have altered the site since the original plans were made;

(d) appointing a competent person to supervise the complete lifting operation particularly when tandem or multi-lifts are used.

64 Guidance on the types of crane most commonly used in construction is given in CP301O:1972 Code of *Practice for the safe use of cranes (mobile cranes, tower cranes and derrick cranes).* This code draws attention to some of the more common hazards and potential dangers. It

*BS5531:1 978 *Code of Practice fcr safety in erecting structural frames*

recommends general precautions to be taken to avoid accidents.

65 Guidance on the use of single pole derricks is not included in CP301O. Whenever possible, cranes should be used for lifting when erecting but where sites such as those used for some masts and towers are located in positions which are inaccessible for cranes, the use of single pole derricks may be unavoidable. In particular these . should be securely fixed before being used, and care taken to ensure that material being lifted does not strike the structure and the winch line does not snag.

Lifting and slinging

66 When lifting:

(a) the total weight to be lifted should be established and should include lifting gear such as slings, lifting beams, crane blocks and rope falls as appropriate;

(b) the use of special devices such as tilting shoes for columns and lifting frames for sub-assemblies should be considered;

(c) all lifting frames and beams should be designed, tested (when applicable) and should display prominently the safe working load and the self weight.

67 When slinging, it is particularly important that use is made of:

(a) lifting aids such as lifting beams to prevent overloading the slings and to provide support for slender flexible assemblies such as roof trusses;

(b) two-leg slings wherever possible as they provide greater stability of the load, although care should be taken to ensure that the included angle is within the safe range;

(c) packing to help avoid damaging the slings and prevent the load slipping.

68 Other factors to be considered include:

(a) preventing unwanted rotational movement of loads, particularly long loads, by using hand lines fixed near the ends of each load;

(b) avoiding shock loading on slings by lifting and lowering slowly at all times;

(c) using timber battens on which to land loads so that the sling can be removed easily and is not damaged by crushing.

Manual handling

69 Care should be taken when manual handling. Advice on manual handling was published in 1982 in a Health and Safety Commission consultative document *Proposals for health and safety (manual handling of loads) regulations and guidance.* Further developments are awaited.

INTERCONNECTING

Before erection starts

70 Checks should be made on site to ensure that the systems of work prescribed in the method statement are still viable and can be undertaken safely. The site supervisor should be responsible for the checks and should liaise with those responsible for coordination, particularly if a change in the erection system to overcome unforeseen difficulties is necessary. The advice applies to the connection of both temporary and permanent members, for instance bracing and even decking on platforms or walkways.

71 When the detailed erection scheme to be adopted is finalised, the check against the method statement should ensure that:

(a) sufficient tools, plant, supporting systems for stability and adequately experienced labour are available;

(b) progress on site is at the stage anticipated so that the intended methods of access and provisions for working places can be implemented;

(c) the exclusion of access and work immediately below the erection areas has been organised and coordinated, where there is liable to be danger from falling material etc;

(d) a physical comparison, of the components with the drawings, for discrepancies is made; this should include the location, number and size of holes, the provision of nibs and brackets in the correct positions and the attachment of the fittings necessary to ensure stability by both temporary and permanent means;

(e) a re-assessment is carried out to establish whether more pre-assembly at ground or floor level can be undertaken;

(f) there is total familiarity with the methods of connecting, particularly where there are difficult joints (including the erection of sag bars if their use has not been eliminated);

(9) joints are identified where particular difficulty is anticipated (trial erections to familiarise erectors with the method of connection may be advantageous);

(h) suitable methods for temporary location and support of components are available particularly where welded connections are to be used.

Assembly and preliminary connection

72 The advice given in this section should assist in the safe making of initial connections by

Table 3 Types of tool for tightening nuts and bolts

Tool	Advantages	Disadvantages	Comments
1 Power-operated wrench	Little physical effort required fortightening enables groups of bolts to be tightened quickly and thus reduces the time required to work at height	Can beheavy to handle (may need two men) Power supply needs to be provided and maintained Lines which supply power may catch and snag Difficulties may arise in feeding power lines to the joint	Platform should be provided for work at height
2 Hand-operated torque wrench	Not too heavy to carry or use No power lines to impede access or to snag	Much physical effort may be required when tightening Wrench may slip off nut when tightening which may cause imbalance of erector	Working platform usually required for work at heights
3 Ratchet wrench for non-torqued bolts	Quite light to carry and use Quick for small numbers of bolts More convenient to use than a spanner	Ratchet device not always reliable	Working platforms may be substituted by tied ladders depending on circumstances
4 Podger spanner	Light to carry and use Easy to handle Can be used to align bolt holes in pieces being connected	Has to be removed from nut during tightening operation Slow with large number of bolts	Can be used while on a tied ladder or platform depending on circumstances

Note: Check that there is adequate clearance and space to use the type of tool chosen

reducing the time that erectors need to work at height.

73 To aid the positioning of components prior to fixing, consideration should be given to:

(a) provision of bearing places such as nibs, cleats or flats;

(b) provision of a minimum of two holes at a bolted connection to enable one hole to be used to aid alignment of the pieces;

(c) fixing of hand lines near the ends of members or assemblies being lifted to increase manoeuvrability from a safe place;

(d) use of jacking and pulling systems, but only if their safety in use can be assured: methods of achieving this include arranging for regular inspection of all apparatus to ensure secure fixings at all anchorages and reaction points, and checking that the parts of the structure which are being used as the reaction points are capable of withstanding the likely loads

When making connections:

(a) the working place should be safe, secure and spacious enough to allow the use of appropriate equipment which may include welding gear, heavy tools and tools with power lines;

(b) support from the crane and lifting gear should not be relieved until the stability of each component or sub-assembly is ensured (in the case of initial connections, the minimum number, types and positions of fasteners should be as specified on the checked drawings);

(c) any modifications should be made only with the prior permission of the supervisor and, where appropriate, the person with responsibility for coordination;

(d) small equipment and fasteners should be lifted in suitable containers with the components to enable the erector to be as free as possible from encumbrances while gaining access to the work positions;

(e) the most suitable tools for the job should be used; guidance on choosing tools for tightening bolts is given in Table 3.

75 Poor fit of components is sometimes apparent when initial connections are being made. There are a number of reasons for this lack of fit, such as manufacturing or assembly errors, differential temperature movements, elastic self-weight deflections, welding distortions, rolling tolerances, elastic shortening, changes in moisture content and those due to structural forms, such as three-dimensional space decks, where the triangulated frames allow little give. Undue force should not be used to overcome lack of fit. Advice on avoiding lack of fit is given in CIRIA Report 87 *.

Final alignment and permanent connection

76 Final alignment of structures should be undertaken progressively as erection proceeds. No more than two bays should be erected prior to final alignment and the permanent connections being made, unless the person responsible for coordination has given his approval.

77 If the final alignment is delayed, there is a greater risk of instability and thus danger from building on, or next to, misaligned unsecured components. This delay can have a progressively adverse effect on erection as dimensional variations can occur leading to further problems with fit.

78 When making the final alignment of a section, the effectiveness of any permanent or temporary supporting system should not be impaired by the slackening of fixings to the extent that instability may occur. This is especially pertinent if jacking and pulling systems are used to obtain the correct alignment. Comment on the use of jacking and pulling systems is given in para 73(d).

79 Safe means of access and safe work places should be maintained for the permanent connections to be made and inspected for compliance with the design. Advice on safe access and safe working places is the subject of *the third Guidance Note + in this Series.*

* CIRIA Report 87 Lack of fit in steel *structures*

\+ HSE Guidance Note GS 28/3 *Safe erection of structures. Part 3 Working places and access* (in preparation)

After the permanent connections

After the permanent connections have been made, activities still to be undertaken include:

(a) removal of temporary supporting systems, but only with the prior approval of the supervisor, who normally should first check with the method statement: if there is any doubt, the supervisor should consult the person responsible for coordination;

(b) removal of temporary attachments, such as cleats and brackets where this has been considered essential; special thought should be given to the method of removal and the means of gaining access to suitable working positions;

(c) informing all those concerned that the structure, or a defined part of it, is completed and that no subsequent alteration should occur without reference to the site manager with appropriate responsibility.

STATUTORY REQUIREMENTS

81 Work should be planned so that there can be effective compliance with all the statutory requirements and detailed information is given in the fourth Guidance Note* **in this** series. The legal requirements with possible relevance to site management and procedures are extensive and their application in practice is dependent upon the nature of the work undertaken and the organisation of the project. As a broad guide, the legislation most likely to be directly applicable includes:

(a) the duties imposed on employers, employees and self-employed persons by Sections 2 to 9 of the HSW Act for the purpose of securing the health and safety of persons at work and other persons (including members of the public) at risk from that work;

(b) the Construction (General Provisions) Regulations 1961 in relation to safety supervision (regulations 5 and 6), overhead electric cables (regulation 44), protection from falling material (regulation 46), lighting of working places (regulation 47), projecting nails and loose materials (regulation 48), construction of temporary structures (regulation 43), avoidance of danger from collapse of structures (regulation 50), wet paint or cement wash on ironwork or steelwork (regulation 51) and lifting excessive weights (regulation 55);

* HSE Guidance Note GS 28/4 Safe erection of *structures. Part 4 registration and training* (in preparation)

(c) the Construction (Lifting Operations) Regulations 1961 in relation to lifting appliances (regulations 10-33), chains, ropes and lifting gear (regulations 34-41) and carrying of persons and secureness of loads (regulations 47-49).

BIBLIOGRAPHY AND USEFUL ADDRESSES

(a) HMSO

Health and Safety at Work etc Act 1974 (ISBN 010543774 3)

The Construction (Working Places) Regulations 1966 (S1 1966 **No** 94; ISBN O 11 100264 8); these requirements, however, are more appropriate to the subject matter of the third Guidance Note in the series.

The Construction (General Provisions) Regulations 1961 (S1 1961 No 1580 as amended; ISBN O 11 100143 9)
The Construction (Lifting Operations) Regulations 1961 (S1 1961 No 1581; ISBN O 11 100151 x)

The Construction (Health and Welfare) Regulations 1966 (S1 1966 No 95; ISBN O 11 100120 x)

Health and Safety at Work Booklet 47 Safety *in the stacking of materials*

(b) British Standards Institution
Linford Wood,
Milton Keynes,
MK14 6LE

British Standards Institution Code *of Practice for safety in erecting structural frames 1978* BS 5531 ISBN O 580099873

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92-96 Vauxhall Bridge Road,
London SWIV 2RL

BBS 8/80 *Ho/ding down systems for steel stanchions* ISBN O 850730090 (Joint publishers with the Concrete Society and CONSTRADO)
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Structural steelwork erection (in preparation)

(d) Construction Industry Research and Information Association (CIRIA)
6 Storey's Gate
London SWIT 3AU
Report 87 *Lack of fit in steel structures* (ISBN 0305 408X)

(e) National Federation of Roofing Contractors
15 Soho Square, London W1
Roofing and cladding in windy conditions 1982

(f) Precast Concrete Frame Association
60 Charles Street,
Leicester LE1 IFB

(9) Timber Research and Development Association
Hughenden Valley, High Wycombe,
Buckinghamshire HP14 4ND

(h) Constructional Steel Research and Development Organisation (CONSTRADO)
N LA Tower, Addiscombe Road,
Croydon CR9 3JH

(j) **The Concrete Society**
Terminal House, Grosvenor Gardens
London SWIW OAJ

APPENDIX A: CONTENTS SUMMARY

The contents of the *Safe erection of structures* series of Guidance Notes (General series 28) are as follows:

Part 1 Initial planning and design

Pre-site considerations, including design, specification, planning and preparation of proposed methods of work; scheme coordination and management.

Part 2 Site management and procedures

Site management, including supervision, coordination and liaison; site preparation, including plant access; stacking, storing and delivering of materials; stability, including temporary supports and restraints; holding down and locating arrangements; lifting and handling; and advice on interconnecting.

Part 3 Working places and access (in preparation)

Access, egress and working at heights; minimizing the need to work at heights; systems and devices to aid safety at heights.

Part 4 **Legislation and training** (in preparation)

Legislation applicable to erection projects; training and health surveillance of personnel.

APPENDIX B: METHOD STATEMENT FORMAT

1 Although the format of method statements may vary they should:

(a) form a single document and preferably include annotated diagrams;
(b) be capable of being modified to cater for any planned change in the system of work;
(c) be indexed for ease of reference;
(d) follow a logical sequence, have each stage of the sequence clearly titled, and be concise and unambiguous;
(e) refer to the grid line and member identification marks;
(f) be clearly marked with the date of preparation and revision number or letter, where applicable, so that the issue being used at any instant can be identified readily

2 Many tasks are repetitive and may be covered by standard sheets. Activities which are critical to safe erection, however, should be specified in full on each new document. The text should be succinct.

APPENDIX C: STRUCTURAL LOADINGS

Loading conditions on a structure during erection may include:

(a) self weight;

(b) wind (including sail effects of cladding), snow, ice, temperature and pending of water;

(c) dynamic effects, including impact and vibration;

(d) stacking and storing of materials;

(e) plant, tools and equipment;

(f) workforce (including supervisory staff);

(9) access equipment such as platforms and ladders (including horizontal, vertical and component forces);

(h) reactions from elements previously erected;

(j) deliberate reactions imposed by jacking, pulling, lifting and lack of fit (undue force should not be used to overcome lack of fit);

(k) misalignment of members (including non-vertical and deflected or bent ones);

(m) other temporary fixings and resulting imposed loads;

(n) those loads which apply reverse stresses in members;

(P) those loads imposed by other site activities, which may be by other contractors, e.g. *in situ* concrete flooring.

FURTHER INFORMATION

This Guidance Note is produced by the Health and Safety Executive. Further advice on this or any other publications produced by the Executive is obtainable from St Hugh's House, Stanley Precinct, Bootle, Merseyside L20 3QY, or from Area Offices of HSE.

uidance Notes in the General Series

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