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Code of Practice for

Safe use of cranes (mobile cranes, tower cranes and derrick cranes)

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Amendments issued since publication

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Contents

Foreword

This Code of Practice, which is published under the authority of the Codes of Practice Committee for Mechanical Engineering deals with those types of crane most commonly employed in works of engineering construction; mobile cranes, tower cranes and derrick cranes. A further British Standard is to be prepared which will cover electric overhead travelling cranes, portal cranes, high pedestal cranes and other types.

Preparation of this Code was prompted by concern at the increasing number of accidents involving cranes which, quite apart from the costly damage sustained, often result in serious personal injury or death. With a growing number of cranes being employed in an ever wider variety of job applications and environmental conditions and with the introduction of novel designs of crane offering greater technical sophistication, increased lifting capacities and new extremes of operating range, the accident rate will continue to rise unless positive measures are urgently taken to counter this trend. The misuse of cranes through lack of knowledge and understanding, rather than by intent, is a major cause of accidents. The aims of this Code are therefore:

1) to describe the principal characteristics of the various forms of cranes of the types most commonly used in works of engineering construction;

2) to draw attention to some of the more common hazards and potential dangers which may be encountered in their use; and

3) to recommend general precautions to be taken and procedures to be followed to avoid accidents.

Recommendations are advisory in nature and are intended to supplement relevant Government regulations which should be observed.

The Code was prepared by a committee of representatives from different branches of the crane industry. Their combined experience and specialist knowledge in the fields of crane design, manufacture, application and safety ensured that the recommendations are well-founded and practical. It was recognized by the Committee that the safe use of a crane ultimately rests with the operating personnel and the Committee were unanimous in their view that there is an urgent need for the introduction of a national system for licensing crane drivers to operate only those types of cranes for which they have received training and have demonstrated their competence. However, management have the overall responsibility for safety and supervision and it is to management that this Code is primarily directed. It is hoped that the Code will be used by management both as a working guide and in the training of personnel and that appropriate information and recommendations will be incorporated in their company standing instructions for the safe use of cranes.

The Committee acknowledges with appreciation the great assistance given by many persons and organizations whose names do not appear in the Constitution.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 80 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 General

1.1 Scope

This Code gives guidance for the safe application and operation of mobile cranes, tower cranes and derrick cranes. Subjects covered include general recommendations for testing, maintenance, erection and dismantling procedures and siting of cranes together with recommended requirements for drivers, slingers and signallers.

Reference is also made to relevant Government regulations and attention is drawn to statutory requirements for the testing and examination of cranes.

Section **1** contains guidance notes and general information pertaining to the safe use of cranes of the types covered in Sections **2**, **3** and **4**.

1.2 Definitions

For the purposes of this Code the following definitions apply. Where appropriate, definitions from existing British Standards have been used. Where more than one term is shown for a definition, that first listed is the preferred term. The second term, shown in brackets, is an alternative in common use.

"**A**"-**frame**.
see "Gantry"

anchorage
a means of securing a crane in position such as foundation bolts

anemometer
an instrument for measuring wind speed

angle indicator
see "Jib angle indicator"

automatic safe load indicator
a device fitted on a crane which normally provides an automatic warning of approach to the safe working load and gives further indication when this has been reached (see definition of "safe working load"). Under certain statutory regulations the automatic safe load indicator should be of a type approved by H.M. Chief Inspector of Factories. See also "Load/radius" indicator

auxiliary hoist rope
a secondary load-lifting rope from an auxiliary drum, usually for use in lifting lighter loads than the main hoist rope, for example, over the fly-jib (see Figure 15)

axle lock
a device which may be fitted on wheel-mounted mobile cranes to prevent relative movement between a sprung/pivoted road axle and the chassis frame of the crane mounting, in order to increase the stability of the crane during lifting operations

"**Baby**"
see "overhauling weight"

back stays (or guy legs)
the structural members of a derrick crane which extend backwards and down-wards from the top of the mast (or king post) to the outer end of the crane sleepers (or lying legs) (see Figure 27)

ballast (kentledge)
dead weight built-in or added to the structure of a crane to ensure adequate stability. On derrick cranes the ballast, also known as kentledge is applied centrally at the intersection between the sleepers and the back stays

blocked condition
see "Outriggers set"

blocking-up base
the effective spans of the supporting base when outriggers or other means are used to increase stability (see Figure 16)

bogies

1) *Rail-mounted cranes.* The multi-axle wheeled carriages on which certain rail-mounted cranes travel. Bogies can be with or without a power driven travelling motion (see Figure 21, Figure 28 and Figure 29).

2) *Truck-mounted crane.* Two or more close-coupled axles on a vehicle used as a mounting for a crane.

bolster
a safety structure fitted on the truck of a truck crane to prevent the crane jib bouncing or striking the truck driving cab during transportation
(For travelling conditions, the jib should be fully supported by the crane suspension ropes and positioned with adequate clearance to ensure that it does not strike the bolster when in transit.)
(See also "Jib rest".)

bowsill (or stringer)
the horizontal structural member of a derrick crane which connects the sleepers at or near to the outer or stay ends, so forming with the sleepers and pivot structure a rigid triangle (see Figure 29)

bracing (or lacing)
the secondary structural elements of a jib which join together (or brace) the main chord members

cantilever jib
a jib supported at two places near to its lower end. Essentially the upper end of the structure is not externally supported (see Figure 14)

capacity chart (or plate)
a notice fitted on a crane specifying the lifting capacities of the crane at different load-radii and for different operational conditions

cat-head
that part of a tower crane structure above the tower, to which jib ties are attached (see Figure 18)

caterpillar tracks
see "Crawler tracks"

centre of rotation (or slewing centre)
the vertical axis about which the upperworks of a crane slews or rotates (see Figure 1)

climbing crane
a tower crane which is supported by the building or structure within which it stands, and which can be raised as the number of storeys increases (see Figure 20)

climbing frames
frames which carry the tower of a climbing crane and which transfer the loadings from the crane on to the structure that supports it (see Figure 20)

climbing ladders
vertical structural frameworks by means of which some types of climbing crane are raised (see Figure 20)

condition of tipping
a crane is deemed to be in a condition of tipping when it is subjected to an overturning moment which cannot be increased by even a small amount without causing the crane to fall over

counterbalance
dead weight added to the structure of a tower crane to balance the weight of the jib (see Figure 21)

Counterbalance hanger bars
bars holding the counterbalance weights in position on the counter-jib of a tower crane

counter-jib
a secondary jib which carries the counterbalance (see Figure 21). Some types of tower crane have no counter-jib, the counterbalance being incorporated in the ballast which is situated at or near chassis level (see Figure 21)

counter-jib ties
ties which support the outer end of the counter-jib on a tower crane

counterweight
weights added to a crane in such a position as to provide a counterbalancing effect (see Figure 1 and Figure 21)

crane
a machine incorporating an elevated structural member or jib beneath which suspended loads can be controllably raised or lowered vertically and also moved horizontally either by slewing the crane, derricking the jib or by other means not solely involving a travelling motion of the crane

crane centres
the distance between the centre line of the mast of a derrick crane and the centre line of the pin connecting the back stay to the sleepers (see Figure 27 and Figure 28)

NOTE Depending on the design of the crane, this dimension may not be the same as the track centres.

crawler tracks (or caterpillar tracks)
self-laying tracks to assist travel over soft or unmade ground (see Figure 13 and Figure 24)

derrick crane
see Section 4

derricking (or luffing or jibbing)
angular movement of the crane jib in a vertical plane to change the hook radius
(See also "Trolleying".) (See Figure 1.)

derricking ties (or suspension or jib ties or pendants)
ties which support the outer end of the jib. On a derricking jib, the ties are usually fixed lengths of rope incorporated in the suspension system to reduce the length of the live derricking part of the suspension system. Also, sectional lengths of ties facilitate adjustment in suspension length when changing the length of the jib on mobile cranes (see Figure 15)

digging lock(s)
a ratchet safety mechanism fitted on some crawler cranes which can be selectively engaged to prevent movement of the tracks in one or other direction or both. Usually found on cranes derived from excavators; hence the term digging lock

fall-block
see "Hook block"

falls of rope
the total number of vertical parts of rope or lines from which the pulley hook block is suspended
(See "Parts of rope".)

fixed luff jib
a jib which can be adjusted to a fixed angle of inclination (see Figure 19.)

fixed tower
a tower which does not slew with the jib and load, the slewing ring being situated at or near the top of the tower (see Figure 18)

fly-jib (or jury jib)
a detachable auxiliary jib fitted at the end of the jib (see Figure 14)

fly-jib mast
a tall structural member located near the jib-head which carries the fly-jib suspension guys (see Figure 15)

folding jib
see "Gate hinge section"

free-on-wheels (or mobile condition)
the operational condition of a wheel-mounted crane when supported solely by its wheels and able to handle appropriate loads without requiring the use of outriggers. Note that free-on-wheels duties, if permitted, may be accompanied by restrictions imposed by the crane manufacturer in respect to travelling the crane with loads suspended from the hook, travelling speed, jib length, etc.

free-standing height
the maximum height at which a tower crane can operate without being held by ties or guys

gabbards
a structure of vertical towers and where necessary inter-ties on which a derrick crane is erected. They may be in fixed positions or mounted on travelling bogies (see Figure 29)

gantry (or "A"-frame)
an elevated structure in the basic crane which carries the jib suspension ropes (see Figure 15)

gate hinge section
a structural element inserted in a jib to permit folding of the jib to reduce the overall length when transporting a crane. (Certain designs of jib incorporate pinned folding hinges which are an integral part of the jib structure to achieve the same object.)

gauge
the dimension between the inner faces of the rail heads of the rail track

hammerhead (or swan-neck jib)
a jib incorporating a forward off-set or crank in the upper part of the structure to achieve, for example, an increased clearance between a suspended load and the jib structure

height of lift
the vertical distance between the ground or other datum level and the seat of the hook, when the hook is in the highest position

hoisting/lowering
the movement of the hook/load in the vertical direction (see Figure 1)

hook block (or fall block)
the pulley block attached to the crane hook which is suspended in the falls of the load hoisting rope

inner and outer tower
a structural arrangement whereby the jib of a tower crane is carried by a small slewing inner tower which is supported at the top of the larger fixed outer tower (see Figure 18)

intermediate suspension
additional suspension ropes attached at one or more intermediate positions along the length of a jib. The purpose of the intermediate suspension is to reduce the sagging deflection of long jibs and to dampen out vibrations (see Figure 15)

jib (or boom)
the main structure from which the load is suspended

jib angle indicator
a device fitted on a crane with derricking jib which shows the angle of inclination of the jib

jib foot
the end of the jib nearest to the crane

jib head (or point)
the end of the jib remote from the crane

jib length
the shortest distance between the centre of the jib pivot or foot pin and the centre of the jib head pulley pin

NOTE If jibs have a portion which extends to the rear of the jib pivoting point, that portion is ignored when stating the jib length.

jib rest
a structure fitted on the truck of a truck-mounted crane to provide support for the crane jib during transportation (The jib is usually positively attached to the jib rest which may incorporate springs or other means to protect the structure from shock loadings in transit.) (See also "Bolster".)

jib safety stops
structural members, which bear on the jib when it is raised to maximum elevation to help prevent the jib kicking backwards over the cab. Also to protect the driver and minimize damage to the machine should the jib fall backwards over the top of the cab (see Figure 15)

jib safety ropes
see "Safety ropes"

jib ties
see "Derricking ties"

kentledge
see "Ballast"

kingpost

1) *Mobile crane.* The vertical pivot in the axis of rotation about which the crane upperworks slews (or rotates).

2) *Derrick cranes.* See "Mast".

lacing
see "Bracing"

level indicator
a device fitted on a crane which shows whether the crane is standing level or not

level luffing
an arrangement whereby the hook moves approximately horizontally when the jib is derricked (or luffed)

limit switch
an automatically-actuated device to stop a particular crane motion at its extremity(ies) or limit(s) of operation

load-radius indicator
a device fitted on a crane which shows the radius of the hook and the corresponding safe working load

lowerworks
the non-rotating lower part of a crane, including mounting, located below the slewing ring (see also "Upperworks")

low pivot jib
a jib in which the jib foot is pivotally attached directly to the revolving frame or turntable of a mobile crane

luffing
see "Derricking"

main chords
the principal longitudinal structural members of a jib. For example, a jib of rectangular cross section would have four main chords. The chords may be of angular, round tube, rectangular tube or other cross section

main hoist rope
the principal load lifting rope

margin of stability
when the crane is handling any safe working load at the appropriate radius, the margin of stability is the additional load, expressed as a percentage of the safe working load, which is required to bring the crane to a condition of tipping with the jib adjusted as necessary to maintain the same operating radius

mast

1) *Mobile cranes:* Suspension mast (or Forward A-frame or Forward gantry): A tall structural member located at or near the jib foot which carries the jib suspension ropes. The mast supplements the function of the gantry. (See Figure 15.) See also "Mast crane".

2) *Derrick cranes* (Mast or Kingpost): The vertical rotating structural member of a derrick crane to which is attached the machinery and jib foot mounting (see Figure 27).

mast crane
a mobile crane on which a jib is mounted near the top of a structural mast member which is erected to and maintained in a substantially vertical position by a suspension system. The crane is generally operated from the conventional crane cab (see Figure 14)

mobile condition
see "Free-on-wheels"

mobile crane
see Section **2**

mono tower
an arrangement whereby the jib of a tower crane is carried by a single tower which may be either fixed or slewing (see Figure 18)

outreach
the horizontal distance from the centre line of the lifting hook to the nearest point of the machine other than the jib (see Figure 1)

outriggers
extensible structural members on the crane mounting to increase the effective base on which the crane stands (See "Blocking-up base".) (See Figure 16, Figure 22 and Figure 24.)

outriggers set (or blocked condition)
the operational condition of a wheel-mounted crane when supported on its outriggers to permit handling of appropriate loads (see Figure 16)

overhauling weight (or ponder weight, pear weight or "baby")
a weight securely fitted to the hoisting rope above the lifting hook, to cause the empty hook to lower under gravity

parts of rope
the total number of rope lines supporting a structure, e.g. the jib (See also "Falls of rope".)

pear weight
see "Overhauling weight"

pendants
see "Derricking ties"

ponder weight
see "Overhauling weight"

proving ring
a weighing device sometimes used in the testing of cranes. An accurately calibrated steel ring is suspended between the crane hook and the load. The measured diametral deformation of the ring is proportional to the weight of the load

pulley (or sheave)
a grooved wheel over which a rope passes. On cranes pulleys are usually shaft mounted and free to rotate under movement of the rope

radius
the horizontal distance between the point at which the centre of rotation of the crane meets the ground, and the vertical centreline through the hook (see Figure 1)

NOTE In the case of a non-slewing crane, the radius is the horizontal distance from the centre of the lifting hook to the centre line of the nearest axle or bogie measured at ground level.

rail centres
the dimension between the centres of the rail heads

rail clamps
crane fittings which can be engaged with the rail to prevent a rail-mounted crane being blown along the track under out-of-service conditions

rail stops
brackets bolted to rails, or other devices, to prevent rail-mounted cranes running off the end of the track

rail ties
ties used to retain rails at the correct distance apart and to withstand the imposed tensile and compressive forces

rear pivoted luffing jib
a luffing jib which is pivoted towards the rear of the tower on which it is supported (see Figure 19)

saddle (or trolley)
a wheel-mounted structure mounted on the jib of a crane and from which the hook is suspended. Movement of the saddle along the jib is controllable and provides the means of varying the hook radius (see Figure 19)

saddle jib
a jib which carries a saddle or trolley from which the hook is suspended (see Figure 19)

Safe working load (also rated load or rating)
the maximum load which can be safely handled by a crane **under specified conditions**

NOTE The safe working load may include the weight of the hook block and load/hook attachments such as slings, spreader bar, etc. The weight of these should be deducted from the listed safe working load to obtain the nett load.

safety hook
a crane hook provided with a safety latch across the throat opening of the hook to prevent the sling being accidentally dislodged

safety ropes (jib arrestors)
ropes fitted between the underside of the jib and a fixed part of the crane to counter whip-back of the jib, for example, if a load is suddenly released. Safety ropes may also be fitted between a fly-jib and jib (see Figure 15)

scotch derrick
see Section 4

service conditions

1) *In service.* With the crane handling loads up to the safe working loads in permissible wind pressures specified in the appropriate British Standard.

2) *Out of service.* With the crane not required for use or out of use when wind pressures exceed those permitted for in-service conditions, and without load on hook.

sleepers

1) *General.* Ground supports for rail tracks.

2) *Scotch derrick sleepers (or lying legs).* The horizontal structural members of a derrick crane which connect the crane sole plate at the bottom of the mast to the bottom end of the back stays (see Figure 29).

3) *Slewing.* The rotary motion of a crane jib or load about the centre of rotation (see Figure 1).

slewing centre
see "Centre of rotation"

slewing lock (swing lock)
a mechanical device (such as a pin or latch) to lock the crane upperworks positively against rotation in one or more positions relative to the lowerworks (See also "Swing brake".)

slewing ring
a bearing (or bearings) on which the slewing part of a crane rotates (see Figure 1 and Figure 18)

slewing tower
a tower which slews with the jib and is mounted on a slewing ring (see Figure 18)

sliding tower section
a section of tower which is supported within the top of the main tower of a crane, and which carries the jib, counter-jib and cat-head assembly. When additional sections are added to the main tower, the sliding tower can be raised within it to increase the height of the crane (see Figure 25)

sole plate (or pivot structure)
the structural base under the mast of a derrick crane which carries the slewing rack and the pivot about which the mast rotates (see Figure 29)

stiff leg derrick
american term for Scotch derrick (see Section **4**)

stringer
see "Bowsill"

strut jib
a jib supported and located at its lower end and supported at its upper end by a suspension member, such as a tie rope (see Figure 14 and Figure 21)

suspension ties
see "Derricking ties"

swing brake (slewing brake)
a friction device to retard the slewing motion of a crane or to hold the crane upperworks against rotation in any desired position relative to the lowerworks. (See also "Slewing lock")

tagline rope (or steady rope)
a rope which may be fastened to a crane hook attachment to restrain spinning of the attachment

tail radius
the maximum distance between the centre of rotation and the rearmost point of the revolving upperworks (or superstructure) (see Figure 1)

telescopic cage
a cage which encircles the tower of a crane and is used to raise the jib/counter-jib/cat-head assembly when additional tower sections are to be added to increase the height of the crane (see Figure 25)

telescopic jib
a jib which incorporates extension elements in the basic jib structure. The jib length can be extended (or shortened) by a telescoping motion (see Figure 14)

telescopic tower
a tower which is composed of two or more main sections which nest into each other and enable the height of the tower to be altered by a self-powered procedure (see Figure 18)

tie bars
see "Rail ties"

tie frames
frames by means of which ties can be attached to the tower of a tower crane (see Figure 26)

ties
means by which the tower of a tower crane can be braced from an adjacent structure to enable its free-standing height to be exceeded (see Figure 26)

tipping
see "Condition of tipping"

tower
that part of the structure of a tower crane which provides elevation and support for the jib mounting. The tower may or may not slew with the jib. (Types of tower are shown in Figure 18.)

tower crane
see Section **3**

tower-head
the uppermost part of the main tower of a crane. On a fixed mono-tower the tower-head is immediately beneath the slewing assembly which it supports (see Figure 18)

track centres

1) *Crawler-mounted cranes.* The distance between the centres of the crawler tracks.

2) *Derrick cranes.* The horizontal distance between the centres of each pair of track rails (see Figure 30). (See also "Rail centres".)

travelling
self-propelling movement of a crane along the ground or track (see Figure 1)

trolley
see "Saddle"

trolleying (or racking)
the movement of the saddle (or trolley) along a jib to vary the hook radius

upperworks (or superstructure)
the upper part of a crane which can slew (or rotate) about a vertical axis (the centre of rotation) relative to the non-rotating mounting or lowerworks

wedges
means of securing the tower within tie frames or climbing frames (see Figure 26)

1.3 Legislation

Statutory regulations relating to cranes are contained in the following:

Factories Act 1961.

The Construction (General Provisions) Regulations, 1961.

The Construction (Lifting Operations) Regulations, 1961.

The Construction (Lifting Operations) Certificates Order, 1962.

The Construction (Working Places) Regulations, 1966.

The Docks Regulations, 1934.

The Ship Building and Ship Repairing Regulations, 1960.

Mines and Quarries Act, 1954 (and General Regulations made thereunder).

Motor Vehicles (Construction and Use) Regulations, 1969.

Road Traffic Regulations Act, 1967 (Chapter 76).

Motor Vehicles (Authorisation of Special Types) General Order, 1969.

Road Vehicles Lighting Regulations, 1971.

The Motor Vehicles (Rear Markings) Regulations, 1970.

Factories Act (Northern Ireland), 1965.

The Construction (Lifting Operations) Regulations (Northern Ireland), 1963.

The Docks Regulations (Northern Ireland), 1934.

The Ship Building and Ship Repairing Regulations, 1960.

1.4 British Standards

The following British Standards relate to cranes referred to in this Code of Practice and certain accessories and attachments used in lifting operations.

1.4.1 Cranes

BS 327, *Power-driven derrick cranes.*

BS 357, *Power-driven travelling jib cranes (rail-mounted low carriage type).*

BS 1757, *Power-driven mobile cranes.*

BS 1761, *Single bucket excavators of the crawler-mounted friction-driven type.*

BS 2573, *Permissible stresses in cranes — Part 1: Structures.*

BS 2799, *Power-driven rail-mounted tower cranes.*

BS 3810, *Glossary of terms used in materials handling — Part 4: Terms used in connection with cranes.*

1.4.2 Accessories and attachments

BS 302, *Wire ropes for cranes, excavators and general engineering purposes.*

BS 461, *Bordeaux connections.*

BS 462, *Bull dog grips.*

BS 463, *Sockets for wire ropes.*

BS 464, *Thimbles for wire ropes.*

BS 590, *Mild steel chain Grade 30, short link and pitched or calibrated for lifting purposes.*

BS 1290, *Wire rope slings and sling legs.*

BS 1663, *Higher tensile steel chain Grade 40 (short link and pitched or calibrated) for lifting purposes.*

BS 2830, *Suspended safety chairs and cradles for use in the construction industry.*

BS 2902, *Higher tensile steel chain slings and rings, links alternative to rings, egg links and intermediate links.*

BS 2903, *Higher tensile steel hooks.*

BS 3017, *Mild steel forged ramshorn hooks.*

BS 3032, *Higher tensile steel shackles.*

BS 3113, *Alloy steel chain Grade 60. Short link for lifting purposes.*

BS 3458, *Alloy steel chain slings.*

BS 3551, *Alloy steel shackles.*

1.4.3 General

CP 94, *Demolition.*

1.5 General considerations

Cranes are used under a wide variety of conditions but the following minimum requirements generally apply:

1) A test certificate should be available for the crane, as constructed, before the crane is put into service. Further tests will be required following repairs or substantial alteration, or periodically as prescribed by legislation. All test certificates or copies of certificates, and related documents should be with the crane or be available on the site of operation.

2) Periodic examination and inspections, systematic maintenance, repairs, renewals and any necessary heat treatment of lifting tackle should be carried out and recorded. Records should be with the crane or be available on the site of operation.

3) Cranes and lifting attachments should be clearly marked with their safe working loads and means of identification and should not be overloaded, except by a competent person for the express purpose of a test.

1.6 Recommended requirements for driver, slinger and signaller

1.6.1 The crane driver should:

1) Be more than 18 years of age.

2) Be medically fit, with particular regard to eyesight, hearing and reflexes.

3) Have the stature to enable him to operate the crane safely.

4) Have been adequately trained in the operation of the type of crane he is driving and be able to judge distances, heights and clearances.

5) Have been authorized to operate the crane.

6) Have sufficient knowledge of the working of the crane to enable him, as may be instructed, to carry out routine checks as specified in **1.10.2**.

7) Understand fully the duties of the slinger and be familiar with the signal code shown in Figure 8 in order to implement safely the instructions of the slinger (or banksman) or signaller.

1.6.2 The slinger should:

1) Be more than 18 years of age.

2) Be medically fit, with particular regard to eyesight, hearing and reflexes.

3) Be agile and have the physique to enable him to handle lifting equipment and tackle.

4) Have been trained in the general principles of slinging and to be able to establish weights and judge distances, heights and clearances.

5) Be capable of selecting tackle and lifting gear suitable for the loads to be lifted.

6) Understand the signal code shown in Figure 8 and be able to give clear and precise signals.

7) Be capable of directing the movement of the crane and load in such a manner as to ensure the safety of personnel and plant.

1.6.3 Where the slinging of a load is not visible or not clearly visible to the crane driver, a signaller should be employed to relay the slinger's instructions to the driver.

The signaller should:

1) Be more than 18 years of age.

2) Be medically fit, with particular regard to eyesight, hearing and reflexes.

3) Understand the signal code shown in Figure 8 and be able to transmit the instructions of the slinger (or banksman) in a clear and precise manner.

4) Be easily identifiable to the crane driver (by wearing "high-visibility" clothing, or other means).

1.6.4 The driver, slinger and signaller should all be aware of the respective responsibilities of each, which should be clearly defined by the competent person in charge of the lifting operation. Where the signaller may be out of plain view of the driver, suitable telephone or radio communications will be necessary.

1.7 Choice and selection of crane

The Sections of this Code cover the classes of crane most commonly used on construction work and for general load-handling operations. Each class of crane possesses certain basic characteristics which will usually dictate the one most suited to a particular application.

1.7.1 Mobile cranes (*see* **2.7**). Mobile cranes are suitable where on-site or between-site mobility is a primary requirement or where the job duration is short. Mobile cranes are usually adaptable to a wide variety of job applications and environmental conditions.

1.7.2 Tower cranes (*see* **3.7**). Tower cranes are suitable for handling of relatively light loads to extremes of height and reach, particularly where the space for crane standing is confined.

1.7.3 Derrick cranes (*see* **4.7**). Derrick cranes are suitable for handling of relatively heavy loads at long radii and where the duration of operations justifies the setting up and installation of the crane.

1.7.4 Each of the above classes of crane is available in a number of different types and the characteristics of the various machines available should be considered against the job requirements in selecting the type, number and size of crane(s) to be used for a particular application. Points to be considered in making the selection include:

1) Weights and dimensions of loads.

2) Heights of lift and distances/areas of movement of loads.

3) Number and frequency of lifts.

4) Length of time for which the crane will be required.

5) Site conditions, including ground conditions for crane standing, and space available for crane access, erection, operation and dismantling.

6) Any special operational requirements or limitations imposed.

1.7.5 Reference should be made to the relevant clauses of the appropriate Section of this Code for details of the different types of crane and their operational characteristics.

1.7.6 Having decided upon the type of crane to be used on a site and knowing the overall requirements to be involved, a machine having a working margin in respect both to load radius and maximum hook height should be selected.

1.8 Siting of cranes

In siting a crane for operation particular attention should be given to two factors; the crane standing or support conditions and the presence of proximity hazards.

1.8.1 Crane standing or support conditions. The ground or foundations, temporary supporting structure, grillages, packings, connections and anchorages for cranes should be of sufficient strength to withstand the maximum loadings imposed in-service and out-of-service without failure, and settlements or deflections which might endanger the stability or safety of the machine. The siting of the crane, the assessment of maximum loads and the design of foundations, supporting structures and ancillary details should be approved by a competent engineer. Particular care should be taken to ensure that the imposed loadings are not underestimated and also a careful assessment of probable wind pressures should be made, taking into account the degree of exposure of the site and any other special factors. Crane manufacturers' data relating to the dead weight of the crane and the dynamic forces which can occur during operation of the crane, should always be obtained.

Under working (in-service) conditions, the loads imposed on the crane standing or support are usually due to the combined effects of:

1) the dead weight of the crane (including any counterweight and/or ballasting);

2) the dead weight of the load and any lifting attachments;

3) dynamic forces caused by movements of the crane and load during operation; and

4) wind loadings, resulting from operation in wind speeds up to the maximum permitted for in-service conditions, acting in any direction on the crane and load.

When out-of-service, the loads on the crane standing or support are imposed by the dead weight of the crane (including the counterweight or ballasting) combined with the wind loadings, acting in any direction, due to the maximum wind pressures anticipated on the particular site as specified by a competent engineer.

Particular care should be taken to estimate dynamic loads arising during operation for which data should be obtained from the crane manufacturer. A generous margin should be allowed for unpredictable effects.

When cranes are mounted on temporary elevated structures, it is essential that due account be taken of torsional reactions arising from slewing of the crane with load.

The overall stability and safety of a crane should be carefully checked in relation to local conditions and particularly when the crane must operate close to excavations or embankments, or on soft or sloping ground, or in tidal or floodwater areas, or over or adjacent to cellars or embankments, or on bridge decks, or partially completed building frames or other structural supports. These matters are further considered in **2.8.2** and **3.8.2**.

The analysis of the forces imposed by a crane on its standing or support is a vitally important matter which should always be checked by a competent engineer. The vertical and horizontal forces imposed are not uniformly distributed; their magnitude may be much greater than the loadings which cause them and will vary according to the position and movement of the crane and load and the direction and speed of the wind. Although crane manufacturers' instructions may specify maximum wind speeds for service conditions, they cannot give recommendations for survival wind conditions on a particular site. On tall cranes, wind forces will have a considerable influence on the strength requirements of the supports and foundations and the greatest care is necessary in the fitting-up and fixing of any holding-down devices, rail clamps, temporary connections or anchorages.

1.8.2 Proximity hazards, etc. Consideration should also be given to the presence of proximity hazards such as overhead electric lines or conductors, nearby structures or other cranes, public access areas including highways, railways and rivers, etc. Nor should the danger to or from underground services, such as gas mains or electric cables, be overlooked. Precautions should be taken to ensure that the crane standing is clear of any underground services or, where this is not possible, that the services are adequately protected to safeguard against any damage being caused.

1.8.3 Overhead electric lines and cables. Many fatal accidents have occurred from some part of a crane touching, or even coming near to overhead electric lines or cables, *without actually touching*. Wherever a crane must operate in the vicinity of, or travel under overhead lines or cables, the District Engineer of the local Electricity Board or Generating Board should be consulted well in advance of the start of any operations. He will advise on safety precautions or arrange to disconnect the supply and make the line dead.

In the absence of this expert advice a safe general rule for crane operations is to position the machine no closer to the plumb of the nearest line or cable than a distance equal to the length of the crane jib fitted, plus six metres (twenty feet) measured along the ground (see Figure 2). It should be noted that in certain cases of overhead lines with long spans, the line may swing laterally due to the wind. Allowance should be made for this to maintain the safe clearance distance at all times.

There are certain proprietary devices available, which are designed to be fitted on cranes and to give warning when the crane jib comes within a pre-determined distance of the power line. Such devices have limitations and the principles outlined above should be followed irrespective of whether a proximity warning device is fitted or not.

Where a crane must travel underneath an overhead line the crossing route should be plainly marked and "goal posts" erected each side of the crossing approach, to ensure that the jib or moving parts are lowered to a safe position (see Figure 3).

The dimensions of the goal posts and their distance from the nearest power cable is to be decided in consultation with the District Engineer of the local Electricity Board. Large notices should be posted stating:

"DANGER. OVERHEAD ELECTRIC LINES"

Crossing routes should be located as close to the power line support tower or pole as possible, in order to take advantage of the greater ground clearance.

When working parallel to overhead power cables, a string of warning markers should be erected at a safe distance from the cables. The string should be supported on posts at convenient intervals and each post should carry the warning notice described above.

Additional to the above, notices should be inserted in the driver's cab of all cranes likely to operate in the vicinity of overhead electric lines and cables stating:

WARNING. When working near overhead electric lines or cables unless otherwise agreed by the District Engineer of the local Electricity Board, the crane should be positioned no closer to the plumb of the nearest line or cable than a distance equal to the length of the crane jib fitted, plus 6 metres (20 feet) measured along the ground. Failure to comply with these instructions can kill you and/or other people working in the vicinity of your crane. If in doubt or difficulty consult the local Electricity Board Engineer.

Never travel a crane in the vicinity of overhead electric lines unless guided by an experienced banksman or slinger. Always try to keep the overhead lines in view when manoeuvring the crane, but remember it is difficult to estimate the heights or clearance distances of the lines by normal methods of observation.

If at any time the machine makes electrical contact with a live overhead electric line observe the following precautions:

1) Remain inside the cab.

2) Tell all other personnel to keep away from the machine and not to touch any part of the crane, rope or load.

3) Try, unaided, and without anyone approaching the machine, to back off the crane until it is well clear of the power line.

4) If the machine cannot be self-propelled away or disentangled from the line, remain inside the machine. If possible, get someone to inform the Electricity Board at once. Take no action until they confirm that conditions are safe.

5) However, if it is essential to leave the cab because of fire or some other reason then, to avoid being electrocuted, *jump* clear as far away from the machine as possible and avoid touching the machine and the ground at the same time. The District Engineer of the local Electricity Board or Generating Board should be informed of the situation immediately, but until assistance is received an attendant should remain near the crane to warn of the danger."

1.9 Erection and dismantling

Accidents frequently occur during crane erection and dismantling operations due to failure to follow the correct procedures specified by the crane manufacturers, use of incorrect parts, the wrong size or type of bolt, or the incorrect assembly or sequence of assembly or taking apart of components. To avoid dangerous and expensive consequences the following points should be observed.

1.9.1 Identification of machine components. All jib sections should be clearly marked to identify the correct sections to be used for the crane and to prevent incorrect assembly. It should be noted that certain regulations require the jib of a crane to be identified with a specified machine. The materials of construction should be indicated on each jib section. Special bolts, such as high tensile steel bolts should be clearly marked and used where specified. Care should be taken not to intermix imperial (British threads and inch-sized) and metric (metric threads and millimetre-sized) fasteners such as nuts and bolts.

1.9.2 Manufacturers' instructions. It is essential that crane manufacturers' instructions be strictly adhered to. Any departures from the specified procedures may impose excessive loadings on structural and mechanical parts leading to a failure or collapse of the crane. It should always be ensured that:

1) The manufacturer's instruction book is available to erection staff.

2) The correct instruction book, appropriate to the particular crane, is used. (This should bear the manufacturer's machine serial number *and* the owner's plant number.)

3) The erection or dismantling operation is supervised by a competent person.

4) Erection staff are fully briefed and familiar with the prescribed procedures.

5) Before any departure is made from the prescribed procedures this is checked with and approved by the crane manufacturer.

6) Only correct parts and components are used.

1.9.3 Ropes. General comments on the installation, use and maintenance of ropes are given in **1.13**.

1.9.4 Electrical supply. The following points should be noted.

1) *Earthing.* Electrically-operated cranes should have an effective earth connection. In the case of rail-mounted cranes where the rail track forms part of the earthing circuit, at least one track should be electrically bonded at each joint and the track effectively earthed.

2) *Supply voltage.* Before connecting the crane to an electrical supply, it should be ensured that the supply voltage characteristics correspond with those of the crane equipment.

3) *Connections.* When possible the supply to a travelling crane should be through a cable winding drum or a properly installed and protected collector system.

If a trailing cable is used it should be mechanically protected, such as with wire armour, and incorporate an earthing core, and should be suitably terminated at each end. Care should be taken to ensure that the trailing cable is not damaged during operational movement or when travelling the crane.

4) *Isolation.* In addition to any isolator within the crane capable of cutting off the supply to the crane motions, there should be an isolator remote from the crane which can be used to cut off the electrical supply to the crane itself.

1.10 Procedures and precautions

1.10.1 Leaving the crane unattended. In no case should a crane be left unattended, even for short periods, unless all loads have been removed from the hook and the electric power supply switched off, or the engine stopped, and appropriate motion brakes and locks have been applied to put the machine in a safe condition. For longer periods and for out-of-service conditions, isolation should be more permanent, i.e. switches locked off, fuel supplies cut off and any doors giving access to machinery or control cabs locked to prevent unauthorized access. The ignition key and any other keys should be removed from the crane at any time when the driver is absent from the machine.

For details of methods to safeguard particular types of cranes, reference should be made to the appropriate Section of this Code, and the crane manufacturer's instruction book.

1.10.2 Routine checks. At the beginning of each shift or working day, the driver, if competent for the purpose, or other competent person, should carry out routine checks including the following:

1) Check that the automatic safe load indicator is correctly set and/or fitted with the correct cam appropriate to the jib length, or jib and fly-jib lengths and falls of hoist rope.

2) Check that the correct load-radius scale appropriate to the jib (or fly-jib) length is fitted on the visual indicator.

3) Check the security of the counterweight or ballasting. Where this is in the form of removable weights, check that the weights fitted correctly correspond to those shown on the counterweight chart for the operating condition in use.

4) Check the oil level(s), fuel level and lubrication.

5) Check the ropes, and rope terminal fittings and anchorages for obvious damage and wear.

6) Check the condition and inflation pressure(s) of tyres (where applicable).

7) Check that all water is drained from any air reservoirs.

8) Check the jib structure for damage.

9) In the interest of safety and fire prevention, check that the crane cabin is in a tidy condition and free from tins of grease and oil, rags, tools, or materials other than those for which storage provision is made.

10) Check the operating pressures in any air and/or hydraulic system(s).

11) Check the operation of the crane through all motions with particular attention to brakes to ensure that these are operating efficiently.

12) Check the operation of all limit switches or cut-outs (use caution in making the checks in case of non-operation).

1.10.3 Reporting of defects and authorization for use. Should the driver or maintenance staff find any defect or abnormality in the crane or in the operation of the crane, or should the crane be accidentally damaged, this should be reported immediately to the person responsible for the safe use of the crane. The machine should be taken out of service until the faults have been corrected and/or clearance is given by the responsible person.

1.10.4 Permit to work. Before any repairs, adjustments or inspections are carried out on a crane, a proper system of granting permission to work should be followed. Such a permit-to-work system properly implemented will ensure that the necessary precautions are taken to make the crane safe for maintenance or repair work, etc. (e.g. by isolation of electrical equipment, removal of ignition keys, etc.) and will notify all affected persons that the crane may not be used.

A permit to work is a specially designed form issued only by a responsible person which indicates that special precautions have been taken to make it safe for work on the machine to proceed for a specified period of time. The form may also specify any additional precautions which should be observed by persons carrying out the work.

The responsible person charged with the certification and issue of the permit should be the person in charge of the site operations and the permit should be issued to the person in charge of those who are to carry out the work. The issuer and receiver should never be the same person.

In the design of the permit it is usual to make provision for the signatures of the person actually to perform the work, and his foreman, thereby indicating that they have read and understood the conditions and any limitations of work imposed by the permit.

Most systems require that the person performing the work should retain the permit in his possession while carrying out this work. Where several persons are involved on the same job, the permit should be held by the senior person (e.g. a foreman). A commendable practice in this respect is for the permit to be placed in a specially designed carrier and hung in a prominent position on the crane involved, such as on the access door or at the crane driver's station, to indicate that men are working on the machine.

The permit will remain in force until the expiry of the time limit (if any) or until the end of the day or shift. A permit is not transferable and, for longer jobs, a new permit is required for each day or shift and whenever there is a change of labour on the job.

When the work is completed all permits should be returned, duly endorsed, to the person who issued them before the crane is "handed over" for normal use. This part of the procedure is just as important as the original certification, in that the responsible person in charge should ensure that all persons who were working under the permit are now clear of the machine or area, that any items of equipment brought in for that work have been removed, that all guarding and other safeguards on the crane have been replaced and that the machine is in all respects safe for normal use, subject to the conditions specified in **1.5** 1), **1.5** 2) and **1.12**.

1.10.5 Safe means of access. There are statutory requirements that safe means of access shall be provided to the driving position of the crane and to enable inspections and maintenance work to be carried out. Personnel should be instructed to use only the proper means of access provided.

1.11 Safe working loads and operational conditions

1.11.1 Safe working loads. The safe working load of a crane is the maximum load UNDER SPECIFIED CONDITIONS for which a crane may be used. Safe working loads are generally calculated as a percentage of the ultimate load of a crane. The ultimate load will be the tipping load for certain cranes but for others a structural failure would occur before the crane reached a tipping condition, and, in these cases the ultimate load will relate to the manufacturer's design capacity of the crane. The margin between the safe working load and the ultimate load is a safety margin to allow for the various forces which will act on the crane in operation. These include allowances for wind loading and for dynamic forces set up by normal operational movement of the crane and load. Care should be taken during operation of a crane to avoid sudden snatching or stopping of the suspended load. Care should also be taken to prevent pendulum swinging of the load by careful control of the operating motions to match the swing of the load and to keep it under control at all times beneath the jib point (see Figure 4).

Crane manufacturers' safe working loads apply only to machines which are standing or installed on a LEVEL, FIRM AND UNIFORM supporting surface (see **1.8.1**). Failure to meet these conditions may be dangerous. Maximum wheel, outrigger, track or base loadings should be ascertained and catered for. The stability of a crane may be much reduced when operating on a slope and this should be avoided (see Figure 5 and **2.8.2.2** A level indicator should be available on site and preferably fitted on the crane.

A published load-radius dimension is the radius of the hook WITH THE SAFE WORKING LOAD suspended, unless otherwise specified. When a load is picked-up, owing to the stretch in the loaded jib suspension ropes and/or deflection of the jib structure, the hook radius will increase. With near-maximum safe working loads this increase may take the load outside the permitted radius and before the lift is made the jib should be derricked-in to bring the load back into radius, as necessary (see Figure 6). Conversely when settling down loads with the jib positioned at steep angles, it should be ensured that the jib is not damaged by contacting the "closed" jib safety backstops or by extreme tensioning in the jib safety guy ropes. Sudden setting-down or release of loads should always be avoided in order to prevent the jib springing backwards or the machine becoming unstable in a backwards direction.

Safe working loads apply only to freely-suspended loads. It is expressly forbidden to use the crane hook or slewing motion of a crane to drag any load along the ground, etc. Also before lifting a load the hoist line should be plumb (see Figure 7). Failure to observe these points may hazard the stability of the crane or introduce loadings (stresses) into the jib for which it has not been designed and even with an automatic safe load indicator fitted, a structural failure may result without any warning being given.

Published safe working loads generally include the weight of the hook block and/or load lifting attachment(s) and in such cases the weight of these should be deducted to obtain the nett working load.

Crane manufacturers' safe working loads are based on and apply only to cranes in good condition. It should be ensured that the jib structure is not damaged with structural members bent or kinked. If the jib structure is damaged or should become damaged in service, such as might occur if the load strikes the jib, the driver should report this at once to his supervisor.

Reference should always be made to the crane manufacturer's handbook or appropriate machine specification to establish the restrictions, limitations or special conditions applicable to a particular crane.

Further reference should be made to the relevant clauses of this Code dealing with safe working loads for different types of crane and to the factors affecting safe working loads.

1.11.2 Mode of operation and control. Each crane control should be clearly identified to show the motion and direction of movement and, when practicable, should be so arranged to prevent inadvertent operation.

Before starting any lifting operation with a crane, the driver should ensure:

1) that he has a clear and unrestricted view of the load and operational area. If not, he should act under the directions of the slinger or an authorized signaller who is positioned to have such a clear and uninterrupted view;

2) where telephone or radio communications are being used, that the calling signal is functioning and that verbal messages can be clearly heard;

3) that all gauges are reading correctly and that air or hydraulic systems are up to operating pressure.

When handling loads which approach the maximum working load for an operating radius, crane motions should be operated with extreme care. The load should initially be lifted just clear of the supporting surface and brought to rest while the slings, balance of the load, etc., are checked, before proceeding. Proper care should be exercised by the driver, at all times, to avoid shock or side loadings on the jib. Care should also be taken to avoid the hook contacting the jib head structure, either through overhoisting or when derricking out the jib. In the latter case, as the jib is derricked out the hook should be lowered off in order to maintain an adequate clearance.

During normal operations if it is necessary to hold a load suspended for any period of time, the driver should remain in the driving position. The machine should be fully operational to meet any emergency arising but with the hoist brake lock, the boom derricking safety pawl and the swing lock/brake, where fitted, all engaged. Under no circumstances should the crane be left unattended with the load suspended.

1.11.3 Ropes. See **1.13**.

1.11.4 Handling of loads near persons and carrying of persons

1.11.4.1 *Handling of loads near persons.* When loads have to be handled in the vicinity of persons, extreme care should be exercised and adequate clearances allowed.

Lifting of loads over highways, railways, rivers or other places to which the public have access should be avoided. If this is not possible, permission should be obtained from the appropriate authority and the area kept clear of traffic and persons.

1.11.4.2 *Carrying of persons by crane.* The carrying of persons by crane is subject to certain statutory regulations. (See Regulation 47 of the Construction (Lifting Operations) Regulations, 1961.) Requirements include provision of a properly designed safety chair or suitable skip or cradle. Skips which can tip should not be used. It is recommended that personnel should not be lowered other than by an engine-power-controlled load-lowering mechanism.

1.11.5 Tandem lifting. Lifting a lead with two cranes is a potentially dangerous operation which should be avoided except where the physical dimensions, characteristics or weight of the lead prevent this being handled by a single crane. The operation requires extremely careful planning and an accurate assessment of the share of the lead which is to be carried by each crane. There should be a full appreciation of how and to what extent this can vary should the lead come out of level or should one or both cranes have to derrick, travel or slew, resulting in the hoist ropes coming out of plumb.

If any of these circumstances occur an additional lead can be thrown on either or both cranes which may affect crane stability or cause a structural collapse.

Special lifting tackle may be also necessary to suit the maximum variation in lead distribution and direction of application which can occur during tandem lifting.

All tandem lifting operations should be thoroughly planned in advance by a competent person. Where possible cranes of equal capacity and similar characteristics should be used. The cranes and lifting tackle to be used should bc selected to have a capacity margin greater than that needed for the proportioned lead when handled as a single lift. It is recommended that the safe working lead of each crane for the required jib length and operating radius should be at least 25 % in excess of the calculated share of the lead to be handled by each crane during the tandem lift.

A competent person should be specially appointed to supervise the operation, and the signals to each crane driver should be clear and well rehearsed.

Multiple lifting operations using more than two cranes arc not recommended.

1.11.6 Special duties. In all cases involving special duties manufacturers' guidance should be obtained.

1.11.6.1 *Grabbing and magnet crane service.* When using cranes for special duties such as grabbing or magnet crane service, allowance should be made not only for the weight of the grab, magnet or other attachments, together with lead, but also for additional loadings imposed on the crane resulting from fast slowing, grab suction effects, impacts, etc. In general, for grabbing or magnet crane service the weight of the grab and contents, or the weight of the magnet and lead will be less than the corresponding safe working loads for crane service. Reference should be made to the manufacturer's specification for details of special duty ratings for any machine.

1.11.6.2 *Demolition ball service.* In this service a round or pear-shaped weight, known as a demolition ball, is suspended from the hoist rope of a crane and caused to move to strike the building, structure or other object to be demolished so that the impact causes collapse.

By the nature of demolition ball service, dynamic loadings arc imposed on the jib structure and other parts of the crane by the movement and impact of the ball. In rating a machine for this service, the crane manufacture will assume certain dynamic loading values, but in practice the magnitude of these will vary widely according to the method of using the demolition ball, the skill of the operator in controlling the ball and the impact resistance of the building being demolished. Manufacturers' recommendations and working loads should, therefore, be regarded only as a guide. Lesser loads and/or shorter jibs should be adopted by the demolition contractor in the light of his practical experience in the use of the particular machine in similar applications and according to the technique adopted and proven skill of the operator.

In practice three operational techniques are used in demolition ball service.

1) *Vertical drop ball.* The ball is suspended above the building to be demolished and the holding brake released allowing the ball to fall vertically under gravity onto the building. Sudden braking to arrest the fall should be avoided as this is likely to result in overturning of the machine or cause a structural failure.

2) *Swinging the ball in line with the jib.* An additional rope from a second drum on the crane is attached to the ball and is used to pull the ball in towards the machine. The pulling rope is then released allowing the ball to pendulum outwards, in the plane of the jib, to strike the building. The second rope is used to control and limit the outward swing of the ball. Care should be taken to ensure the stability of the crane is not hazarded.

3) *Slewing jib.* By this technique the demolition ball is suspended some distance below the jib head and the slewing motion of the crane is engaged causing the ball to swing in an arc and strike the building. When using this technique high torsional and side loadings can be imposed on the jib structure in its plane of least strength. For a given weight of ball and attachments, the actual stress levels set up in the jib structure will be governed by a number of factors including:

a) length of jib and operating radius;

b) distance of ball below the jib head;

c) rate of acceleration of slewing motion;

d) speed of ball at impact and the impact resistance of the building or structure;

e) position of the jib head relative to the demolition ball when the ball strikes the building;

f) rate of checking of slewing motion.

The drivers of cranes engaged in demolition ball service should be not only skilled and experienced in the use of the equipment and techniques of demolition, but also familiar with the machine in use and aware of the potential dangers and their possible cause. Operational methods should be used which do not overstress the jib or hazard the stability of the crane. There should be a high standard of inspection and maintenance of the machine, jib, ropes and all attachments.

It should be noted that certain manufacturers do not recommend use of their machines for demolition ball duties or may only approve this conditionally such as with restriction in the technique to be followed, the maximum jib length to be used, etc.

The use of swinging ball demolition techniques should be restricted to machines designed for arduous or heavy-duty service, such as convertible dragline excavators. For a required ball weight and working height, only a machine of excess capacity both in respect of working load *and* jib length should be used. The shortest practical length of jib, within the manufacturer's recommendations, should be adopted at all times, reducing the length of jib if possible as the demolition proceeds and the working height diminishes.

An anti-spin swivel should always be fitted between the hoist rope and demolition ball to prevent twisting of the rope. Also where the technique involves swinging the ball, a restraining/controlling rope from the second drum of the machine should be attached to the ball to prevent it swinging out to a radius which might hazard stability. The jib derricking mechanism should not be used for swinging the ball.

Care should be taken to prevent the ball striking the jib structure or buildings other than that to be demolished. As a protection against the jib springing over the cab on release of the ball, jib angles greater than 60° from the horizontal are not advisable for demolition ball operations. Jib safety stops should always be fitted on the crane and adequate protection against flying debris provided for the driver.

In all cases the demolition ball should only be used when the crane is standing stationary on firm and level ground. Generally the equipment should be used from outside a building and not from the inside. When demolishing masonry arches, suspended floor slabs, etc., care should be taken to avoid the ball becoming trapped, as a sudden collapse of the structure could overload the crane. If the ball does become trapped, it should be lowered off before being freed as a dragging or lifting action might cause the structure to collapse on top of the ball, so pulling the crane over.

Cranes equipped for vertical dropball operation are also used in applications other than demolition. These include their use in the secondary breaking of blasted material in quarries or for slag breaking in steelworks operations. In these other applications the same basic precautions should be applied.

1.11.6.3 *Piling service.* Although a number of different techniques are used in piling operations the objects, in most cases are the same; to position a pile in the ground either to carry superimposed vertical loads (bearing piles) or to resist horizontal loads imposed by earth or water pressure (sheet piles). Pre-formed concrete or steel piles are usually driven into the ground by means of an impact or reciprocating hammer. Bored-pile techniques, with or without casings, may also be used in certain applications whereby the pile is cast in its location by pouring concrete into a hole driven or bored into the ground. A further feature of piling operations is the need, on occasions, to withdraw or extract the piles (or pile casing) once their useful purpose has been served.

Piling service necessitates the use of special equipment. Depending on the type or sophistication of piling, this equipment may either be in the simple form of a temporary attachment to a crane or, at the other extreme, may form a permanent special-purpose installation on a machine. In addition to the pile hammer or driver attached to the end of the hoist line, pile leaders or a piling frame may be suspended from the jib head to locate and guide the pile during the driving operation. It is essential to ensure that the additional weight of the piling equipment and the loads arising during operation do not overload the crane or jib structures or hazard the stability of the machine under any conditions of service.

By the very nature of piling duties the crane will frequently operate on or traverse over soft and uneven ground. Particular attention should be paid therefore to the standing of the crane during operation to guard against differential settlement of the crawler tracks or crane supports, which might adversely affect the stability of the machine (or the efficient driving of the pile). When travelling and steering the machine, precautions should be taken to prevent the suspended leaders or the piling frame from swinging and imposing excessive side loading on the jib.

Owing to the high impact or shock loadings which can be imposed on machines engaged in piling operations, it is essential that only cranes of adequate capacity and in first class mechanical and structural condition be used. The magnitude of the loadings imposed will depend to a large extent on the skill, knowledge and experience of the operator both in the techniques of piling and the capability of his machine. Frequent inspections of the crane and jib structures should be made by a competent person, with special attention being given to the welds on the jib. Any repairs found necessary should be effected immediately. Hoist and suspension ropes should also be frequently examined for wear or other deterioration and replaced as necessary.

Particular care should be given to examination of ropes lying round pulleys or on drums and to rope terminal fittings.

1) *Pile driving.* Where practical, adequate packing or support should be provided between the bottom of the leaders and the ground to give support to the leaders. When pitching a pile in position for driving, care should be taken not to impose excessive side loading on the jib. Side dragging of piles should be avoided. To minimize transmission of shock loads to the jib structure when a drop hammer is used, premature catching of the falling hammer or snatching the hammer following over-running of the rope on the hoisting drum, after the hammer has struck, should also be avoided.

If a drop hammer is used on a crane mounted on a barge or other floating plant, the hammer striking the pile is equivalent to sudden release of a load and produces a reaction on the vessel which should be taken into account in considering the stability of the unit.

2) *Pile extraction.* For pile extraction, an extractor, which is usually of reciprocating or vibratory type (and may be used either for driving-in or pulling-out piles) strikes the pile upwards and loosens its adhesion in the ground. The actual pull to withdraw the pile is done by the crane hoist line from which the extractor is suspended. Extraction should be effected by a "smooth" pull on the hoist line and under no circumstances should the hoist rope be jerked or the machine tipped to achieve faster results.

In view of the arduous nature of pile extraction it is strongly recommended that this service be restricted to machines designed for heavy-duty work such as convertible dragline excavators.

In assessing the required capacity of a crane for pile extraction duty, in addition to the weight of the extractor and pile, account should be taken of the frictional forces occurring between the ground and the pile during extraction. In the case of sheet pile extraction a further allowance is necessary for the friction between the clutches of the pile being extracted and the adjacent pile remaining in the ground. As the frictional effects are largely unknown factors, until extraction commences, the largest crane practicable will always give the safest and quickest results providing the pull does not exceed the extractor rating.

The length of jib used should be the minimum to provide the necessary headroom for the extracted pile and great care should, be exercised in ensuring that the standing of the machine is firm and level and the fall(s) of the hoist rope is vertical when the pull is applied. Any deviation from vertical could cause a structural failure due to an eccentric loading on the jib or could lead to failure of the web of the sheet pile resulting in sudden release of the hoist line so causing the jib to whip backwards. To guard against this it is recommended that an adequate safety bond, such as a chain, is shackled between the pile head and the extractor or crane hook. Some extractors have self-locking type wedge jaws to hold the sheet pile but when the operation includes lowering of the pile to the ground it is again recommended that a safety bond be fitted in case of accidental jaw release when the end of the pile touches the ground.

1.11.6.4 *Special lifting attachments.* The weight of the lifting attachments should always be included as part of the load to be lifted and deducted from the permissible safe working load. Attachments should be tested, certified and plainly marked with the safe working lead and weight of attachment. They should only be used for the purpose for which they were designed. Vacuum lifting attachments should be regularly checked to ensure that adequate suction is maintained over the required period.

1.11.7 Weather conditions

1.11.7.1 Cranes are generally designed to operate in conditions of normal steady wind speed. Gusting wind conditions may have an adverse effect on safe working loads and machine stability. Even in relatively light wind conditions it is prudent to avoid handling loads presenting large wind-catching surfaces which might result in loss of control of the lead or overturning of the crane despite the dead weight of the load being within the normal working capacity of the machine.

Any instructions issued by the crane manufacturers advising conditions under which a crane should be taken out of service and recommending the condition in which it should be placed, should be strictly followed.

A wind speed indicator or anemometer should be available on the working site. In the case of tower cranes the anemometer should be mounted at the highest point of the crane structure.

1.11.7.2 If the visibility or range of sight of the driver is impaired by snow, fog, or other adverse weather conditions, strict supervision of the crane operation should be exercised. Where appropriate crane operations should be temporarily suspended.

1.11.7.3 Brake or clutch units on all cranes should be protected against rain or other adverse weather conditions. Following shutdown periods and before starting lifting operations, all friction brakes and clutches should be cautiously test tried for efficiency to ensure freedom from moisture.

1.12 Testing

In most cases it is a statutory requirement that all cranes be tested by a competent person before being taken into use and periodically thereafter. In addition, a further test may be required following any substantial alteration or repair to the crane. Reference should be made to **1.15.1** and the schedule of legal requirements listed in Table 1.

1.12.1 Ballasting and anchorage test. Under the Construction (Lifting Operations) Regulations, 1961, after each erection of a crane or alteration affecting the anchorage or ballasting, tests should be carried out to establish the security of the anchorage and adequacy of the ballasting. These tests require the imposition of a 25 % overload above the appropriate maximum safe working lead to be lifted by the crane at a position where there is a maximum pull on each anchorage or by the imposition of a reduced lead at an increased radius to give an equivalent test of the anchorage or ballasting arrangements. When making these tests caution and care should be exercised to avoid the possible overstressing of crane components (see **1.9.2** and **1.12.2**).

Records of this test are required to be entered in the appropriate register.

1.12.2 Overload test. An overload test generally requires the imposition of a lead, or loads, 25 % in excess of the safe working lead. An exception to this is the Dock Regulations, 1934, and the Ship Building and Ship Repairing Regulations, 1960, which stipulate the proof loads required. Before any overload test is carried out, it should be established that the design of the crane allows for the imposition of an overload and the amount and position at which such an overload may be handled. It should be noted that the maximum lead may be limited by the structural strength of the crane and not by the stability of the machine in which case a structural failure might occur, e.g. the jib might collapse, without warning, before the crane started to tip. Before a test is carried out reference should be made to a competent person or authority experienced in crane design and construction. Due account will then be made for the actual condition of the used crane at the time of re-testing. It should be noted that an overload test is not the sole criterion for assessing the safe working lead of a crane.

To protect the automatic safe lead indicator from possible damage, this should be disconnected during the period that the test overload is being applied to the crane. On completion of the test, the indicator should be re-connected and carefully checked to ensure correct functioning following which the appropriate certificate should be issued.

1.12.3 Automatic safe lead indicator test. Under the Construction (Lifting Operations) Regulations, 1961, automatic safe lead indicators on cranes require to be tested, using known weights, after erection, installation or removal likely to have affected the operation of the indicator. Automatic safe load indicators also require to be inspected at least once a week.

The tests on all cranes other than mobile cranes should be carried out by a competent person other than the driver. On a mobile crane the test may be carried out by the driver if competent to do so. The weekly inspection of indicators on all cranes may be carried out by the driver if competent to do so.

1.13 Ropes

1.13.1 Selection. Many factors influence selection of a wire rope for a particular application on a crane. The strength of a rope, although of major importance, is only one of these factors; it is essential therefore to use only ropes of the correct size, type and construction as specified by the crane manufacturer.

1.13.2 Rope reeving. Where it is possible to vary the number of falls of the hoist rope or parts of rope in the derricking system, it is important to ensure that these are in accordance with the crane manufacturer's recommendations for the heaviest load to be handled and for the particular jib length to be used. It should be noted that if an automatic load indicator is fitted, this will generally only operate accurately providing the indicator cam and/or setting corresponds with the length of jib fitted and the rope reeving adopted.

1.13.3 Rope lengths. It should be ensured that the correct length of rope is fitted. Particular care should be exercised on cranes with variable jib lengths as it may be necessary to change the rope and to fit a specific length of rope for a particular jib length and rope reeving combination. Too short a rope could result in the rope completely paying out, and all the load would be taken by the anchorage. (An extremely dangerous situation could arise following a rope or jib length change if the first lift is from an elevated position to ground level, e.g. in a dismantling operation.) Too long a rope may exceed the drum spooling capacity and result in the rope riding over the flanges and becoming trapped in the machinery causing severe damage and possibly premature failure.

After changing the length of jib, or the length and/or number of falls of the hoist rope, it is good practice to check the adequacy of the rope length before making the first operational lift. (This is particularly important where abnormal conditions occur, such as when a load is to be lowered to below ground level.) Before lifting operations commence the jib should be raised to its maximum working angle and the hook lowered to ground level or a lower point, if required, to ensure that at least two dead coils remain on the drum; then to the highest point to check that the drum capacity is not exceeded.

1.13.4 Rope handling and installation. Careless handling of a new rope can lead to damage, short life and unsatisfactory performance in service. Rope manufacturers' recommendations on rope handling and installation should be followed.

When installing a rope on a crane drum care should be taken to avoid kinking or twisting of the rope as this will damage the rope and will adversely affect spooling and may cause the vertical falls of the hoist rope to twist together during operation. Also to ensure correct initial spooling a tension should be applied to the rope as it is guided onto the crane drum.

If the rope is supplied in a coil, this should be uncoiled by rolling along the ground in the same way that a fireman runs-out a hose (see Figure 9*a*). Alternatively, a rope supplied on a reel should be uncoiled either by rolling the reel along the ground (see Figure 9*b*) or by rotating the reel mounted on a support axle (see Figure 9*c*). Under no circumstances should the rope be pulled from a coil (see Figure 9*d*) or reel (see Figure 9*e*) lying flat on the ground.

When it is necessary to lay a rope out on the ground care should be taken to ensure that the surface is free from any matter likely to be injurious to the rope.

1.13.5 Rope spooling. If at any time during crane operation the hoist rope is relieved of tension by over-lowering and the rope on the drum becomes slack and cross-coiled or trapped in part of the crane machinery, no further lifting operations should be undertaken until the rope has been payed out, examined for possible damage by a competent person and replaced or re-spooled correctly.

1.13.6 Rope guards. Where rope guards are fitted to pulleys or drums it is essential that these remain in their correct positions and are removed only for the purposes of maintenance, inspection or adjustment. This is of particular importance where, under certain circumstances, the rope system may be relieved of tension. Failure to observe this procedure may allow a rope to run off a pulley or drum and become trapped.

1.13.7 Guide rollers and pulleys. Rollers or guide pulleys are sometimes fitted on the jib to ensure that the rope does not rub against the jib structure. Where these are fitted it is essential to check frequently that they are free to rotate. A seized roller or pulley will cause serious damage to a rope, leading to its premature failure.

1.13.8 Rope drums and pulleys. Where drum/laggings are replaceable it should always be ensured that the correct drum or lagging is fitted for the size of rope used and the duty requirements.

Rope drums and pulleys should be examined at regular intervals for if they are badly worn this will have an adverse effect on rope life. Where replacement is necessary only items supplied or approved by the crane manufacturer should be fitted. Some designs may allow for drum and pulley grooves to be re-machined, but this operation should only be undertaken in accordance with the manufacturer's instructions. There is a limit to the amount of metal which can be removed before the strength of the component will be affected.

Pulleys should revolve freely on their supporting shafts and particular attention should be paid to lubrication.

1.13.9 Rope terminal fittings. Only rope terminal fittings as specified by the crane manufacturer should be used to attach a rope to a drum, hook block or the structure of the crane. Care should be taken to ensure that anchorage points are securely fastened in accordance with instructions.

Particular attention should be paid to wedge and socket fittings.

1.13.9.1 *Assembly of wedge and socket terminal fittings for ropes.* The following points should be noted.

1) It is essential to use only a wedge and socket of the correct size for the rope fitted. Failure to do so may result in the rope pulling through the fitting as soon as a load is applied.

2) Wedges and sockets for a particular size of rope obtained from different manufacturers may not be interchangeable owing to dimensional differences. The mixing of components obtained from different suppliers should be avoided and the fit of the wedge (with rope) in the socket should always be checked at the time of assembly. Too large a wedge or a wedge of incorrect taper will not sufficiently enter the socket to give a secure termination; too small a wedge will protrude too far through the socket and the local loading may cause the socket to crack and open out allowing the wedge to pull through.

3) The rope should be fitted so that the live or loaded part of the rope is not kinked where it leaves the socket, but pulls directly in line with the point of attachment of the socket as shown in Figure 10. Incorrect fitting will result in premature failure of the rope.

4) When making up the termination, a dead-end length of rope not less than 15 times the diameter of the rope should be left protruding from the socket, e.g. 190 mm ($7\frac{1}{2}$ in) dead-end length for a 13 mm ($\frac{1}{2}$ in) rope. If a rope with tapered end is used, the tapered section should be clear of the socket fitting.

5) After making or re-making a wedge-and-socket termination, it is essential that the wedge and rope are properly seated in the socket before the crane is put into service. Failure to do so may allow the rope to pull through the fitting or, particularly when using a new rope, the wedge to be sprung out of the socket.

Initially the wedge should be hammered home, protecting the fitting and rope agains damage, by a wooden packer. Simultaneously a second man should be pulling on the ends of the rope. The jib should then be raised to a working position and a load suspended to firmly seat the wedge and rope into the socket before the crane is used operationally.

1.13.9.2 *Inspection.* Rope wedge and socket terminal fittings should be inspected weekly by a competent person. Particular attention should be paid to rope damage as might be evidenced by broken wires or deformation of the rope where it emerges from the socket; to the condition of the socket, i.e. that there are no cracks in the socket or deformation of the socket as might be expected if the wedge is seen to protrude excessively; and to the security and tightness of the wedge fitting.

The socket and wedge and part of the rope lying inside the fitting should be examined each time the socket is disassembled for any reason; such as to change the number of falls of the hoist rope, or at intervals not exceeding three months (or at more frequent intervals in the case of severe or arduous service applications). If necessary an undisturbed portion of the rope should be used when re-making the anchorage. Wedges found to be damaged by rope indentation should be replaced by new wedges of correct size for the rope in use. Sockets should be cleaned and carefully examined for cracks or other signs of damage and replaced as necessary.

1.13.9.3 *Special care applications.* Special care is necessary in any application where there is a possibility of the rope dead-end in a wedge-socket termination coming into contact with an obstruction which might loosen the wedge causing the rope to pull free. In such cases it is recommended that the dead-end length of rope is lashed to the live rope using soft wire binding.

1.13.9.4 *Exceptions to use.* The use of rope wedge and socket terminations is not recommended in any case where a crane hoist rope supports a man carrying skip or platform.

1.13.10 Examination of ropes. Thorough examination is necessary periodically to ensure the safety of rope systems. Ropes should be thoroughly examined by a competent person for wear, damage and corrosion. Particular attention should be paid to tucked splices and those sections of rope lying close to the terminal fittings. In the case of ropes which are composed of more than one layer of strands, such as non-rotating ropes, deterioration may occur internally at the interface between the layers and it is therefore essential that the rope is opened and the inner strands also examined. Where multi-layer drums are used, it is necessary to examine not only that part of the rope which is in constant use, but also the rope which may remain spooled and inoperative on the drum for long periods.

By the very nature of their function, jib and fly-jib suspension ropes are often situated at positions remote from the basic crane structure. It is essential that these ropes are carefully examined and particularly those sections of rope adjacent to fittings or lying round pulleys. Note should be made of possible effects due to climatic and environmental conditions; particularly where a crane is operating in a saline or other corrosive atmosphere. Wear is not normally a criterion for suspension ropes but the presence of abrasive dust in the atmosphere can contribute to wear. Nor should the possibility of damage be discounted as this may have occurred during erection and dismantling operations.

Current legislation requires examination of ropes at specified intervals and attention is drawn to the relevant sections contained in the regulations listed under **1.5**.

1.13.11 Rope care and lubrication. New ropes will have been lubricated during manufacture and this lubricant will be adequate for initial storage and the early stages of a rope's working life. This initial lubrication may be supplemented at regular intervals with a dressing in accordance with the crane manufacturer's instructions or as approved by the rope maker. However, before a rope preservative dressing is applied it is essential that the rope is thoroughly clean and free from matter which may be injurious to rope life. Also consideration should be given to the environmental conditions in which the rope is to be used. In applications where driving sand, fly ash or abrasive dust may adhere to the treated surface, the rope manufacturers should be consulted before any dressing is applied.

1.13.12 Rope storage. Replacement or alternative ropes should be stored, preferably on reels, with the outer surface covered to protect the rope and prevent the ingress of water or matter injurious to the rope. Where storage is required over long intervals it is good practice to examine the ropes periodically and to apply dressing as necessary. Alternative ropes which have been removed from a machine should be thoroughly cleaned and dressed before being stored under clean and dry conditions.

1.14 Slinging and handling of loads

1.14.1 Use of correct tackle. Only slings and tackle for which a valid test certificate has been issued and which have been thoroughly examined within the previous six months should be used. Slings and tackle should be clearly marked with the safe working load and an identification number (for test record purposes). All slings and tackle should be visually inspected on each occasion before use. When not in use such tackle should be maintained in a serviceable condition in a suitable store. Tackle should be released from the store only on the instruction of a responsible person.

When used in connection with the handling of molten metal or slag the safe working load of all lifting tackle should be de-rated to half the normal safe working load.

Chain(s) should not be joined by means of bolts or wire and when shackles are used it is essential that the proper pins be fitted. Under no circumstances should chains be knotted.

Chains and slings should never be dragged along the ground or floor.

1.14.2 Multiple-legged slings (*see Figure 11*). At the present time a revised method of specifying the safe working load for multiple-legged slings is being introduced. By this method a single value of safe working load will apply to multiple-legged slings for *all* leg angles up to normal maximum working limit of 90°. Reference to a chart to establish the safe working load for different leg angles will not then be necessary. The upper terminal fitting of assembled slings will carry an inscription giving the safe working load in kilogrammes (kgs) or tonnes (t) and also the permitted range of leg angles for which the slings may be used; e.g. 0° to 90°. The specific angle in the case of 3-leg slings is the included angle between any two adjacent legs and, for 4-leg slings, the included angle between any two diagonally opposite legs (see Figure 11*a*).

Until existing slings in use have been re-certified and marked in accordance with the new practice, the safe working load for multiple-legged slings should be established, as before, from a chart showing the permitted loads for different leg angles. Sling charts should be prominently displayed in the sling storage area and for site operations a copy of the chart should be carried on the crane. (Ideally this would be fitted on the crane in a suitable location for reference by the slinger or banksman; such as at eye level on the outside of the cab.) It should be noted that the safe working load of multiple-legged slings indicated in the charts assumes equal distribution of load between the legs of the sling. If the load tilts excessively when lifted, it should be put down and the slinging points further adjusted so that the load hangs level, i.e. the sling points are equidistant from the centre of gravity of the load (see Figure 11*b*).

The length of sling used should be sufficient to avoid requiring wide angles between the legs which, in any event, should not exceed the maximum angle specified. Where headroom does not permit use of long slings, a spreader bar should be used.

1.14.3 Rope slings. Although the practice is not recommended, if it is necessary to form the eye by the use of rope grips (bull dog grips), the grips should be attached with the "U" bolt side on the dead-end of the rope (see Figure 12). Where appropriate a rope thimble should be used when making a connection with grips to prevent bending the rope over too small a radius. As a general rule the centre distance between grips should be six times the diameter of the rope; the minimum number of grips used will depend on the diameter of the rope but should in no case be less than three. After a short period of service, nuts on a new grip attachment should be tightened. Grips should be inspected regularly thereafter to check that the nuts are tight and that the rope has not slipped.

1.14.4 Slinging of special loads. When handling irregular-shaped loads, such as machine tools, where the position of the centre of gravity is not readily ascertained it is essential to determine this by trial and error without lifting the load completely off the ground. Having established this, the tackle should be adjusted to ensure that the load is evenly balanced for lifting without tendency to topple over, and that no part of the load is subjected to excessive strain which might cause damage to the load (see Figure 11*b*). Slings should be protected against any sharp edges on the load.

The weight of all slings, tackle and lifting beams should be regarded as part of the load to be lifted.

1.14.5 Assessment of weights. Whereas loads should be of known weight and clearly marked, the occasion will arise when the weight of a load will have to be assessed. This should be done by calculation making ample allowance for unknown factors.

In cases where assessment of the load is difficult, e.g. when handling timber or scrap, an approved type of automatic safe load indicator or weighing device should be fitted.

1.14.6 Signalling systems *(see Figure 8).* In the interests of safety it is recommended that copies of the signal code shown in Figure 8 be issued to all crane drivers, slingers and any other persons concerned so that a standard signalling code may be adopted (see **1.6**).

In certain situations and where special lifts are involved it may be necessary to supplement or substitute hand signals by other forms of communication such as radio or telephone.

1.14.7 Hooks and hook blocks. It should always be ensured that the hook or hook block is of adequate capacity for the load(s) to be lifted. The hook should not be loaded beyond its safe working load. To prevent displacement of the sling or load, the hook should be provided with a safety catch or other efficient device. (This is a legal requirement on sites subject to the Construction (Lifting Operations) Regulations, 1961.) Alternatively the hook should be of such a shape (e.g. a Liverpool hook which is shaped like the letter "C") as to minimize, as far as possible, the risk of the sling or load becoming detached. Under certain regulations, these are statutory requirements.

Wherever possible, the placing of more than one sling on a hook should be avoided and the slings should instead be attached to a ring which is then placed onto the hook. This prevents the danger of the hook being strained due to the spread of the slings and also the danger of a sling fouling the safety catch and/or slipping over the nose of the hook. All end links, rings or shackles should ride freely upon any hook on which they are used.

When working with a single fall of rope and the load is set down, relieving the tension in the hoist rope, the hook may spin. The slinger, therefore, should always exercise caution in approaching the hook to disconnect the sling(s).

Chains, slings and hooks should never be dragged along the ground or floor.

1.15 Maintenance

1.15.1 Statutory examination requirements. Table 1 gives the legal requirements under certain statutory regulations for the periodic testing and thorough examination of cranes. The relevant sections of the regulations are quoted.

The requirements specified in the schedule apply to all cranes unless otherwise stated. However, the schedule does not give requirements for lifting gear and tackle.

1.15.2 Planned maintenance. In order that cranes may operate safely and efficiently, it is essential to plan maintenance work so that the risk of accidents and stoppages owing to breakdowns are reduced to a minimum. Manufacturers' instruction books recommend that specific tasks be carded out at stated intervals and these should be followed. Any repairs or replacement components should be in accordance with the manufacturer's recommendations or specifications. To avoid excessive down-time, expendable items such as ropes, friction linings, etc., should be kept in stock. In addition to any statutory regulations, a record or log should be kept of all cranes, giving information such as diameter, length and construction details of ropes, hours worked, adjustments, insulation checks, renewal of parts, thorough examinations and repairs. Based on this record a programme of planned maintenance and repair work should be introduced to contribute towards trouble free and safe operation.

Any fire extinguisher carried on the crane should be scheduled for periodic inspection and renewed as necessary.

1.15.3 Competence of maintenance personnel. All maintenance staff should be fully aware of the hazards involved in working on cranes and the maintenance foreman should be responsible for instructing the staff in all aspects of safe working, including the use of tackle. Maintenance staff should have an adequate working knowledge of the machinery they are required to maintain and have access to the manufacturer's relevant literature. Where special machinery is involved, personnel should be properly instructed, such as by attending maintenance, service and operating courses given by the manufacturer of the equipment.

2 Mobile cranes

2.1 Description of types

This Section of the Code covers power-driven mobile cranes which are usually equipped, in basic form, with a low-pivot derricking jib and which are capable of travelling under their own power with a suspended load. A wide variety of forms and designs of power-driven mobile cranes exist but principal basic differences relate to the type of mounting, the ability to travel with loads, the degree of slewing and the type of jib. Illustrations of the principal types are shown in Figure 13 and Figure 14.

2.1.1 Type of mountings (*see Figure 13*). Types of mountings for mobile cranes are described as follows.

1) *Truck-mounted crane.* A crane mounted on a truck or lorry chassis with or without a sprung suspension. For travelling between points of operation the truck is generally driven from a position on the truck chassis. Depending upon design the crane may be operated from a crane control cab or from the truck driving position. Separate power units may be provided for the crane and truck or alternatively a single power unit may provide power for both.

2) *Self-propelled wheel or crawler-mounted cranes.* A crane mounted on a wheeled or crawler-tracked chassis which is able to travel under its own power. Travel motion, steering and crane operation are all controlled from the crane cab. A single power unit generally mounted in the crane upperworks, provides power both for travelling and for the crane motions.

3) *Portable crane (special case).* A crane not provided with power to travelling mechanism and which is towed or transported. A power unit provides power for some or all of the crane motions.

2.1.2 Mobility with loads. Some cranes are fully mobile and able to travel with any load, up to their maximum safe working load, suspended from the hook. Others may be restricted in respect to the load they can carry when travelling and may require to be stationary and to use outriggers, or other supplementary means, in order to handle their maximum safe working loads. Certain cranes, such as portable cranes, cannot be moved with any load suspended from the hook.

2.1.3 Degree of slewing. Most power-driven mobile cranes are capable of continuous slewing through an unlimited number of revolutions in either direction. Other designs are limited in their degree of slewing whilst some cranes are not fitted with any slewing mechanism and must be travelled to obtain equivalent translation of the load.

2.1.4 Types of jibs (*see Figure 14*). Jibs are either of strut type, held at the upper end by suspension ropes, or are of cantilever type. They may be of open lattice or plated box-section construction. Many designs make provision for lengthening of the basic jib either by the introduction of additional structural elements into the basic jib structure, or by telescoping of the jib which incorporates extending members in the basic structure. Many variations in jib configuration and features are available on mobile cranes. Amongst the most common are fly-jibs, interchangeable heavy-duty and lightweight jib head sections and mast crane attachments. These are further discussed in subsequent clauses.

2.2 Definitions. See **1.2**.

2.3 Legislation. See **1.3**.

2.4 British Standards. See **1.4**.

2.5 General considerations

General considerations relating to the use of all types of cranes are given in **1.5**.

2.6 Recommended requirements for driver, slinger and signaller. See **1.6**.

2.7 Choice and selection of crane

In selecting the right mobile crane or cranes for a particular job, not only should the more obvious job requirements of load capacity, reach and height of lift be considered but also the type of crane mounting and jib which will best suit the conditions of operation.

2.7.1 A crawler-mounted crane will generally be the most advantageous type for operation on soft or unmade ground where the large ground-bearing area of the tracks helps prevent sinkage of the crane and assists stability of the machine in operation. A crawler crane is highly manoeuvrable in areas of limited access and can be turned virtually about its own centre.

Table 1 — Schedule of legal requirements for the testing and examination of cranes (See 1.12 and 1.15.1)

Authority	Before first being taken into use	Weekly	12-monthly	14-monthly	4-yearly	After substantial alteration or repair	Before erection. Before being taken into use after each erection, adjustment, removal or exposure to weather conditions affecting anchorages or ballasting of cranes	Before being taken into use for the first time after dismantling or being out of regular use for a period exceeding two months
The Docks Regulations 1934	Test and examination Regulation 18(a)		Inspection of derricks Regulation 18(b) i Thorough examination of all other cranes Regulation 18(b) ii		Thorough examination of derricks Regulation 8(b) i			
The Shipbuilding and Ship Repairing Regulations, 1960	Test and thorough examination Regulation 34(1)		Thorough examination Regulation 34(2)			Test and thorough examination Regulation 34(1)		
The Factories Act 1961	Test and thorough examination Section 27(6)			Thorough examination Section 27(2)				
The Construction (Lifting Operations) Regulations, 1961	Test and thorough examination Regulation 28(1) Test of automatic safe lead indicators Regulation 30(1) and (2)	Inspection Regulation 10(1) (c) Inspection of automatic safe lead indicators Regulation 30(1) and (2)		Thorough examination Regulation 28(3)	Test and thorough examination Regulation 28(1)	Test and thorough examination Regulation 28(2) and (3)	Examination of anchorages and/or ballasting Regulation 19(3) and (7) Test of anchorages and ballasting Regulation 19(4) Test of automatic safe lead indicators Regulation 30(1) and (2)	
The Quarries (General) Regulations 1956				Thorough examination Regulation 13(1)				Thorough examination Regulation 13(2)
Miscellaneous Mines (General) Regulations 1956				Thorough examination Regulation 51(1)				Thorough examination Regulation 51(2)

NOTE 1 The requirements for lifting gear and tackle are not included in the above schedule.

NOTE 2 The requirements specified apply to all cranes unless otherwise stated.

NOTE 3 Reference should be made to the full text of the Act or Regulation indicated.

NOTE 4 Copies of the Statutory Instruments and the prescribed reports and certificates associated with the above requirements are obtainable from Her Majesty's Stationery Office (HMSO).

2.7.2 Where maximum mobility is required between lifting operations, a wheel-mounted crane is idea for use on hard or reasonably compacted surfaces. The choice between a self-propelled crane and a truck crane is then determined by the distances to be travelled. Generally the self-propelled crane will be chosen for local lifting operations whilst the truck crane will be selected when considerable travelling between sites is involved.

2.7.3 A further factor to be considered when choosing a mobile crane is selection of the best type of jib for the job. Cantilever jibs give the greatest clearance under the jib for handling bulky loads, whilst strut-type jibs generally offer greater heights of lift and maximum operating radii. Telescoping jibs offer an operationally-variable jib length which greatly facilitates manoeuvring and placing of the load in confined areas, such as when working into a steel-framed structure. Also, with this type of jib operational set-up and strip-down times are much reduced over the conventional strut-type jib crane. However, owing to the heavier relative weight of a cantilevered telescoping jib, working loads at longer radii are generally less than at comparable radii with a lattice-construction strut jib. For the same reason the maximum length of a telescopic jib is also restricted and for long range work or high lifts a strut-type jib crane is generally the only answer. A further restriction imposed by the weight of the cantilevered telescoping jib on a truck-mounted hydraulic crane is the severe limitation imposed on "free-on-wheel" duties. These may be excluded entirely or restricted to a pick-and-carry duty with the jib positioned over the rear of the carrier.

The advantages of a fly-jib or mast crane should not be overlooked for operations involving the handling of relatively light loads to extremes of height and outreach.

2.8 Siting of cranes

General comments on the siting of cranes are given in **1.8** to which reference should be made.

2.8.1 Ground bearing pressures. A common mistake in calculating maximum bearing pressures of the crane on the ground or supporting surface is to assume an average value equal to the total weight divided by the ground contact area. In fact, maximum values will generally be far in excess of this average bearing pressure. This is often a critical factor, particularly in the case of wheel-mounted cranes where the loading transmitted to the ground by the wheels or outrigger feet should be distributed over a sufficiently large area to avoid sinkage, or collapse of the supporting surface. Failure to do so may result in overturning or collapse of the crane. Steel plates of adequate strength or suitably prepared timber blocking, placed under the outrigger feet, should be used for this purpose. Crane manufacturers should be consulted for data and information on weights and loadings.

Frequent examination of the supporting surface, should be made during the working day to ensure there has been no movement or sinkage which might affect the stability of the crane.

2.8.2 Crane standing or support conditions. Unless appropriate precautions are taken, mobile cranes should only be operated providing they are standing on uniform, firm and level ground which will safely support the maximum loading imposed on it by crane service (see also **1.8**).

2.8.2.1 *Soft ground.* Soft or water-logged ground is not generally suitable for supporting a crane in operation unless special steps are taken to provide a satisfactory standing for the machine. Mats, steel plates, timber sleepers or a concrete raft, etc., may be used to distribute the operational loads under the support points of the crane to ensure that the bearing strength of the ground is not exceeded.

2.8.2.2 *Sloping ground.* Operation of a crane on sloping or unlevel ground should be avoided. Such conditions will hazard the stability of the crane (see Figure 5).

Where operation on slopes cannot be avoided either the machine should be levelled using outriggers or other means, or the slope should be built up locally to give a level, firm and stable working "platform".

The levelness of the crane should be checked before starting lifting operations and also at frequent intervals during the operation to ensure that no movement or tilting has occurred. It should be noted that a relatively small slope angle can significantly affect the stability of a crane operating with a long jib at steep angles, and it is recommended that a level indicator, capable of registering throughout 360° in a horizontal plane, be fitted on all mobile cranes.

2.8.2.3 *River bed, tidal or flood water areas.* If a crane is standing in flowing water the effects of scouring of the ground around the machine supports represents a serious hazard. Constant checks should be made and appropriate precautions taken.

The possibility of a crane being trapped by flood water or in tidal areas, by an incoming tide, should not be overlooked and cranes should be moved to safe positions on high ground, as necessary.

2.8.2.4 *Working over cellars or ground cavities.* A careful investigation should always be made to ensure that a mobile crane is not positioned over or adjacent to cellars or basements or on inadequately compacted ground as might exist following demolition of buildings or where earth filling has taken place.

2.8.2.5 *Nearby excavations.* Particular care and appropriate precautions should be taken when a crane is required to work in the vicinity of an excavation. The weight of the crane and load may affect the stability of the excavation wall and a slip occur causing the crane to over-turn and hazarding the safety of personnel both on the bank and in the excavation.

2.8.3 Proximity hazards

2.8.3.1 *Overhead electric lines and cables and obstructions.* Many fatal accidents occur when a crane is travelling onto, or working on, a site due to the jib approaching or contacting an overhead line conductor. By the nature of their duties mobile cranes are frequently exposed to this hazard and attention is drawn to **1.8.3** which should be carefully studied by all concerned with the selection, use and operation of mobile cranes.

In general, where there is a danger of the jib or any part of the crane fouling any overhead or other obstruction, such as bridges, gantries, pipework, scaffolding, buildings or walls, the driver should operate only under the direction of a slinger or signaller so positioned to have a clear view of the crane and the obstruction and able to assess whether there is adequate headroom and clearance (see **2.9.9.6**). For purposes of visual sighting and warning it is recommended that the point of the jib and the front and rear of the crane should be painted in a distinctive manner.

2.8.3.2 *Proximity of other cranes.* In positioning a crane for operation, regard should be given to the proximity of other cranes, especially when their working areas overlap. Even when such cranes are operating with different lengths of jib or at different levels, the possibility of the hoisting rope or suspended load fouling the lower crane should not be overlooked.

Cranes should always be sited in such a way that the drivers have a clear view of any other cranes operating in the collision danger area.

2.9 Erection, dismantling and transportation

Since, in general, mobile cranes are subject to frequent assembly and dismantling it is particularly important to observe the general points outlined in **1.9** relating to:

1) identification of machine components,
2) manufacturers' instructions,
3) ropes and
4) electricity supply.

When assembling or dismantling cranes or other equipments, it is essential to adhere strictly to manufacturers' instructions and recommendations. Departure from specified procedures may impose loadings for which the machine has not been designed and which may hazard the safety of machine and personnel. It can be fatal to improvise or to try taking short-cuts and only the correct tackle and tools should be used. For this reason a copy of the crane manufacturer's Instruction Book for the particular machine should be carried at all times on the crane.

Owing to the complexity and wide variation in designs of mobile cranes, it is not possible to present a comprehensive summary of procedures and precautions. The following points, therefore, merely highlight some of the more general and common procedures and precautions which would apply to most mobile cranes.

2.9.1 Folding or hinging jibs. Certain designs of crane are provided with jibs which can be folded "down-and-under" or hinged "sideways" in order to reduce the projection of the jib when travelling or transporting the crane. When setting up the crane jib for operations, or performing jib folding operations, the manufacturer's instructions should be followed and it should be ensured that the jib is restrained by the hoist rope or otherwise, as specified, to prevent it swinging uncontrollably on release from its stowed position or when pins are removed for folding.

Jibs may be provided with integral pinned folding-hinges incorporated in the structure of jib sections. Other designs provide a separate hinge or gate section to perform the same function. It is essential that any gate or hinge section provided be positioned at the location and in the manner specified by the crane manufacturer or removed altogether from the jib structure before any attempt is made to erect the assembled jib.

2.9.2 Jib assembly. Where jibs are designed to be extended by the introduction of intermediate sections into the basic jib, the following points should be observed.

1) It should be ensured that only correct sections for the particular crane are used and that these are in undamaged condition without bent bracings or main chords, broken welds, etc.

2) Only the correct size and quality of bolts and/or pins for joining sections should be used.

3) Any jib length should be made up using the minimum number of intermediate sections in accordance with the manufacturer's specified make-up procedure.

4) It should be ensured that jib sections are assembled in the correct manner and sequence in accordance with the manufacturer's instructions and part identification so that the bracing pattern continuity is maintained throughout the length of the jib.

5) To facilitate and speed-up jib length changing, certain designs of jib employ pin connections instead of bolted joints to link jib sections together. Before any of the pins are removed, it is essential that the jib is supported in accordance with the manufacturer's instructions, at the appropriate sections of the jib, i.e. on each side of the joint being disconnected. Failure to do so may cause the jib to "knee" down on to the ground, damaging the structure and trapping personnel. (As a safety precaution personnel should never work or pass underneath a jib during these operations.) So that jib section pins can readily be removed without hazarding safety of personnel, they should preferably be inserted from the inside of the jib pointing outwards. However, in this case extreme care should be taken to ensure that the suspension ropes or ties do not foul the locking pins or clips of the pin connections when the jib is being raised from ground level. It should always be ensured that the locking pins or spring clips are in good condition and offer effective security of the jib section pins. If not, they should be replaced.

6) When extending the length of a strut jib no attempt should be made to lift the jib on the suspension unless the suspension rope is attached to the extremity of the part-assembled or fully-assembled jib, or otherwise in accordance with the manufacturer's instructions.

7) When a fly-jib is to be fitted, it should be ensured that the angle, and/or length of suspension ties, between the fly-jib and the main jib is in accordance with the manufacturer's recommendations. It should be also ensured that safety ropes or arrestors are fitted to prevent backwards instability of the fly-jib.

2.9.3 Jib suspension (*see* **Figure 15**)

2.9.3.1 It should be ensured that the correct length of derricking rope or lengths of derricking rope and ties (pendants) are used for the jib length fitted in accordance with the crane manufacturer's instructions. Failure to do so may result in the length of the jib derricking rope exceeding the spooling capacity of the drum and use of the incorrect length of suspension ties may overstress the jib structure in service or introduce some other hazard. (It should be noted that if an automatic safe load indicator is fitted in the jib derricking rope, this will not function correctly unless the number of parts of the derricking rope or, in the case of a crane with mast suspension, the length of the derricking ties, correspond to those for the cam fitted in the indicator.)

2.9.3.2 Longer jibs may require special or auxiliary suspension equipment such as a high gantry, mast, intermediate suspension, etc. No attempt should be made to raise a jib until such equipment has been fitted. Crane manufacturers will specify the maximum length of jib which can be raised with standard equipment using the crane machinery, or which requires the use of special or auxiliary equipment.

2.9.4 Load hoist rope (see also 1.13)

2.9.4.1 It should be ensured that the correct type and length of hoist rope is fitted and that the manufacturer's recommendations are also followed in respect to the number of falls of hoist rope according to the jib length or maximum load to be lifted. (It should be noted that if an automatic safe load indicator is fitted, the indicator may not function correctly unless the indicator cam and/or setting correspond with the jib length fitted and the number of falls of the hoist rope used.)

The above hoist rope considerations are important to ensure that the rope system is strong enough to handle the maximum load required to be lifted on a jib. It is also important to ensure that the rope is sufficiently long to perform the load lifting or lowering operation while at the same time ensuring that not less than two coils always remain on the drum and, at the other extreme, the drum capacity is not exceeded.

2.9.4.2 Reference should be made to the rope manufacturers' handbook or crane instruction manual for details concerning examination of ropes. This is of particular importance with certain constructions of rope where deterioration and wear can take place internally where it is not readily observed.

2.9.5 Safety devices. During erection and dismantling operations, it is sometimes necessary to disconnect or by-pass load indicators, overload cut-outs or motion limit switches. Before the crane is put into operation a careful check should be made to ensure that all devices have been re-connected and are functioning correctly.

NOTE It is usually necessary to make adjustment to the visual load-radius indicator(s) and to the automatic safe load indicator(s) each time the crane condition or front-end equipment is varied; for example, for changes in:

jib length, fly-jib length, falls of hoist rope (main or auxiliary); angle of fly-jib off-set, etc. Also between mobile (on tyres) operation and operation with outriggers set (see **2.9.3.1** and **2.9.4.1**).

It can be highly dangerous to use a load-radius indicator with the incorrect scale fitted or an automatic safe load indicator with the wrong cam.

2.9.6 Outriggers *(see Figure 16).* If a mobile crane is fitted with outriggers and is required to operate with working loads and/or jib lengths which require use of these, the following should be observed.

1) ALL operational outriggers should be fully extended and pinned in position [see 4) below].

2) ALL outrigger jacks should be correctly fitted with feet and carefully tightened in accordance with manufacturers' instructions to provide a firm and level base for the crane. It should be noted that failure to tighten the outrigger jacks sufficiently to lift pneumatic tyres clear of the supporting surface, where specified by the crane manufacturer, will adversely affect the stability of the crane.

3) Prior to tightening the outrigger jacks, plates or packing should be inserted underneath the feet to distribute the operational loading to ensure that the bearing capacity of the supporting surface is not exceeded (see **2.8.1**).

4) The erection of long jibs sometimes requires the use of auxiliary outriggers or additional counterweight, or use of a second crane. Such requirements will be specified by the manufacturer and should be strictly adhered to. It is particularly important to remember that the same precautions will apply when lowering the jib back to ground level.

2.9.7 Crane stability, erection and dismantling procedures. The following procedure should be followed.

1) Counterweights may sometimes be removed from a crane for movement between sites. Before any attempt is made to elevate a jib it should be ensured that the correct amount of counterweight is fitted on the crane and at the appropriate location as specified on the crane manufacturer's counterweight chart.

2) Certain crane designs require additional counterweight when longer booms are fitted. It should be remembered to remove this additional counterweight when reducing the operating length of jib, otherwise the backward stability of the crane may be hazarded.

3) Unless otherwise stated in the crane manufacturer's instructions it is always advisable (and may be essential) when erecting or lowering long jibs to perform this operation with the jib axis in the longitudinal axis of the mounting, i.e. in the position offering greatest stability of the machine. In the case of a crawler-mounted crane operating on a hard concrete surface, wooden packers placed under the ends of the crawler tracks will reduce the tendency for the machine to rock when lowering long jib equipments to ground level.

4) Before lowering long jibs to the ground it is important to remember to take appropriate precautions, including the re-setting of auxiliary outriggers, where these are required.

5) To maintain the best margin of stability when lowering long jibs to ground level, the hook block(s) should be lowered and rested on the ground before lowering the jib.

2.9.8 Tyres. On all wheel-mounted cranes, including truck cranes, which are fitted with pneumatic tyres, particular attention should be paid to the condition of tyres and a check made to ensure that these are inflated to the recommended pressure(s) before any lifting operation is carried out. Under-inflated tyres can seriously affect the stability of cranes working free-on-wheels and the resulting tyre damage may cause a blow-out. It is essential that any replacement tyres fitted conform to the crane manufacturer's specification in respect to size, construction and rating.

2.9.9 Travelling and transportation

2.9.9.1 *Site travelling with long jib fitted.* Owing to space restriction in the working area, it is sometimes necessary to assemble and erect the jib at a remote location and to travel the machine to the place of work with the jib erected. With long jib cranes this can be an extremely hazardous operation and should only be undertaken with great care and under expert supervision. In such cases the ground to be traversed should be firm and level. The operation should be carried out at creep speeds with the jib in line with the direction of travel and with the slewing locks and/or swing brake engaged.

2.9.9.2 *Loading cranes for transportation.* Crawler cranes and certain types of wheel-mounted mobile cranes require to be transported between operating sites. When loading and off-loading on to the transporter, care should be exercised when negotiating what can be short but deceptively steep ramps onto the vehicle, to ensure that the crane does not tip over backwards. The specified maximum gradient for stability of the crane, as equipped for transportation, should not be exceeded.

2.9.9.3 *Security of crane for transportation.* When transporting mobile cranes by road, the crane should be stowed on and securely attached to the carrying vehicle in such a way as to prevent any possibility of movement of the crane or any part of the crane or its equipment during transit. Failure to do so may result in the crane shifting in position and striking roadside obstructions, bridges, or other vehicles or, in extreme cases, the crane may roll or slide off the transporting vehicle.

In all cases crane manufacturer's instructions or recommended practice should be followed for transportation of machines. This is particularly important in respect to restrictions in jib length, jib suspension and counterweights.

The following general precautions should be observed when transporting cranes.

1) Only a suitable transporting vehicle of adequate loading capacity and bed dimensions to accommodate the crane should be used.

2) The crane's operational brakes (and, where fitted, propel or digging locks) should be engaged but not relied upon to withstand the forces arising from accelerations and decelerations of the transporting vehicle and the crane should be fully chocked against all movement.

3) The crane should be securely lashed to the vehicle to prevent the crane bouncing, tipping or sliding off the bed. In the absence of identified lashing points on the crane, these should be chosen with care both to effect good security and avoid damaging the crane's structure and components.

4) With slewing cranes, the upperworks should be cross-chained against possible rotation in addition to setting the swing brake and/or slewing lock of the machine.

5) Any loose items such as the hook block should be securely lashed to prevent any movement during transportation.

In the case of truck cranes, it is essential also that the outrigger beams and feet are securely stowed and fastened in position to prevent any possibility of movement occurring during travelling.

2.9.9.4 *Transportation of jibs and jib sections.* When transporting mobile cranes or travelling truck cranes at normal road speeds, it is important that jibs and jib sections, either fitted on the crane or carried separately, are properly stowed, supported and secured to avoid the possibility of damage occurring. Any structural damage to the elements of the jib, such as bent chord angles or kinked bracings will reduce the load carrying capacity of the jib. If not detected the jib may collapse when next in service.

Where a jib support is fitted on a truck crane this should be used in accordance with the manufacturer's instructions. On some trucks a timber bolster only is provided to prevent the jib being lowered or bounced on to the truck cab. In this case, unless otherwise specified by the crane manufacturer, lattice strut jibs should be carried not less than 100 mm (4 in) clear of the bolster and supported only by the jib suspension rope during travelling operations. The suspension rope will effectively damp out any shock loads.

In general, adequate clearance allowance should be allowed between the jib and the nearest foul point with the truck mounting or transporting vehicle to cater for bouncing of the jib in transit. (This factor should also be taken into account when establishing overall clearance height for bridges and other overhead obstructions.) Some manufacturers make provision for stowage of jib sections on mobile cranes. Otherwise, it is recommended that these be transported on a separate vehicle which should be of sufficient size to permit the jib main chords to be supported along sufficient of their length to sustain the self-weight of the section and to withstand transmitted shock loads without damaging the structure. Jib sections should be firmly secured to the vehicle by fibre ropes or a webbing harness to prevent any movement. Under no circumstances should sections be secured using chains.

2.9.9.5 *Regulation requirements.* The movement of cranes on highways is governed by statutory regulations relating to permissible weights (axle load and total weight), overall length, maximum width, forward and rearward projections, lighting, speed limits, etc. For details of requirements reference should be made to the pertinent motor vehicle regulations including those listed under **1.3**.

2.9.9.6 *Travelling clearances.* Before travelling or transporting cranes along the highway special attention should be given to the overall clearance height of the machine and overhanging projections (such as jibs) (see Figure 17*a*).

When the machine is ready for movement the overall height should be physically established (by measuring with a tape) as a check for bridge clearance. In transit, the crane should be checked periodically to ensure that no movement has occurred affecting the clearance height or safety of the crane.

Projections should always be minimal to avoid side-swiping other vehicles or roadside obstructions when negotiating bends or turning at road intersections or junctions (see Figure 17*b*).

When approaching bridges of marginal clearance height, the driver should proceed under the bridge at "creep" speed under the direction of a second man who should be so positioned both to have a clear view of the critical clearance and to be able to direct the driver.

Particular attention and care is also necessary when passing under a bridge where a restriction in clearance width at maximum clearance height exists (e.g. an "arch" bridge). Under such circumstances the critical dimension may be the height of the shoulder of the crane cab instead of the maximum height of the crane or jib (see Figure 17*c*).

Allowance should also be made for the greater arc of movement of the end of a forward or rearward projection, such as a jib, which will occur where the road bends or has a gradient in the vicinity of a bridge (see Figure 17 *d*). In either case unless appropriate caution is exercised, the jib may strike the bridge structure.

2.10 Procedures and precautions

2.10.1 Leaving the crane unattended. A mobile crane should not be left unattended even for short periods, unless the load has been removed from the hook (which should then be raised to a high position at which it will be safely clear of other operations), the engine has been stopped and appropriate motion brakes and locks (including those preventing rotation of the upperworks) have been applied to put the machine in a safe condition. The ignition key and any other keys should be removed from the crane at any time when the driver is absent from the machine.

When leaving the machine for any longer period, including overnight, isolation should be more permanent, e.g. switches locked off, fuel supplies cut off and any doors giving access to machinery or control cabs locked. The jib should be secured or lowered in accordance with the instructions laid down by the crane manufacturer for out-of-service conditions. When it is necessary to lower the jib, the correct sequence of operations and appropriate precautions should be observed (see **2.9.7**).

If it is not possible to lower the jib owing to space restrictions, the hook block should be lowered near to ground level and secured to a substantial anchorage vertically below the jib point.

2.10.2 Routine checks. Attention is drawn to **1.10.2** of this Code. The following additional points apply to mobile crane service.

1) Before starting operations the crane driver should check that the machine has not moved during the period it has been unattended. Also, the level of the crane should be verified and a check made to confirm that there has been no sinking of outrigger feet or settling of the foundation.

2) Automatic safe load indicator. It should be noted that the test button provided on certain indicators only confirms that the electrical circuit and power supply are satisfactory. Such test buttons cannot confirm the correct functioning of the indicator mechanism which can only be effectively checked by lifting a known load at the appropriate radius.

2.10.3 Reporting of defects and authorization for use. See **1.10.3**.

2.10.4 Permit to work. See **1.10.4**.

2.10.5 Safe means of access (see 1.10.5). Provision should always be made for safe access to the crane cab or any other areas necessitating periodic access for maintenance, inspection, or adjustment purposes. The crane driver and authorized maintenance staff only should be allowed to climb on the crane and then only in order to gain access to the cab or to carry out such tasks as maintenance or inspection.

Because of the risk of trapping and injury, no person should be allowed to approach within the crane'. radius of operation unless the crane driver is aware of this and has clearly indicated that it is safe to do sos

2.11 Safe working loads and operational conditions

General precautions in respect to safe working loads and operational conditions are given in **1.11** and have particular relevance to mobile cranes.

The advantages of flexibility, versatility and the wider range of action offered by a mobile crane, over other types of crane, are the very factors which introduce hazards in operation by the wide variety of applications possible and the different conditions which may be encountered. With this broad scope it is impossible to give more than general guidance on their safe use.

2.11.1 Safe working loads

2.11.1.1 *Limitations.* Crane manufacturers' safe working loads may be limited either by:

1) stability of the crane, which is a function of the weight and weight-distribution of a crane and the physical size of the supporting base, or

2) the structural or mechanical strength of the crane or components, such as the jib, machinery, ropes, etc.

It should, therefore, be carefully noted that stability is not always the limitation and under certain conditions a structural failure may occur *before* the machine gives any indication of tipping under load. (This is of particular significance in the case of mobile cranes operating with outriggers set, hydraulic telescoping cantilevered-jib truck cranes, and for mast cranes but may also apply to other designs.) Published safe working loads should not be exceeded, therefore, under any circumstances.

Some manufacturers make different versions of the same model of crane and it is essential therefore only to use the correct table of safe working loads, appropriate to the design capacity of the jib, the counter-weight fitted and the specification of the mounting.

2.11.1.2 *Deductions.* Owing to variations in the weight of the hook blocks and slings which can be used in mobile crane lifting operations, published safe working loads may relate to total hoist line load. In these cases the weight of the hook block and slings should be considered as part of the safe working load. Also due allowance should be made, in accordance with the manufacturer's instructions, when auxiliary equipment such as a fly-jib or additional lifting attachments are used. Deductions may also be necessary for the weight of hoist rope when working at depths below ground level.

2.11.1.3 *General.* It is good operational practice to avoid working at extremes of load or reach wherever possible. The feature of mobility should be used to position the crane in the most favourable position so that it may be operated with as short a jib as possible and at a mid-radius position. It should be noted that at any given radius the safe working load generally varies with jib length and any extension in jib reduces the safe working load. It should be noted also that derricking-out the jib increases the radius of the load and will generally result in a reduced lifting capacity.

Fierce movements of any operational control should at all times be avoided as these could be dangerous and damaging to the structure or machinery of the crane, even when working without a load on the hook. In particular, great care should be exercised when operating cranes fitted with long jibs (and particularly extended telescopic jibs) at longer radii. Under these conditions the influence on overturning moment due to the weight and dynamic effects of the jib itself may be very large by comparison with that due to the suspended load. Operational controls, and in particular the jib derricking control, should be operated sensitively and smoothly.

2.11.1.4 *Zone of operation for truck-mounted cranes.* Owing to the weight distribution of the machine, the lifting or movement of loads over the front of the truck mounting may overload the front axle(s) or chassis frame. Truck-mounted cranes are, therefore, usually restricted to duties over the rear-end or sides of the truck both for the mobile free-on-wheels condition or with outriggers set. Reference should be made to the manufacturer's literature for details of restrictions. [It should be noted that in some instances operation of hydraulic cranes with telescopic jibs may be restricted to the blocked condition with outriggers set and free-on-wheels duty may not be permissible (see **2.7.3**).]

2.11.1.5 *Axle-locking devices.* Truck cranes with a sprung-suspension are sometimes fitted with a means for locking out or reducing the spring effect of the suspension during crane operations. Where such a device is fitted, the manufacturer's instructions should be followed in respect of its use.

2.11.2 Near maximum working loads. When operating with near maximum working loads, the weight of the load should be established as reliably as possible (by use of a proving ring or other means), before attempting to lift the load. As a check of the operational stability a trial lift should then be made raising the load just clear of the ground and at a radius corresponding to the maximum radius at which the load is to be handled. The load should then be replaced on the ground to check if adjustments to the outriggers, slinging and radius are required before making the final lift. Proper care should be exercised by the driver, at all times, to avoid shock or side loadings being imposed on the jib.

It should be noted that any automatic safe load indicator fitted should be used only as a check that the load is within the capacity of the crane. It may be dangerous to depend solely on the indicator.

2.11.3 Travelling with suspended loads

2.11.3.1 *General.* Where a crane is to travel with a suspended load, safe working loads appropriate to free-on-wheels or mobile operation should not be exceeded. Any special restrictions imposed by the crane manufacturer should be followed.

As a general rule, when travelling with a suspended load, the jib should be positioned in the line of travel of the machine. With crawler or self-propelling cranes the load should be carried forward, in full view of the driver but with truck-mounted cranes the load should be carried at the rear of the truck (see **2.11.1.4**). In the latter case the crane driver should remain in the crane cab to control the load and a second man should be used to drive the vehicle. A further competent person should co-ordinate the operation and warn of hazards.

In all cases travelling acceleration and braking motions should be operated gently to limit the swing of the load. To prevent pendulum motion steady lines should be attached to the load, which should be carried as near to the ground as possible (see Figure 4).

2.11.3.2 *Ground preparation.* Where necessary the ground to be traversed should be prepared to ensure a firm and level access route for the crane. Ground depressions and pot-holes should be filled to prevent the crane tilting laterally or in the direction of travelling. Where sinkage of the wheels or crawlers could occur in soft ground, mats or other suitable travelling surfaces should be laid.

2.11.3.3 *Slopes.* Negotiation of slopes by mobile cranes travelling with suspended loads *should be avoided,* wherever possible. Figure 5 illustrates the effect of sloping ground on load radius. If unavoidable, before negotiating a slope, a competent person should be consulted and in attendance to advise on the feasibility of the operation or the precautions to be taken. It is essential that any crane used in this type of operation has a generous margin in capacity over the loads to be lifted. In general, the load should always be carried on the uphill side of the crane, irrespective of the direction of travel. The swing brake and/or slewing lock should be engaged. Slewing should be avoided except to maintain the load in the uphill direction. Loads should always be placed on the uphill side of the crane and precautions taken to ensure that neither the jib nor crane become unstable on release of the load. Loads should always be carried as near to the ground as possible.

In the case of a crawler crane, before starting up a gradient, digging locks (where fitted) should be engaged in the position to prevent the crane from running backwards. On reaching the working location, both digging locks should be engaged to prevent any movement of the crawlers before shifting the clutch from travel to slew.

2.11.4 Other duties. When a mobile crane is to be used for duties such as magnet or grabbing crane service, working loads should be reduced according to the duty conditions applying. Manufacturers' recommendations should in all cases be followed.

Mobile cranes are also frequently used for tandem lifting, demolition work, and piling operations. All these are potentially hazardous operations and the clauses relating to these duties under **1.11** of this Code should be studied with particular care.

2.11.5 Handling of cranes near persons and carrying of persons. See **1.11.4**.

2.11.6 Slewing clearances and safety of personnel. Adequate clearance should be allowed between any part of a crane and the nearest obstruction, to prevent trapping of personnel when the crane is slewed. Where it is not practicable to maintain such clearance or where only limited slewing of the crane is possible, special precautions should be taken to avoid a trapping hazard. Personnel should not be allowed to approach near a crane when it is operating or travelling as there is a danger that they may be struck or trapped between fixed and moving parts of the crane (e.g. between the slewing upperworks and the non-rotating mounting of the crane). It is advisable to paint "Keep Clear" notices on the slewing upperworks to be visible from the sides and rear of the machine. The counterweight or rear-end should also be painted distinctively.

A further notice should be displayed on the crane to the effect "NO PERSON IS ALLOWED ACCESS TO ANY PART OF THE CRANE WITHOUT THE PERMISSION OF THE DRIVER".

2.12 Testing. See 1.12.

2.13 Ropes. See 1.13.

2.14 Slinging and handling of loads. See 1.14.

2.15 Maintenance

Details of statutory examination requirements, comments on planned maintenance and the competence of maintenance personnel are given in **1.15**. Attention is also drawn to **1.10.4** and **1.10.5** which relate to the reporting of defects and authorization for use, permit to work and safe means of access.

3 Tower cranes

3.1 Description of types

This Section of the Code covers power driven cranes which-have a vertical tower designed to be free-standing up to a specified height. Other types of cranes which have a vertical or near vertical tower (i.e. mast cranse) but which are adaptations of low-pivot luffing jib machines, are dealt with in Section 2.

Static and mobile tower cranes are available in a wide variety of types and configurations according to the particular combination of tower, jib and type of base which they employ. Principal features and types are described below. Individual cranes may comprise almost any combination of the features shown.

3.1.1 Types of towers (*see Figure 18*). Tower cranes have either a fixed or a slewing tower. With the former, the slewing ring is situated at or near the top of the tower and the jib slews about the vertical axis of the tower, which remains stationary. The slewing ring of a slewing tower is situated at the bottom of the tower and the whole of the tower and jib assembly slews relative to the base of the crane.

Towers can be further divided into three principal types; mono towers, inner and outer towers and telescopic towers.

1) *Mono towers.* With this type, the jib is carried by a single tower structure which may be either slewing or non-slewing. Provision may be made in the design to permit the tower to be extended. (See also Figure 25*a*).

2) *Inner and outer towers.* The jib is carried by a slewing or non-slewing inner tower which is supported at the top of the fixed outer tower. Provision may be made in the design to permit the outer tower to be extended. (See also Figure 25*b*).

3) *Telescopic towers.* The tower structure consists of two or more main sections which nest into each other to enable the height of the crane to be altered without the need for partial dismantling and re-erection. Telescopic towers are usually of the slewing type and are more common on mobile tower cranes.

3.1.2 Types of jibs (*see Figure 19*). The main types of jib used on tower cranes are saddle jibs, luffing jibs, fixed-radius jibs and rear-pivoted luffing jibs.

1) *Saddle jibs.* These are held by jib-ties in a horizontal or near horizontal position, the hook being suspended from a saddle or trolley which moves along the jib to alter the hook radius.

2) *Luffing jibs.* These are pivoted at the jib foot, the hoist rope which supports the hook usually passing over a pulley at the jib head. The hook radius is altered by changing the angle of inclination of the jib.

3) *Fixed radius jibs.* These are mounted on pivots at the jib foot but are held by jib-ties at a fixed angle of inclination. On some the hook is suspended from the jib-head and the hook radius cannot be altered; on others the hook is suspended from a saddle or trolley as with a saddle jib.

4) *Rear-pivoted luffing jibs.* The jib pivot of this type of jib is situated at the top and behind the centre line of the tower, and the jib is luffed by hydraulic rams or other means.

3.1.3 Types of static bases (*see Figure 20*). Static tower cranes usually have a fixed tower, but may have any of the types of jibs described in **3.1.2**. There are three main types of static bases or mountings: an in-situ base, a static mounting on the crane's own base and climbing crane attachments.

1) *In-situ base.* With this type of base the crane is mounted on special corner angles, frames or an expendable tower section, cast into the concrete foundation block.

2) *On own base.* The crane is mounted on its own base section or chassis which, less wheels and travelling gear, but with ballast, stands on a concrete base. The crane base may or may not be held in position by means of holding-down devices.

3) *Climbing crane.* The crane is supported by the structure which it is being used to construct, and to which it is attached by climbing frames and wedges. The height of the crane can be extended as the height of the structure increases by means of climbing ladders attached to the frames.

A climbing crane may be mounted initially on a fixed base and its support later transferred to climbing frames and ladders.

3.1.4 Rail-mounted tower cranes (*see Figure 21*). These are mounted on a chassis frame which is supported on rail wheels which are usually double flanged. There may be four single wheels or four double-wheel bogies. The wheels or bogies can have special mountings to enable the crane to negotiate bends. With all wheels and bogies removed, some tower cranes can be used as static-base cranes. Rail-mounted tower cranes may have a fixed or slewing tower and any of the types of jib described in **3.1.2** above.

3.1.5 Truck-mounted tower cranes (*see Figure 22*). Tower cranes are available mounted on truck or lorry chassis. In some cases standard vehicle chassis which have been specially strengthened, are used, while in others the chassis are purpose-made. It is essential that this type of crane has its outriggers extended and is set up secure and level on its jacks when handling loads. The majority of these machines have slewing towers, which are also telescopic to facilitate transportation and erection.

3.1.6 Wheel-mounted tower cranes (*see Figure 23*). Some smaller capacity tower cranes are available on wheel mountings with pneumatic tyres. These machines are not normally self-propelling and may be moved by towing behind a suitable vehicle. Cranes of this type are provided with stabilizers or outriggers and jacks which should be set (and the wheels either removed or raised clear of the supporting surface) before commencing erection or lifting operations. Speed and ease of erection, and compactness for transport action are features of this type of crane, which usually has a slewing tower and remote "wanderlead" control.

3.1.7 Crawler-mounted tower cranes (*see Figure 24*). There are two principal types of crawler base used on this type of machine. One is a twin-track type which is mounted on one pair of crawler tracks and which requires outriggers to be extended and jacks set when handling loads. The other is the straddle-type which is mounted on four (or less frequently on three) widely spaced crawler tracks, each of which can be adjusted for height.

Both types of machines should be set firm and level when handling their rated safe working loads. In general, they do not have the same freedom of mobility as for example crawler-mounted mobile cranes. Reference should be made to the crane specification and/or to the manufacturer regarding conditions under which these machines may travel in their erected state.

This type of tower crane usually has a telescopic tower but may have a saddle, luffing or a fixed radius jib.

3.2 Definitions. See 1.2.

3.3 Legislation. See 1.3.

3.4 British Standards. See 1.4.

3.5 General considerations

General considerations relating to the use of all types of cranes are given in **1.5**.

3.6 Recommended requirements for driver, slinger and signaller

The general requirements for drivers, slingers and signallers are given in **1.6**.

The cabins of tower cranes are usually positioned at the top of the tower many metres above the ground or working surface. It is therefore important that tower crane drivers are agile, have good eyesight and are not prone to ill effects from height exposure.

3.7 Choice and selection of crane

3.7.1 Requirements. In selecting the most suitable number, type and size of tower crane(s) for a particular application, the characteristics of the various machines available should be considered against the requirements imposed by the loads to be handled and the surroundings in which the crane will operate. The information required includes:

1) the length of time for which the crane will be required,

2) the weights and dimensions of loads, the distances and heights they have to be moved,

3) the frequency of lifts and the distances between the positions from which loads have to be picked up,

4) special requirements such as the need for fine positioning of heavy loads, rapid lowering, or for hoist ropes of extra length where there are exceptionally high lifts,

5) details of the size, configuration, and ground conditions of the area in which the crane will operate, and the nature of the work being carried out,

6) the amount of space available for the erection, operation and dismantling of the crane. Possible limitations imposed by the proximity of other structures, roads, railways, etc.

3.7.2 Operating characteristics. Descriptions of the principal types and features of tower cranes are given in **3.1**. The operating characteristics of a tower crane are largely determined by its type of base or mounting, type of tower and type of jib.

It is essential that a tower crane on a static base is able to cover from its fixed position all points at which loads are to be handled. Rail-mounted tower cranes have a larger area of coverage as they can travel along their track carrying their rated loads provided the height requirement does not exceed the free standing (travelling) height as recommended by the manufacturer. The largest tower cranes available are static or rail-mounted machines. Generally truck-mounted tower cranes are completely self-contained and in travelling order can be driven along roads. They are usually capable of comparatively rapid erection and dismantling. In general, they are unable to travel in their fully erected state and cannot handle loads whilst travelling.

Crawler-mounted tower cranes require to be transported on a low-loader or towed on special road axles when travelling on public highways. On site some can travel over firm, flat, level ground carrying loads up to a specified proportion of their rated loads. They are also able to travel in a partially erected state but without load over unmade ground provided it is within certain limits of level and condition. All truck-mounted and some crawler-mounted tower cranes require their outriggers to be extended and jacks set when handling loads.

Where a static or rail-mounted tower crane is used at a height which is to be later extended, it is advantageous if the tower has the facility for adding sections without dismantling any of the jib/counter-jib/cat-head assembly. Equally, if a truck or crawler-mounted tower crane is to be frequently dismantled for travel between lifting operations it is preferable if the tower is telescopic or is otherwise capable of rapid dismantling and erection.

With a saddle-jib the hook is suspended from the trolley or saddle and moves in a horizontal direction when the radius is changed. Unless a luffing jib is equipped with a level-luffing device, the hoist motion will have to be simultaneously operated to achieve level travel of the hook when changing radius.

A saddle-jib usually has a smaller minimum radius than the equivalent luffing-jib (see Figure 19) and is thus able to handle loads closer to the tower of the crane. For a given height of tower, however, a greater height of lift is available with a luffing-jib, and the jib/load can be raised to clear obstacles. One advantage of a fixed luff is that its extra height at the jib head might enable it to clear objects that would obstruct a saddle-jib. The advantage of a rear-pivoted luffing jib is that it has a smaller minimum hook radius than an ordinary luffing-jib.

The selection of a crane or cranes for any job should be made only after a thorough examination of all the factors involved. In general, it is good practice to select a machine which has a working margin in respect of the load capacity and other anticipated requirements.

3.8 Siting of crane

3.8.1 General comments. General comments on the siting of cranes are given in **1.8**. It is essential that the maximum pressures or forces which can be exerted by the crane on the ground or on other supports and tie frames are known. Crane manufacturers should provide this information or give a method and data from which it can be calculated.

Particular care should be taken in the assessment of wind loadings, both operational and out-of-service. High winds exert considerable forces on tower cranes which are often sited in the vicinity of tall buildings and in such conditions a generous allowance should be made for local wind pressures of high intensity due to funnelling and gust effects. Particular care should be taken in the design and details of all supporting structures, connections and anchorages.

3.8.2 Crane standing or support conditions. It is essential that the ground on which a crane stands has adequate bearing capacity. In assessing this, account should be taken of seasonal variations in ground conditions. Where a crane is to be supported on, or tied to a permanent or temporary structure, a thorough check should be carried out to ensure that the structure and all crane anchorages are sufficiently strong to carry the maximum loads that the crane may exert upon them in service and out-of-service. This is particularly important where the use of a climbing crane is contemplated.

3.8.2.1 *Underground hazards.* Cranes should not be sited where there is danger to their foundations or supporting structure from cellars whether filled or not, temporary shorings, excavations, embankments, buried pipes and mains, etc. It may be necessary to provide additional special foundations to ensure the safety of the crane.

3.8.2.2 *Tidal or flood water areas.* In areas subject to tidal or seasonal flooding, or where there is a high water table, the crane may require deep foundations or special ground consolidation. In such situations all machinery and electrical equipment should be positioned where it is not in danger from any rise in the water level. Unless adequate precautions are taken, cranes should not be sited where there is danger to foundations, rail tracks or temporary access roads from surface water drainage, flooding or rises in the water level.

3.8.2.3 *Gradients.* The bases for static tower cranes and the tracks for rail-mounted tower cranes should be firm and level. Truck and crawler-mounted tower cranes have a very limited ability to travel and operate on sloping ground. In all cases where the instruction handbook for the crane does not specify the limits of slope which the crane can traverse, the manufacturer should be consulted.

3.8.3 Proximity hazards. Cranes should be sited where there is clear space available for erection, operation and dismantling. Consideration should be given to the proximity of power cables (see **1.8**), other cranes, structures and buildings, hoists, stacked materials, other construction works and the flight paths of airfields, and private air-space. In some situations aircraft warning lights should be fitted to the top of tower cranes. As far as possible cranes should be sited so that loads do not have to be handled over occupied premises such as dwellings, factories, and schools, over public thoroughfares and highways, other construction works, and rivers or railways.

Where it is necessary for two or more cranes to be sited in positions where their jibs or counter jibs would touch any part of the other crane, arrangements should be made for one jib to oversail the highest possible point of contact. In addition to the danger of collision between crane structural members, even when these are staggered in height, there is the risk of the jib or counter jib of one crane fouling the ropes of the other. These risks are greatest between two or more travelling cranes which only periodically come within reach of each other. When two or more rail-mounted cranes are operated on the same track, cut-out switches should, if possible, be installed on the track to avoid collision.

When two cranes are overlapping there should be either a direct means of communication between them, or a distinctive and clearly audible warning system operated from the cabs, so that one driver may alert the other to impending danger. Where more than two cranes are overlapping, it is recommended that their overall lifting programme is set-out and is controlled by one man who is in contact with all drivers and banksmen and can thus assign a priority of working and operate a right of way system for the cranes. Alternatively, automatic proximity warning devices and/or cut-outs should be used.

Precautions in respect of underground hazards are given in **3.8.2.1**.

3.9 Erection and dismantling

3.9.1 General comments. IN ALL CASES IT IS ESSENTIAL THAT THE MANUFACTURER'S INSTRUCTIONS ON THE METHOD AND SEQUENCE OF ERECTION/DISMANTLING ARE STRICTLY FOLLOWED, and the appropriate precautions set out in this Section and in **1.9** observed.

All operations should be carried out under competent supervision by erection crews who have been adequately trained and have experience of erecting/dismantling the particular type of crane involved. Safety helmets should always be worn and safety harnesses used where practicable. The use of erection platforms is recommended.

For the erection/dismantling operation, a roped-off area is required which has been cleared of personnel and stacked materials, etc. There should be sufficient room to erect/dismantle the crane, to stack sections, and to load/unload vehicles. There should be adequate access for vehicles delivering or taking away the dismantled parts. Where a mobile crane is used in this operation, it should be operated in accordance with the appropriate requirements of Section **2**.

The weights and sizes of all components, assemblies, etc., should be accurately determined and the erection crane should have a working margin in respect of load, radius and maximum hood requirements. Components should be clearly marked. Bolts of the correct size, type and quality, tightened to the recommended torques should be used at their appropriate locations. All bolts should be carefully inspected before re-use.

Any special erection gear should be carefully maintained and should be inspected and checked for damage and correct operation before use.

Some erection ropes are highly loaded during the erection operation and it is therefore important to ensure that they are in good condition, correctly reeved and that all pulleys turn freely.

Most manufacturers specify limiting wind velocities for the erection/dismantling, tower extension and climbing operations, and these operations should not be undertaken in higher wind speeds. Particular care should be taken in gusty conditions and where there are shielding and funnelling effects in the vicinity of tall buildings.

Assemblies should be slung from the points recommended by the manufacturer and in such a way that they will not swing or become unstable when lifted.

Concrete used for crane foundations, ballast or counterbalance, should be of the correct mix, and given sufficient curing time to attain an adequate strength. At each stage of the erection/dismantling operation, care should be taken to ensure that the correct amount of ballast and/or counterbalance is in the appropriate position on the crane in accordance with the manufacturer's instructions.

On all cranes capable of height extension, care should be taken to ensure that with the required number of falls to the hook there is sufficient rope to give two full turns on the hoist drum when the crane is at its highest, and hook is at its lowest operating position. In this respect special care should be taken when the hook is required to work below ground level. Where it is practicable to do so, derricking, holding, hoisting and traversing ropes should be attached to the crane while the structure is on the ground.

Some erection procedures require part or all of the electrical installation to be in service during the erection operation. In such cases work should be carried out under the supervision of a competent electrician who will ensure that all power is isolated whilst the electrical system is being worked on, that the earthing arrangements are adequate, that the voltage of supply matches that of the crane and that all circuits are tested before being energized. In some cases it may not be possible to adjust limit switches with the power off but this should be done as soon as practicable and in any case before the crane is released for service. Earthing requirements for the track of rail-mounted tower cranes are given in **3.9.2.3**.

3.9.2 Provision of foundations, rail tracks and temporary roads

3.9.2.1 *Static cranes, expendable in-situ base.* The design and construction of the foundation should be the responsibility of a competent person. Corner angles, frames or expendable cast-in sections, should be accurately positioned and rigidly held by the base section of the tower or appropriate jig, during concreting and curing. Frequent checks of position and plumb should be made. The concrete for the crane foundation should be made with ordinary Portland cement. Extra rapid hardening cement or admixtures to the concrete mix which contain calcium chloride to promote rapid hardening should be used only with the express permission of the competent person responsible for the design and construction of the foundation.

Provision should be made for the inspection of holding down bolts, and means provided to prevent the collection of water on the crane foundation.

3.9.2.2 *Static cranes, on own base* (*without bogies or wheels*). The design and construction of the foundation should be the responsibility of a competent person. Concrete for the crane foundation should be made with ordinary Portland cement (see **3.9.2.1**). Holes for holding down devices should be accurately positioned, and the top surface of the foundation struck off level. Means should be provided for the inspection of holding down devices, and for preventing the collection of water around the crane base.

3.9.2.3 *Rail-mounted cranes, tracks.* The track is of extreme importance to the safe operation of the crane. It should be designed by a competent person.

Every track should be regularly inspected. The track should be level and should be secured to foundations or sleepers of strength and spacing adequate to take the maximum applied wheel pressure, and designed to suit the safe allowable bearing pressure on the gound.

Under normal conditions crane wheels may be considered to make an effective earth with the rail track and in these circumstances at least one rail of the track should be electrically bonded at each joint by means of a copper tape or wire having a minimum cross-sectional area of 65 mm^2 (0.1 in^2). This rail of the track should be effectively earthed and maintained in a clean condition. Where a deposit on the rails arising from infrequent use, dust, corrosive atmosphere or other causes cannot be avoided and is likely to lead to inadequate contact, an additional collector suitable for engaging with an auxiliary earthing wire or rail should be used.

Rails used for tower crane track should be of flat bottomed section, and of the correct linear weight recommended by the manufacturer for the operational conditions. Care should be taken in setting the tracks, and the correct curve radii used for curve going or non-curve going bogies. Adjacent ends of rail should be tightly butted. Rail ties or tie bars should be able to withstand compressive as well as tensile forces. Holes for fish plates and rail ties should be located over sleepers. Travel limit switches, sand-boxes and stops should be positioned in that order towards the end of the track, so that in the event of the crane over-running the switches, its travelling inertia will be largely reduced by the sandboxes before it comes against the stops. The stops should be in-line, at a distance of half the crane base from the ends of the track, or some other measures should be taken to ensure that the permissible ground bearing pressure beneath the ends of the track is not exceeded. On bad ground, longitudinal bearers can be used to minimize rail deflections.

Where used materials are employed, they should be of sound quality and adequate strength. Badly worn rail should not be used; there should be sufficient depth of head on the rail to prevent bogie wheels fouling on fish plates.

The heating of rails during flame cutting or welding may cause embrittlement of the metal and subsequent fracture, particularly in used rail which could already have become work hardened. For this reason, holes in rails should not be flame-cut. In other cases special precautions should be taken, such as when flame cutting or welding new rail. Used rail should not be flame cut or welded.

Where vehicles have to cross or travel over tower crane track, the track should be adequately protected by sleepers and hard core, or other covering material.

3.9.2.4 *Climbing cranes, supporting structure.* Assemblies for transferring the load from the crane onto the supporting structure should be designed by a competent person, who should check that with the particular fixing centres and tower height employed, the structure is able to withstand the maximum combination of static and dynamic loadings that may be applied to it by the crane. It is essential that concrete structures are sufficiently cured before having crane loads imposed upon them, and that the manufacturer's instructions are closely followed in respect of the total height of the crane, and the support centres to be used in relation to the height projecting above the top support. Holes provided in the structure to accommodate the tower of the crane should be of adequate size to give sufficient clearance between the tower and/or climbing frames and any protruding reinforcement. If the crane is first used on a fixed base, care should be taken at the time of installation to ensure that the tower is correctly orientated, that the climbing equipment is correctly positioned and attached, and that the crane is securely held by the climbing frames before the bolts attaching it to the base are released. All wedges should be secured to prevent them working loose and falling out during operation.

3.9.2.5 *Truck, trailer and crawler-mounted tower cranes.* Temporary access roadways or work plateaux provided for these machines should be of adequate surface quality and load bearing resistance, properly consolidated, and level to within required limits. There are strict limitations on the use of truck, trailer and crawler-mounted tower cranes on slopes, and the manufacturer's instructions should be followed (see **3.8.2.3**).

It is recommended that these types of tower crane are fitted with a level indicator which is conveniently positioned and is sufficiently accurate to enable the crane to be set correctly.

3.9.3 Installation of crane base of chassis, and initial tower section

3.9.3.1 *On expendable in-situ base.* Most climbing cranes and other tower cranes which are capable of height extension or dismantling by methods similar to those described in **3.9.11** have special lugs or other attachments fitted on certain sides of their tower sections to facilitate these operations. Therefore, when installing the base and initial tower sections, it is necessary to ensure that they are correctly orientated so that the jib, which may not be allowed to slew during extension or dismantling, will be in the correct position relative to the sides of the tower and to surrounding structures. This may present no serious problem during extension because clear space is usually available and it involves only lifting additional tower sections and placing these in position at the top of the tower. During dismantling, however, whilst the jib and counter-jib are being lowered, they should clear the face of the building and all surrounding structures, which they can do only if the tower has been correctly orientated initially.

If corner angles are found to be incorrectly positioned or out of plumb, no attempt should be made to correct these by bending, nor should bolt holes be elongated.

3.9.3.2 *On own base* (*without bogies or wheels*). The crane base should be assembled in the correct orientation relative to surrounding structures and construction work (see **3.9.3.1**). It should be set level, adequately packed and supported on suitable material, and grouted in to ensure even distribution of load. Holding down devices should be tightened and the whole assembly checked for correct positioning and plumb.

3.9.3.3 *Rail-mounted cranes.* The rail track should be checked for correct gauge and level before the crane base is assembled. For reasons similar to those given in **3.9.3.1** the crane base should be assembled on the rails in the correct orientation. Driven bogies and/or sliding axles should be correctly positioned in relation to rail curves in accordance with the manufacturer's instructions. All bolts should be securely tightened and rail clamps attached where necessary.

3.9.3.4 *Climbing cranes.* Where the crane is to be used initially on an expendable in-situ base or on its own base without bogies or wheels, the precautions given in **3.9.3.1** and **3.9.3.2** above should be observed. In all cases care should be taken at the time of installation to ensure that the tower is correctly orientated and that climbing equipment is correctly positioned and attached.

3.9.3.5 *Truck, trailer and crawler-mounted tower cranes.* These are usually erected by a self-erection procedure. The manufacturer's instructions should be strictly followed, and general precautions given in **3.9.1** observed where applicable.

3.9.4 Erection of tower. When the base or chassis has been set up, the tower (which may include the slewing gear and tower head) is then erected and attached to it using a second crane or a self-erection procedure. In either case the tower should be correctly orientated within the base section.

Where the jib is attached to the tower head before the tower is raised from the horizontal to the vertical position, some means, such as a plank or board should be placed beneath the outer end of the jib to ensure that it can move freely across the ground as the tower is raised.

Where a second crane is used for erection, the number of sections in any tower sub-assembly should not be sufficient to cause excessive stresses in the assembly when it is raised from the horizontal to the vertical position. It is recommended that jib-ties are attached before the jib is raised and positioned at the top of the tower section.

When a tower section or sub-assembly has been placed in position, all bracings, locking devices, etc., should be attached and bolts securely tightened before proceeding with the next stage of the erection operation. It is essential to ensure that any specially strengthened tower sections are positioned where required.

3.9.5 Assembly and erection of counter-jib. The counter-jib should be correctly assembled on level ground or on levelled trestles. Where it carries a trolley to which the counterbalance weights are attached, the trolley (without weights) and its associated ropes should be attached to the counter-jib before it is erected and securely fastened so that it will not slip when the counter-jib is lifted into position.

Where a second crane is used for erection, the counter-jib should be slung in a way that facilitates the entry of its foot into the slewing section of the tower.

Undue force should not be used when inserting foot pins which should be lubricated before insertion, and locked in position before the free ends of ties are attached.

Where a self-erection procedure is used, erection ropes should be correctly reeved and the appropriate locking devices used at all times.

At the completion of this stage of the operation, the security of all pins, bolts and other locking devices should be checked.

3.9.6 Counterbalance and ballast weights. It is again emphasized that at each stage of the erection/dismantling operation the correct amount of ballast and counterbalance should be in the appropriate position on the crane. The manufacturer's specific instructions should be followed on this point and particularly in regard to slewing the counter-jib and counterbalance before the main jib is installed.

Weights for ballast or counterbalance should be made in accordance with the manufacturer's instructions. Where reinforced concrete is used, weights should preferably be cast within a containing metal framework, the lifting loops being integral with the reinforcement which should have adequate cover. Sufficient time should be allowed for the concrete to cure. All pieces of ballast and counterbalance should have their weights clearly marked upon them. The construction of counterbalance weights should include the facility for adding small amounts in order to obtain the correct total.

Counterbalance weights made of concrete should be adequately reinforced, and of good fairfaced condition not susceptible to frost attack. Where the counterbalance is made up of a number of individual weights, they should be tied together to prevent movement.

Permeable substances such as sand and shingle whose weight is affected by moisture content, should be used as counterbalance or ballast only where their weight can be accurately determined and they are held on the crane in a weatherproof container on which the contained weight is clearly marked.

3.9.7 Assembly and erection of main jib. The assembly of the main jib should be carried out in accordance with the manufacturer's instructions, preferably at ground level. Care should be taken to ensure that the jib sections are assembled in their correct order and relative positions. It is essential that at all times the jib is correctly supported as specified by the manufacturer in order to avoid overstressing during assembly and erection. Saddle jibs should be held clear of the ground on trestles or other supports in order to facilitate the attachment of the trolley. With the trolley positioned on the jib, the traversing rope should be tensioned initially with the tension adjusting devices backed-off. The trolley should be temporarily secured to the jib whilst the jib is raised into position. The correct functioning of pulleys and other mechanical devices on the jib should be checked, and limit switches and associated wiring installed, whilst the jib is on the ground.

Where a second crane is used to erect the main jib, precautions similar to those given for the counter-jib should be observed regarding slinging and the insertion and locking of jib pins, etc. Sufficient hand lines should be attached to the jib to ensure that it can be held under complete control during the whole of the lifting and attaching operation, and these should not be detached until all stays are secured and all pins have been locked.

Where a self-erection procedure is used, the jib should be assembled in the appropriate position and line relative to the tower. And, as stated in **3.9.4**, some means should be provided to ensure that the outer end of the jib is free to move along the ground. Where the inner end of the jib is first attached to the slewing section of the tower, care should be taken to ensure that pins are in position and securely locked and that the erection rope has been correctly reeved and re-attached before the outer end of the jib is raised. The erection rope should not be released until the jib is securely held in the erected position by stays, luffing rope, or other means.

Where the jib is held in position by a number of ties or holding ropes these should be correctly paired, positioned and adjusted to the appropriate tensions.

Where the jib is luffed by means of hydraulic rams, the correct functioning of these and the associated lock valves, should be carefully checked before the jib is raised.

On some cranes, the jib, counter-jib and slewing assembly are put together at ground level and then raised to the top of the tower by a self-erection procedure. Where this operation is carried out by means of an erection rope as distinct from jacks, this rope may have heavy strains placed upon it and should accordingly be in good order and correctly reeved. Care should also be taken to ensure that all pulleys are free to rotate and that movement of the rope and the assembly being erected is not obstructed in any way.

3.9.8 Ropes. General comments on the installation, use and maintenance of ropes are given in **1.13**.

3.9.9 Attachment of load-radius indicators. On saddle jibs where the positions for the load-radius indicators are not marked, the appropriate distances should be accurately measured from the centre of rotation of the crane.

When calibrating or checking the load/radius indicator on a luffing jib, the radii corresponding to each safe working load should be accurately measured from the centre of rotation of tale crane to the centre line of the hook which should carry the appropriate load. The indicator should be set to read correctly when viewed from the operating position.

3.9.10 Checks on completion of erection. On completion of erection, before being taken into use, it is essential that all tower cranes, other than those of the self-erecting mobile type, are tested by a competent person in accordance with the statutory requirements given in **1.12** and **3.12**. Before these tests are carried out, or before the crane is put into service if these tests are not required, a thorough visual examination of the crane should be made, followed by functional checks.

In the visual examination, particular care should be taken to ensure that all bolts and locking devices are correctly positioned and secured; the load/radius indicator and automatic safe load indicator are correctly fitted; access ladders, safety platforms and walkways are in position and secure; ropes are correctly reeved; and all machinery guards have been replaced.

A functional check of the crane should then be carried out under no load conditions to ensure the correct operation of all motions, limit switches and brakes. It is recommended that these tests are then repeated with a light load on the crane. On cranes equipped with change speed gear, these checks and tests should first be carried out in low gear and then repeated in fast gear with appropriate loads. On hoist mechanisms where the gear change passes through neutral between low and high speed, when changing gear, the hook block should be lowered to the ground or other suitable precaution taken to prevent the block from falling and the hoist rope unwinding from the drum. Under no circumstances should the gear change be operated when a load is suspended from the hook. Where no statutory tests are necessary the crane may then be put into service. Otherwise the statutory tests should be carried out and when these have been completed the automatic safe load indicator should be reset. Before the crane is put into service a further check should be made of all fastenings and anchorages.

3.9.11 Extending the height of a tower crane. The height of some tower cranes can be increased by adding sections to the tower without dismantling the jib/counter-jib/cat-head assembly or other parts of the crane structure.

One method employs a telescopic cage which encircles the top of the tower and has one "open" side (see Figure 25*a*). When additional tower sections are to be added, the cage is used to raise the jib/counter-jib/cat-head assembly from the top of the tower. Additional sections can then be lifted, passed through the "open" side of the cage and attached to the top of the tower and to the tower head.

Another method employs a sliding tower section within the top of the main or outer tower and which carries the jib/counter-jib/cat-head assembly (see Figure 25*b*). The height of the crane is extended by successively attaching additional sections to the top of the outer or main tower and then raising the sliding tower section within them.

In each case, the telescopic cage or sliding tower section is raised by means of lugs or other attachments on certain sides of the tower, and the self-dismantling procedure is the reverse of the erection procedure. In general, the jib/counter-jib/cat-head assembly should not be slewed during tower extension or dismantling operations; the consequent importance of the correct orientation of the tower is discussed in **3.9.3**.

Before proceeding with tower extension or dismantling, checks should be carried out to ensure that the wind speed does not exceed the limit specified for this operation, that the correct amount of ballast is in position on the crane, and that the final height will not be greater than the free standing height without ties or the appropriate height above the last tie as specified by the manufacturer (see **3.9.12**). The jib should be correctly orientated relative to the tower, and when necessary locked in position to prevent uncontrolled slewing. Before tower locking devices are freed and the height extended, the correct attachment and functioning of tower extension equipment should be ensured, and the crane correctly balanced. Care should be taken to guard against over-extension of the telescopic cage or sliding tower, and to ensure that the whole operation is carried out in accordance with the manufacturer's instructions. The tower sections to be inserted should be correctly assembled on the ground, and controlled by hand lines whilst being lifted into position and attached. Access ladders and safety platforms should be added at the appropriate positions as the height of the crane is extended.

On climbing cranes where the crane is supported and its height extension effected within a structure or building, the climbing operation should be carried out in accordance with the manufacturer's instructions. All climbing frames, ladders, locking devices and machinery should be correctly installed, adjusted, and in good working order. At the end of the climbing operation it is particularly important that the wedges securing the tower are driven home and secured.

Upon completion of extension or climbing operations, all fixings and structural joints and permanent locking devices should be checked, before the statutory tests are carried out as indicated in **1.12** and **3.12**.

3.9.12 Free-standing height and tying back. Static and rail-mounted tower cranes are designed to be free-standing up to a specified height. If this height is to be exceeded, the tower of the crane should be securely anchored at the appropriate levels (see Figure 26).

Some rail-mounted tower cranes may be used as static machines up to a specified height which is greater than their free-standing (travelling) height and in such cases the wheels should be blocked in position on the rails and the travelling controls disconnected to ensure that at the increased height they do not travel when handling a load. It should be noted that Section 19(2) of The Construction (Lifting Operations) Regulations, 1961 stipulates that no part of any rails on which a crane is mounted or the sleepers supporting such rails shall be used as anchorage for the purpose of ensuring the stability of the crane.

The free-standing height of the crane should be given in the handbook, but the manufacturer's advice should always be sought on appropriate methods of tying back the crane, and the maximum in-service and out-of-service forces that the crane will transmit to the ties, the tie frames bracing member(s) and to the structure to which it is tied. It is then the responsibility of a competent person to ensure, by means of an adequately designed and braced anchorage, that the structure is able to withstand the additional forces and that as the height of the crane is increased ties and tie frames are attached at the appropriate levels.

Before any ties are attached, the crane should be balanced in accordance with the manufacturer's instructions to ensure that the tower is vertical and that the restraint afforded by the ties does not subsequently cause any undue stress in the tower. The manufacturer's advice should also be followed in respect of the position of tie frames relative to the tower joints, and where ties occur between tower joints, whether diaphragm bracing or other stiffening of the tower is necessary. The tower should be securely wedged within the frame, the wedges being locked in position. During attachment, the weight of the tie should be supported from the tower of the crane to prevent it deflecting at the tower end.

Provision should be made for the inspection of all tie anchorages (see **3.10.2**).

The attachment, addition, or alteration of any ties which connect a tower crane to a structure so that its normal free-standing height can be exceeded is taken to be alteration to the anchorage and/or structure of the crane which should then be re-tested in accordance with the statutory requirements given in **1.12** and **3.12**. Before the statutory tests are carried out a thorough visual check should be made to ensure the security of all fixings, structural joints, wedges and locking devices.

3.9.13 Dismantling. Dismantling a tower crane can be difficult and potentially dangerous operation which should be carried out only by skilled and experienced staff under competent supervision. The relevant precautions given in **3.9.1** should be observed at all times, particularly in respect of the manufacturer's instructions, also ensuring that the correct amount of ballast is in the appropriate position on the crane during all stages of the operation.

Dismantling a crane is inevitably more complicated than erecting it because of space restrictions imposed by the structure which the crane has been used to construct and by the proximity of other buildings. It is essential therefore that the requirements for dismantling and removing the crane are considered at the outset of a project when selecting the type, size and position of the crane to be used.

With many tower cranes the dismantling procedure is the reverse of the erection procedure, the whole of the jib, counter-jib, and slewing section of the crane being lowered as a single assembly as sections are removed from the tower. In some situations this procedure can be followed only until the crane has been lowered to just above the top of an adjacent building or structure. It may be necessary to lower all or part of the assembly on to a roof or top of a structure where it can be dismantled prior to lowering to ground level for removal. Where this has to be done it is essential to ensure that the building or structure can withstand the loads applied to it by the crane and by any equipment used to lower the dismantled assembly to the ground, or to what extent its load carrying capacity should be increased by propping or shoring. Equipment used to lower dismantled assemblies should be of adequate load/radius capacity to enable these to be lowered to the ground well clear of the building or structure. It is recommended that hand lines are used to steady any load that has to be lowered down the face of the building, and that these are attached before lowering commences.

Whatever procedure and means for lowering are used in dismantling the crane, sections to be dismantled and lowered should be secured to the hook or lifting attachment of the lowering equipment before any bolts or locking devices are released.

3.10 Procedures and precautions

3.10.1 Leaving the crane unattended. On all occasions when the crane is to be left unattended, even for very short periods, all loads should be removed from the hook, the hook brought to the highest working position at the appropriate radius and the power switched off.

For longer periods (i.e. after working hours) and at all times when adverse weather conditions are expected, the appropriate out-of-service procedures should be followed which may include moving the crane to an anchorage point and attaching rail clamps and/or other means of security. The main jib should be slewed to the side of the tower away from the wind, and then put into free slew; the power supply switched off and locked; any fuel supplies cut off; and doors or panels giving access to electrical or mechanical equipment closed and locked.

Where the crane has warning lights fitted to the top of the tower or to the jib, these should be switched on if it is to be left unattended overnight.

Before being left for a long period, tower cranes which do not have continuous full-circle slewing should be slewed-back into their mid-position (see **3.11.2**).

3.10.2 Routine cheeks. At the beginning of each shift or working day, the driver, or other competent person should carry out the routine checks given in **1.10** as applicable. In addition he should carry out an inspection to ensure that:

1) On rail-mounted cranes the wheels and axles are in good condition; the cable drum is free to revolve and the cable does not foul on any part of the crane structure.

2) All rail clamps and out-of-service anchorages have been released.

3) The track is in good condition and clear of obstructions, and that there is no undue settlement, loose joints, cracks, or gaps between adjacent lengths of rail.

4) The wind speed does not exceed that specified for in-service conditions and that where an anemometer is fitted to the crane, it is in working order.

5) Split pins and locking collars are in position on jib and counter-jib ties and counterbalance hanger bars.

6) The travel warning device operates.

7) On a climbing crane all climbing frames and wedges are secure, and that the anchorages and wedges on any tower ties or tie frames are secure and locked in position where necessary.

8) For safety and to prevent the risk of fire, the crane cabin is in a tidy state, is free from tins of grease and oil or other fluids; from rags, tools, shackles and other materials; and that a fire extinguisher suitable for extinguishing both electrical and other types of fire is available in a convenient place in the crane cabin.

9) Any additional instructions issued by the manufacturer are carried out.

At least once a week, a full inspection of all anchorages, fixings and structural members should be carried out. Bolts should be checked for tightness and welded joints inspected for cracks.

Fire extinguishers should be periodically inspected and renewed. It is also recommended that a tower crane driver should examine the joints in the tower as he climbs to the cabin. Loose joints can be readily noticed by flaking or marking on the paint surface or by rust marks. Similarly, cracks can often be detected by rust runs.

If any unusual noise or movement occurs during crane operation or if any incidents arise which may cause overload or damage to the crane, or which impair the effectiveness of the controls, the crane should be taken out of service and not re-used until it has been completely checked and certified as fit for use by a competent person.

3.10.3 Reporting of defects and authorization for use. See **1.10.3**.

3.10.4 Permit to work. See **1.10.4**.

3.10.5 Safe means of access. See **1.10.5**.

In addition to providing safe means of access in accordance with statutory requirements it is recommended that cat-walks are provided wherever they would facilitate access for the purpose of routine maintenance or inspection. It is also recommended that safety lines with runners for the attachment of safety harnesses are fitted to saddle jibs wherever personnel are required to work on or move along the jib. An alternative means of access is by means of a safety platform or trolley attached to the saddle. The movement of the platform should be controlled by the person or persons travelling in it.

The crane driver and authorized maintenance staff only should be allowed to climb onto the crane structure and then only in order to gain access to the cab or to carry out such tasks as maintenance of inspection.

Because of the risk of trapping, no person should be allowed to climb the mast to the cab, jib, counter-jib or cat-head, unless the crane driver is aware of this and has clearly indicated that it is safe to do so.

3.11 Safe working loads and operational conditions

3.11.1 Safe working loads. General precautions in respect of safe working loads and operational conditions are given in **1.11**. The safe working load of a tower crane is the hook load specified for a given radius, with the appropriate rope reeving and length of jib, and with the crane standing on a firm, level base or track. In assessing the weight of the useful load, allowance should therefore be made for the weight of slings or other tackle used to attach the load to the hook.

Any tower crane should be on a firm, level base or track with its tower vertical when handling loads. The manufacturer's advice should be sought before the crane is used under other conditions.

Where a crane can be fitted with hoist drum shells of different diameters, the manufacturer's advice should be obtained on the diameter to be used in relation to the height of the crane, the number of falls on the hook, and the specific duties involved. Also, where a crane is to be used at above its free-standing height the manufacturer's advice should be sought on the possible need for de-rating to make allowance for the weight of the rope, the number of falls on the hook, and the use of an overhauling weight.

Where a crawler- or truck-mounted or wheel-mounted tower crane is designed to be partially or completely supported on outriggers and jacks when handling loads, these should be extended and set in accordance with the manufacturer's instructions. On machines with pneumatic tyres it is important to ensure that the tyres are in good condition and inflated to the recommended pressures.

Where permissible, special care should be taken when travelling mobile tower cranes in their working state (i.e. with tower and jib erected) across ground on which changes of slope occur or where there are wide variations in the bearing capacity of the ground surface.

It is recommended that an anemometer or wind speed measuring device should be provided at a suitably elevated position on all tower cranes. Where practicable the indicator of the instrument should be fitted at the crane driver's station.

Where a load has a large surface area in relation to its weight, for example a large timber shutter or panel, the action of the wind on the load may give rise to unsafe working conditions in respect of the strength or stability of the crane, or because the load cannot be adequately secured against swinging or spinning; with some loads this can occur at wind speeds below that specified for in-service conditions. Under such circumstances the size of the hook load should be limited to that which can be safely handled by the crane and which will not create unsafe conditions for operatives. Arrestor devices or brakes should be provided to prevent the load being moved by the wind to a radius at which it would exceed the safe working load of the crane.

Name boards or other items presenting a wind catching area should not be fitted to the jib, counter-jib, or tower of a tower crane without the express approval of the manufacturer.

3.11.2 Mode of operation and control. Each crane control should be clearly marked to show the motion and the direction of movement that it controls. Where practicable, controls should be arranged so that accidental displacement is prevented and inadvertent pressure on them does not cause the crane to be set into motion.

Where a wanderlead and control box is provided for the remote operation of a tower crane particular care should be exercised when operating the crane by this means. The controls should be isolated when the wanderlead is being moved from one operating position to another. Any carrying harness attached to a control box should be fitted with a quick release device.

Before starting to operate a crane the driver should ensure that he has a clear and unrestricted view of the load and operating area, or that the slinger or authorized signaller, whose instructions he will follow, has a clear and uninterrupted view. The signalling system in **1.14.6** should be used.

The driver should be thoroughly conversant with the crane controls.

When handling loads which approach maximum safe working loads, and when working at long radii, all crane motions should be operated with extreme care. The load should initially be lifted just clear of the supporting surface, and brought to rest, and the slings, balance of the load, and stability of the crane, etc., checked before proceeding.

Care should always be exercised when operating a crane in high speed drive to prevent snatching and excessive load swing.

On cranes which do not have continuous full circle slewing, care should be taken to ensure that the stipulated number of turns in one direction is not exceeded. It is recommended that this type of crane is fitted with a slewing revolution counter which can be read from the crane cabin or operating position.

3.11.3 Handling of loads near persons and carrying of persons. See **1.11.4**.

3.11.4 Special duties. In all cases where a tower crane is to be used for a purpose or in a manner outside normal duty, the manufacturer's advice should be obtained. Tower cranes should not be used for grabbing, magnet or demolition ball service, tandem lifting, piling operations or any other duties which might impose excessive and/or indeterminate loadings on the crane structure.

In all situations where the crane driver does not have an unrestricted view of the load and is acting upon the instructions of a slinger or authorized signaller, the responsibility for the lifting operation should be clearly designated, and understood by all those involved. Exceptionally difficult lifting operations should be rehearsed with a dummy load on the hook.

3.11.5 Special lifting attachments. Comments on the use of special lifting attachments are given in **1.11**.

3.11.6 Weather conditions. The operation of cranes under various weather conditions is dealt with in **1.11**.

3.12 Testing

The statutory requirements and details of the ballasting and anchorage test and the overload test are given in **1.12**.

It should be noted that when a tower crane is climbed within a building or structure by means of its climbing frames and ladders, or when its height is raised by adding sections to the tower, or when there is any alteration in the ties which connect it to a structure so that its normal free-standing height can be exceeded, this constitutes an alteration to the anchorage and/or the structure of the crane which should therefore be re-tested in accordance with statutory requirements.

3.13 Ropes. See 1.13.

3.14 Slinging and handling of loads. See 1.14.

3.15 Maintenance

Details of statutory examination requirements, comments on planned maintenance and the competence of maintenance personnel are given in **1.15**. Attention is also drawn to **1.10.4** and **1.10.5** which relate to the reporting of defects and authorization for use, permit to work and safe means of access.

4 Derrick cranes

4.1 Description of types

This Section of the Code covers two of the more sophisticated types of derrick crane used on works of engineering construction; the Scotch derrick and the guy derrick. Both forms of derrick crane incorporate a vertical mast, which carries the suspension ropes for a low-pivot derricking jib and in both cases the mast rotates with the jib as the jib is slewed. The basic difference between the two types arises from the method by which the mast is supported and this gives to each particular characteristics.

4.1.1 Scotch derrick (*see Figure 27, Figure 28, Figure 29 and Figure 30*). The rotating mast on a Scotch derrick crane is held in the vertical position by two inclined rigid structural backstays attached to the top of the mast. At their lower ends the stays are tied back to the sole plate under the mast by horizontal fixed structural members (sleepers).

The horizontal angle between the two backstays is about 90° and since the jib of a Scotch derrick is normally greater in length than the height of the tower, the angle of slew is limited to slightly less than 270°. (It should be noted that the jib of a Scotch derrick should never operate (or be erected) between the backstays.)

Designs of Scotch derrick exist which offer the following forms of mounting:

1) Mounted direct on the ground with ballast added to sleepers or mounted direct on concrete blocks which act as ballast (see Figure 27).

2) Rail-mounted with or without power driven travelling motion (see Figure 28).

3) Erected on fixed or rail-mounted towers or gabbards with or without power driven travelling motion (see Figure 29).

4.1.2 Guy derrick *(see Figure 31).* The rotating mast on a guy derrick crane is held in the vertical position by means of a number of anchored steel guy ropes, as distinct from the rigid structural stays used on a Scotch derrick.

The jib on a guy derrick is normally shorter than the height of the mast and this enables it to be slewed through a full circle when it is derricked in to near-vertical position.

Essentially the guy derrick is a stationary crane for installation on a prepared base or concrete block foundation.

4.2 Definitions. See 1.2.

4.3 Legislation. See 1.3.

4.4 British Standards. See 1.4.

4.5 General considerations

General considerations relating to the use of all types of cranes are given in **1.5**.

4.6 Recommended requirements for driver, slinger and signaller. See 1.6.

4.7 Choice and selection of crane

In general, Scotch and guy derricks are able to handle their maximum loads over a greater range of operating radius than most other types of crane of comparable capacity. The decision to use a Scotch derrick or guy derrick crane is governed by the crane characteristics in relation to the work to be done and the conditions prevailing.

4.7.1 Scotch derrick. In making the decision to use this type of crane the load-radius characteristic should be considered in relation to the amount of ground space occupied and the limited arc of slewing.

The maximum effective outreach is governed by jib clearance over adjacent obstacles and gabbards may be needed to increase this clearance.

Scotch derricks are usually provided with two drums which enables two-rope (grabbing/hoisting rope and holding rope) grabbing operations to be carried out. The favourable load-radius characteristic may allow the use of a maximum size of grab over a wide area.

4.7.2 Guy derrick. Like the Scotch derrick, the guy derrick is a crane of high lifting capacity but should be considered when the weight and size of the objects to be handled form the criterion for selection, rather than the mobility or productivity of the crane. Guy derricks are much used in the erection of steel framed structures or buildings because of their manoeuvrability, high load-lifting capacity and the small standing area they require. However, adequate site clearances and suitable anchor locations for the guy ropes and winch gear are essential (see **4.9.3.2**).

4.8 Siting of cranes

Having decided on the load capacity and jib length of derrick crane required, consideration should be given to the layout to which the machine is to be built with reference to the loads it has to handle and the area to be covered bearing in mind the limited angle of slew of a Scotch derrick. Various typical configurations are shown in Figure 30.

4.8.1 Crane standing or support conditions (*see* **1.8.1**). It is essential that the ground on which a crane stands has adequate bearing capacity. In assessing this, account should be taken of seasonal variations in ground conditions. Where a crane is to be supported on a permanent or temporary structure, a thorough check should be carried out to ensure that the structure and all crane anchorages are sufficiently strong to carry the maximum loads that the crane may exert upon them.

The ground, rail track or foundation should be capable of supporting the combined weight of the crane, load and ballast without sinkage or collapse. The manufacturer's advice should always be sought as to what these loads are, and the foundation or track design should take into account the worst loading which can occur in both upwards and downwards directions. On a Scotch derrick the downward load below the crane mast is greatest when the maximum load is lifted at the appropriate radius and the jib positioned, in plan, on the extended centre line bisecting the angle between the two sleepers. The maximum downward load at the junction of the back stays and sleepers occurs when the maximum load is lifted at the appropriate radius with the jib slewed round close to the back stay.

Any loadings used in the design of track or foundations should make allowance for the additional loadings due to dynamic and wind forces. Also the foundation design for a fixed or travelling gabbard-mounted derrick should take into account the additional loads imposed by the weight of the gabbards themselves and the extra load imposed on their bases or rails by wind pressure on the whole structure.

The bearing surfaces under the sole plate and the two sleepers should always be in the same plane whether the derrick is static or rail-mounted.

Any difference in ground level can be taken up on a static or travelling crane by variation in the height of foundation block or gabbard above the ground. All rails should always be horizontal.

4.8.2 Proximity hazards (*see* **1.8**). Cranes should be sited where there is clear space available for erection, operation and dismantling. Consideration should be given to the proximity of power cables (see **1.8**), other cranes, structures and buildings, hoists, stacked materials, other construction works and the flight paths of airfields. As far as possible cranes should be sited so that loads do not have to be handled over occupied premises such as dwellings, factories, and schools, over public thoroughfares and highways, other construction works and rivers or railways.

4.8.2.1 *Underground hazards.* Cranes should not be sited where there is danger to their foundations or supporting structure from temporary shorings, excavations, embankments, buried pipes and mains, etc. If the mast or the back anchor blocks are situated near a bank or wall of an excavation, the stability of the bank or wall should be established in relation to the loads imposed upon it. It may be necessary to provide special foundations to ensure the safety of the crane.

4.8.2.2 *Tidal or flood water areas.* In areas subject to tidal or seasonal flooding, or where there is a high water table, the crane may require deep foundations or special ground consolidation. In such situations all machinery and electrical equipment should be positioned where it is not in danger from any rise in the water level. Unless adequate precautions are taken, cranes should not be sited where there is danger to foundations, rail tracks or temporary access roads from surface water drainage, flooding or rises in the water level.

4.9 Erection and dismantling

4.9.1 General comments. IN ALL CASES IT IS ESSENTIAL THAT MANUFACTURER'S INSTRUCTIONS ON THE METHOD AND SEQUENCE OF ERECTION/DISMANTLING ARE STRICTLY FOLLOWED, and the appropriate precautions set out in this Section and in **1.9** observed.

All operations should be carried out under competent supervision by personnel who have been adequately trained and who have experience of erecting/dismantling the particular type of crane involved.

Particular care should be taken in the design and construction of all supporting structures, connections and anchorages.

4.9.2 Scotch derrick cranes. It is essential that the crane sleeper (lying leg) connections to concrete foundation blocks, bogies and gabbards are designed to withstand the uplift specified by the manufacturer. Where ballast is installed in the base of the gabbards, it is essential that these are designed to withstand tensile as well as compressive forces.

4.9.2.1 *Concrete block foundations.* The design and construction of the foundations should be the responsibility of a competent person. Concrete for the crane foundation blocks should be made with ordinary Portland cement. Extra rapid hardening cement or admixtures to the concrete mix which contain calcium chloride to promote rapid hardening should be used only with the express permission of the competent person responsible for the design and construction of the foundation.

Concrete used for crane foundations should be of the correct mix and given sufficient curing time to attain an adequate strength.

Holding down bolts should be set accurately in the correct location but should not generally be grouted in place until the pivot structure and sleepers have been finally set in position.

Provision should be made for the inspection of holding down bolts, and means provided to prevent the collection of water on the crane foundation.

4.9.2.2 *Bogie mountings.* The track and track foundations (see **4.8.1**) are of extreme importance in ensuring safe operation of the crane and these should be designed by a competent person.

Rails for bogie mounted derrick cranes should be of flat bottomed section and of correct profile and linear weight recommended by the manufacturer for the wheel loads imposed. Care should be taken in setting the rails to the correct gauge and to the correct track centres throughout the travel length. The track should be level and should be secured to foundations or track sleepers. Where track sleepers are used these should be of sound quality and placed at intervals appropriate to the weight of rail being employed and to ensure an adequate spread of the load so as not to exceed the allowable bearing pressure on the ground. The whole track should be adequately ballasted or otherwise located to prevent all movement.

Rails should be properly secured to track sleepers to prevent all movement and should be free of holes except those necessary for fish plates and rail ties. Where it is essential that holes are made in the rail for fish plates, these should be drilled and not flame cut. The heating of rails during flame-cutting or welding may cause embrittlement of the metal and subsequent fracture, particularly in used rail which could have become work hardened, For this reason special precautions should be taken when flame cutting or welding new rail and used rail should not be flame cut or welded.

Adjacent ends of rail should be tightly butted and the fish plate rail joint should be located over a track sleeper. Where ties are used and are fixed between the webs of rails, these should also be located directly over a track sleeper.

Rail stops should be fitted, in line, at least 1.0 m (3 ft) from the end of the track. However, it may be necessary to set these further back to ensure that the permissible ground bearing pressure is not exceeded under the ends of the track. On bad ground longitudinal bearers can be used to minimize rail deflection.

Where vehicles have to cross or travel over the rail track, the track should be adequately protected by sleepers and hard core, or other covering material.

Rail tracks for electric travelling derrick cranes should be efficiently earthed. Under normal conditions bogie wheels may be considered to make an effective earth with the rail track and in these circumstances at least one rail of the track should be electrically bonded at each joint by means of a copper tape or wire having a minimum cross sectional area of 65 mm^2 (0.1 in^2). This rail of the track should be effectively earthed and maintained in a clean condition. Where a deposit on the rails arising from infrequent use, dust, corrosive atmosphere or other causes cannot be avoided and is likely to lead to inadequate contact, an additional collector suitable for engaging with an auxiliary earthing wire or rail should be used.

4.9.2.3 *Erection procedure.* The sole plate should be securely fixed in position to resist the slewing forces and the sleepers are then attached and fixed down at the outer end. If bogie mounted, the bowsill is fitted between the end of the sleepers and the mast is lifted into the boom pivot and securely guyed in a vertical position to ensure stability.

The back stay splice nearest the jib should be fitted with countersunk or round-headed bolts to prevent the jib chord angles fouling when working close to the stay. The shortest back stay should be placed in position first; this stay should be clearly marked to indicate whether it is on the left or the right when viewed from the rear. The back stays should be fitted with lifting lugs or have the point of slinging marked on them to allow them to hang at the correct angle for easy positioning of the stay glands on the top pivot pin. The top collar and fixing device should then be properly secured. Ropes should be of the size and construction specified by the manufacturer.

Unless the crane is anchored to a concrete foundation, the full amount of ballast should be positioned before the jib is installed. The ballast blocks should be placed symmetrically round the point where the back stay and sleeper centre lines intersect and the holding down eye or holding down bolts should be directly in line with or symmetrically placed on either side of this point also. If this is not done the effective weight of the ballast will be reduced and hence the margin of stability of the crane. If any doubt exists the manufacturer should be consulted.

Each successive layer of ballast blocks should be placed on timber boarding to give a good seating and the whole should be adequately secured in position to prevent accidental dislodgement during operation. If ballast other than cast iron or concrete blocks is used, i.e. offcut rails or sand and gravel, the total weight should be accurately determined and it should be contained to prevent accidental loss or unauthorized removal. Although not recommended practice, if sand or gravel is used, the weight should be determined in the dry state and special care should be taken to prevent the escape of material from the ballast container and to prevent entry of water. The height of any ballast container should be kept to the minimum to reduce wind loading. The derrick crane should not be used to install its own ballast.

All ballast blocks or tanks should be marked to indicate their individual or contained weights and a plate should be attached permanently to the crane stating how much total ballast is required on each crane sleeper. The effect of rail clamps should not be considered as a means of reducing the amount of ballast and increasing the crane stability.

Safe means of access should be provided for the statutory weekly anchorage inspection of gabbard mounted cranes.

If it is necessary to use the crane hoist rope to assist in the jib installation by lifting the bottom end, it should not be reeved round the safe load indicator pulley as damage may result. The rope should be reeved round the mast top hoist pulley or round a separate return block at the mast top. Having lifted in the jib foot, the manufacturer's instructions should be followed as to the angle to which the jib should be raised using auxiliary means, such as a second crane, before it is safe to derrick it into the operating range under its own power. Failure to observer the precaution could result in structural or mechanical overloading. The jib should never be erected to operate between the back stays, nor should the jib be used to drag loads which are located between the back stays.

4.9.2.4 *Electrical supply.* The electric power supply to the crane and the cable used should be as recommended by the manufacturer to suit the electrical system of the crane.

For fixed cranes the electrical supply should be taken direct through the centres of the mast bottom pivot to the collector system.

For bogie mounted cranes on permanent installations a cable winding drum or properly installed and protected collector system should be used. (Earthing recommendations are included in **4.9.2.2**).

If the installation is of a temporary nature and neither of these systems can be used, the electrical supply cable should be brought to a point on the crane sleeper well clear of the slewing mechanism, rail tracks and any other obstacles on the ground. The cable should be securely fixed along the crane sleeper up to the point where it enters the collector system, through the mast bottom pivot. Bogie mounted cranes connected in this manner should not be travelled without first checking that the supply cable is unobstructed and ensuring that labour is available to keep it free of obstructions throughout the crane movement.

There should be means of isolating the electrical supply on the crane itself and also at a point on the track side where a travelling cable connects to the main supply. The crane should be protected by an earth leakage trip device. Where trailing cables are used a four-core cable with an earth conductor should be employed.

4.9.2.5 *Safety devices.* The automatic safe load indicator and all limit switches should be correctly installed and tested as set out in **1.12**. Where access to any point of the crane is difficult after erection, or it is not possible to lower the jib, bridle and derricking ropes should be well treated with the proper dressing before erection, paying particular attention to tucked splices.

4.9.2.6 *Dismantling.* The reverse sequence to the erection procedure should be followed for dismantling, with particular care being taken to guy the mast effectively before the back stays are removed.

4.9.3 Guy derrick cranes

4.9.3.1 *Foundations.* The same comments apply to general requirements for foundations for guy derrick cranes as for Scotch derrick cranes (see **4.9.2.1**).

Since the hoisting and derricking winches of a guy derrick may be separately mounted from the slewing structure base, adequate allowance should be made for the horizontal pull on the mast foot and winch bases and their connections. It should also be ensured that there is sufficient resistance to horizontal movement of the anchor blocks.

4.9.3.2 *Guying ropes.* Guying rope anchor stirrups or plates bedded in concrete anchor blocks should be mounted in the line of pull of the rope to obviate bending.

Where practicable guying ropes should be equally spaced radially around the mast with a horizontal angle between adjacent guys not exceeding 60°. The guying ropes should have as large a spread as is practical but the vertical angle between the mast and guy should not be less than 45°.

Guying ropes are usually fitted with turnbuckles for tensioning adjustment. Since it is important that the ropes are not overtensioned, this operation should be supervised by an experienced person competent to do this.

It should be noted that the safe working loads and anchor weights required will be influenced by the inclination of the guys (see **4.11.1**).

The manufacturer should always be consulted if there is any doubt as to the duty of the guy derrick in relation to its anchors and guys.

4.9.3.3 *Erection.* The sole plate and winches should be securely fixed on the prepared foundation blocks to resist slewing and other operational forces. The mast, with the guying ropes attached to the upper end, should then be lifted by a second crane into the bottom pivot and the guying ropes tensioned to the prepared anchor blocks to secure the mast in a vertical position. The jib foot should then be located at the base of the mast and the derricking and hoist ropes reeved before lifting the jib up to its working position. Any restrictions imposed by the manufacturer on use of the derricking winch to elevate the jib into its working range should be observed (see **4.9.2.3**).

4.9.3.4 *Dismantling.* The reverse sequence to the erection procedure should be followed for dismantling.

4.10 Procedures and precautions

4.10.1 Leaving the crane unattended. The same general comments apply as in **1.10.1**.

When the crane is out of service and left unattended the jib should, when applicable, be lowered below the mast top level and the hook attached to an anchor block in line with the mast track, if on bogies, or to a suitable anchorage point in the ground, if fixed.

If the jib of a Scotch derrick is to be secured to the back stay when out of service, a timber block should be firmly attached to the back stay and the connection should be tight so as to prevent any chafing or impact due to wind.

On bogie mounted cranes, all rail clamps should be securely fixed in position.

4.10.2 *Routine checks.* At the beginning of each shift or working day, the driver, if competent for the purpose, or other competent person, should carry out the routine checks given in **1.10** as applicable. In addition he should carry out an inspection to ensure that:

1) the derricking clutch interlocking mechanism on single motor cranes is in correct operational order and that undue wear has not developed between mating faces;

2) general lubrication has been carried out;

3) the holding down bolts are secure and in good condition;

4) the ballast is complete, securely fixed and has not become displaced;

5) on travelling derricks the wheels and axles are sound;

6) the connection between each sleeper and its guy leg is secure;

7) the rail has no undue settlement, loose connections or cracks;

8) the fixing and positioning of the electric supply cable is correct;

9) any other points as recommended by the manufacturer have been attended to.

4.10.3 Reporting of defects and authorization for use. See **1.10.3**.

4.10.4 Permit to work. See **1.10.4**.

4.10.5 Safe means of access. See **1.10.5**.

4.11 Safe working loads and operational conditions

4.11.1 Safe working loads. See **1.11.1** for general considerations. The manufacturer's recommendations should be followed regarding safe working loads in relation to jib length, sleeper length and the amount of ballast per anchorage for Scotch derrick cranes.

A load radius indicator appropriate to the jib length in use should be fixed where it is clearly visible to the driver.

A chart also clearly visible to the driver, showing the load-radius duty of the crane, together with the loads which can be lifted in each gear, should be fixed in the driver's cabin. No attempt should be made to increase the safe working load either by adding more ballast or by narrowing the angle between the back stays unless the manufacturers have been consulted.

The safe working load of a guy derrick is governed by the structural and mechanical design, together with the size, number and spread of the guy wires and their fixing in the ground. Makers' recommendations should be followed. A chart showing safe working loads at different radii for the various lengths of jib should be affixed to the base of the mast. This chart should also list rope dimensions and show the angle of inclination and anchor weights for each guy.

Under no circumstances should a derrick crane jib be extended beyond its normal maximum length to give greater outreach with reduced loads unless the manufacturer has approved this.

4.11.2 Mode of operation and control. See **1.11.2** with the following additions.

4.11.2.1 *General comments.* Whereas all derrick cranes require a trained and competent driver, a single motor derrick incorporating an interlocked derricking clutch and pawl presents more potential operating hazards than a machine with a separate derricking motor and should, therefore, not be driven by any person who has not had specific instruction on this type of machine and its controls. A machine fitted with an independent derricking motor is recommended as being a safer and simpler unit to operate.

The jib of a single motor Scotch derrick is supported by means of a pawl which engages in a ratchet on the derricking drum; no separate brake is fitted. The jib is derricked in and out by engagement of a sliding jaw clutch. A properly designed and effective interlock should be fitted and correctly adjusted to ensure that it is not possible to disengage the pawl until the derricking clutch is engaged and it is not possible to disengage the derricking clutch until the pawl is fully engaged, otherwise the jib can fall.

When derricking out from the minimum radius, at which the weight of the jib has the least effect, care should be taken that the speed of the driving unit does not exceed the speed at which the jib can lower, otherwise the clutch is forced out of engagement due to the shape of its profile. Under these circumstances unless the design of the derricking clutch mechanism incorporates a spring-loaded operating arm to ensure re-engagement, damage to the clutch mechanism itself could result and the jib could fall.

On machines with independent hoisting and derricking motors and brakes no interlock is necessary.

On Scotch derricks fitted with a fly jib and auxiliary hoist motion, the main and auxiliary hoists should not be operated simultaneously unless the manufacturer has been consulted as to the weights which can be lifted at the appropriate radii, in order to avoid structural overloads or a hazard to the crane's stability.

When the jib is operating close to either of the back stays of a Scotch derrick or the guy ropes of a guy derrick, slewing and derricking should be carried out with extreme care to prevent damage through contact.

4.11.2.2 *Travelling of Scotch derrick cranes.* A derrick crane on bogies is most effectively travelled by means of an independent drive to the bogie wheels or axles.

If only one of the three bogies is motorized it should be the one which has the heaviest loading when there is a load on the hook. If two are powered, one should be located under the mast and the second on the other track. If motorized bogies are not used, the crane can be moved with separate hand or power driven winches of the appropriate size and number. Moving the crane by means of the hoist rope is not recommended owing to possible overloading which might result in a structural failure.

4.11.3 Ropes. See **1.13**.

4.11.4 Handling of loads near persons and carrying of persons. See **1.11.4**.

4.11.5 Tandem lifting. See **1.11.5**.

4.11.6 Special duties. Generally see **1.11.6** with the following additions.

4.11.6.1 *Grabbing and magnet crane service.* The manufacturer's recommendations and ratings for the particular crane should be followed when using it for these duties.

When grabbing with a Scotch derrick it is general practice to fit a wider hoist pulley to the jib head to allow a Bordeaux connection and swivel to pass over. It is desirable to fit the holding-line pulley lower down the jib head from the closing-line hoist pulley to give a spread of the ropes to prevent twisting. The lengths of closing and holding ropes should be checked when lowering a grab or load below crane base level to ensure that at the maximum depth or minimum operating radius, whichever is the worst condition, there is sufficient rope on the drum to leave at least two dead turns before the rope anchorage.

4.11.6.2 *Demolition ball service.* Demolition, or other service, using a captive ball is not recommended with Scotch derricks under any circumstances. Magnet ball duty is however permissible providing the combined weight of ball and magnet does not exceed that allowed by the manufacturer for grabbing duties at the same radius.

4.11.6.3 *Piling operations.* Heavy rigid pile driving frames or leaders should not be attached to the jib of a Scotch derrick as these might impose excessive side loadings or twisting on the jib. Under no circumstances should the safe working load of the derrick be exceeded when extracting piles and the hoist rope should always be kept vertical, otherwise severe overstressing could occur with resultant structural failure.

4.11.6.4 *Special lifting attachments.* The same provisions apply as in **1.11.6.4**.

4.11.6.5 *Special mountings.* Any mounting problems such as that involved in floating a derrick on one or more pontoons should be investigated by a competent person in conjunction with the manufacturer. The prime consideration is the stability of the derrick and the floating unit itself, especially as the centre of gravity of the whole unit changes when loads are lifted. Adequate additional structural connections should be provided beneath the crane sleepers if the unit is supported by more than one pontoon.

The fullest study should be made of the wave, wind and tidal conditions both in and out of service, and their effect on the crane and the pontoon on which it is mounted. The greatest care should be exercised when handling loads due to the effect of the wave and tide action.

4.11.7 *Weather conditions.* The same general comments apply as in **1.11.7**. All brakes should be protected against the ingress of water which would affect their efficiency.

Special care should be exercised when operating in exposed areas and in gusting wind conditions, owing to the large wind area of the jib.

Scotch derricks mounted on bogies should always be provided with adequate rail clamps which should be fixed to prevent the crane blowing along the rail either in or out of service. More substantial clamps may be required if the machines are on gabbards, owing to the increased wind area of the gabbards.

4.12 Testing

The same remarks as in **1.12** apply to Scotch and guy derricks.

4.13 Ropes. See 1.13.

4.14 Slinging and handling of loads. See 1.14.

4.15 Maintenance

Details of statutory examination requirements, comments on planned maintenance and the competence of maintenance personnel are given in **1.15**. Attention is also drawn to **1.10.4** and **1.10.5** which relate to the reporting of defects and authorization for use, permit to work and safe means of access.

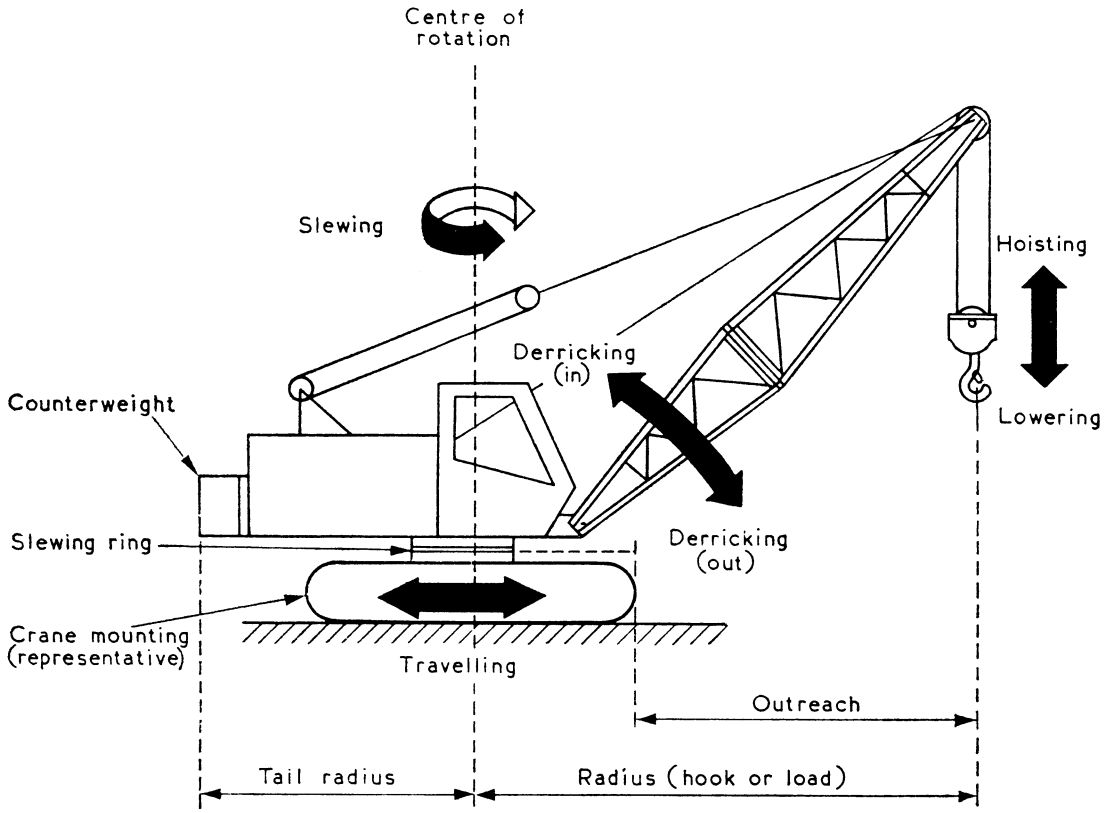
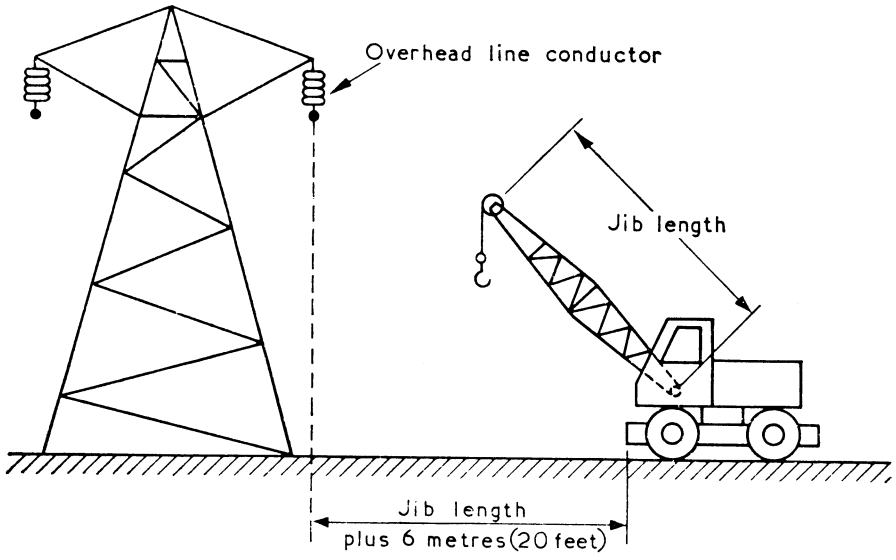


Figure 1 — Illustrated basic terminology for typical jib crane



KEEP CLEAR OF OVERHEAD CONDUCTORS

Figure 2 — Overhead electric lines (see **1.8.3**)

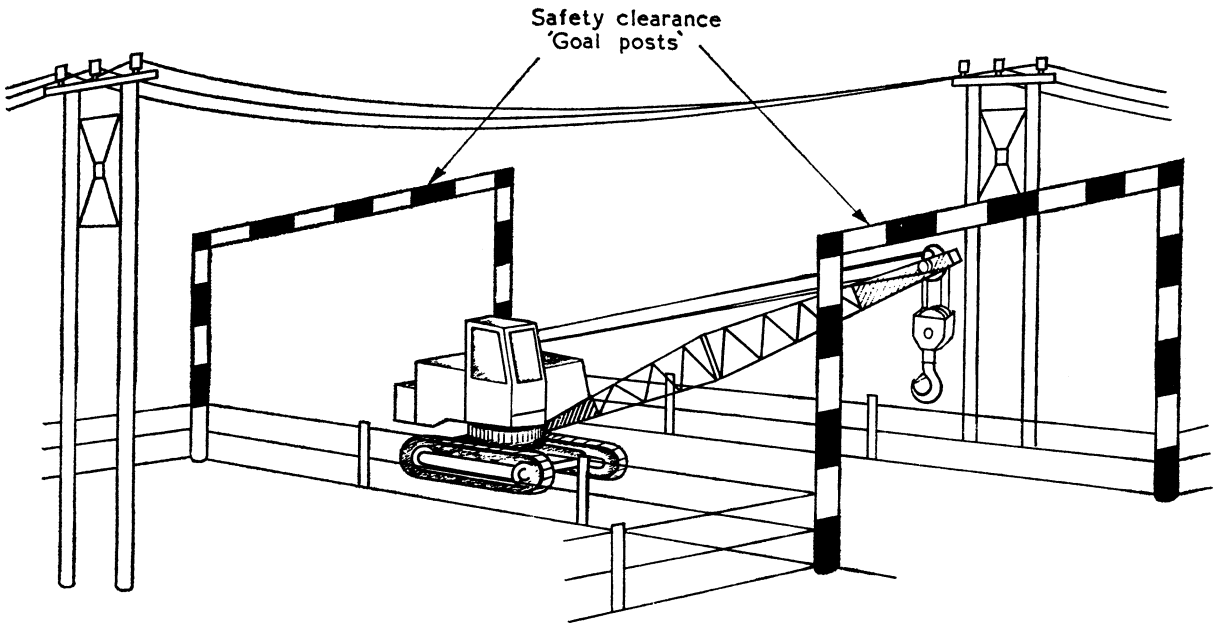
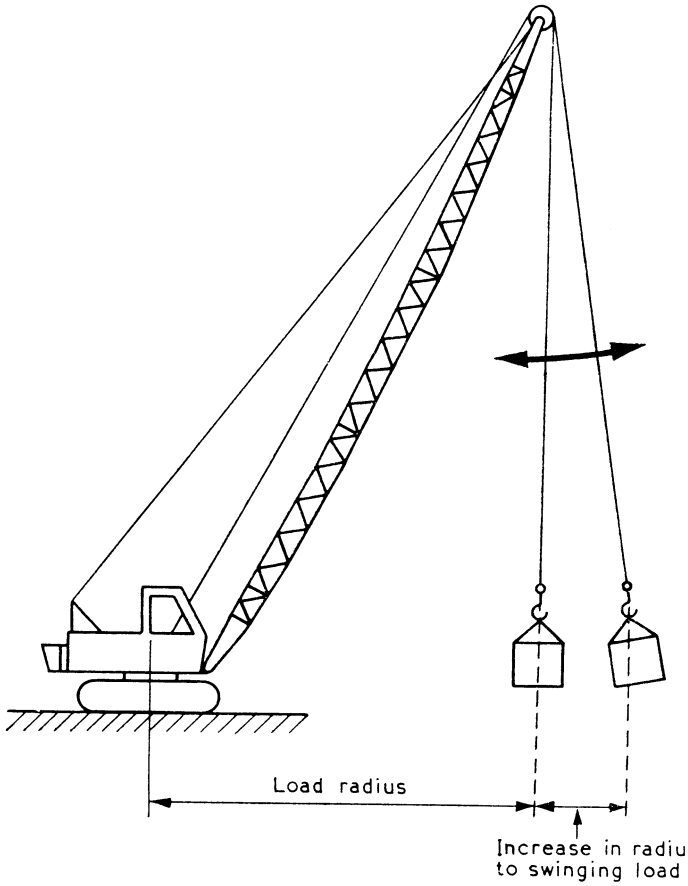


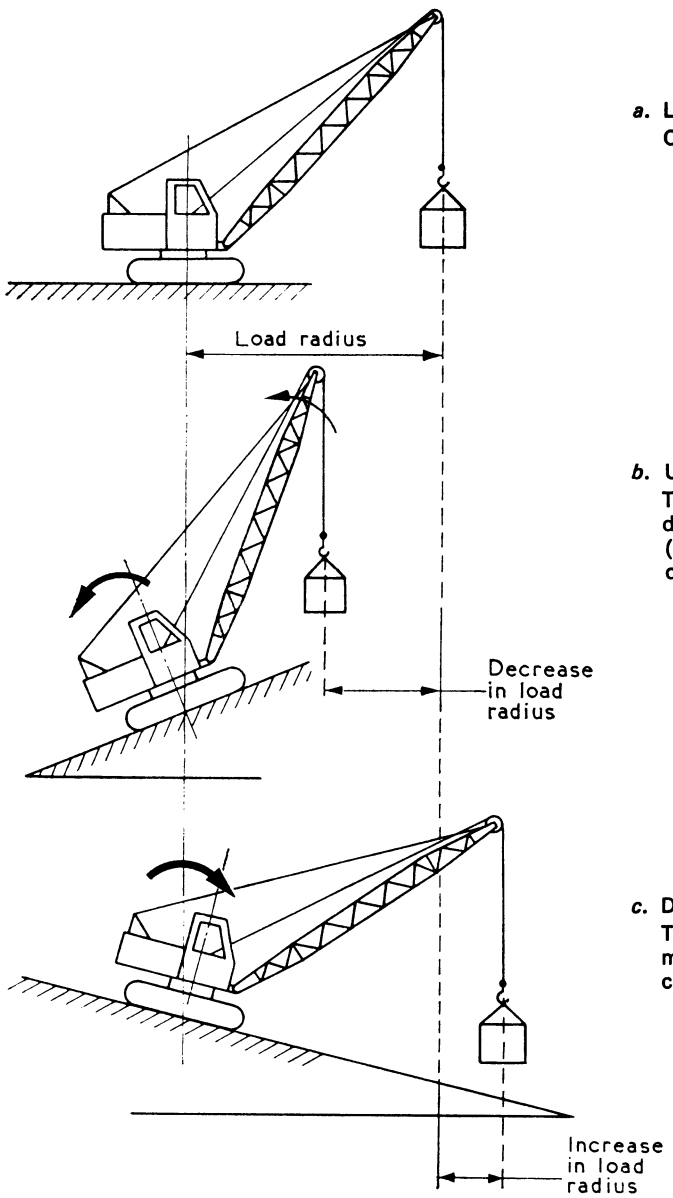
Figure 3 — Travelling under overhead electric lines and cables (see **1.8.3**)



Always lift loads gently and operate crane motions smoothly to avoid loads swinging. (A swinging load can tip the crane or cause other damage.) Use steady lines where necessary and where load presents wind catching area. Always travel with load near to ground level so load swinging can be controlled.

KEEP THE LOAD UNDER CONTROL

Figure 4 — Effect of a swinging load on load-radius (see **1.11.1**)



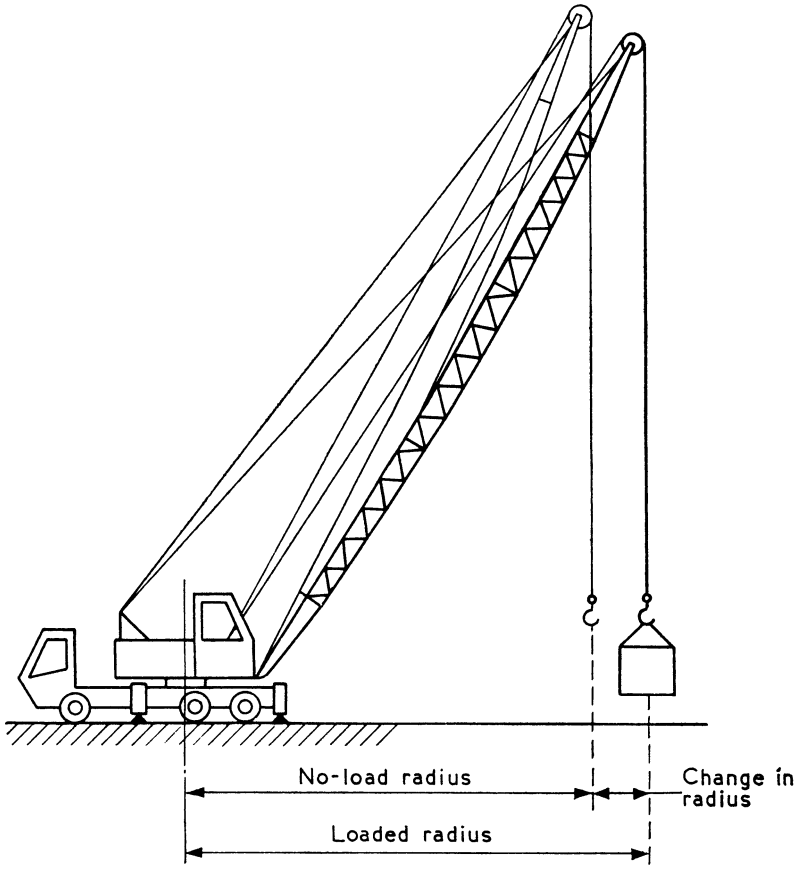
a. Level ground.
Correct load radius.

b. Uphill position.
The load moves in towards the machine. The decrease in load radius may cause the machine (or jib) to tip over backwards. Greatest danger of instability occurs when load set down.

c. Downhill position.
The load moves out of radius away from the machine. This may overload the crane and cause the machine to tip over forwards.

AVOID WORKING ON SLOPING GROUND

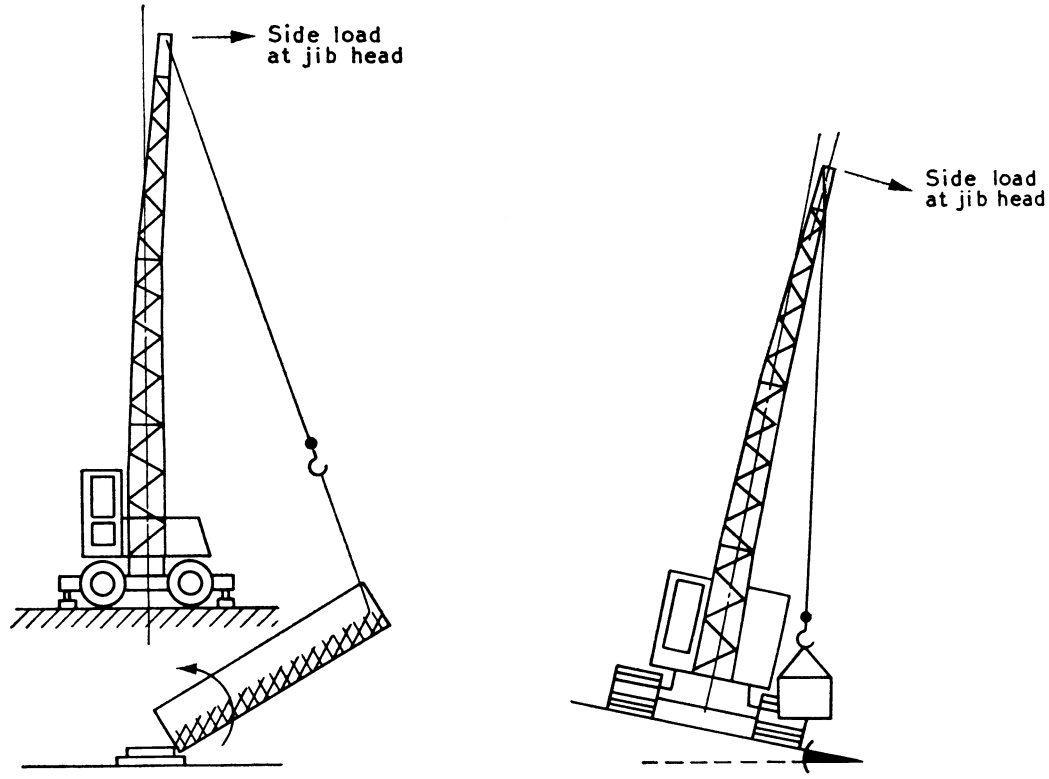
Figure 5 — Effect on load-radius when working or travelling on slopes (see **1.11.1**)



The figure shows the effect on radius when picking-up or setting down loads due to stretch in jib suspension ropes and jib and machine deflection. Where necessary re-adjust the radius after lifting the load just clear. Always place loads gently. When operating near to minimum radius ensure jib does not strike closed back stops when load set down otherwise the jib may collapse or be damaged.

CHECK THE LOAD RADIUS DURING OPERATION

Figure 6 — Influence of rope stretch on load-radius (see **1.11.1**)



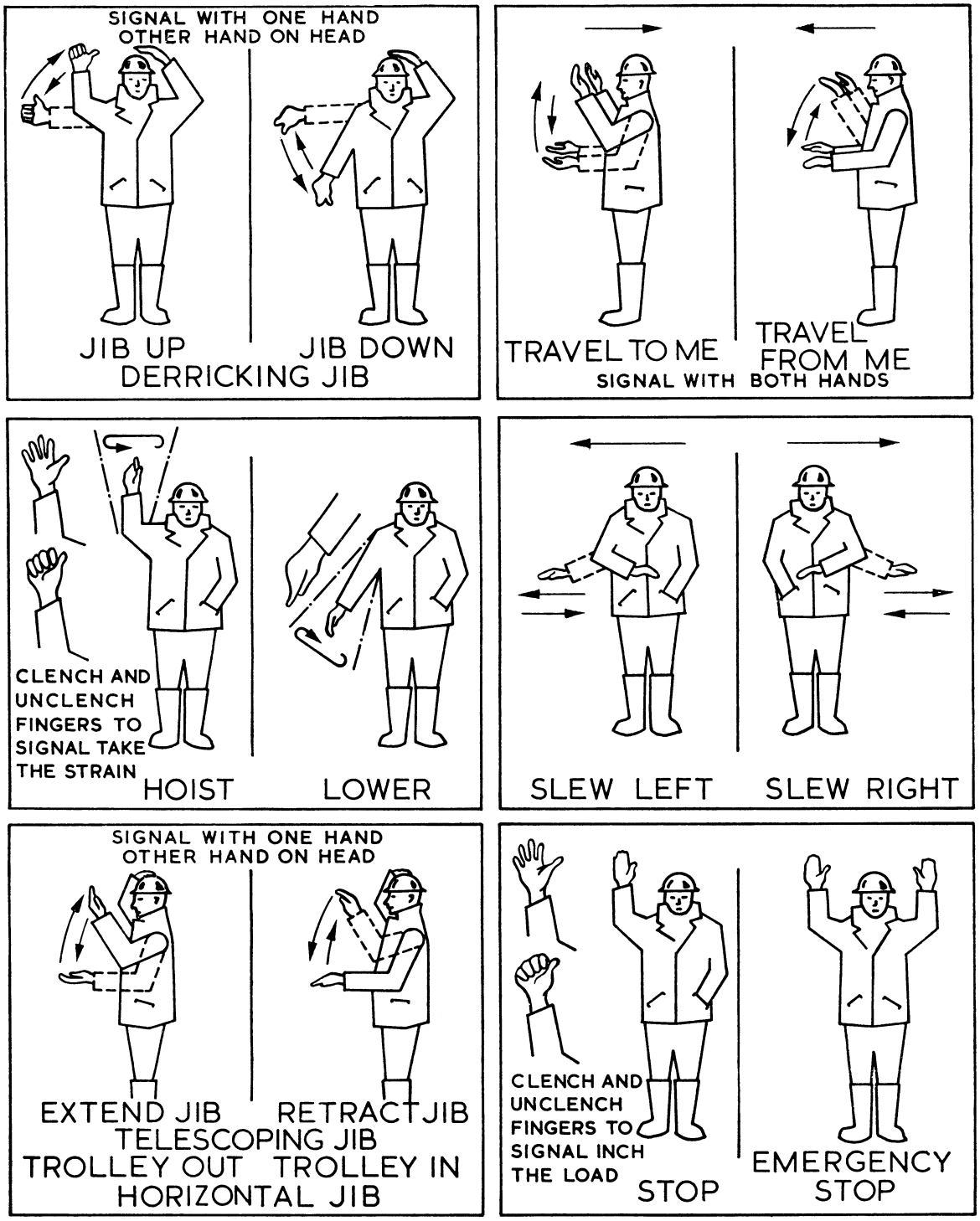
a. Pulling a load sideways.

b. Travelling across a slope.

Figures show typical operational conditions imposing a side loading on the jib of a crane. Jibs are not designed for high side loads in crane service. Do not pull or drag loads sideways either using the slewing motion or hoist line. The hoist line should always be in the plane of the jib and hanging plumb.

AVOID SIDE LOADING THE JIB

Figure 7 — Side loading on jib (see **1.11.1**)



Signaller should stand in a secure position where HE CAN SEE THE LOAD AND CAN BE SEEN CLEARLY by the driver. Face the driver if possible. Each signal should be distinct and clear.

Figure 8 — Know your crane signals (see **1.14.6**)

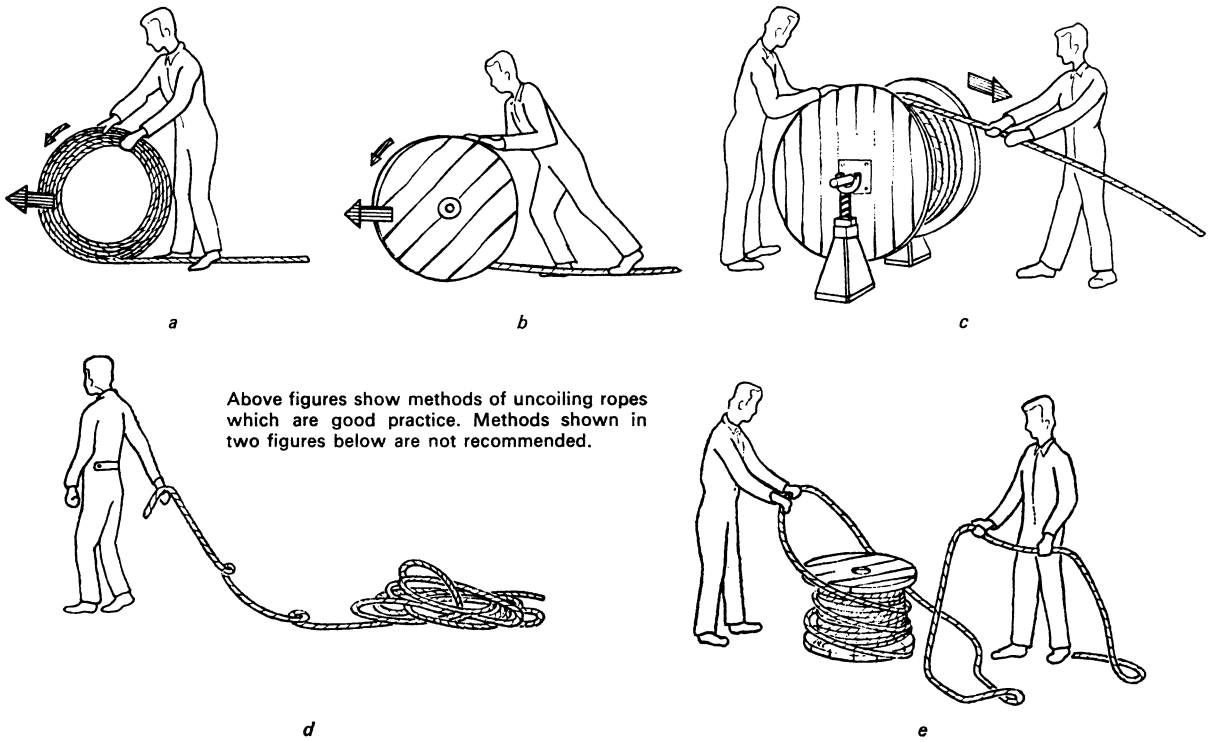


Figure 9 — Rope handling (see **1.13.4**)

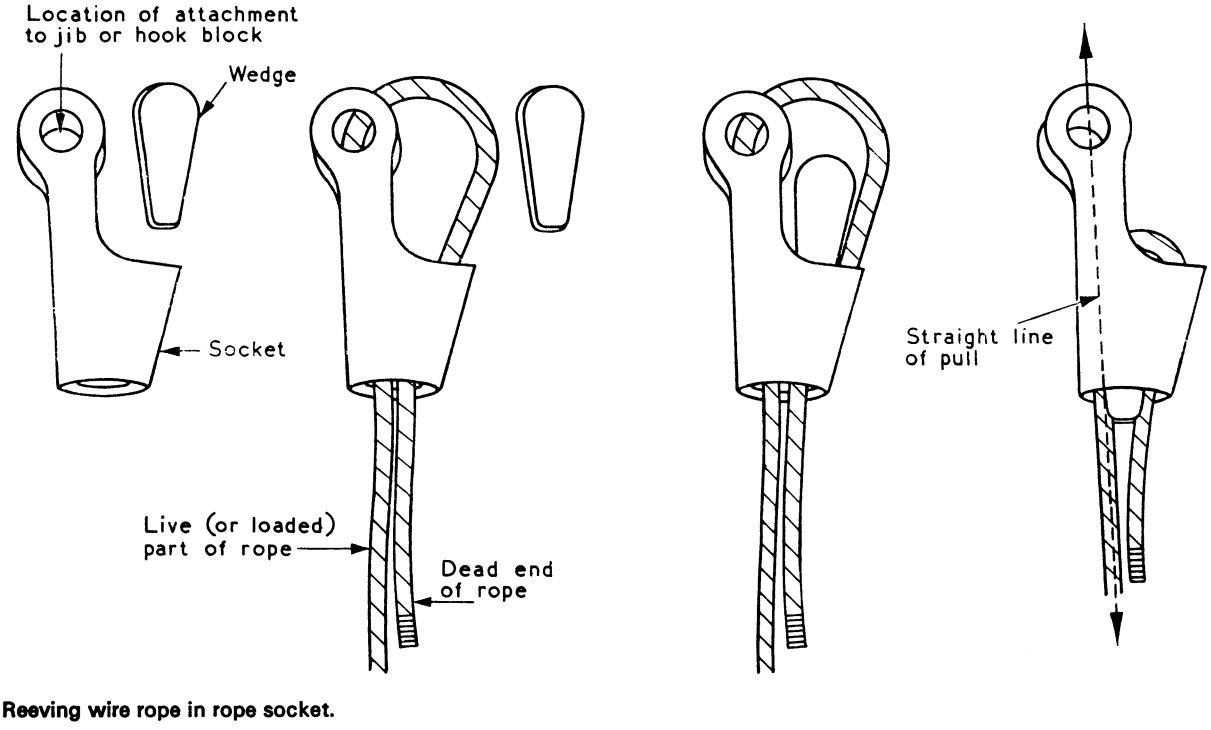
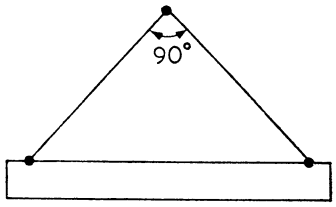
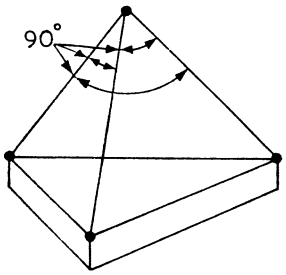


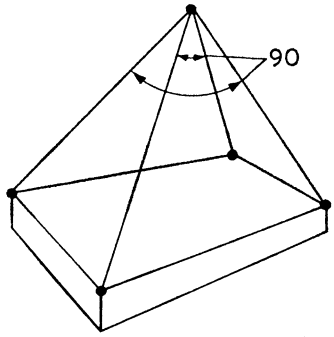
Figure 10 — Wedge/socket rope terminations (see **1.13.9**)



Two-legged sling



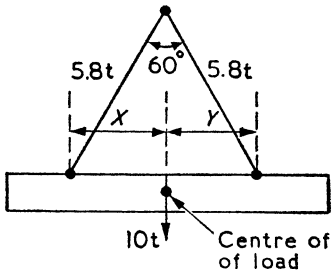
Three-legged sling



Four-legged sling

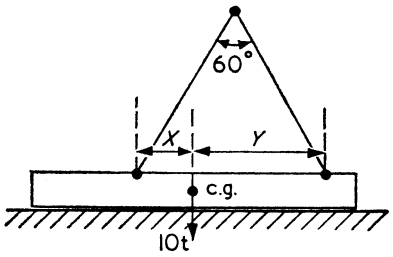
a. **Maximum leg angles.**

With *X equal* to *Y*.

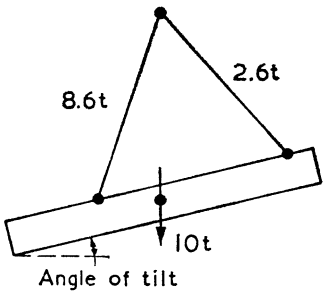


Load hangs level when lifted with equal loading in sling legs

With *X not* equal to *Y*.

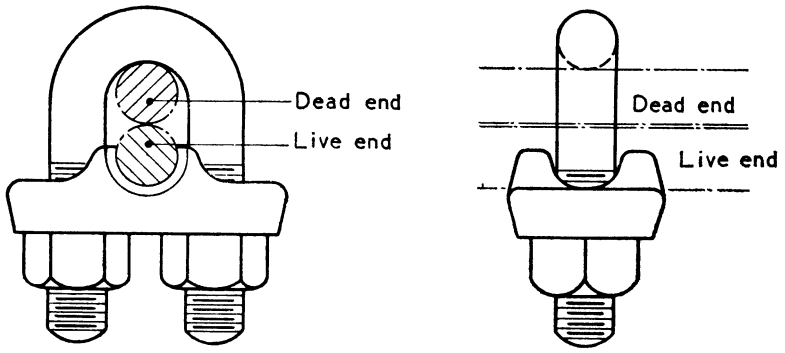


Load tilts when lifted giving unequal loading in sling legs

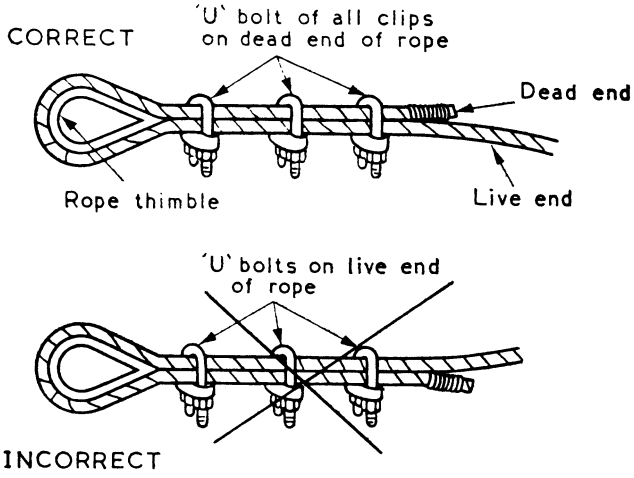


b. **Distribution of load between sling legs (typical example only).**

Figure 11 — Multiple-legged slings (see **1.14.2**)

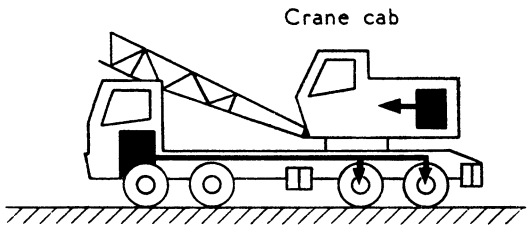


a. **Bull dog grip.**



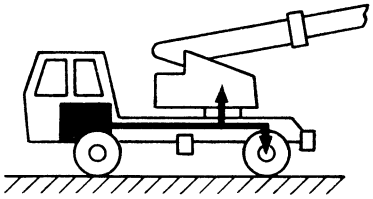
b. **Method of fitting rope grips.**

Figure 12 — Use of rope grips (see **1.14.3**)



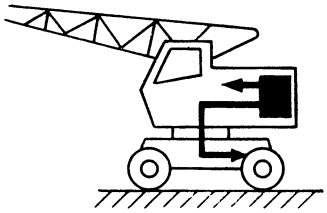
Truck driving cab

Truck mounted crane
Designed to travel at speeds up to 30 m.p.h. or more



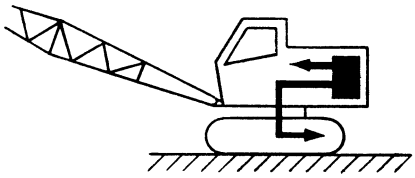
Crane controlled from truck driving cab

Alternative arrangement

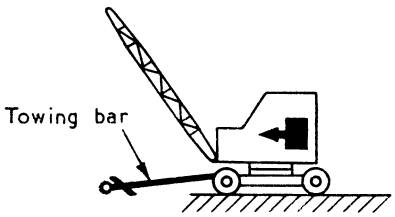


Propel and steering controlled from crane cab

Self-propelling wheel mounted crane
Designed to travel at speeds up to 12 m.p.h. or more



Self-propelling crawler track mounted crane
Designed to travel at speeds up to 2 m.p.h.

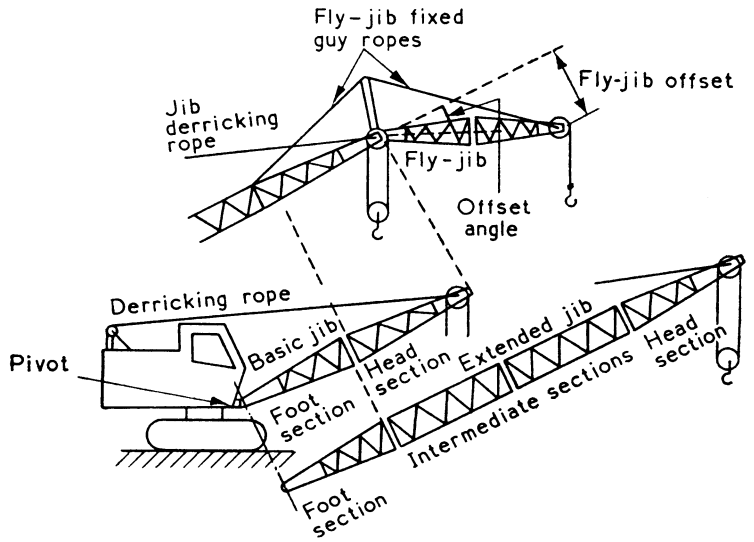


Portable crane
Without power travelling mechanism

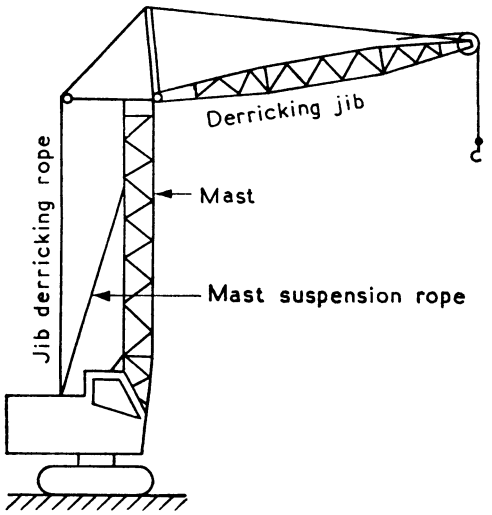
In the above diagrams the symbols shown ←■ represent the power unit(s) and transmission(s).
(Ropes and other crane details omitted for clarity.)

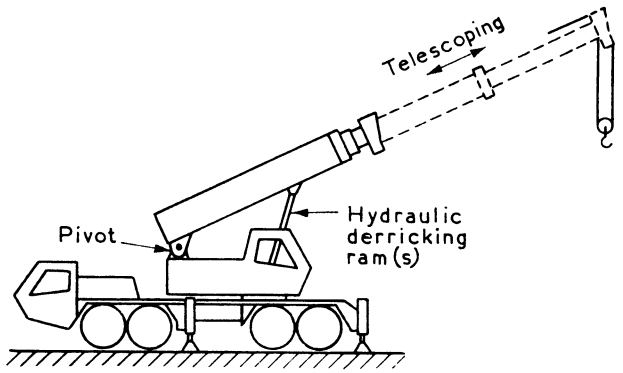
Figure 13 — Types of mounting for mobile cranes (see **2.1.1**)

a. Lattice strut type jib



b. Mast crane





c. Telescopic cantilever jib (Hydraulic)

d. Lattice cantilever jib

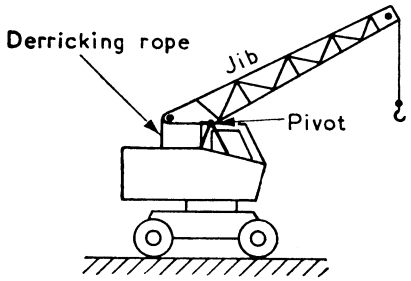


Figure 14 — Types of jib on mobile cranes (not relatively scaled) (see **2.1.4** and **2.7.3**)

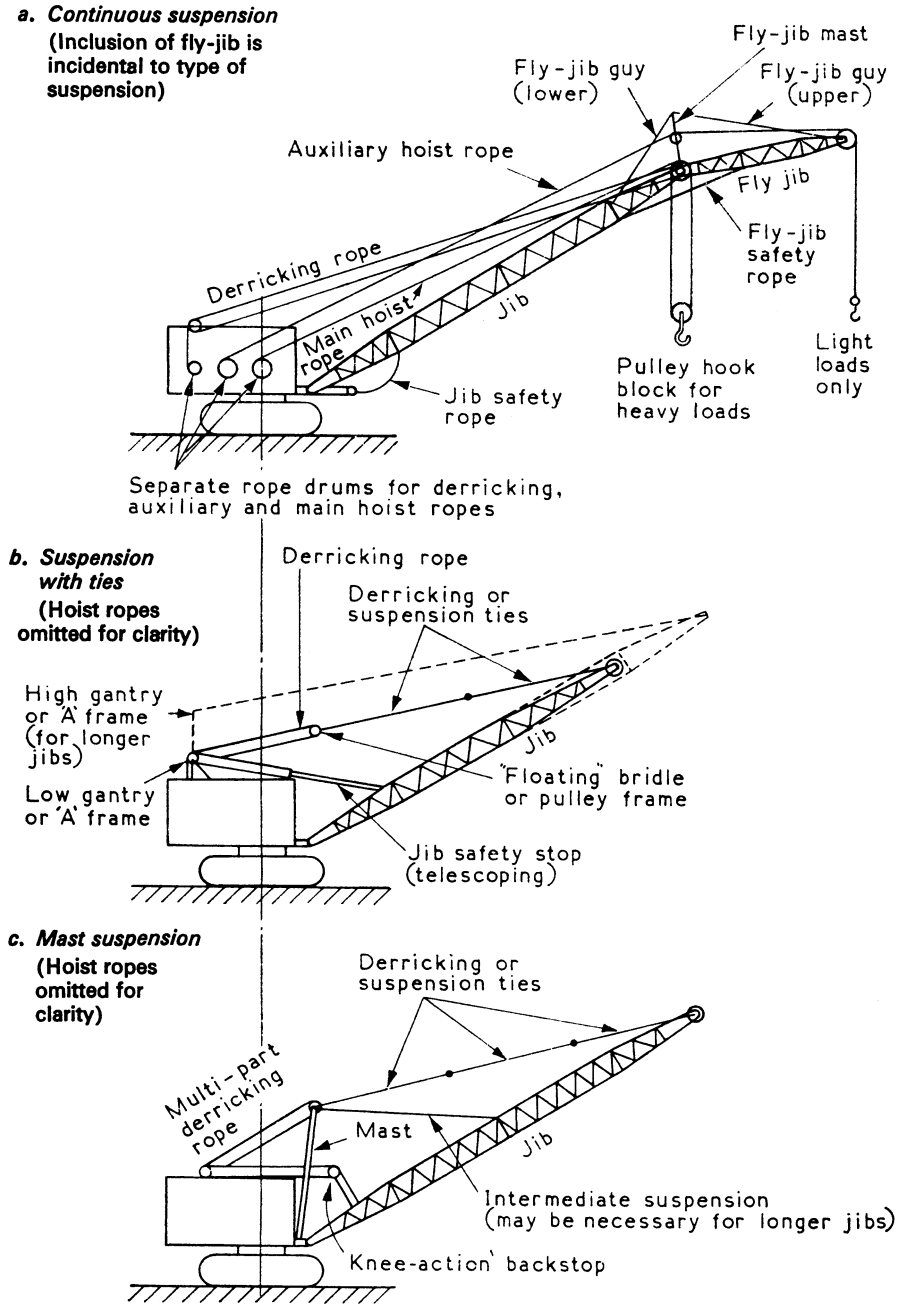


Figure 15 — Typical rope and suspension systems on mobile cranes (see **2.9.3** and **2.9.4**)

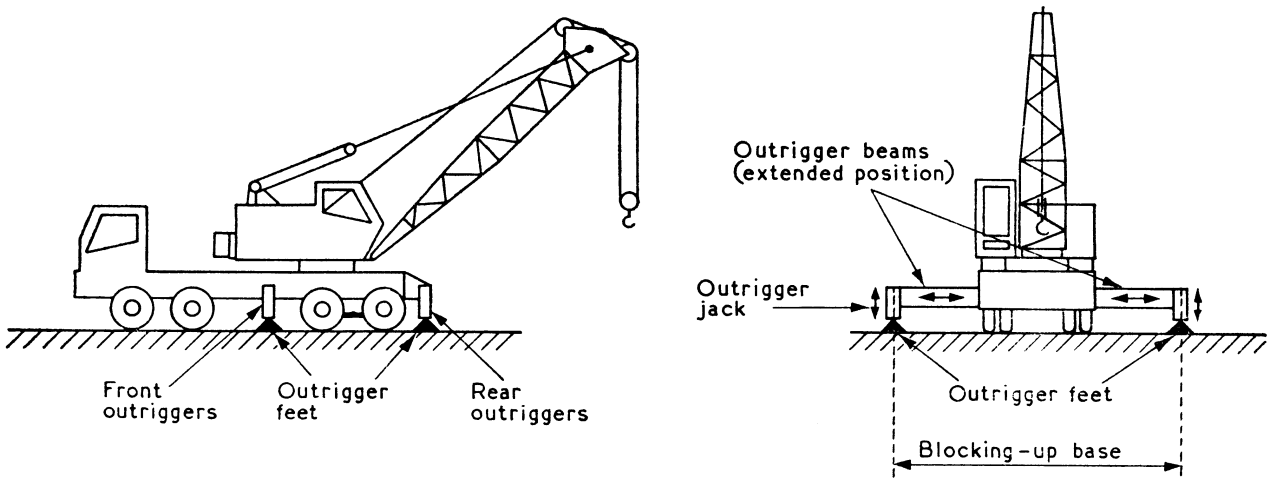


Figure 16 — Typical truck crane shown with outriggers set (see **2.9.6**)

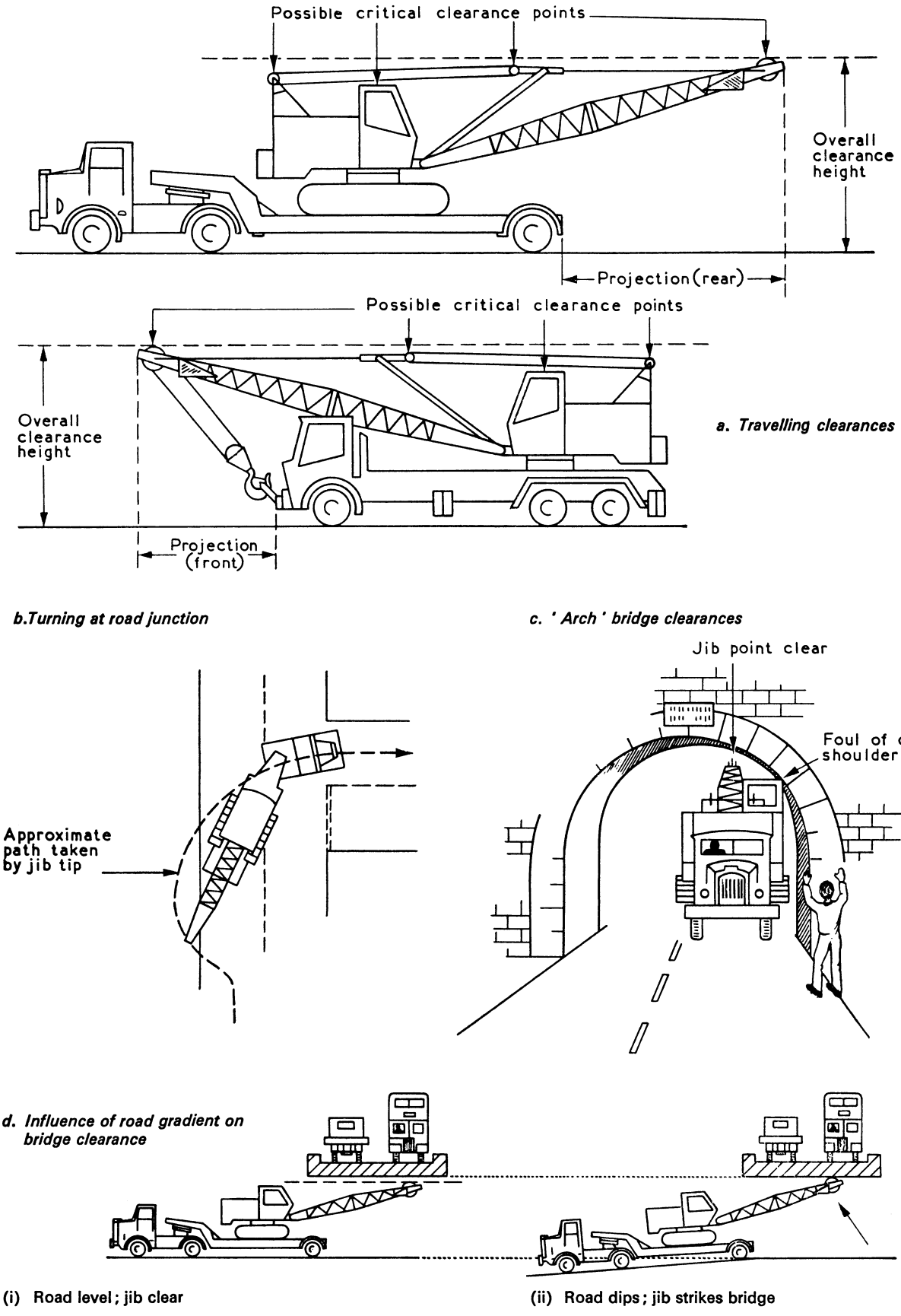
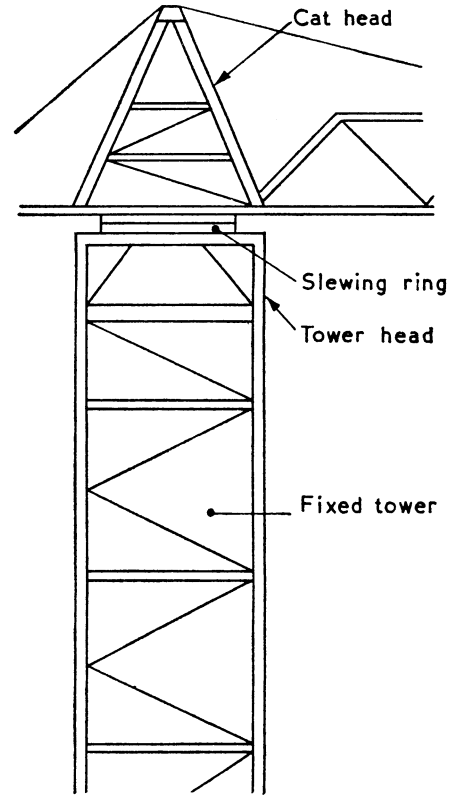
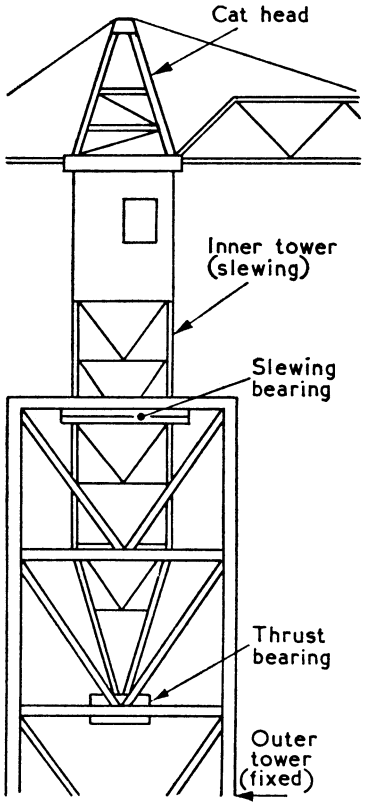


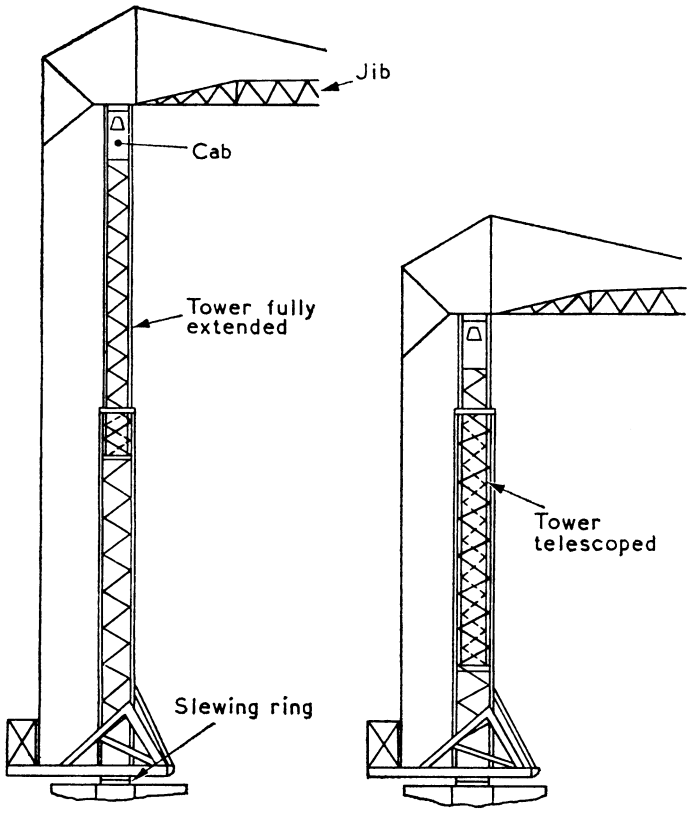
Figure 17 — Transportation and travelling (see **2.9.9.6**)



a. Mono tower

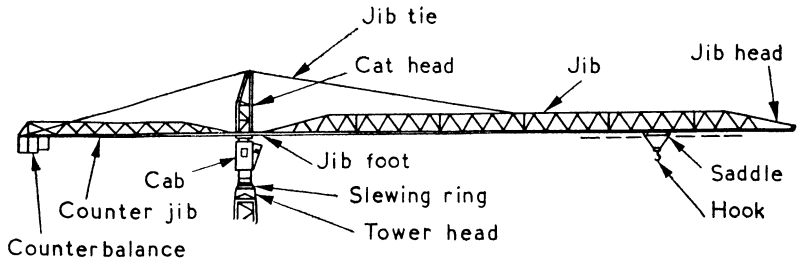


b. Inner and outer tower

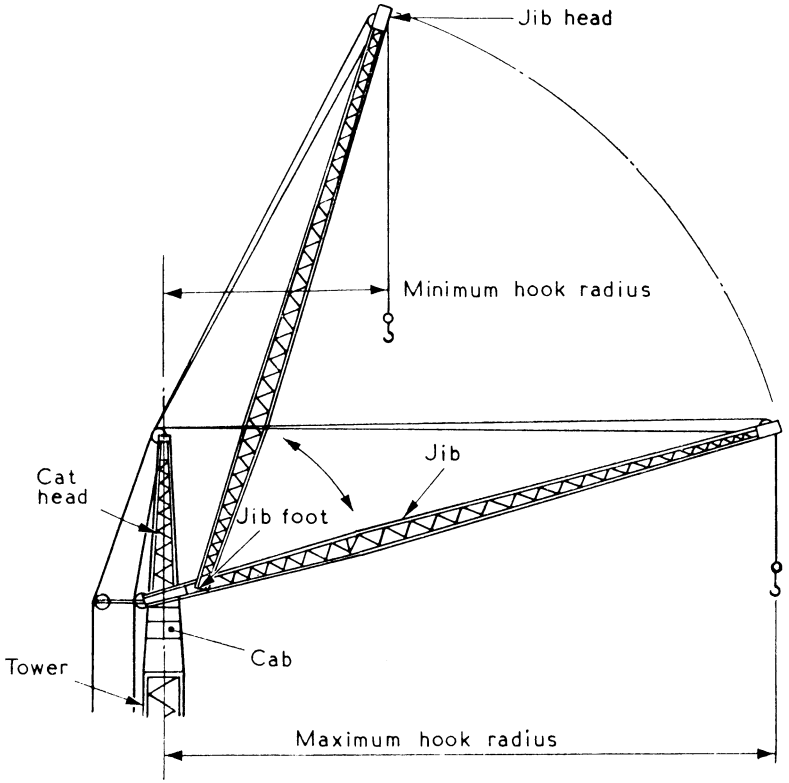


c. Telescopic tower

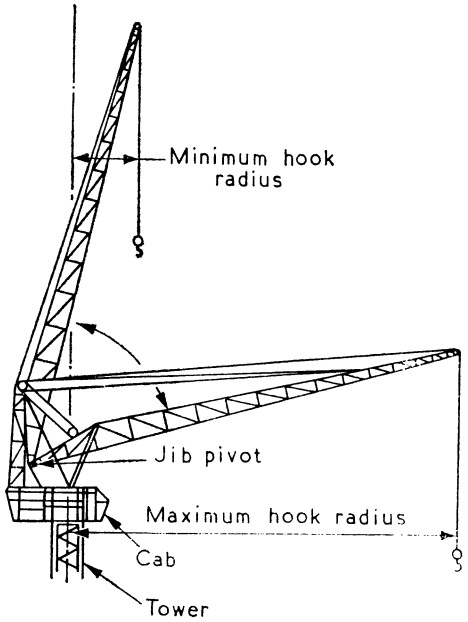
Figure 18 — Types of tower on tower cranes (see **3.1.1**)



a. Saddle jib

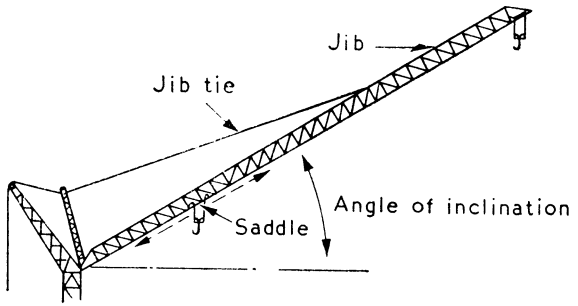


b. Luffing jib



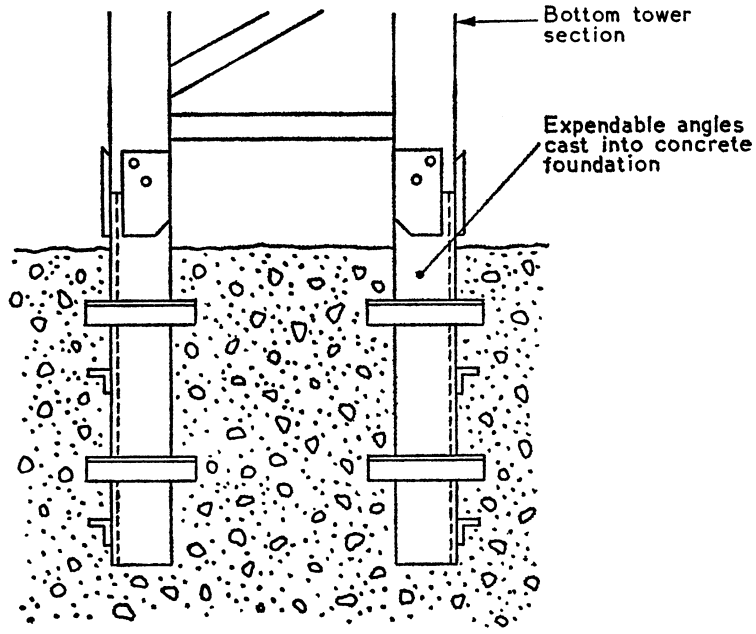
d. Rear pivoted luffing jib

NOTE. On some jibs of this type, the hook radius is altered by moving the saddle along the jib. On others the saddle is locked in position at the jib head and the hook radius is fixed.

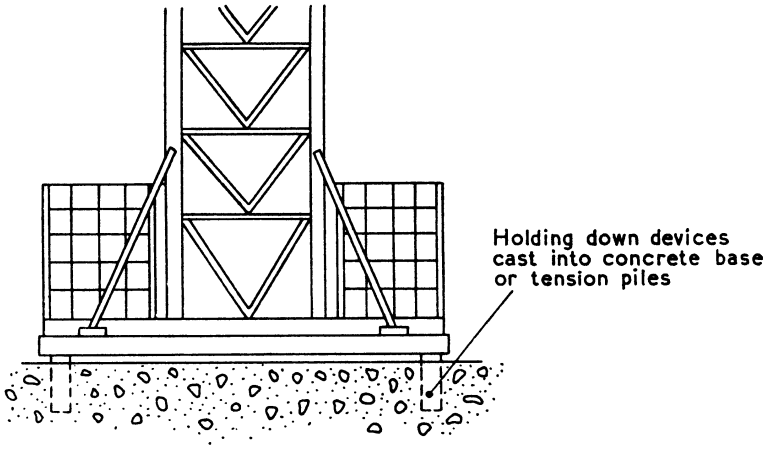


c. Fixed luff jib

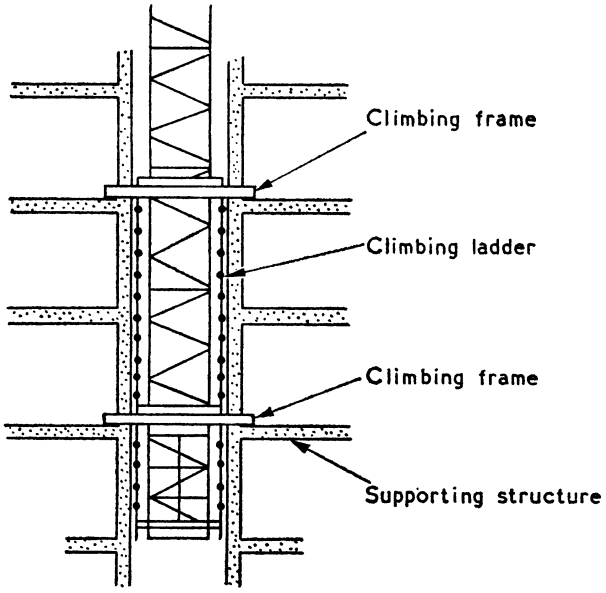
Figure 19 — Types of jib on tower cranes (see **3.1.2**)



a. In-situ

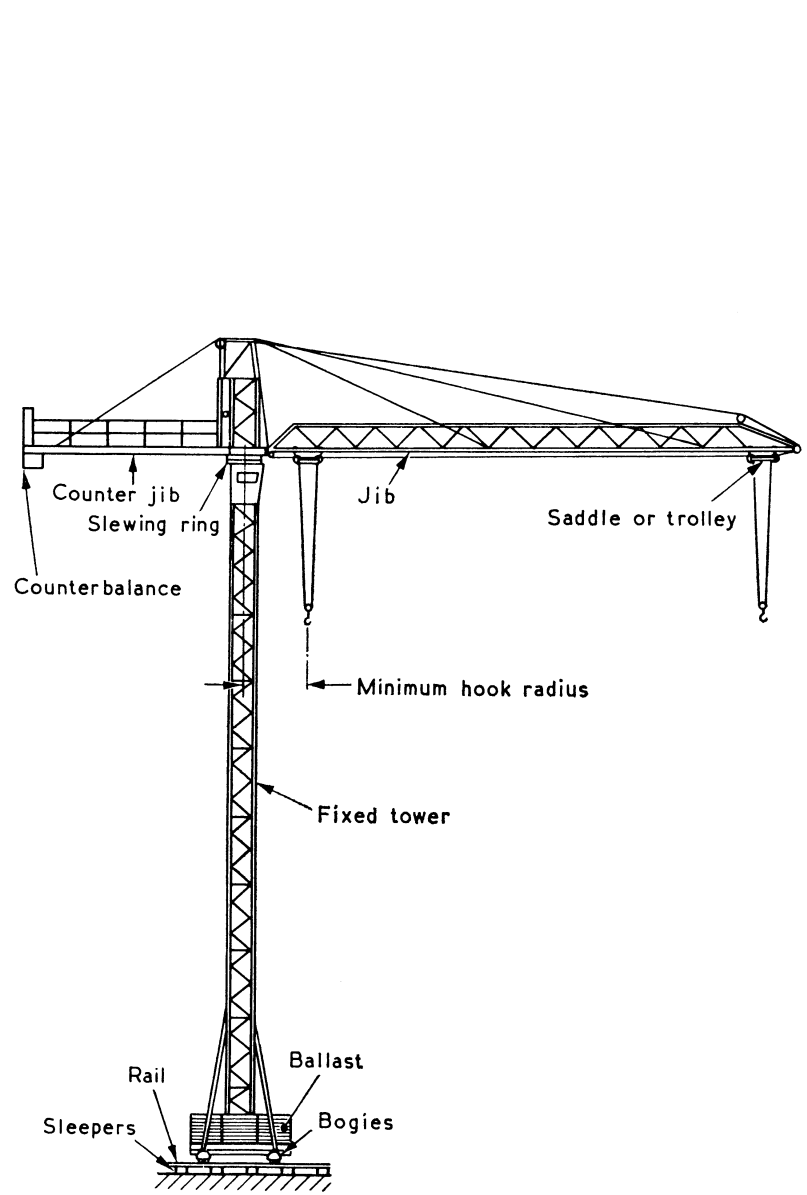


b. On own base

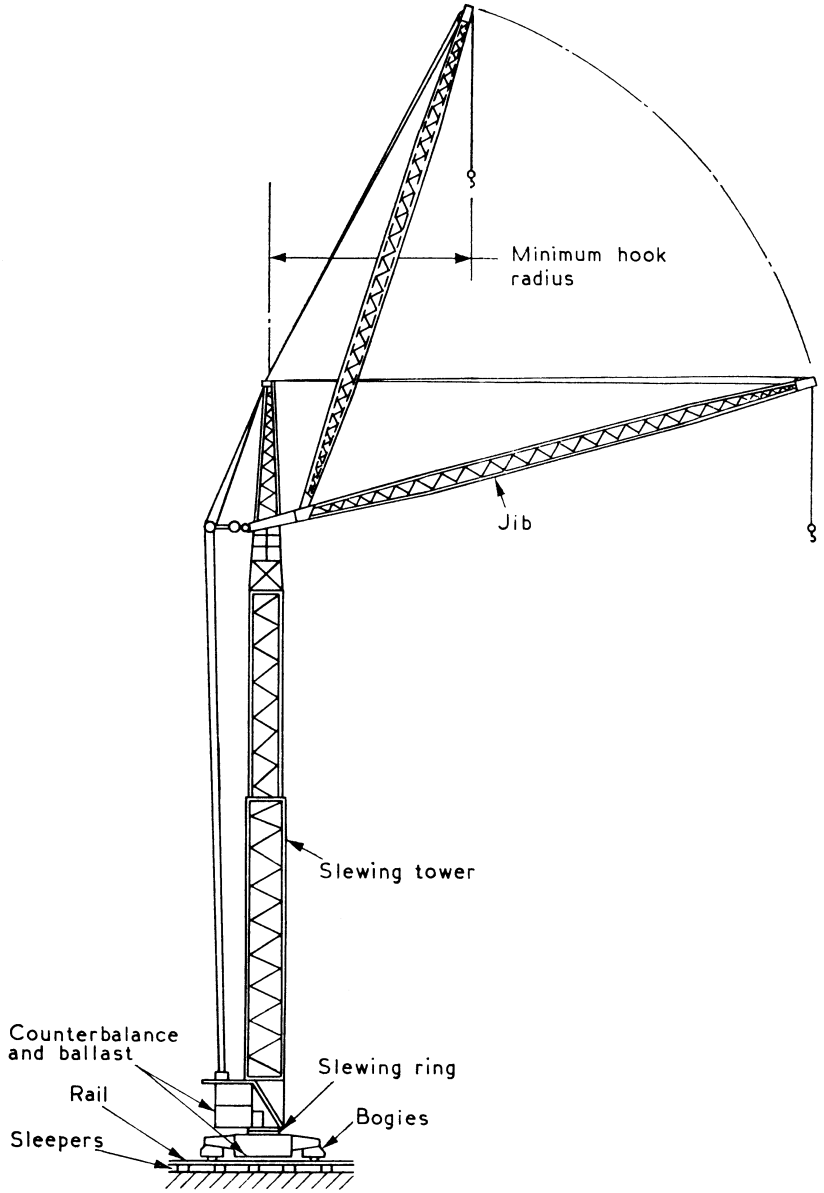


c. Climbing crane

Figure 20 — Types of static base for tower cranes (see **3.1.3**)



a. With saddle-jib and fixed tower



b. With luffing jib and slewing tower

Figure 21 — Rail-mounted tower cranes (see **3.1.4**)

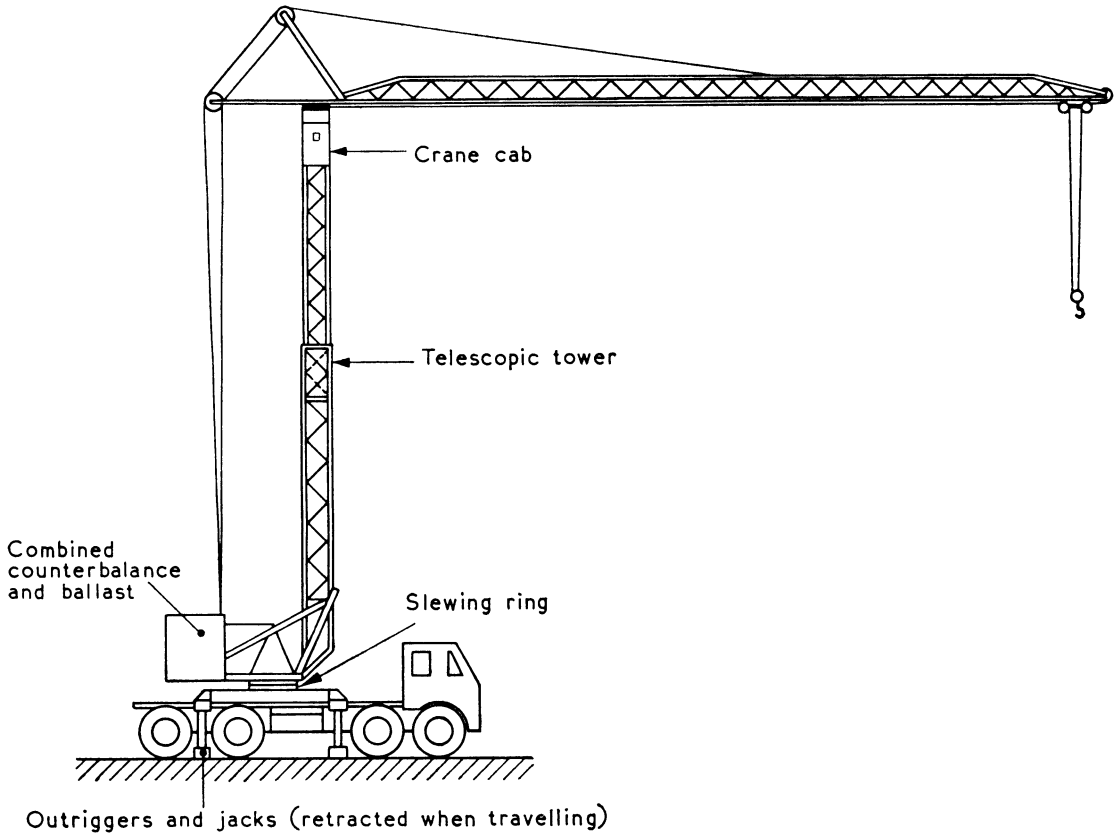


Figure 22 — Truck-mounted tower crane (see **3.1.5**)

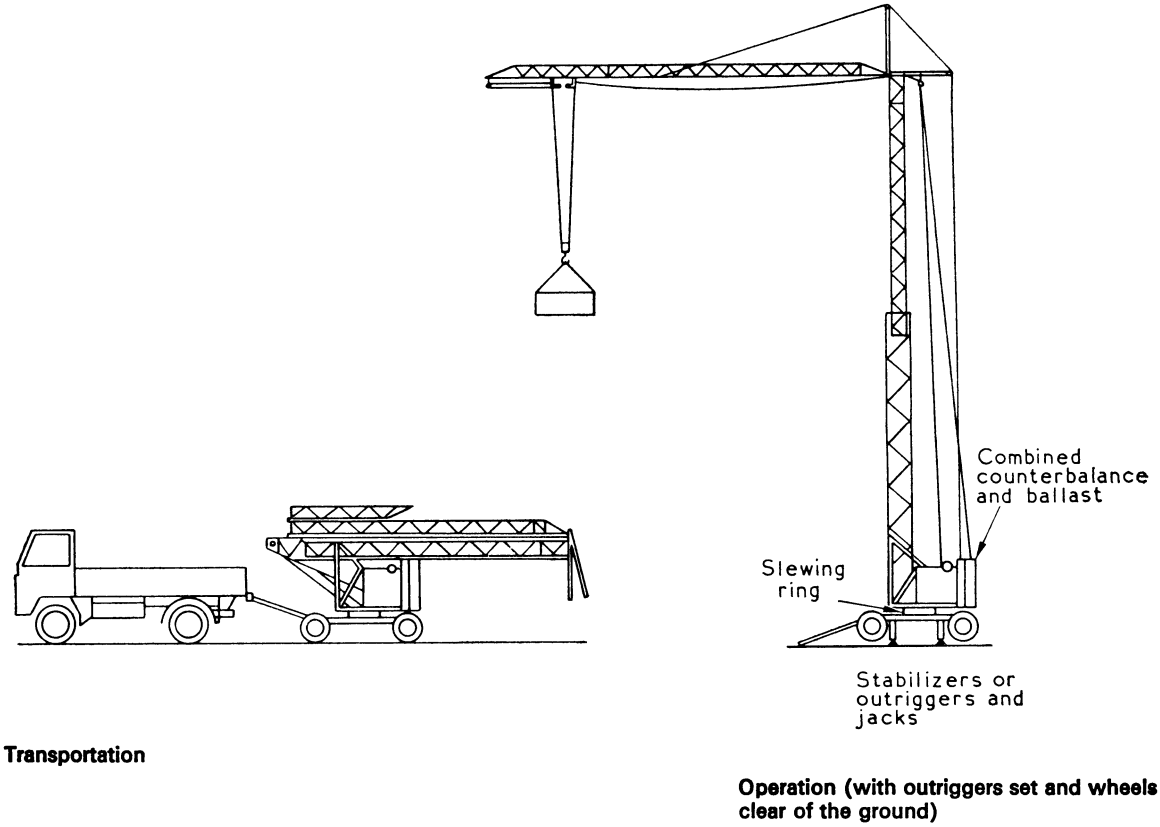


Figure 23 — Wheel-mounted tower crane (see **3.1.6**)

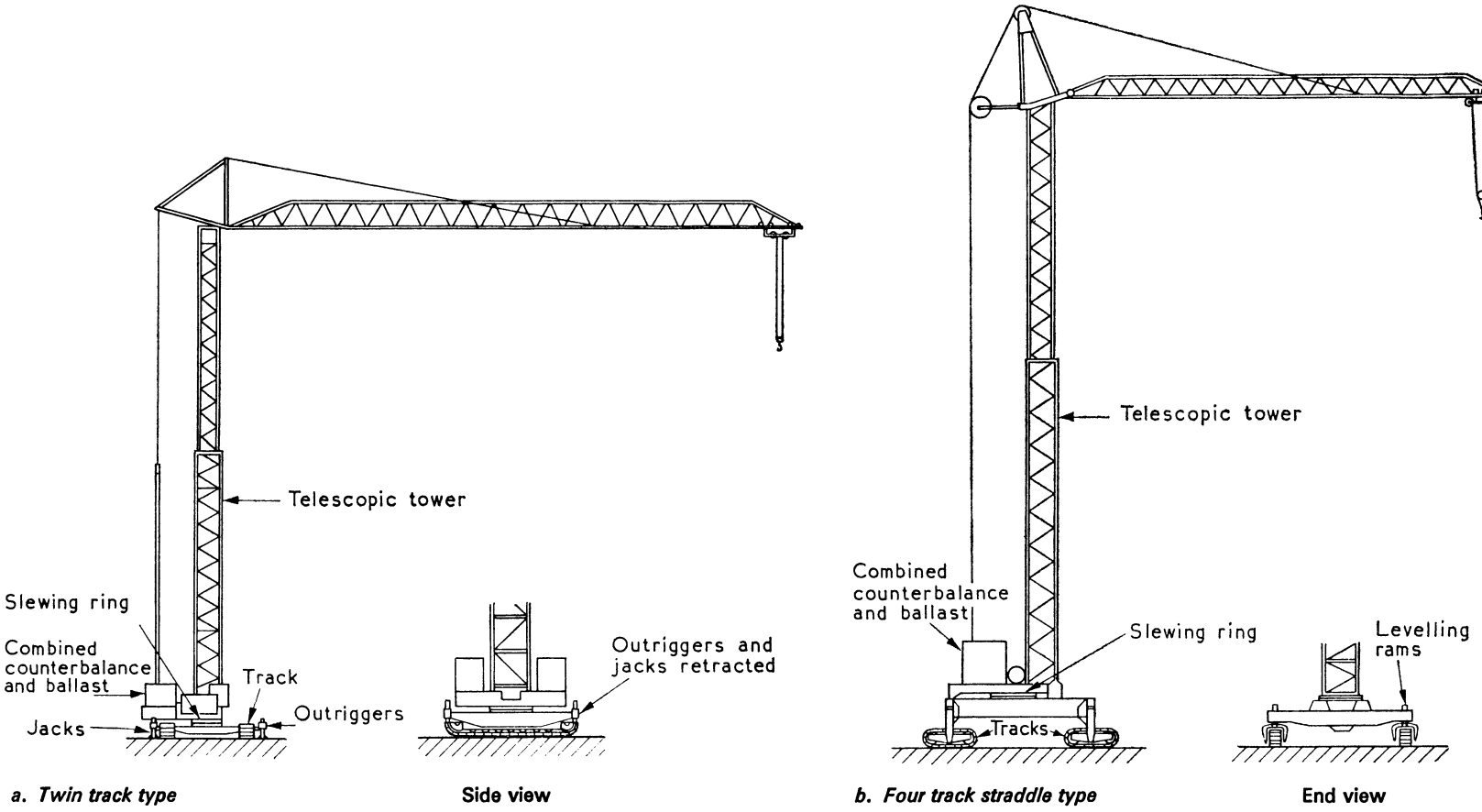


Figure 24 — Crawler-mounted tower cranes (see **3.1.7**)

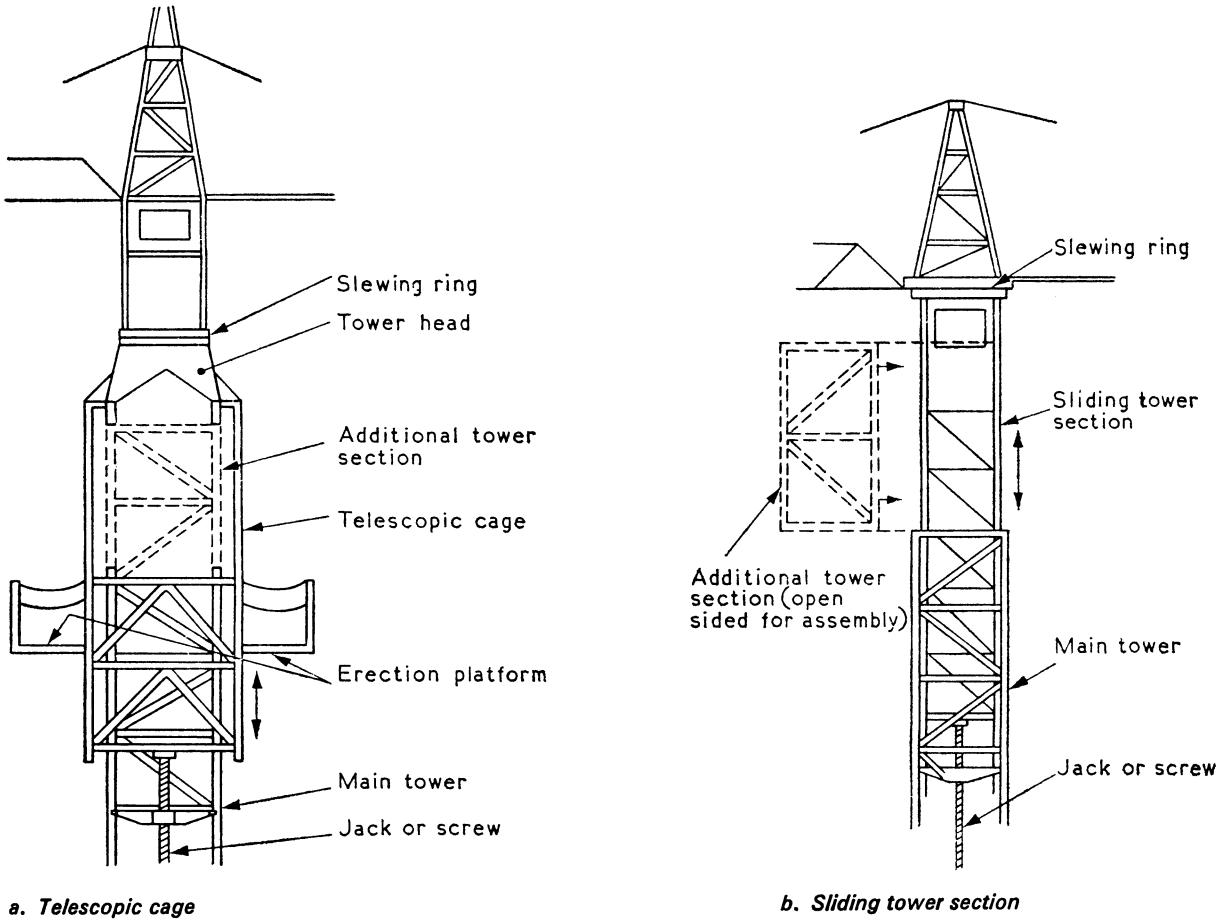


Figure 25 — Tower extension equipment (see **3.9.11**)

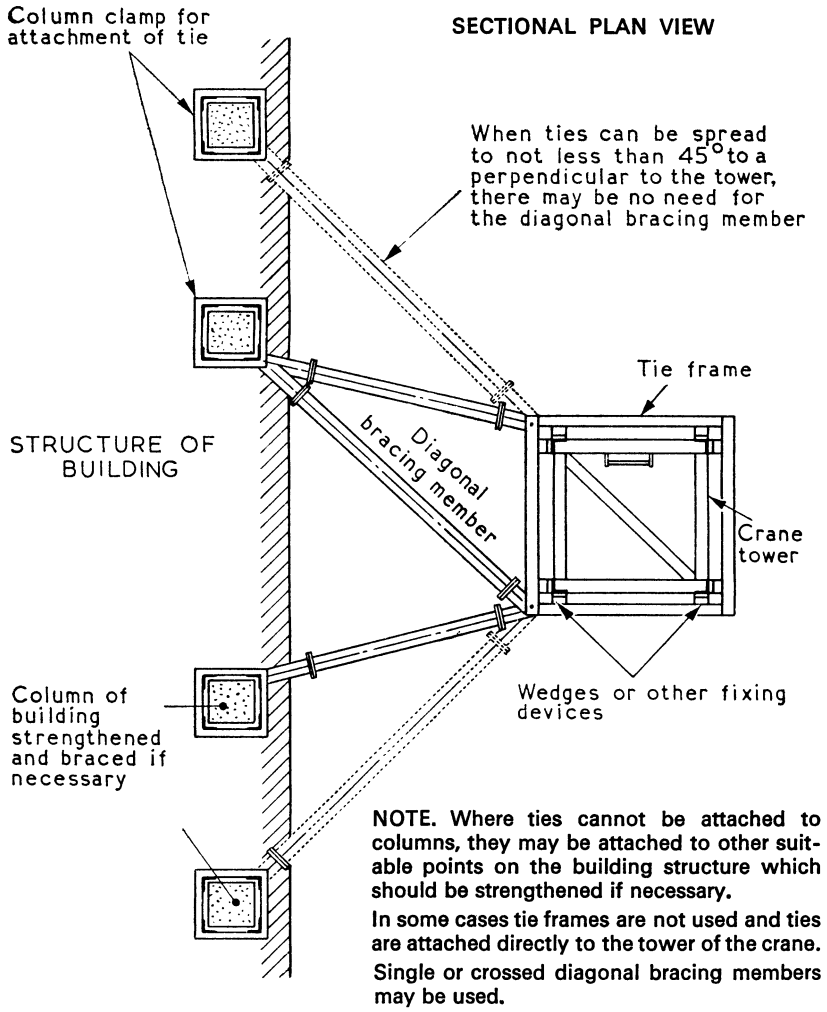


Figure 26 — Tying back a tower crane (see **3.9.12**)

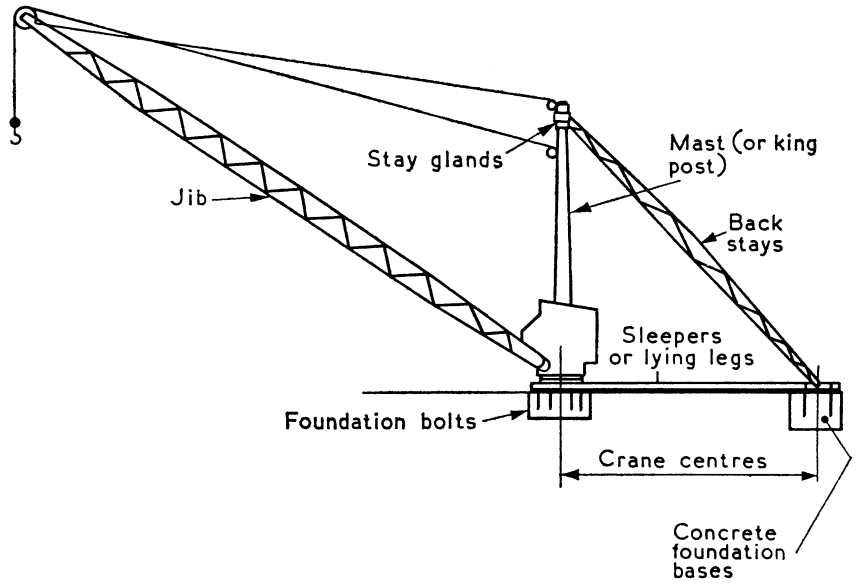
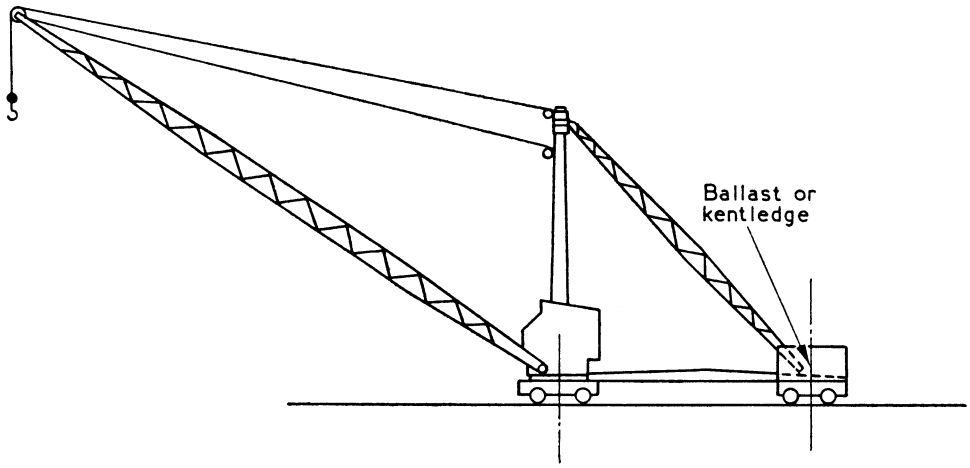


Figure 27 — Scotch derrick on concrete blocks (see **4.1.1**)



(See Figure 30 for typical plan layouts)

Figure 28 — Scotch derrick on bogies (see **4.1.1**)

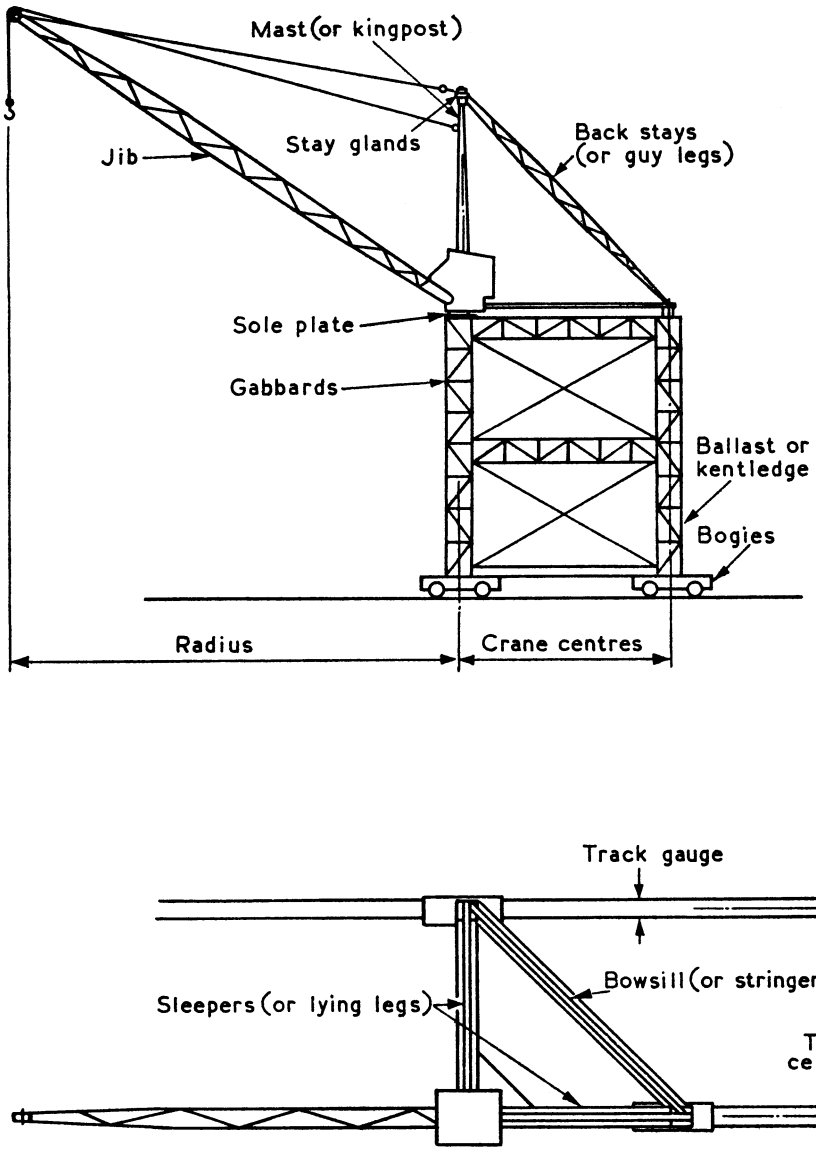
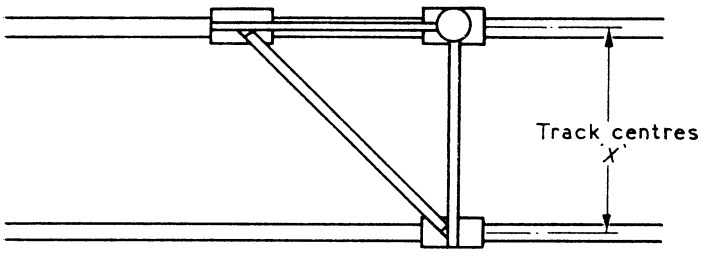
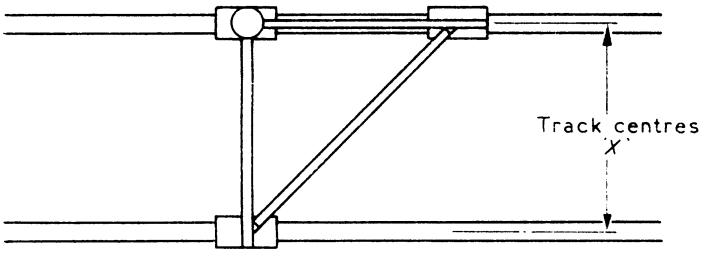


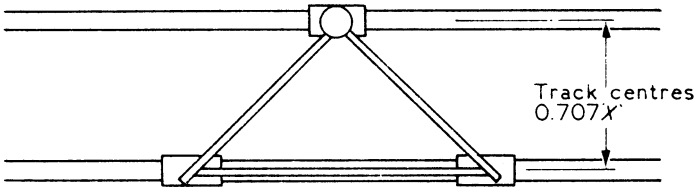
Figure 29 — Scotch derrick on bogie-mounted gabbards (see **4.1.1**)



a. ' L ' formation or square on mast and left leg



b. ' L ' formation or square on mast and right leg



c. ' A ' formation or ' butterfly'

Figure 30 — Building configurations of Scotch derrick (see 4.8)

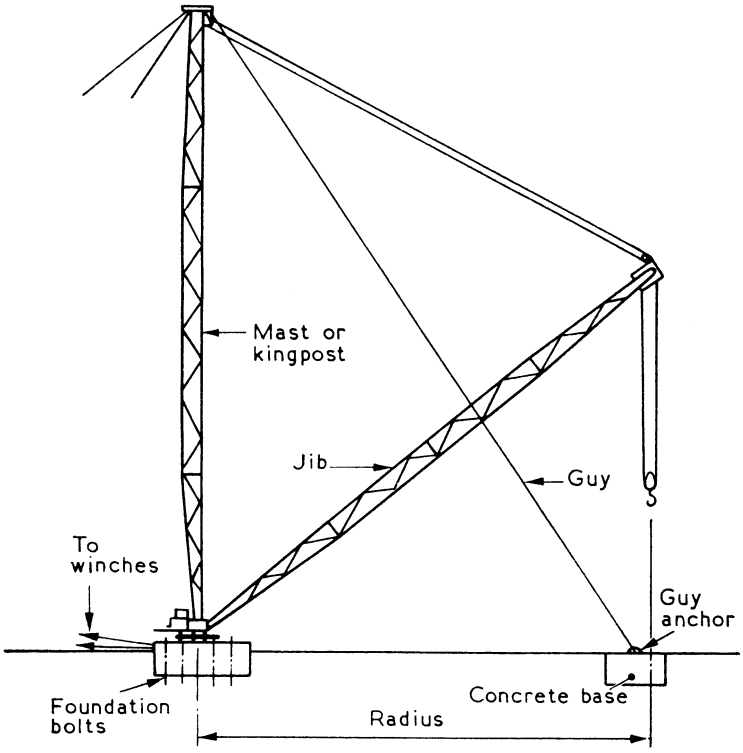


Figure 31 — Guy derrick (see **4.1.2**)

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