A guide to rigging

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1. Rigging
2. Certification
3. Occupational health and safety

Second edition 1997

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Information on the latest laws can be checked by visiting the NSW legislation website (www.legislation.nsw.gov.au) or by contacting the free hotline service on 02 9321 3333.

This publication does not represent a comprehensive statement of the law as it applies to particular problems or to individuals or as a substitute for legal advice. You should seek independent legal advice if you need assistance on the application of the law to your situation.

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Foreword

This competency guide has been developed jointly by the WorkCover Authority of NSW and the Victorian WorkCover Authority.

It is a major revision of the old and widely respected NSW publication, *A guide for riggers*. It has been structured to reflect the nationally uniform certificate classes for rigging and conform to the standards for rigging set out in the *National OHS Certification Standard for Users and Operators of Industrial Equipment*. The text is also consistent with the nationally uniform assessment instruments used by certificate assessors and a range of Australian Standards which cover equipment and work involved with rigging.

This guide is designed to be a useful reference for trainee riggers, certificated riggers, leading hands and rigging supervisors, training providers, certificate assessors, and government inspectors.

General Manager
WorkCover Authority of
New South Wales

Chief Executive
Victorian WorkCover Authority
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Introduction

Rigging is work involving the use of mechanical load shifting equipment and associated gear to move, place or secure a load including plant, equipment or members of a building or structure and to ensure the stability of those members and the setting-up and dismantling of cranes and hoists.

There are four certificate levels involved in rigging:

- Dogging
- Basic rigging
- Intermediate rigging
- Advanced rigging.

This guide outlines the competency based skills needed to carry out basic, intermediate and advanced rigging safety. Basic rigging incorporates the skills needed for dogging. Refer to A guide for dogging, WorkCover Authority of NSW.

Basic rigging

Those qualified in basic rigging must know how to carry out work associated with:

- movement of plant and equipment
- steel erection
- particular hoists
- placement of pre-cast concrete
- safety nets and static lines
- mast climbers
- perimeter safety screens and shutters
- cantilevered crane loading platforms.

Intermediate rigging

Those qualified in intermediate rigging must know how to carry out work associated with all basic rigging competencies and:

- the rigging of cranes, conveyors, dredges and excavators
- all hoists
- tilt slabs
- demolition
- dual lifts.
Advanced rigging

Those qualified in advanced rigging must know how to carry out work associated with all basic and intermediate rigging competencies and:

• the rigging of gin poles and shear legs
• flying foxes and cableways
• guyed derricks and structures
• suspended scaffolds and fabricated hung scaffolds.

Occupational health and safety

Under occupational health and safety legislation in each of Australia’s states and territories:

• employers must provide and maintain equipment and systems of work that are safe and without risk to health
• employers must provide the correct equipment so that rigging work can be carried out safely
• employees must take care for the health and safety of themselves and fellow workers and cooperate with their employer while at work.

This guide

This guide aims to:

• prepare readers to pass an examination for basic, intermediate and advanced rigging certificates
• provide the basic knowledge to help the reader to carry out rigging work safely
• be used as a reference book when carrying out rigging work.

In addition to covering all rigging competencies there is a ‘Glossary of Terms’, a set of ‘Sample Assessment Questions’ and an index to assist the reader.
Part one

General rigging principles
Chapter 1 Flexible steel wire rope

Introduction

Flexible steel wire rope (FSWR) is the link between the crane and the load.

The hoist drum of the crane is the pulling mechanism which rotates, hauls in and stores surplus wire. The braking mechanism is connected to either the drum or the gearing which is joined to the drive mechanism.

The wire passes over the head sheave of the crane and then down to the load.

There are many different types of lays and construction of FSWR to combat fatigue and abrasion, the two destructive forces which occur whenever FSWR is bent over a system of sheaves.

Wire flexes as it bends over sheaves and drums. As the wire bends over the sheave fatigue takes place. The outer wires are stretched and the inner wires are crushed against the sheave groove or drum.

Flexible steel wire rope – lays and construction

FSWR is constructed of wires and strands laid around a central core. In the illustration below there are 19 wires to the strand and 6 strands around the core making up the rope.

It is important not to confuse wires and strands. If a strand is broken, the rope is unusable. A single broken wire in a sling is not as important unless broken immediately below a metal fitting or anchorage.
The core can be:

- Fibre Core (FC)
- Independent Wire Rope Core (IWRC)
- Plastic Core (PC)

The tensile strength of wire ranges from 1220 megapascals (MPa) to 2250 MPa. The most commonly used tensile strengths are 17770 MPa and 1570 MPa.

A 6/19 (six strands of 19 wires each) is the minimum FSWR construction that can be used for slings.

The size of a rope is determined by its diameter. The smallest diameter FSWR that can be used for lifting is 5 mm.

Lay is the direction the wires are formed into strands and the strands are formed into the finished rope. The strands can be laid either left or right around the core. In left hand lay the strands are laid anti-clockwise and in right hand lay they are laid clockwise.

Ordinary lay is where the wires are laid in the opposite direction to the strands.

Lang’s lay is where the wires are laid in the same direction as the strands. There is therefore:

- Right hand ordinary lay – RHOL
- Left hand ordinary lay – LHOL
- Right hand Lang’s lay – RHLL
- Left hand Lang’s lay – LHLL
Lay does not affect the working load limit of the rope but it does determine characteristics such as the spin of the rope.

Lang's lay is used where both ends are fixed to prevent rotation such as for luffing. It must not be used for lifting. (Inspection for birdcaging at the anchorage point must be done regularly.)

Most general purpose ropes are right hand ordinary lay.

**Pre- and post-forming**

Flexible steel wire ropes that are used as crane rope and for slinging are either pre- or post-formed.

Pre-formed ropes have the spiral (helix) put in the individual wires before the wire is laid into the strand.

Post-formed ropes are put through a series of off-set sheaves to bend the spiral into the individual wires after the rope is laid into the strand.

Both pre-formed and post-formed ordinary lay ropes are more resistant than unformed or Lang’s lay to unlaying when cut.

**Lang's lay FSWR**

Lang’s lay is more flexible and harder wearing than ordinary lay ropes. It is used as excavator, dragline, and pile driving ropes where severe abrasion occurs. It is harder wearing because more of the individual wires are exposed to the sheaves.

Lang’s lay has a tendency to unlay if it is used as a single fall crane rope because both wires and strands are laid up in the same direction into the rope. Pre- and post-forming make the rope easier to handle but it will still unlay under load.

**Ordinary lay FSWR**

Ordinary lay ropes are used extensively for slinging.

They are more resistant to unlaying and have less wire exposed to sheaves because of the opposite spiral. They are also more resistant to crushing and kinking because of the very short length of exposed wires.

Ordinary lay ropes are less resistant to abrasion than Lang’s lay.

**Left hand lay FSWR**

A manufacturer may make up a FSWR with left hand lay strands on request. Left hand lay ropes are usually made for a special purpose. They will kink and twist when laying up into a purchase or system of sheaves if they are not laid up in the opposite direction to right handed lay.

**Non-rotating ropes**

Under load all FSWRs have a tendency to unlay including pre- or post-formed and ordinary or Lang’s lay.

To prevent unlaying a left hand lay rope is layed inside a right hand lay rope. This is called a non-rotating ordinary lay rope and is usually used as crane rope. Under strain the opposite spiral in both the inner and outer layers are counter balanced and the rope does not twist.
Core slippage

Non-rotating ropes require careful handling. If the outer strands slip or unlay slightly the core will protrude from the end of the rope. This is called core slippage.

Core slippage can occur if the ends of the rope are not properly whipped before making a cut. Whippings of annealed wire must be put on either side of where the cut is to be made.

The whippings should be put on with a serving mallet very tightly for a distance of at least 1 to 2 times the rope diameter each side of the cut for ropes to 24mm diameter and 4 times for ropes over 24mm diameter.

Core slippage can occur as a wire is rope around a thimble for splicing. The outer wires may ‘birdcage’ or open up as the rope is bent around the small diameter thimble. It is preferable to use large diameter thimbles.

The rope should be tightly served (bound) with marlin or spun yarn for the distance of the length around the thimble, plus twice the length of the annealed wire flat throat seizing.

The seizing should be put on both parts of the rope immediately after securing the thimble into the served eye of the rope. The length of the throat seizing should be equal to at least 3 times the rope diameter.

Severe core slippage can occur when bending non-rotating ropes into wedge socket anchorages due to the small radius of the wedge.

If a wedge socket is used on a non-rotating hoist fall the rope should be frequently inspected.

Handling

Non-rotating ropes are counter balanced to stop the tendency to twist or spin either way. However they are very pliable and bad handling can put turns into the rope.

As turns are put into a rope the outer strands become shorter and the inner core slips along and protrudes from the end and the outer strands bulge into birdcaging. The inner core therefore takes all of the load and may break.

Non-rotating ropes can be used successfully as single and multi-fall crane hoist ropes. However birdcaging at the anchorage is a common fault when they are reeved up as luffing ropes.
Installation

There is a danger of kinking or putting turns into the uncoiled rope when uncoiling it from the manufacturer’s spool or reel.

If a loop forms in the slack rope a kink will form as the rope is drawn tight, or wound on to a drum. Therefore this section of the rope should be discarded.

Mount reels or spools onto a shaft so that the reel will revolve when the rope is pulled off. Care should be taken to brake the spool to keep tension on the rope as it is removed.

Non-rotating constructions

Three common multiple strand, non-rotating ropes are:

17 x 7 N.R – 11 (strands) of (6/1) over 6 (strands) of (6/1) over hemp core.
18 x 7 N.R – 12 (strands) of (6/1) over 6 (strands) of (6/1) over hemp core.
34 x 7 N.R – 17 (strands) of (6/1) over 11 over 6 of (6/1) over hemp core.

Non-rotating ropes prevent spin in nearly all circumstances.
Construction types

Traditionally, round strand Lang’s and ordinary lay FSWR have been constructed of:

- 6 strands of 19 wires (6 X 19)
- 6 strands of 24 wires (6 X 24)
- 6 strands of 37 wires (6 X 37).

Four strand ropes are also being used in newer cranes and hoists which have the same number of wires as six and eight strand ropes.

Most FSWR are parallel or equal laid with the inner wires in the strand laid in a longer spiral so that the top wires do not cross the inner wires.

To prevent a different spiral in the inner and outer wires of strands and to obtain parallel lay, different size wires are laid into the same strand. The standard constructions which use this method are:

- **Seale**
  Large diameter wires are laid up on the outside and smaller wires are laid up on the inside over a central core wire. The large wires resist abrasion and the small wires give flexibility.

- **Warrington**
  Alternative large and small wires are laid up on the outside of the strand combining flexibility and resistance to abrasion.

- **Filler**
  A number of wires are laid over a central wire and an equal number of very small wires are laid in the valleys of these wires. Larger wires are then laid in the valleys between the large and small wires.

  Seale and Warrington, and Filler and Seale have been combined to make ‘Warriflex’ and ‘Seale-Filler’ which both have greater flexibility combined with resistance to abrasion.
6 x 19 Rope group constructions

6 x 19 (12:6:1) F.C.
3 x 19 (12:6:1) W.S.C.
6 x 19/3 x 37 F.S.C.
6 x 19/5 x 7 F.W.R.C.

6 x 19 S. (10/8:1) F.C.
6 x 19 S. (10/8:1) F.C.
6 x 19 S. (10/8:1) F.C.
6 x 19 S. (10/8:1) F.C.
6 x 20 S.W. F.C.

6 x 19 W. (6 & 6 6/1)
6 x 27 F.W. (10/15 + 5/11) F.C.
6 x 26 F.W. (12/6 + 6/1) F.C.
6 x 25 F.W. (12/6 + 6/1) F.C.
5 x 25 F.W./3 x 47 F.S.C.

6 x 25 W. (7 & 7 4/3)
6 x 19 S. (10/9:11)
6 x 21 F.W. (10/5 + 3/1)
6 x 21 F.W. (10/5 + 3/1)
6 x 21 F.W. (10/5 + 3/1)
6 x 21 F.W. (10/5 + 3/1)
1 x W.R.C.
6 x 37 Rope group constructions

8 x 19 Rope group constructions
Rope inspection

When inspecting ropes inspect the whole system not just the FSWR. Ropes can be affected by:

- physical and mechanical factors such as abrasions, fatigue, reverse bends and so on
- environmental conditions such as the weather, salt air, freezing conditions, extreme heat, steam, acid vapours, dust and so on.

1. Mechanical damage due to rope movement over sharp edge projection whilst under load.

2. Localised wear due to abrasion on supporting structure. Vibration of rope between drum and jib head sheave.

3. Narrow path of wear resulting in fatigue fractures, caused by working in a grossly oversize groove, or over small support rollers.

4. Severe wear in Lang’s lay, caused by abrasion at cross-over points on multi-layer coiling application.

5. Severe corrosion caused by immersion of rope in chemically treated water.

6. Typical wire fractures as a result of bend fatigue.

7. Wire fractures at the strand, or core interface, as distinct from ‘crown’ fractures, caused by failure of core support.

8. Typical example of localised wear and deformation created at a previously kinked portion of rope.


**Broken wires**

As the rope lays into a sheave friction occurs and the outside of the wires wear and become flat. Langs lay ropes are much less prone to outer wire wear than ordinary lay.

As outer wires wear and the wire rope is bent over sheaves the fatigue will start to break them.

The maximum number of broken wires allowed in a FSWR is 10 per cent of the total number of wires over a length 8 times the diameter of the rope.

For example: 25mm diameter / 6 x 19 Seale.

Diameter = 25mm

25 x 8 = 200mm length

Total wires in 6 x 19 = 114 wires

10 per cent of 114 = 11.4 wires

**Maximum number of broken wires allowed in a length of 200mm**

= 11

Condemn any FSWR showing broken wires in the valleys between the strands (an indication of extreme fatigue).

Condemn a FSWR where there is one broken wire at the start of any anchorage. This is a sign of localised fatigue.

Crane or luffing pendant ropes should be checked for broken wires. Although they do not pass over sheaves they are subject to fatigue due to vibration.

If there are three or more broken wires in eight rope diameters the pendant should be inspected by a rope expert.

*The rope must be replaced*

*Watch for broken wires in this area*
Reduction in diameter

External wear on the individual wires is caused by friction on drums and sheaves.

Where the rope diameter has reduced to 85 per cent or less of the original diameter, the rope should be discarded even if there are no broken wires.

Fibre rope cores can be crushed and broken if the rope is bent over sheaves while the core is frozen. Under these conditions the FSWR can eventually lose its shape with serious internal corrosion.

When first reeved up and put to work a wire will show considerable wear because it is ‘bedding in’ to the sheave and drum grooves. After bedding in the outer wires will slowly continue to wear and the wearing surface will increase, although on crane ropes the rate of wear will slow down. Consider condemning FSWR when wear on the individual wires starts to exceed one third of their original diameter.

Before re-roping a thorough inspection should be made of the whole sheave system with special attention given to the sheave and drum grooves. A sheave which has been damaged by a previous rope will seriously damage a new rope.

The anchorage should be inspected. One broken wire at an anchorage condemns the rope at that point.

Also check for:

- cracks
- chafing of wires
- worn pins
- worn clevises
- worn thimbles
- corrosion – rust
- crushed or jammed strands especially where the rope may have jumped off the sheave and jammed between the sheave and cheek plate
- wear on the outside wires when the individual outside wires are worn to more than one third of the original diameter
- bird caging in Lang's lay or non rotating ropes especially at the anchorage
- overloading which can usually be seen by the elongation of the lay. (A normal lay takes approximately 8 diameters for a complete spiral.)
Handling new rope

When a new rope is ordered it is essential that the manufacturer’s recommendations regarding length, lay, construction and diameter are followed. If this is not done the life of the rope can be severely reduced.

Laying onto a drum

The new rope should be delivered on a spool. Set up a spool so that the rope runs from the top of the spool to the top of the drum, or from the bottom of the spool to the bottom of the drum.

If a new rope is delivered in a coil, a turntable should be rigged up to run the rope onto the drum. A coil of rope must not be laid on the ground and wound straight onto the drum otherwise there will be severe twisting and kinking of the rope.

Do not take rope off one side of a reel laid flat on the ground as a loop because a kink may be produced from each wrap of the rope taken.

The whole cross section of the rope must be held solid when bolting or securing hoist or luff ropes to winch drum anchorages. If a rope is not completely secured the inner strands can pull out leaving only the outer strands secured at the anchorage.

It is preferable to make some form of gripping mechanism to keep the rope tight as it is wound onto the drum. Two pieces of 100mm x 50mm timber bolted either side of the rope and secured to the head of the boom can be used. The bottom layers of the rope must be tightly and neatly laid onto the drum.

The bottom layers on multiple layered drums must be laid on correctly. If they are not, the lead rope will jam in between lower layers under a heavy load causing condemnable defects in a new rope.

Wire rope: methods of uncoiling

When laying the rope onto an ungrooved drum, use a mallet or a piece of timber (to prevent damage to FSWR) to tap the turns together as they wind onto the drum to ensure that there are no gaps between the lays.
Manual uncoiling

If it is not possible to remove the rope from the reel by using jacks, stands, a turntable or by rolling the reel use the following procedure:

- with the reel resting on its flanges, unwind several wraps of rope to accumulate sufficient slack
- backup the rope to make a loose loop on the spool, slip one loop off the right flange and lie this loop on the floor
- slip a similar loop off the left flange and also lie it on the floor. The rope on the floor will then be in the form of a figure eight
- repeat this procedure first on the right, then on the left, until the required length has been unreel
- roll the reel back off the accumulation of rope on the floor, and pull away the end of the rope. Watch out for any loops thrown out to prevent kinking.

Where the same situation exists with a coil of rope (eg where there is no turntable), the coil should be stood on edge and unrolled as previously described.

If as a last resort the rope must be laid on the ground and uncoiled, extra precautions must be taken to prevent kinking:

- the coil should be laid down so that the outside end of the rope finishes or spirals clockwise for right hand lay or anti-clockwise for left hand lay
- the stops or ties securing the coil may then be removed and the outside end carried along in a straight line, allowing the rope to revolve in the hands as the turns or loops are lifted carefully from the coil by another person and thrown or straightened out immediately as the rope is stretched along.

Rope that has been coiled with underturns by an experienced rigger, will pull away without kinking.

At all times care should be taken to prevent wire rope from running in sand, ashes, clinker, earth, mud and so on.

Hand splicing

A splice is a join in a rope or on to another rope by the interweaving of the separated strands of one part into another part, or into those of another rope.

For an eye splice made on the end of a rope, a short end of the rope is bent back on its own part to form the eye. The strands in the short end are separated, then secured into the main part of the rope by interweaving the strands into those of the main part.

Eye splices, short splices, and cut splices must be made by passing the strands over and under against the lay of the rope. Splices must be tightly drawn and neatly made.

Where a thimble or dead eye is inserted in an eye it must be a tight fit. To achieve a tight fit use a mild steel annealed strand ‘flat’ or ‘round’ seizing applied at the throat of the splice before beginning the splice.

Thimbles must be used where ropes are spliced to hooks, shackles, rings, swivels, pins, eyes, and similar fittings.

Hand splicing can only be learned under experienced supervision and with the correct materials. This section is designed to be referred to by those learning to hand splice.
Tools used for hand splicing

- at least two marlin spikes, sufficiently large for the rope being spliced, (one may be smaller than the main spike). They should have a knob at the butt end to grasp, be round for two thirds of the length before tapering gradually to a slightly oval section, and finish with a blunt chisel point at the tip.

The use of flat spikes with a flat T handle is not recommended as they can jar fingers or wrists if they slip after being turned at right angles. The chisel point and oval section of the spike described permit easier insertion, while the rounded section opens strands enough to tuck.

- wooden mallet or copper hammer.
- wire cutters and pliers.
- vice fixed to bench, preferably having grooved jaws.
- rope cutting machine, or cold chisel and a large hammer.
- a press for larger sized ropes instead of a vice.
  These have a right and left handed screw thread attached to brass jaws and are operated by a wheel. Jaws should be pointed for breaking thimbles into a rope and have flat caps to fit over when required for squeezing and seizing of ropes together.

Making a splice

Before commencing an eye splice whip the rope at the point where the splicing allowance of 1m for each 24mm has been made. Position the whipping level with the throat of the thimble and apply rope yarn or marline seizing to secure the rope to the thimble.

Bend the rope around the thimble and place it in a vice with the throat of the thimble above or at the end of the jaws. Screw the vice tight, being careful not to damage the rope (on small ropes lash a folded strip of canvas to the vice jaws).

Then drive a spike between the two parts of rope at the throat of the thimble. This drives the thimble up and seats it tightly in the rope. Apply seizings to the throat and to the crown of the thimble (for large wires, use seizing wire).

If a flat throat seizing has to be applied, the rope around the thimble and for 12mm beyond the length of the seizing should have been served with tarred marline. The seizing is now put on by neatly tapping a thimble held in a vice.

Grip the rope in the vice ready to commence splicing. (Some splicers prefer to have the rope vertical and others prefer horizontal). The rope is now ready for splicing.

Remove the endbinding and unlay the short end of the rope to provide the tails for splicing, and remove the crutch seizing.

The fibre main core is tucked with tail number 1 for the first tuck. It is then cut off where it emerges from the main part.

Wire cores must never be cut from the rope. The core must be split up and the wires or strands distributed among the tucking tails then tucked with them for at least three tucks.
If the rope is not pre-formed it is advisable to whip the ends of each tail separately.

In all splices the spike must be entered as near as possible to the thimble or end fitting, and the tucking tail must enter into the portion of loop which is nearest the thimble or end fitting, i.e. under the spike. All tucks must be pulled down hard.

To 'break out' wires when reducing the number of wires per strand, take each wire separately, snatch back to the point where it emerges from the rope and then twist the wire (handle fashion) reversing direction if necessary and the wire should part at the gusset.

**Six strand rope – Five tuck splice**

The inexperienced splicer should only learn firsthand from the expert splicer and use the description above as a guide. Only an experienced person can teach a novice the art of holding a spike, of taking a half a turn out of the strand end before inserting, the dipping of a tucked strand around the spike and so on.

The method described here is just one standard method of splicing. It is not possible here to describe all the splices, seizings and so on that are used. Use the steps below as a guide:

1. thimble in vice. Rope vertical. Main part of rope on right hand. Tail strands on left hand
2. thimble seized at crown and both flanks
3. the strands separated and the tails whipped at the ends
4. length of tails 100mm for each 3mm diameter of rope
5. for the first series of tucks a fibre main core should be tucked with Tail number 1 and then cut off. A wire main core must be split up, distributed among the tails, and tucked with them for at least three series
6. after the third series, the wires of a wire main core may be ‘broken off’ and the number of wires in each of the main tails reduced to half of the original number, preferably by ‘breaking out’. The remaining wires must be twisted to a rough strand formation, and at the same time enclosing cut ends in the centre
7. remove the splice from the vice and hammer down the taper, starting from the eye end and working down the taper. This is to tighten up the tucks and to round up the taper. Remove the protruding wire ends, preferably by breaking them out, and again round up over the broken off ends. The taper or at least that portion containing the wire ends of the tails should be served with wire strand or spun yarn to give protection to the user when handling
8. each strand must be pulled down as tightly as possible. The tails should be pulled down in line with the centre of the thimble
9. to get the tuck tight and short, it should be beaten with a mallet or hammer. One object is to get the tuck as near as possible at right angles to the axis of the rope. Working the tucks with a mallet or hammer forces any slackness out of the tucking tails through the loop, and the beating should start on the position of the tail before its entry into the rope, and continue on the tuck itself. The strands of the main rope where they had lifted are beaten down to hold the tuck in place.
First Series
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Second Series
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<th>Out at</th>
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Third Series
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Fourth Series
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<tr>
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<tr>
<td>2</td>
<td>B</td>
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<tbody>
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<td>C</td>
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<tr>
<td>2</td>
<td>D</td>
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<tr>
<td>3</td>
<td>E</td>
<td>F</td>
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<tr>
<td>5</td>
<td>F</td>
<td>A</td>
</tr>
<tr>
<td>4</td>
<td>A</td>
<td>B</td>
</tr>
</tbody>
</table>

Diagrams:
- First tuck
- Second tuck
- Third tuck
- Fourth tuck
- Fifth
- Sixth
- Tails
- Main part
**Serving**

Splices in multiple strand ropes subject to constant handling should be properly parcelled and served with marline, spun yarn or annealed strand seizing wire, preferably for the full length of the splice, to the throat seizing to prevent laceration injuries.

![Serving mallet](image)

**Slings and standing ropes**

Slings and standing rigging ropes, up to 24mm diameter, must have at least three full tucks with each whole strand of rope and two alternative tucks, made by tucking alternative strands twice.

Over 24mm diameter and up to 32mm diameter there must be at least four tucks and two alternative tucks.

Ropes over 32mm diameter must have at least four full tucks and two split, reduced, or tapered tucks made with all strands, with one half of the wires in the fifth tuck and one quarter of the wires in the sixth or final tuck.

**Crane ropes**

Crane ropes up to 24mm diameter must have at least four full tucks with each whole strand of rope, and two alternative tucks, made by tucking alternate strands twice.

Over 24mm diameter, there must be at least four full tucks and two split, reduced, or tapered tucks, with all strands, with one half of the wires in the fifth tuck and one quarter of the wires in the sixth or final tuck.

**Lang's lay**

Lang's lay ropes of all sizes must have at least six full tucks with each whole strand of rope and two split, reduced, or tapered tucks with all strands.
Chapter 2  Winches, sheaves and purchases for flexible steel wire rope

Sheaves

Sheaves lead the rope over the head of cranes and hoists and are used in pulley systems to gain a mechanical advantage.

Flare angle and groove depth

The groove depth of a sheave should not be less than 1.5 times the rope diameter. However if the rope is positively prevented from leaving the groove the minimum depth of the groove can be equal to the rope diameter.

The sheave groove sides should have a flare angle of a minimum of 42° and a maximum of 52°.

The grooves should be slightly larger than the nominal diameter of the rope. Grooves which are too large will flatten the rope. Grooves too small will pinch the rope and the extra friction can cut it to pieces.

Sheaves should have a smooth finish with flared edges which are rounded off.

Sheave diameters

The table below gives sheave diameters and safety factors for types of work:

<table>
<thead>
<tr>
<th>Duty</th>
<th>Classification</th>
<th>Type of work</th>
<th>Ratio to rope diameter</th>
<th>Safety factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>M1</td>
<td>Manual lifting with a chain block or 'one off' installations</td>
<td>11.2 12.5 11.2</td>
<td>3.15 2.5</td>
</tr>
<tr>
<td>Medium</td>
<td>M5</td>
<td>Normal use such as operation of a mobile crane</td>
<td>18.0 20.0 14.0</td>
<td>4.5 4.0</td>
</tr>
<tr>
<td>Heavy</td>
<td>M8</td>
<td>Continuous operation such as EOT crane in steel prod. or a tower crane on building site</td>
<td>25.0 28.0 16.0</td>
<td>9.0 5.0</td>
</tr>
</tbody>
</table>
**Caution:** Modern cranes and hoists are complex engineering equipment, and many have special construction luff and hoist ropes. It is essential that the sheaves which were designed for a particular crane or hoist are used for that purpose.

It is also essential that when a rope is replaced, the replacement is the same diameter and construction and that the sheave system is thoroughly checked to ensure that any damaged or worn grooves likely to ruin the new rope are repaired or replaced.

**Reeving**

Large capacity cranes have several parts to the main hoist fall, making the main hook very slow.

When reducing the number of parts to give a faster hook ensure that the falls are not reduced from one side of the boom head sheaves and the main hoist block.
Unsymmetrically reeved blocks will tilt under heavy load.

Otherwise rotational torque can develop on the boom head exerting side pull on the main hoist block. When reducing parts the rope must be reeved again to ensure that there are an equal number of parts either side of the boom head and the main hoist block.

The number of parts must be capable of supporting the load to be lifted. A fast hook must still be a safe hook.

**Inspection**

Sheaves should be inspected regularly. Pay particular attention to the sheave groove and flange. Any cracks or chips on the flange can cut the rope as it lays into the groove.

The groove should be checked for wear that will result in the reduction of the groove diameter and give an uneven bearing surface for the rope.
All sheaves should be checked for lubrication. Badly lubricated sheaves cause extra friction in the system and wear on the sheave pin and bearing.

The pin should be prevented from rotating with the sheave. Some sheave pins only have a small cotter pin which fits into a recess on the cheek plate. The cotter pin sometimes shears and allows the pin to turn with the sheave. Rotating pins are dangerous as they turn and can cut through the cheek plate.

A ‘jockey sheave’ is sometimes used as the first diverting sheave to reduce the fleet angle.

This sheave fits on an extended pin to allow it to slip from side to side reducing the fleet angle. The jockey sheave pin should be kept well greased and free from grit and dirt to allow the sheave to slide across the pin.

Drums

Drums are the pulling mechanism which rotates, hauls in and stores surplus wire. The braking mechanism is connected to either the drum or the gearing which is joined to the drive mechanism.

Drums are measured from the centre to the inside of the flange. A drum which measures 1m from flange to flange is therefore a 0.5m drum.
The rope should lay neatly on the drum and not be bunched up. There should be a minimum of two full turns on the drum at all times.

The rope must be anchored to the drum with a fixed mechanical anchorage. Be aware of the danger of not properly tightening an anchorage. Do not rely on the frictional grip relayed by the two turns on the drum.

![Diagram of grooved and ungrooved drums](image)

Comply with the crane manufacturer’s recommendation about whether drums are overwound or underwound. If a drum is wound up incorrectly it can affect the anchorage, brake and drive mechanism to the drum, resulting in mechanical failure.

The lay of the rope and whether the drum is overwind or underwind determines where the rope is to be anchored.

Be especially careful when raising very heavy loads to a great height such as with long boom mobile cranes. The amount of turns on the drum determines the drum diameter. As the diameter increases the torque to the drive mechanism and brake increases. As a result the higher the load is raised the faster it is raised, and the more difficult the load is to control.

Operators should ensure that the hoist brake is adjusted to take the extra torque when the load is raised to its maximum height. A brake which holds the load near the ground may fail when the load is high.

The top layer on a multi-layered drum must not be closer than two rope diameters to the top of the flange when the drum is full.

**Fleet angles**

The maximum fleet angle is measured from the centre of the drum to the centre of the first diverting sheave then back to the inside flange at the middle of the drum.

The maximum fleet angle for a grooved drum is 5° and for an ungrooved drum is 3°. To achieve these angles the distance from the drum to the first diverting sheave must be a minimum of:

- 19 times half the width of the drum for an ungrooved drum
- 12 times half the width of the drum for a grooved drum.
Example 1:
Width of the grooved drum = 1 metre
12 x 1 x 0.5 = 6
Therefore the sheave must be 6 metres from the drum.

Example 2:
Width of the ungrooved drum = 1 metre
19 x 1 x 0.5 = 9.5
Therefore the sheave must be 9.5 metres from the drum

If the fleet angle is too large or the distance between the drum and the first lead or diverting sheave is too short, the rope will not lay neatly on the drum and will create severe wear on the rope and the sheave flange.

When the fleet angle is too large

Severe flange and rope wear results

Rope wear

Windings will be too tight

When the fleet angle is too small poor spooling results

Effect of fleet angle on spooling
Safe loads on wire rope purchases

Use in connection with works of a temporary nature.

The figures in each diagram indicate the number of turning sheaves in each pulley block.
Tabulated safe loads allow for one extra (lead) sheave (not shown in diagrams) and 5% friction in each sheave.
LL = Load in the lead rope (as fitted by size of rope) – 1
D = Minimum diameter at bottom of groove of sheave – mm
W = Safe load that may be lifted

<table>
<thead>
<tr>
<th>Rope size diameter (mm)</th>
<th>D</th>
<th>LL</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<tbody>
<tr>
<td>8</td>
<td>120</td>
<td>0.58</td>
<td>0.93</td>
<td>1.61</td>
<td>1.45</td>
<td>1.86</td>
<td>2.23</td>
<td>2.58</td>
</tr>
<tr>
<td>10</td>
<td>150</td>
<td>0.9</td>
<td>0.82</td>
<td>1.57</td>
<td>2.25</td>
<td>2.86</td>
<td>3.46</td>
<td>4.00</td>
</tr>
<tr>
<td>12</td>
<td>180</td>
<td>1.3</td>
<td>1.18</td>
<td>2.20</td>
<td>3.23</td>
<td>4.16</td>
<td>5.00</td>
<td>5.78</td>
</tr>
<tr>
<td>13</td>
<td>195</td>
<td>1.5</td>
<td>1.35</td>
<td>2.61</td>
<td>3.75</td>
<td>4.80</td>
<td>5.77</td>
<td>6.77</td>
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<tr>
<td>14</td>
<td>210</td>
<td>1.8</td>
<td>1.64</td>
<td>3.13</td>
<td>4.56</td>
<td>5.75</td>
<td>6.92</td>
<td>8.00</td>
</tr>
<tr>
<td>16</td>
<td>240</td>
<td>2.3</td>
<td>2.00</td>
<td>4.00</td>
<td>5.75</td>
<td>7.36</td>
<td>8.86</td>
<td>10.22</td>
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<tr>
<td>20</td>
<td>300</td>
<td>3.5</td>
<td>3.27</td>
<td>6.25</td>
<td>9.00</td>
<td>11.52</td>
<td>13.85</td>
<td>16.00</td>
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<tr>
<td>22</td>
<td>330</td>
<td>4.3</td>
<td>3.91</td>
<td>7.48</td>
<td>10.75</td>
<td>13.76</td>
<td>16.54</td>
<td>19.11</td>
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<td>24</td>
<td>360</td>
<td>5.2</td>
<td>4.73</td>
<td>9.04</td>
<td>13.06</td>
<td>16.64</td>
<td>20.03</td>
<td>23.11</td>
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<tr>
<td>26</td>
<td>420</td>
<td>7.0</td>
<td>6.36</td>
<td>12.17</td>
<td>17.50</td>
<td>22.40</td>
<td>28.92</td>
<td>31.14</td>
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<tr>
<td>32</td>
<td>480</td>
<td>9.2</td>
<td>8.96</td>
<td>16.00</td>
<td>24.00</td>
<td>29.44</td>
<td>35.36</td>
<td>40.93</td>
</tr>
</tbody>
</table>

Note: The above masses must not exceed those marked on the blocks as being the safe mass that may be lifted. Most blocks are limited by the size of hooks and other components and not the number of falls of rope. A factor for friction has been added.

• the safe masses shown in this table are for rope of 6 x 24 construction.

• the working load limit together with any conditions of loading deemed necessary for safe use is to be stamped or otherwise marked on each block.

• sheave diameters measured at the bottom of the groove may be as follows (temporary use only):
  • For power operated blocks: 15 x rope diameter
  • For hand operated blocks: 10 x rope diameter

• the becket of blocks should be steel, preferably of drop forged or wrought construction. If welded they should be to an engineered design and strongly made.

• the locking pins of hook nuts, where used, should be closely adjacent to the nut top surface.

• hook shank collars should not be welded without an engineered design.

• snatch blocks should incorporate a locking pin of positive type not requiring the use of any tool for its effective positioning. A drop nose pin used as a hinge pin is recommended and the locking device must be strongly made and suitable for the intended use of the block.

• formula for calculating the load in lead rope: $LL = BL + (BL \times \text{No Sheaves} \times \% \text{Friction})$ better formula is below as usually know winch capacity.

• formula for calculating a particular load in lead rope: $BL = LL + (1 + \text{sum of (sheave x % friction)})$ and can have different friction on each sheave if wanted.
Purchases

A wire rope reeved through sheaves to obtain a mechanical advantage is known in rigging as a ‘purchase’.

Purchase and lead blocks should have the close fitting cheeks pattern, or be the dished type where the sheave is recessed into cheeks.

Self lubricating sheaves are recommended, but if reservoirs are used they should be filled periodically, and leathers and set screw washers checked for tightness.

Snatch blocks

Snatch blocks can be dangerous and should always be carefully watched. The gate must be properly closed and the split pin inserted and split open.

As the winch takes the weight, lead blocks stand up and lay into the strain. As snatch blocks stand up the split pin must be facing down and must be spread. There have been many fatal accidents because the split pin has been inserted face up and then dropped out, the gate opening allowing the hoist rope to drop out of the sheave.

The eyebolt and shackle type of block is preferable to the hook type. If the hook type is used it is important that the hook is placed into the sling with the hook facing down. If the hook faces up, it can drop out of the eye of the sling as the winch takes the strain. The hook must be properly moused to the sling.

Sheave blocks

Sheave blocks should be pulled apart, inspected and greased before each new set-up with particular attention given to the pin. If sheaves are not properly greased, friction increases dramatically through the system as the load is raised. This can overload the hoist rope at the winch.

Ensure that all cotters, nuts and bolts are tight. Lead blocks should be supported at the becket to prevent the block from twisting. Twisting would cause the rope to jam or ride on the rim of the sheave, and slip between the sheave and the cheek plate, jamming and destroying the rope.

The anchorage at the standing part of a purchase must be made at the becket at the bottom of the top block. If the becket is defective the eye of the standing part should be shackled to the head sling of the top block. Do not secure the end to the upper eye or shackle of the top block because the rope may cut where it passes over the cheek plate.

The screw pins of ‘D’ or bow shackles should be moused where used on standing rigging, and running rigging where the pin can become unscrewed, causing a serious accident.

When lifting loads by bridle or cock billing, make sure that lifting slings are ‘stopped’ and packing and lagging is lashed on. Head slings must not render or slip during fleeting operations.

The lead from the head block of any purchase must not foul its own block or any part of a structure. Head slings must be prevented from slipping by a ‘stopper’ lashing. Prevention from slipping must be against the pull from the load in the lead or from any fleeting action.

Where any fleeting action takes place the load must be kept as low as possible to the ground or any supporting structure.

During fleeting do not stand in the line of pull from either set of blocks. Many people have been seriously injured because they were in the way of a surging load.

Timber packing or dunnage should be used if slings are likely to jam when landing a load.
How to work out the load in a single part of a purchase

The greatest load on any rope in a purchase is the load in the lead rope to the winch. This is due to the friction between the rope in the groove of the sheave and the sheave pin. Friction is estimated at between 3 per cent and 5 per cent per sheave (ie up to one twentieth of the rope load that would occur if there was no friction).

The effects of friction, acceleration or deceleration are not usually included when dealing with work of a temporary nature unless a number of falls are used or the rope velocity is high, ie. 0.6m/sec.

When a load is at rest, suspended from the lower block, the becket load (the load in each part of the rope purchase) is found as follows:

**Becket load** = Total load on lower block ÷ No. of parts of rope supporting load

**Note:** The total load on the lower block includes the load to be lifted plus packings, slings, shackles, blocks etc.

For example – (including frictional effects)

Total load on the lower block = 10t including gear

Number of parts of rope = 5 supporting the moving block

**Becket load (BL)** = 10 ÷ 5 = 2t

However as lifting commences friction causes the load in the rope falls to increase by up to 5 per cent for each sheave the rope passes over, including lead sheaves (if any).

The load in the lead to the winch (given 5 per cent friction) may be calculated as follows:

**Load in lead to winch (LL)** = BL + (BL x number of sheaves x 0.05)

= BL + (BL x number of sheaves x 5 ÷ 100)

or for a given load in the lead, the maximum load that can be lifted is calculated as:

Load = LL x no. of parts supporting load

1t (number of sheaves x friction)

**Example 1:**

No. of sheaves in purchase = 5 (3 top block + 2 bottom block)

Number of parts of rope = 5 supporting lower block

Number of lead blocks = 2 (7 sheaves in total)

Total load on lower block = 10t

Becket load = 10 ÷ 5 = 2t

Load in lead rope to winch = 2 + (2 x 7 ÷ 20)

= 2.7t

**Example 2:**

Calculate maximum load for the above arrangement using a winch with a 2.7t line pull

Load = \[
\frac{2.7 \times 5}{1 + (7 \times 0.05)}
\]

= 13.5

1.35

= 10t

The above calculations do not allow for sudden impact, acceleration and deceleration which can cause very high loads in the rope. These should all be avoided.
Where the angle in a lead rope is less than 90 degrees, the strain on the lead block is double the strain on the lead rope.

If the lead block is shackled to, or hooked into a sling which is reeved, the sling has to have a capacity which is four times the load in the lead rope.

**Reverse bends**
Avoid reverse bends because they cause much greater fatigue than if all bends were made in the one direction.

A rope running in one direction over one sheave and then in a reverse direction (ie ‘S’ fashion) over another sheave will suffer early fatigue and deterioration. As the rope passes over a sheave it is bent, and as it leaves the sheave it is straightened, two distinct actions causing fatigue. This is made worse if the rope after being bent in one direction is then straightened, and again bent in an entirely opposite direction over another sheave after which it is again straightened.

**Multiple layers on drums**
If a load is to be lifted to a height where multiple layers must be layed onto a drum, there are several safety precautions that should be taken.

Independent steel wire cored ropes should be used to prevent crushing. Do not use 6/37 construction ropes because the small wires will suffer badly from crushing.

The drum must have the capacity to take the amount of rope. The bottom layers must be tightly and neatly laid onto the drum.

In the absence of any test certificate it must be assumed that the rope is made from 1570 MPa and the safe working load should be calculated accordingly.

**The capacity of drums and storage reels**
There is a rule of thumb formula for determining the amount of rope that can be stored on a storage reel. This formula can be used when determining whether the winch drum has sufficient capacity to take the amount of rope needed in a purchase.

**Length of rope that can be stored on a reel**

\[
\text{Capacity } L \text{ in metres} = (A + D) \times A \times C \div 1000 \times K \\
L = \text{Length} \\
A = \text{Depth of reel flange in mm} \\
D = \text{Diameter of reel in mm} \\
C = \text{Distance between flanges in mm} \\
K = A \text{ multiplying factor for various rope diameters (see table)}
\]
### Multiplier ‘K’ Table

<table>
<thead>
<tr>
<th>Rope diameter in mm</th>
<th>Multiplier ‘K’</th>
<th>Rope diameter in mm</th>
<th>Multiplier ‘K’</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>11.2</td>
<td>36</td>
<td>400</td>
</tr>
<tr>
<td>10</td>
<td>31</td>
<td>40</td>
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<td>240</td>
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<td>1120</td>
</tr>
<tr>
<td>32</td>
<td>315</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

**Length of rope that can be stored on a drum**

While a storage reel can be filled to the top of the flange a drum must not – 2 x rope diameters must be left from the top layer of rope to the top of the flange.

For drums A = Depth of reel flange in mm – 2 x rope diameter.

**Purchase or tackle block?**

Riggers must know the difference between wire rope purchase blocks and fibre rope tackle blocks. A fibre rope may be used in a purchase block but a wire rope must not be used in a tackle block.

A fibre rope tackle block would be greatly overloaded if used for the WLL of a wire rope of the same size. The difference between the two types of blocks is:

- the depth of the groove in a fibre rope tackle block should be not less than half the diameter of the rope used
- the depth of the groove in a wire rope purchase block must not be less than 1.5 times the diameter of the rope used
- the diameter of a fibre rope block is much less than that of a wire rope block for the same size rope
- pins and becket are heavier and stronger in wire rope blocks.

**Cable pulling stockings**

Cable pulling stockings are used for reeving wire ropes through purchases and for fitting cables in various places where the opening or access is restricted.

They are especially useful where the boom head, luff drum, and hoist winch of tower cranes are high above the ground.

A fibre rope is reeved and attached to the drum, and then is attached to the rope which is fitted with a cable pulling stocking. The rope is then pulled through the system by the fibre rope.

Cable pulling stockings must not be used for load lifting purposes.
Method for replacing an old rope

1. Cut the eye splice or metal clamp from the end of the old wire rope in the crane.
2. Remove grease from the cut end of the old wire rope for a distance of approximately one metre. Also remove grease from the new wire rope for a similar distance.
3. Slide one cable pulling stocking on to the end of the crane wire rope. Place a short seizing on the wire rope (using a mallet) so that it is under the cable pulling stocking about 50mm from the stocking end caps. Place a second secure seizing, using a stout cord or copper strand around the end of the stocking between the first seizing and the stocking end caps.
4. Repeat step three with the second cable pulling stocking on the end of the new wire rope.
5. Join the eyes of both cable pulling stockings with a sufficient number of turns of nylon cord which is then securely tied. The use of nylon lacing to connect the two stockings lessens the likelihood of snagging at sheaves and other points where clearance is at a minimum.
6. The winch of the crane then hauls the new wire rope into the crane. When the join of the new and old rope reaches the winding drum, the new rope is disconnected from the old rope and anchored temporarily to a suitable part of the adjacent structure. The old rope is then removed from the drum and then the new rope is anchored to the drum and wound on. Cable pulling stockings allow the rope joint to pass smoothly around the sheaves.
Chapter 3 Natural fibre rope and slings

Introduction

Fibre rope, also known as cordage, is used extensively for taglines, whips, tackles, lashings, and snotters for general lifting.

Natural or vegetable fibre ropes are grouped into those made from hard fibres and those made from soft fibres.

Hard fibre ropes are manila, sisal, coir and phormium tenax. Manila and sisal ropes are the main vegetable fibre ropes used for lifting in Australia. Coir is used where flotation is required and so is mainly used for boating.

Soft fibre ropes are jute, flax, hemp, and cotton. The fibres in these ropes are finer and very flexible and are used for ornamental purposes. They are often spun into twines or string for shop or household purposes.

Construction

The sequence of rope construction:

• fibres are combed into slivers
• slivers are twisted into yarns
• yarns are twisted into strands
• strands are twisted into the finished rope.

Hawser laid rope

Plain or hawser laid rope is the rope used for most general purposes including lifting.

For right hand lay hawser rope a number of fibres are twisted into a right hand lay, or spiral (helix) into a yarn. A number of yarns are twisted in a left hand spiral into a strand. Three strands are then twisted in a right spiral into a right hand lay hawser laid rope. Left hand lay rope is laid up exactly the opposite.

The thickness of the rope depends on the number of fibres that are laid up into the yarn and then the number of yarns laid up into the strand. The opposite lay is put in to stop the rope from unlaying and pulling apart.

Marline

Marline is used extensively in rigging for seizings. Three or four yarns are spun together in an opposite spiral and tarred.
Shroud laid rope

Inspection shroud laid rope is a four strand rope with a centre fibre rope heart. It is used for the manufacture of cargo, safety or scrambling nets, and rope ladders where there would be two strands either side of the tuck. The sectional area of four strand rope is less than three strand rope of the same diameter and the centre heart has a smaller spiral than the outer strands.

Shroud laid rope is therefore much weaker than hawser laid rope of the same diameter and should not be used for load lifting.

Cable laid rope

Cable laid rope is three hawser laid ropes laid up in an opposite spiral. They are used where great stretch is needed. They were used extensively in the shipping industry as mooring lines.

Inspection

Natural fibre rope is made from dried vegetable fibres and is subject to many deteriorating factors.

The whole rope should be inspected in a good light. Look at and feel the rope along the entire length. Open and inspect the lay and the interior every metre.

Look for the following defects:

- *the effects of heat.* If the rope has been exposed to more than 65°C the rope could be brittle, charred, powdery or brown on the outside

- *sunrot.* The natural colour of the rope will turn to a dirty grey, the outside fibres will turn very brittle and the rope will be much lighter than normal

- *mildew.* Open the lay and smell the inside of the rope and examine it. A musty smell is a sign of mould/mildew. There may be no outside signs of mildew

- *effects of acid and other corrosives.* The outside will be faded yellow to brown colour and powdery

- *overloading.* The fibres will be shorter, the diameter will decrease and the lay will increase in length

- *overworked over sheaves.* When the lay is opened there will be fine powder in the centre of the rope. The powder is fine particles of the inside fibres worn and abraded away and locked inside

- *high stranding.* One strand standing out above the others. It can be caused by faulty splicing or whipping

- *kinks.* Fibre rope will kink especially if it is wet. The outer fibres will be broken in one spot. This defect can be very hard to detect

- *cuts.* Fibre rope snotters should not be reeved around loads with sharp edges. Cuts are easy to detect but can be avoided by packing sharp edges

- *defective splice.* The eye splice in snotters should be carefully inspected. There should be three full tucks against the lay. The inside of the splice should be checked to ensure that there is no wear or broken fibres.

Fibre ropes which have defects should either be destroyed or if the defect is localised such as a cut, the rope should be severed at that point.
Maintenance

To maintain ropes in good condition free from attacks by mould and bacteria:

• store new coils on dunnage in a well ventilated area
• coil handlines and snotters and store on large wooden pegs above the ground
• keep rope dry and stored out of direct sunlight and never in an airtight box
• store away from any heat source, such as steam pipes, flame, sparks from welding or oxy cutting etc
• store away from acids or other corrosives, such as ashes, clinker, coke, oils, grease, steam, batteries etc
• protect from falling or sharp objects
• keep vermin away from ropes. Natural fibre ropes are prone to attack from insects which thrive on cellulose. The most common are clothes moths, beetles, ants, termites, silverfish and cockroaches. A trapped rat will gnaw through a rope to escape but in general rats are not attracted to rope for food or for bedding
• store ropes away from grit, rust, sand, dirt or other abrasive substances
• protect from adverse effects of weather such as sunlight, (sunrot) and mildew, caused by storing wet rope away in a toolbox or other area where there is no breeze to dry it out.

Handling

When a new coil of rope is delivered to the site it is covered with hessian bagging. Do not remove the cover. The coil is also tied with twine to keep it together.

If there is a turntable to uncoil the rope it can be unwrapped and lengths cut as required.

Do not remove the hessian covering if there is no turntable. The best way to uncoil the rope is from the inside. Turn the coil so that the loose end is on the bottom. Cut the inside holding twine and pull the loose end out through the top of the coil. The rope will then be uncoiled left handed.

A rope that is uncoiled right handed will uncoil full of kinks and twists. If this happens, turn the coil over and push the loose end back through the centre and start again.

To remove kinks and twists re-coil the rope left handed or anti-clockwise on a piece of dunnage dipping the end through and under the coil and then re-coil. This may have to be repeated two or three times before all twists are removed (reverse for a left hand lay rope).

Do not disturb frozen rope until it has completely thawed because frozen fibres can be easily damaged when handled.

Factors for assessing the capacity of fibre rope

For safe use as lifelines, slinging and general lifting gear in factories and workshops where not subject to rough usage, the working load limit (WLL) is the guaranteed breaking strain (GBS) divided by six.

Do not use fibre rope of less than 12mm diameter for load carrying purposes.

Fibre rope hauled by hand under load must not be less than 16mm diameter.

Fibre rope must not be subject to heat greater than 65°C.
Rope which has been shock or impact loaded or stretched by overloading must not be used for load carrying purposes.

The included angle between the legs of a sling attachment should not exceed 120°.

**Whipping**

Whippings are put on the end of a rope to prevent the rope from unlaying. They are made by using waxed twine or rope yarn. The length of the whipping should be at least equal to the diameter of the rope.

Whippings are preferable to back splicing on the ends of tackle falls because they will pass through the blocks when reeving the tackle. A second whipping should be applied nine rope diameters from the end for permanent whippings.

Types of whipping:
- the ‘Common’ whipping is used to prevent the rope unlaying while measuring or splicing
- the ‘West-Countrymans’ whipping and ‘American’ whipping are alternatives to the ‘Common’
- the ‘Palm and Needle’ whipping is difficult to apply and is usually only made when a permanent whipping is required.

![Four whippings diagram](image)

- A West countryman’s whipping
- B American whipping
- C Palm Needle whipping
- D Common whipping

**Seizings**

Seizings are used to bind or seize two or more ropes together. They are made with machine cord, light mackerel or cod line. The four types are flat, round, square, and racking seizings.

The racking seizing is applied after a thimble is inserted, to seize the two parts together before making an eye splice.
Worming, parcelling and serving

Worming is the process of laying lengths of spun yarn into the valleys between the strands of a rope to fill them and make the rope completely circular.

Parcelling is the process of wrapping strips of hessian, light duck (calico) or canvas around the rope or finished splice to give protection.

Serving is the process of binding over parcelling with a continuous length of seizing wire, marline or spun yarn. This is tightly laid on with a serving mallet. The rule is: worm and parcel with the lay, turn and serve the other way.

Splicing

Types of splices:

- **eye splice.** Can be either bald or with a thimble inserted. A fibre rope with an eye spliced either end for use in slinging is called a snotter
- **cut splice.** For joining two ropes leaving a loop between the splices
- **short splice.** For joining two ropes, or for joining two ends of a rope to make an endless rope strop
- **long splice.** For joining two ropes where the rope passes around a sheave. It should not be used where the rope supports loads or people. It may be used safely where a jockey, pilot, or dummy gantline is required to reeve off a FSWR purchase or similar use. **Caution:** It is possible for the tucked ends to come unlaid in use
- **back splice.** For preventing the end of a rope from unlaying. Back splicing is used when whipping twine cannot be found. Do not use if the rope has to be reeved into a tackle because the splice is too thick to pass through the sheaves. It is made by tying a crown knot then two or three tucks against the lay.

The short, cut, and eye splices can be used for suspending loads or people, but cannot pass through the sheave cheek plates. They should have at least three full tucks against the lay. After the three full tucks the ends of the strands can be reduced and tapered and the splice served.

However when a load is applied to the rope and the splice stretches, the serving will become loose. It is better, stronger, and safer to dog knot half the strands with a neat seizing after completing the splice.

Thimbles

A thimble should be spliced into the eye of the standing or becket eye of a tackle. Thimbles are solid round, split round or pear shaped split. They are split to enable them to be opened and fitted to the anchorage and then closed before splicing.

There should be no points on the throat of the thimble that could bite into the rope. Thimbles should be large enough to allow the rope to seat well into the score with the rope supported for half of its circumference without the groove edges biting into the rope. A small thimble can cut the rope and do more damage than ordinary wear and abrasion.
Fibre rope slings

Grommets
A grommet is an endless loop of fibre rope similar to a strop. It is formed by laying up a single strand. The length of the strand needed must be at least three and a half times the circumference of the finished grommet. The strand must be married at the required diameter then laid up until it is a three stranded loop. The ends are then halved, overhand knotted, tucked and then reduced.

Strops
A strop is where the two ends of a piece of rope are spliced with a short splice making an endless sling. They are called strops whether they are made of FSWR or fibre rope.

They are used as tackles, whips, lashings, snotters, and general lifting gear where the rope is liable to rough usage. The WLL is the GBS divided by seven.

Snotters
A snotter is a fibre rope sling with eyes spliced into each end. The eyes of snotters should be properly spliced by a competent person with three full tucks against the lay. Snotters should not be reeved or choke hitched around sharp edges unless proper packing is used to protect the fibre rope. Snotters are used where FSWR slings or chains would damage a load or where the use of metal slings could be dangerous. They are seldom used on construction sites and should not be used where the loads are lifted overhead.

Blocks and tackles
A tackle is the term used when fibre rope is reeved around sheaves to gain a mechanical advantage.

Caution: Fibre rope tackle blocks must not be used for FSWR purchases.

Blocks
Blocks are made of wood (clump), wood and steel (internal iron bound IIB), and steel. The wooden clump blocks are fitted with a FSWR or fibre rope strop fitting in a score at right angles to the sheave and steel pin. The sheaves are usually bronze or gunmetal. Some older sheaves were made from the very hard wood, called lignum vitae.
The wooden IIB block has beech cheeks and partitions, with a forged eyebolt and forked steel plates morticed into the cheeks and drilled to take a steel pin. The sheaves are usually bronze or gunmetal and the pin is secured by a steel keeper plate over a square head.

Steel blocks are made of mild steel cheek plates secured to a yoke drilled for an eyebolt or a forged hook. Reinforcing plates often run down outside the cheek plates to the bottom, where they are drilled to take becket, spreader bolts and ferrules.

The sheave pin fits into holes drilled through straps, cheeks and partitions and is usually of mild steel with a flanged end and a spigot with a cotter retainer at the other end. Lifting hooks or eyes are the swivel type (not upset or riveted type).

Care must be taken when maintaining and inspecting to look for worn pins, sheave bushes, insecure fastening of the hook yoke to cheeks and yoke crosshead, securing of sheave pin, becket and pin and general soundness of the whole frame.

Types of tackles:
- gantline – a single fixed block
- single whip – two single blocks
- whip upon whip – two moveable and one fixed single block
- luff tackle – single and double block
- gun tackle – two double blocks
- light gin tackle – or handy billy – double and treble blocks
- heavy gin tackle – two treble blocks.

**Safe loads on natural fibre rope blocks**

Use in connection with works of a temporary nature when hand operated.

<table>
<thead>
<tr>
<th>Rope size</th>
<th>Parts of rope supporting load - tonnes</th>
<th>W</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>1</td>
<td>0.28</td>
</tr>
<tr>
<td>20</td>
<td>2</td>
<td>0.44</td>
</tr>
<tr>
<td>24</td>
<td>3</td>
<td>0.63</td>
</tr>
<tr>
<td>28</td>
<td>4</td>
<td>0.84</td>
</tr>
<tr>
<td>32</td>
<td>5</td>
<td>1.05</td>
</tr>
</tbody>
</table>
Note:

The above masses must not exceed those marked on the blocks as being the safe mass that may be lifted. Most blocks are limited by the size of hooks and other components and not the number of falls of rope. A factor for friction has been added.

- The safe masses shown in this table are for natural fibre rope – 3 strand hawser laid.
- The working load limit together with any conditions of loading deemed necessary for safe use is to be stamped or otherwise marked on each block.
- Sheave diameters measured at the bottom of the groove may be as follows (temporary use only):
  - For power operated blocks: 10 x rope diameter
  - For hand operated blocks: 5 x rope diameter
- The becquets of blocks should be steel, preferably of drop forged or wrought construction. If welded they should be to an engineered design and strongly made.
- The locking pins of hook nuts, where used, should be closely adjacent to the nut top surface.
- Hook shank collars should not be welded without an engineered design.
- Snatch blocks should incorporate a locking pin of positive type not requiring the use of any tool for its effective positioning. A drop nose pin used as a hinge pin is recommended and the locking device must be strongly made and suitable for the intended use of the block.
- Fibre rope should not be less than 16mm diameter when held under load by hand.

Sheaves

The diameters of sheaves used with fibre ropes must be at least five times the diameter of the rope when hand operated. For power operated appliances the sheave diameter must be at least ten times the rope diameter.

The sheave diameter is measured from the bottom of the groove. If a rope sits too tightly in the bottom of the groove it can become damaged when wet or swollen. The depth of the groove should be at least half the rope diameter.

Reeving

A tackle for right hand laid rope must be reeved right handed (clockwise from left to right) starting from the bottom. Lay the blocks down with the becket at the top and finish the reeve with a splice or a buntline hitch at the becket.

Tackles when rove should be left block against block with a tail rope for overhauling on the lower block. As the tackle is overhauled the fall rope should be kept free of turns allowing the tackle to run free of turns and twists.

When tackles are rove off left handed and turns are not shaken out of the running end, the tackle will spin full of twists. A lower block which has toppled will cause turns and twists so care should be taken to dip the lower block back in the correct direction.
Guys and lifelines

Do not use fibre rope for permanent guys. Natural fibre rope shrinks when wet and stretches when dry. Do not leave temporary fibre rope guys supporting or guying an object overnight. Use FSWR as guys wherever possible.

Where fibre rope is used for lifelines, make sure that a back hitch or clove hitch is used at every support point to prevent slackness. They should be tightened and inspected regularly. When rove through stanchions a thimble and lanyard should be provided at one or both ends and always kept tightened to prevent the line from slipping through if anyone leans on it.

Do not use fibre rope where there is a danger of combustion from sources such as welding or oxy cutting.

Frapping or bowsing lashing

A frapping or bowsing lashing is a short lashing used to pass several turns through a thimble or shackle in order to pull a wire rope tighter. It should consist of a number of turns, pulled tight and given a chance to equalise in an outsize thimble or shackle. The lashing may be further tightened by half hitches pulled tight around the several parts. A stack or mast frapping is when a rope is passed around a stack and secured to a boatswain’s chair to prevent the chair from swinging away from the work.
Bends and hitches

Riggers must know how to secure loads and tag lines with bends and hitches. Learn those described and illustrated below.

Snubber turns for holding and lowering heavy loads. Two, three or more turns should be used.

Rolling hitch – To secure stopper, or two ropes pulling in opposite directions. Very useful – preferable to clove hitch or blackwall hitch, providing rolling turns are put on in proper direction of pull. Safe.

Sheet bend – to join two dry ropes of different sizes. Safer when double sheet bend is used. The smaller rope must be bent around the larger rope.

Buntline or becket hitch – to secure ends of tackles to becketts. Foolproof; cannot come undone like half hitches.

Timber and half hitch – useful for hoisting lengths of timber. Only safe when additional half hitch is put on end of hauling part.

Clove hitch – used to commence rope lashing. Not safe for other purposes unless ends secured, with additional half-hitch.

Bowline single – used for making temporary eye in end of rope.

Bowlene running – used for making a temporary eye to run along another part of rope.

(i) Bowline on the bight.

(ii) Bowline on the bight.

(iii) Bowline on the bight – the bowline on the bight is formed by making the first part of a bowline with the bight of the rope and passing the whole hitch through its bight.
Shortener for single part rope or snotter – to join rope to hook of tackle, etc and does not damage the rope. At least two full turns of the standing part are to nip the two bights before the bights are placed on the hook.

**Single snotter shortener partly made. Two bights ready to be placed on hook.**

**Overhand knot – to make a stop on a rope, to prevent ends from fraying or to prevent it slipping through a block.**

**Single snotter shortener with both bights fitted on hook.**

**Figure of eight knot – as for an overhand knot, but easier to untie.**

**Round turn and two half hitches – widely used for securing running ends of tackles. The more turns made before hitches are made the more control is possible.**

Double shortener – each of the two parts of the bale sling or strop is turned back on itself, so that two bights are formed at a suitable length. The bights are then turned about each other as in a simple overhand knot and place on the hook.

**Double shortener for sling on hook.**

**Direction of pull on spike**

**Double shortener for sling partly made.**

**Marlin spike hitch – should not be used for sending tools or materials aloft. A better method for tools is to open up the rope and push tool through.**

**NB When shortening synthetic rope slings it is usually advisable to twist the bights twice about each other because of the slippery nature of many synthetic ropes.**
Chapter 4 Synthetic fibre rope and slings

Introduction

Synthetic fibre ropes are generally made from filaments twisted into yarns, the yarns twisted into a strand then three strands into the rope similar to natural fibre ropes. A filament is one long continuous fibre which can continue for the whole length of the rope. Synthetic fibre rope should conform to AS 4142 Fibre-rope.

Natural fibre ropes rely on the friction of twisting to stop them from pulling apart. Synthetic ropes can be much thinner and yet have a greater WLL than natural fibre rope because they do not have overlapping fibres and because some filaments are stronger than natural fibres of the same thickness.

Each type of synthetic fibre rope is subject to different deteriorating and condemning factors. Some are affected by acids while others are affected by alkalis and most are difficult to tell apart after some use. All types have different strengths and so the WLL is not constant.

Synthetic fibre ropes have a smooth slippery surface which can cause slip and failure of most bends and hitches and are not suitable for hand haulage. Prevent this with additional half hitches or seize the tail with yarn, twine or marline.

Where splices are made, two additional (five) tucks with all of the strands are made and the protruding strands halved and fused together to prevent the splice from drawing or pulling out. All plain ends of rope should be whipped, to hold the strands together until the rope is fused.

Under some conditions synthetic fibre rope can conduct electricity and therefore should not be used as taglines near powerlines.

Types of synthetic fibre rope

Nylon (Polyamide filament)

Nylon has a breaking strength 2.25 times the breaking strength of natural fibre rope. It is not resistant to all chemicals and can be affected by linseed oil and mineral acids such as sulfuric and muriatic acid. Alkalis have little effect.

Heat resistance is higher (250°C) than natural fibre rope, which begins to char at 150°C. Although nylon melts or fuses with excessive heat it stops smouldering when the heat source is removed. It can melt with the heat build up when turns are surged around warping drums.

Nylon has about four times more stretch than natural fibre ropes which is good for shock loads but has little value for lifting gear. It is resistant to rot and mildew.

Dacron-terylene (Polyester filament)

Dacron-terylene has twice the breaking strength of natural fibre rope and is not as elastic as nylon. Resistance to mild acid conditions, rot, mildew, heat or flame are the same as nylon. Exposure to alkaline conditions (eg caustic soda) should be avoided.

Taniklon (Polyethylene filament)

Advantages of synthetic fibre rope Inspection Tankilon has about 1.45 times the breaking strength of natural fibre rope. (Similar features to Terylene).
Kuralon (Polyvinyl alcohol)

Kuralon has about 1.25 times the breaking strength of natural fibre rope. (Similar features to Terylene.)

Silver rope (Flat spin taniklon fibre)

Silver rope has about 1.16 times the breaking strength of natural fibre rope. Thirty per cent lighter than natural fibre rope or nylon. Does not absorb moisture and does not slip as easily as taniklon or other synthetics.

Polypropylene (Laid shattered film type)

Polypropylene has about 1.6 times the breaking strength of natural fibre rope. It is unaffected by water and will float. It is also unaffected by acids or alkalis except in a very concentrated form. Its strength is reduced by heat (15 to 30 per cent loss of strength at 65°C).

Advantages of synthetic fibre rope

Synthetic fibre ropes have many advantages over natural fibre ropes including:

- greater strength size for size
- lighter weight size for size
- greater elasticity or stretch
- greater shock absorption because of greater elasticity
- greater resistance to rot and mildew
- better resistance to abrasion
- some are resistant to acids, others to alkalis
- greater flexibility, ease of handling
- less water absorption.

Inspection

The whole length of synthetic fibre ropes should be inspected for signs of defects that may make the rope fail and therefore condemn the rope. Manufacturers’ information and advice on inspection should be followed.

Conditions and tools for inspecting rope properly:

- a 300mm length of rope for comparison that was cut from the end of the line at the time of purchase
- enough room to handle the whole length of the line systematically
- a good light
- a magnifying glass may be of assistance.

The entire length of the rope must be inspected at intervals of not more than 300mm. The rope strands should be unlaid slightly to inspect the inside. Care should be taken to return them to their original position after inspection.
Look for:

- external wear due to dragging over rough surfaces which causes a general reduction of the cross-section of the strands. This is the most visible cause of weakness. The strands can become so worn that the outer surfaces are flattened and the yarns are severed on the outside. In ordinary use, some disarrangement or breakage of the outside fibres is unavoidable and harmless if not too extensive.

- local abrasion as distinct from general wear. It may be caused by the passage of the rope over sharp edges while under tension and may cause serious loss of strength. It is usually intermittent in the form of tearing of the fibres, yarns or strands. Slight damage to outer fibres and an occasional torn yarn may be considered harmless, but serious reduction in one strand or less serious damage to more than one strand could merit rejection.

- cuts and contusions from careless use may cause internal as well as external damage. They may be indicated by local rupturing or loosening of the yarns or strands.

- internal wear caused by repeated flexing of the rope particularly when wet, and by particles of grit picked up. It is indicated by excessive looseness in the strands and yarns.

- heavy loading may result in permanent stretching so that the extension available in an emergency is reduced. If the original length of the line is known exactly, a check measurement made under exactly the same conditions will indicate the total extension of the line, but may not reveal local extension in part of the line. Measurement of the distances between indelible markers on the line may help reveal local stretching. The local extension should not exceed 10 per cent for synthetic ropes. Immediately after severe loading causing permanent extension, a line may be unusually stiff although flexibility may return.

- mildew does not attack synthetic fibre ropes.

- sunlight – Excessive exposure to sunlight will weaken all synthetic fibres. Unnecessary exposure should be avoided. However, sunlight will degrade polyolefin fibres (polyethylene and polypropylene) more rapidly than others. Degradation is shown by breakage of the fibres into small pieces which gives a hairy appearance as a result of the broken fibres tending to stand up as they break down into a coarse powder.

These symptoms are more readily observed on polypropylene than on polyethylene ropes at similar stages of degradation. The effect extends progressively below the surface of the rope, but because it is primarily a surface effect, small ropes will become unserviceable and unsafe quicker than large ropes. Work to develop suitable protecting agents, pigments and ultraviolet absorbers has been in progress for some time. Carbon black at a concentration of at least one per cent has proved successful for prolonging life. Other compounds show promise and are still being evaluated.

- heat may, in extreme cases, cause charring, singeing or fusing which all merit rejection. **Caution:** A line may be damaged by heat without showing any obvious signs. The best safeguard is proper care of the line in use and storage. Never drag a line in front of a stove or other source of heat.
Synthetic fibre ropes and chemicals

If unsure about the effects of a chemical on a synthetic fibre rope check the Material Safety Data Sheet (MSDS) which should be available for all chemicals used or stored in the workplace.

Polyamide
Polyamide filament is generally resistant to chemicals but solutions of mineral or formic acids (used in insecticides and as solvents for perfumes) cause rapid weakening. Therefore, avoid any contact with acid solutions either hot or cold. Polyamide filament is unaffected by alkalis, such as bleach and detergents, at normal temperatures. It may swell in some organic solvents such as cleaning agents. Avoid exposure to fumes, spray or mist of acids. If contamination is suspected, wash out well in cold water.

Polyester
Polyester filament is generally resistant to chemicals although solutions of strong, hot alkalis progressively dissolve the fibre, causing gradual loss in mass and a corresponding fall in breaking strain. Therefore, avoid exposure to alkaline conditions.

Resistance to acid is good, particularly sulfuric acid, although concentration should not exceed 80 per cent. Therefore, even diluted solutions of sulfuric acid should not be allowed to dry off on a rope. If any contamination is suspected, the rope should be washed out well in cold water. Resistance to oils and common organic solvents is good.

Polyethylene
Polyethylene ropes are highly resistant to chemical attack from both acids, such as battery acid, and alkalis. At room temperature the chemicals which cause serious loss in strength are some oxidising agents eg hydrogen peroxide. At 60°C there is also a loss in strength caused by some organic solvents such as turpentine. If contamination with any of these substances is suspected, the rope should be washed out well in cold water.

Polypropylene
Polypropylene ropes are unaffected by acids or alkalis, but are attacked by organic solvents such as white spirit. Avoid rope contact with wet paint or coal tar or paint stripping preparations.
Flat webbing and round synthetic slings

Flat webbing and round synthetic slings are used for lifting where it is necessary to protect the load from damage and for protection from electrical hazards. They are made from nylon, polyester, polypropylene or aramid polyamide. Each sling must be labelled with the WLL.

Types of synthetic slings and fittings

Inspection

Synthetic slings must be inspected before each use. They must also be inspected at least once every three months. If a sling is subject to severe conditions the inspections should be more frequent. Send each sling for a proof load test at least every 12 months.

Look for:

- any external wear such as abrasion or cuts and contusions
- internal wear which is often indicated by a thickening of the sling or the presence of grit and dirt
- damage to any protective coating of the sling
- damage caused by high temperatures, sunlight or chemicals (indicated by discolouration)
- damage to the label or stitching
- damage to the eyes or any terminal attachments or end fittings
- where the sling is covered by a sleeve, the sleeve must cover the sling for the full length from eye to eye.

Discard a synthetic sling if:

- the label has been removed or destroyed
- there is any damage to the sleeve or protective coating
- a nylon sling comes into contact with acid
- a polyester sling comes into contact with alkaline substances
• a polypropylene sling comes into contact with an organic solvent such as paint, coal tar or paint stripper
• there are any visible cuts on the sling.

NB: A nylon sling will lose more than 10 per cent of its strength when it is wet.

After six months continuous exposure to sunlight send a sling in for testing.

Synthetic slings must be stored:
• in a clean, dry, well ventilated place
• away from the ground or floor
• away from direct sunlight, ultra-violet light and fluorescent lights
• away from extremes of heat
• away from sources of ignition
• away from atmospheric or liquid chemicals
• away from the possibility of mechanical damage.

The working life of synthetic slings will be shortened if exposed to any of the above.
Examples of extreme damage to flat synthetic-webbing slings.

(a) Damaged sleeve  (b) Some damage to load bearing fibres  (c) Badly damaged sleeve

(d) Load bearing fibres have been cut  (e) Cut load bearing fibres  (f) Broken load bearing yarn

(g) The use of hooks that are too narrow has damaged the eye of the sling  (h) Burn damage to sleeve and load-bearing yarn  (i) Surface wear evident by furry surface
Chapter 5 Chain

Riggers must have the knowledge and skills to recognise the types of chain used to safely lift loads and those which are not.

Lifting chain

Lifting chain is uncalibrated, proof tested, short link chain. The barrel of short link chain requires a greater force to bend, provides greater strength, reduces the tendency to twist and provides better reeving performance.

The outside length of the link does not exceed five times the diameter (of the link material) and the outside width does not exceed 3.5 times the diameter.

Lifting chain is produced on a special purpose automatic chainmaking machine to ensure uniformity and homogeneous welds. A continuous coil of carbon steel or alloy steel rod is fed into the machine which cuts and bends the link around dies, then electrically welds the specially prepared join in the formed link. The weld is then trimmed by two methods:

- the welding flash is removed from the outside of the material leaving a bit of weld on the inside of the link
- the welding flash is completely trimmed from all round the weld area.

Grade designation is then stamped or embossed on the chain. In some cases every link is marked, but all lifting chain must show grade marking at least every metre or every 20 links, whichever is less.

Short link chain can also be calibrated to ensure uniform link pitch for running over a pocket sheave which is sometimes called a 'gypsy'. Calibrated chain gives a constant and uniform pitch throughout the length of the chain and improves its lay (it does not twist as much as uncalibrated chain).

Gypsies are used to raise or lower the chain in a chain block. They can be driven by hand, pneumatically or electrically. Although most manufacturers today produce chain for chain blocks of similar size and shape, it is important to obtain replacement chain from the manufacturer of the chain block to ensure correct fit.
If the chain does not fit neatly into the gypsy it will jam, ride out of the wheel pockets, or suffer wear or link damage. If this occurs it could lead to premature failure of the chain, damage to the gypsy pockets and possible accidents from the chain riding out of the pockets under load.

Unpocketed sheaves and drums designed to take chain must be at least 24 times the diameter of the chain. Link length should not exceed 6 times the diameter and the width should not exceed 3.5 times the diameter. Welds must be smoothly finished and the diameter of the weld must not be less than the diameter of the material in the chain.

**Types of lifting chain**

- Mild steel stress relieved chain – stamped L.
- High tensile, quenched and tempered chain – stamped P.
- Higher tensile, quenched and tempered chain branded T, 8, 80, A, 800, PWB, or CM and HA800 alternately.
- Very high tensile, quenched and tempered chain branded 100, Vor 10.

High Tensile and Very High Tensile (Grade T 80 and 100) are used extensively for lifting. Very little low grade chain is used for lifting. Most, if not all, chain components are also High Tensile strength (Grade T or 800) and are branded to show grade and chain size.

**Look for the grade marking**

If riggers do not understand the grade marking of a chain, they should check with the manufacturer or the manufacturer’s supplier for clarification.

**Caution:** Industrial lifting chain is not normally sold through general hardware outlets. Chain from general hardware outlets is usually unsuitable for industrial lifting.

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### MAXIMUM SAFE WORKING LOADS (SWL) IN TONNES OF 1000 KG

<table>
<thead>
<tr>
<th>Chain size mm</th>
<th>Straight</th>
<th>Adjustable</th>
<th>Reeved</th>
<th>Straight</th>
<th>Reeved</th>
<th>Basket</th>
<th>Reeved</th>
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<tbody>
<tr>
<td><em>slings</em></td>
<td><em>slings</em></td>
<td><em>slings</em></td>
<td><em>slings</em></td>
<td><em>slings</em></td>
<td><em>slings</em></td>
<td><em>slings</em></td>
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<tr>
<td>6.0</td>
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<td>0.95</td>
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<td>1.7</td>
<td>1.2</td>
<td>1.6</td>
</tr>
<tr>
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<td>1.6</td>
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<td>2.8</td>
<td>2.3</td>
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<td>2.1</td>
</tr>
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<td>3.5</td>
<td>2.9</td>
<td>2.0</td>
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<td>24.2</td>
<td>55.9</td>
<td>45.6</td>
<td>32.2</td>
<td>41.9</td>
</tr>
</tbody>
</table>

_Safe working loads for slings of special alloy chain (Marked “C.M.”, “A”, “T” or 8)._
Other types of chain:

- **Stud link chain.** A special purpose marine chain with a stud across the centre of each link to prevent the chain from jamming when coming out of ship's chain lockers. Do not use for lifting.

  Stud link chain lacks the flexibility of a lifting chain. Under test, it shows no elongation, whereas open link shows considerable elongation.

- **Bush roller chain.** Including Reynolds, Morse, and Coventry types. It is used as the drive chain on bicycles, motorcycles or the load chain on fork lift trucks. It has no sideways flexibility, so should not be used for suspending loads unless the load is in between guides.

- **Proof coil chain.** Is not made for load supporting. It is used as load binder chains, skid chains, hand chain on chain blocks, or general purposes other than load lifting. Proof coil chain is usually not branded and not made to any standard. It is not made for lifting purposes and should not be used as lifting chain.

- **Grade 65** is a high tensile load binder chain and is branded ‘65’. It is not a lifting chain and should not be used for lifting.

- **Grade 70/75** is a high tensile load binder chain and is branded 70, 7, HI-FRT, or HiLITE and is sometimes supplied gold coloured plating. It is not a lifting chain and should not be used for lifting.

- **Long link chain** is made in various grades from mild steel to Grade 80 and is used on conveyors, as ship cargo chain and for lashing. It is not a lifting chain and should not be used for lifting.

**Inspection of chain**

To prepare for inspection, clean the chain thoroughly, and lay it out in a good light on a table. Use a magnifying lens with a built-in light and examine every link. If the chain is made up into a sling, examine all of the parts of the sling assembly and look for the following defects:

1. **Stretching.** Stretched links are a sign of overloading. Chain should be condemned if links show obvious signs of any stretching.

   ![Stretching](image)

   *New link*  
   *Stretched link*

   - Links tend to close up and elongate
   - Measure length of 10-20 links
   - Re-measure the same section after use to determine amount of stretch
   - When new—gauge a length of the chain

**Look for chain stretch during inspections**

High tensile Grade T, Grade 100 and Grade 800 chain has been proof tested to 2.3 times its working load during manufacture. If chain has stretched in use it has been loaded more than 2.3 times its working load. Grade T, Grade 100 and Grade 800 chain only stretches a significant amount as it approaches its breaking strength, so stretched chain should never be used.

Oblong links or rings have been proof tested to twice the working load and stretching indicates overloading. If oblong links or rings have stretched more than 5 per cent, they should be scrapped.

Chain hooks have also been proof loaded to twice their working load prior to supply, so if the hook has opened it is a sign of overloading or incorrect use. Hooks which have opened more than 5 per cent should be scrapped.
2. Bent links. Links can be bent by reeving chain around square objects which are not properly packed. If the chain is bent at the link weld, the chain should be inspected very closely to ensure that the weld has not begun to fail.

3. Damaged links. Reeving around sharp edges without proper packing will gouge the chain link. Dragging chain along workshop floors can wear chain. Chain which is worn, nicked, cut or gouged to a point where the metal in the link diameter is reduced by 10 per cent or more should be condemned.

4. Rust. Most chains will develop discolouration meaning some surface rust. This should not be confused with deep rust which will make the chain unsafe to use.

5. Cracks. To find cracks soak the chain in a light oil, wipe dry and apply a coating of powdered chalk or whiting to the surface. Leave for several hours and then examine. If a crack exists, the chalk will draw up the oil from the crack and become discoloured, showing up the shape of the crack. There are also special preparations available which can be used for showing up or locating cracks.

6. Wear. Where links seat on each other they wear. This wear is most prevalent in load chain in chain blocks. When the chain passes over the gypsy the links are subject to extreme friction. The links wear very quickly if the chain block is being worked continuously near maximum loading.

   If the tension cannot be released from the chain it should be checked for wear. Caliper across two links and divide by two to obtain the diameter. Then check this against an unworn part of the link. The chain must be replaced if wear exceeds 10 per cent of the diameter.

7. Inspection records of slings and sling leg lengths should be commenced when chain is new and maintained to give a reference check. The length of used sling legs may be greater than their original length due to wear, but caution should be taken to ensure no stretching has occurred.

Care and maintenance of chain

* do not overload chain
* do not use a chain with locked or stretched links or which has links that do not have free movement
* do not hammer a chain to straighten a link or force a link into position
* do not use an excessively pitted, corroded, unduly worn, deformed, chipped, nicked, cracked, or otherwise damaged chain
• do not snatch or jerk loads being handled by chain slings, especially in cold weather. Sudden lifting can have the effect of doubling the load in the sling. Chain and chain slings should not be used in temperatures below –20°C as this extreme cold could make chain brittle

• do not cross, twist, kink or knot chain

• do not drag a chain by force from under a load

• do not drop a chain from a height

• do not roll loads over a chain

• do not use a chain over sharp edges without proper packing on the edges. Hessian bagging is not good enough. Use cut lengths of rubber car tyre, half rounds of tube or timber. All packing should be secured when sending loads aloft. When the load is landed the slings go slack and the packing can drop out

• do not use lifting chain at temperatures over 400°C without consulting the manufacturer. Lifting chain used at temperatures over 200°C requires derating. Refer to table for the reduction factor

<table>
<thead>
<tr>
<th>Temperature range °C</th>
<th>Temporary reduction of WLL while heated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 200</td>
<td>Nil</td>
</tr>
<tr>
<td>200 – 300</td>
<td>10 per cent</td>
</tr>
<tr>
<td>300 – 400</td>
<td>25 per cent</td>
</tr>
<tr>
<td>Over 400</td>
<td>Do not use</td>
</tr>
</tbody>
</table>

• do not place the links of a chain so that they bear on the hook of a crane or hoist (except an endless chain sling)

• do not join chain by using a bolt or a bulldog grip

• do not shorten a chain by twisting or wrapping it around a hook

• when not in use all chain lifting gear should be stored on racks or pegs, under cover

• any screw thread used in connection with chain blocks must be securely locked

• the load chain of a chain block should not be used as a sling

• any repairs to chain should be referred back to the manufacturer or supplier

• chain links and load chains of chain blocks should be frequently inspected and lubricated between uses, or more frequently for repetitive lifts at near capacity

• do not use chain in corrosive environments without reference to the manufacturer.

**Chain sling assembly**

Chain slings should be made up to AS 3775 *Chain slings–Grade T* or the manufacturer’s recommendations. When ordering parts for chain slings ensure that they comply with the appropriate Standard.
Avoid making up slings from different grades of chain or fittings. Try to use only one grade of chain throughout the workplace. This will prevent confusion about the WLL of slings for given diameter chain slings, especially if a WLL tag is missing.

**Typical marking for metal tag**

<table>
<thead>
<tr>
<th>General-use application</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 mm chain</td>
</tr>
<tr>
<td>Serial no.</td>
</tr>
<tr>
<td>WWL, tonnes</td>
</tr>
<tr>
<td>3.2</td>
</tr>
<tr>
<td>2.4</td>
</tr>
</tbody>
</table>

The chain, large oblong link, hammerlocks or couplers, and hook should all be of equal capacity or grade. Riggers should have the knowledge and expertise to inspect a chain sling to ensure that the grade and safe working load of all components match.

The working load limit tag must be fixed on all chain assemblies. The tag must detail the SWL under all conditions of loading.
If a tag is missing the sling should be taken out of service, unless the necessary information is marked on the master link. Once the tag is replaced the sling can immediately be returned to service. The tag should be replaced by a competent person.

Coupling links, often branded Hammerlok or Kuplex are used to connect alloy chain to alloy rings and hooks. Make sure that the pin connecting the two halves is firmly in position and that there are no cracks running from the inside corners of the forked part of the links.

Twist the spacer in the centre of the link to ensure that it is free. A jammed spacer is a sign that the chain has been overloaded.

Four leg chain slings should be fitted with two intermediate links on the main ring.

**Rings**

A ring must be strong enough to safely handle the WLL of all attached chains or slings.

Rings must be inspected frequently. Do not use a ring which has stretched more than 5 per cent of its mean diameter.

Do not place a ring on to a hook unless it hangs freely over the bow of the hook.
Chapter 6 Anchorages and fittings

Wedge rope sockets

Anchorages are used for securing standing and running gear such as attaching the wire rope to the drum, the head of the boom or the crane hook.

The eye on the anchorage for a non-moving rope (called a ‘dead eye anchorage’) must have a thimble. A splice with no thimble (called a ‘bald eye splice’) should not be used on an anchorage.

Wedge type rope socket anchorages are used extensively for cranes where the hoist fall is often re-reeved around the sheaves for extra purchase. These socket anchorages should comply with AS 2740 Wedge-type sockets.

There are many dangers associated with wedge type sockets and riggers should ensure that they are set up correctly.

The rope diameter must be equal to the diameter inside the socket, and when the wedge is pulled tight the wedge must not protrude beyond the socket body.

The hoist rope must be reeved into the socket body so that there is a straight line between the live rope and the anchorage.

If the rope is reeved in the opposite direction so that the live end is on the sloping side of the wedge, the wire will fail at the point where the rope enters the socket.

Do not place rope grips (bulldog clips) across both live rope and the dead end because it can lead to severe damage to the hoist wire. Wedge rope sockets may be used when spliced eyes are difficult to reeve or they would have to be made after the rope is in place.
The wedge rope socket must be properly set up and used, and properly designed and accurately made. They must be designed so that when no rope is fitted the wedge will not pass through the socket.

The advantages of using wedge rope sockets as anchorages are simplicity, ease and speed of applying and detaching, and that they do not damage the rope to any appreciable extent.

Sharp edges must be rounded off at the point where the load bearing rope enters or leaves the socket.

The angle of the wedge should be slightly greater than that of the socket, so that it does not tend to nip the rope as it leaves the socket. The angle of the socket is important and should not be greater than 19 degrees.

Do not set up wedge sockets where a block being raised can hit and dislodge the wedge.

Socket bodies and wedges must be frequently inspected for excessive wear at the point the wire rope strands are jammed into them. Do not use wedge rope socket anchorages where they cannot be easily inspected.

The dimensions of the wedge and socket must be such that when a wedge rope socket with rope is assembled, the narrow end of the wedge does not protrude outside the end of the socket. Do not use wedge rope sockets where moving loads can force the wedge out.

A wire rope grip should be applied to the tail (only) of the rope below the socket to prevent dislodgment of the wedge.

In earthmoving equipment such as drag lines and pile drivers the rope is usually initially much longer than required so that shortening can be carried out several times, quickly and easily, without recourse to splicing. The wedge is punched out of the socket, the bad rope cut off and re-reeved through the socket, the wedge replaced and pulled tight. The rope end should always be visible, protruding 150-250mm from the socket so that rope slippage will be evident.
Thimbles

A thimble is a fitting used in the formed eye of a rope and is designed to protect the bearing area inside the crown of the eye from chafing and distortion.

Socketed terminal fittings

Metal sockets are suitable for standing ropes. Metal sockets used with running gear will crack the ropes at the entry to the socket as the wires move.

Rapid hoisting, road travelling and impact shocks cause severe vibration in the rope directly above the point of the load attachment. Although a visual examination of the rope at this point may not find broken wires (one broken wire is sufficient to cause it to be condemned), the strength of the section from 1-6 mm above the load attachment is likely to be greatly reduced because of fatigue within the wires.

Sockets (metalled, conical) for steel wire ropes

B.S. Open type socket

Section A-A

B.S. Closed type socket
Therefore cut off this damaged section periodically even if it looks sound. About one third of the estimated life of the rope is a good interval.

When socketing or inspecting existing terminals examine closely for corrosion. Corroded wire is very susceptible to fatigue.

After constant vibration, a tensile pull test performed on a sample of the rope which looks sound may disclose a large reduction in its original strength.

A broken rope can kill and can cause severe damage to equipment or plant. Therefore, conduct regular inspections, cropping or renewing wherever vibrational fatigue occurs.

Wire rope grips

Wire rope (or ‘bulldog’) grips are only suitable for permanent fixed stays or guys.

They can be one of the most dangerous fittings used by riggers if not used correctly. If the bolts are over tightened the rope will be crushed or if the bolts are under tightened slipping will occur.

At least three wire rope grips should be used, with the saddles on the live part of the rope, and the U-bolt pressing on the less heavily loaded tail of the rope. They should be spaced at least six rope diameters apart.

Do not use them on temporary stays or guys that have to be shifted and re-fastened, because of the severe crushing and punishing action of the U-bolt. Do not use sections that are damaged by the clips and then straightened out to take the load.

Installation of wire rope grips (bulldog)

Correct method of fitting wire rope grips

Incorrect method of fitting wire rope grips

Note: Do not fit any or all of the grips with the bridge on the side opposite to the working part of the wire rope.

Do not use bulldog grips on any load hoisting ropes. When connecting a lizard to a stay or guy make sure that the crowns of the U-bolts press upon the lizard. Although they will damage it, they are easily replaced.

Correctly applied, bulldog grips may form an eye with 80 per cent of the breaking strength of the rope. If not correctly applied they may have no reasonable safe value.
Do not use a grip that is the wrong size or that has been strained or damaged.

Do not use a bulldog grip to directly connect two straight lengths of rope. If this is necessary, join two thimbles and then use the grips to make two thimble eyes.

**Double or single base clamps (or saddle grips)**

Single base clamps are safer than bulldog grips. They have two saddles and two straight bolts. The rope is therefore protected by saddles from severe local damage.

![Double base clamp for steel wire ropes](image)

Long double base clamps which are not commonly available extend at least 6 rope diameters in length offering a greater purchase on the rope without causing damage and provide 95 per cent of the strength of the rope. Rope life and safety increase accordingly.

**Bordeaux connections**

Bordeaux connections are used for connecting wire ropes to chains where the connections must pass over sheaves.

**Turnbuckles or rigging screws**

Turnbuckle or rigging screws are devices for tensioning or fine length adjustment of FSWR, chain etc. They are also called bottle, union or stretching screws. They should comply with AS 2319 *Rigging screws and turnbuckles*.

Turnbuckles or bottle screws all have a left hand thread at one end and a right hand thread at the other. They can be shortened or lengthened by twisting the frame or bottle. They can be extremely dangerous where vibration causes them to unscrew. Locknuts should not be put on turnbuckles or bottle screws to prevent unscrewing under vibration.

The thread inside the bottle or frame must be examined for slackness or wear before use. The screw thread is easily seen and is not difficult to examine for defects.
Do not use turnbuckles fitted with a hook to support a load.

Use only eye or clevis type turnbuckles to support a load.

On permanent fixings or anywhere where the rigging screw or turnbuckle may be subject to vibration, the frame should be locked out to prevent slackening.

Rigging screws must have inspection holes which give a view of the amount of thread left in the bottle. Do not use if the thread is absent or if the thread is not fully engaged.

Rigging screws or turnbuckles should never be subject to side pull. The line of pull must be straight.

The WLL must be branded on any turnbuckle or rigging screw that is used for load supporting. Do not use if the brand is absent.
Hooks

There are many different shapes and sizes of hooks. They range from mild steel to very high grade alloy steel. The common factor is that they are all designed to support loads.

Hooks used with chain to make chain assemblies are usually Grade T or Grade 800 strength. Very few, if any, other grades are readily available. Hooks used on chain must not have a WLL marked on them as it will lead to confusion when slings are used. The tag is the only reference to loading of a sling. Chain hooks are marked with their chain size and should be matched to the same size and grade of chain.

Hoist hooks and crane hooks must be marked with the WLL. Some hooks, particularly crane hooks, are also marked with the weight of the hook block.

![Diagram of different types of hooks](Image)

**Inspection and use**

The opening of the gap between the ‘bill’ or point of the hook and the shank, must be large enough for any sling, link, ring, shackle, or lifting device to be placed on it. The inside of the bight of the hook should be rounded to avoid cutting any fitting placed on the hook.

Nothing should be placed on a hook which will put opening (stretching) forces on the bill.

Do not use hooks which have had the throat opening stretched more than 5 per cent.

Hooks which are stretched, bent, cracked, or distorted in any way should not be welded or treated by unqualified people. They should be replaced or sent back to the supplier for assessment. Welding can hide a dangerous crack or distortion in the hook.

Hooks should not have any attachments welded to them.
Use a safety hook if there is a chance that the load can become unshipped or displaced.  
**Caution:** Using some spring loaded safety hooks does not guarantee that slings will not be displaced in some circumstances.

Crane or hoist hooks must be able to freely rotate under all conditions of loading. If the load exceeds 2t, they must have a ball or roller thrust bearing between the trunnion and nut. Make sure that no dust or other foreign matter accumulates in the thrust bearing.

Replace any hook that has the bow worn more than 10 per cent.

Do not place multiple eyes of slings directly on the hook. They should be placed on to a bow shackle, and the pin of the shackle should be placed on the hook.

To avoid excessive forces on the bill of the hook place slings which are at a wide angle on a bow shackle and not directly onto the hook.

It is safer to ‘back hook’ to the main lifting ring. Taking the chain sling hooks back up to the main hook can be dangerous if the chain slings do not sit properly on the main hook.

**Shackles**

Shackles are a portable link, used for joining various pieces of lifting equipment. The two main shapes for load lifting are the ‘dee’ and ‘bow’ shackles. Almost all shackles are made of round bar and have circular eyes. The pin of the common shackle screws directly into one eye and should preferably have a collar. In some shackles, the pins pass clear through both eyes and are secured by a splitpin forelock (ie split flat cotter pin) or nut and splitpin.

Shackles are made to AS 2741 **Shackles**. The grades range from grades L and M for small dee and bow shackles to grades S and T for large dee and bow shackles. In order to eliminate projections, shackle pins are sometimes counter sunk flush with the eyes.

The pin and forelock shackle is a safe shackle but is mainly used for standing rigging such as guys.

Always use the correct size shackle pin. Do not use a nut and bolt in place of the proper shackle pin. A bolt that does not fit tightly is likely to bend and break.
Condemn a shackle which is worn either in the crown or on the pin by more than 10 per cent of its original diameter.

Do not use a shackle or pin which is bent, strained, deformed or damaged. Tiny microscopic cracks may have developed during deformation. These can extend under quite small loads and lead to complete failure.

Screw shackle pins should be tightened then loosened very slightly, so that the shackle pin can be unscrewed when the weight is released. If the pins are tightened and the strain is taken on the shackle the pin often jams and is difficult to unscrew.

Where shackles are subject to vibration such as on luffing bridle pendants, mouse the shackle pin to prevent the pin from unscrewing.

Shackles are designed to take vertical forces only. Diagonal forces will strain the shackle and lead to eventual failure.

If any small object such as a single sling or another shackle is placed on the pin the shackle will 'cock bill' or cant. To stop this happening, pack the shackle pin with washers or ferrules to keep the load in the centre of the pin.

When using multiple slings, always use a bow shackle large enough to accommodate all of the eyes safely on the bow. The pin of the shackle should rest on the hook.

Do not use an unmoused screw shackle where the pin can roll under load and unscrew.

Shackles must be branded with the WLL. Do not use a shackle without the WLL clearly marked, for load lifting.

Knocking and leverage can cause vibration which works the pin out of the shackle. To prevent this use the forelock, or the pin with the nut and cotter pin.

Plate shackles are a special shackle made from steel plate with a hole drilled in either end. Two plates are joined by placing bolts through the holes. Plate shackles are used extensively for joining crane luffing bridle pendants. Make sure that the nuts have split pins and that the split pins are spread to ensure safety.

**Eyebolts**

Eyebolts are used extensively as lifting lugs on set pieces of equipment. The safest eyebolt is a collared eyebolt. Uncollared eyebolts should only be used where the pull on the eyebolt is vertical.

Only collared eyebolts should be used where the pull is inclined from the vertical. The underside of the eyebolt should be machined and the seating upon which the eyebolt is tightened should also be machined. The eyebolt should be tightened so that both faces meet in a neat tight fit. If both faces are apart the collar is of no use.

Any diagonal tension applied to an eyebolt should be in line. The pull should never be across the eye.

Do not insert a hook into an eyebolt. Always use a shackle.

Where two eyebolts are used to lift a load, a pair of slings should be shackled into them. Do not reeve a single sling through two eyebolts and then put both eyes on the hook.
Where eyebolts cannot be kept in line with each other when tightened, insert thin washers or shims under the collars to allow the eyebolts to be tightened when in line.

Do not tighten an eyebolt using a heavy hammer. Use a light hammer or a podger bar. After tightening check the ‘solid feeling’ which indicates a properly fitted eyebolt.

 Loads can spin when lifted with a single eyebolt causing the eyebolt to unscrew from the load. Mouse the eyebolt to the load to stop unscrewing.

Eyebolts are often put on large motors or similar to lift the casing off. It can be dangerous to lift loads with the eyebolts that are provided on the load. If no information is provided about an eyebolt sling the load with slings.

**Use of collared eyebolts**

- **Correct**
  - Make sure the eyebolts are screwed down tightly so that the collar is in contact with the load

- **Wrong**
  - Here the strain on the eyebolt is doubled.

If rings are provided with the eyebolt depend on the WLL of the ring or screw thread, whichever is the weakest.

Where a nut is fitted to the end of screwed thread ensure that it bears evenly on the surface around the hole.
Chapter 7  General rigging appliances

Chain blocks

Chain blocks should comply with AS 1418.2 *Serial hoists and winches*. Some could be dangerous and fail under load. If in doubt check with the supplier.

Chain blocks are used for short lifts such as by small monorail cranes, fixed hoists and so on. They are also frequently used by riggers for transferring or ‘fleeting’ loads from purchases.

Do not drop a chain block. The jolt may distort the casing causing the gearing to malfunction and the chain block to fail. The drive pinion could also part from the main driving spur wheel.

Make sure that the hook has not dipped through itself in a two part or multiple chain fall causing the load chain to twist.

Keep blocks away from sand, grit and dust. Some people keep the load chain lightly oiled to create less friction as the chain passes over the gypsy. If the chain is oiled and it becomes covered in sand or grit, the grit becomes a grinding paste which wears the chain very quickly.

The gypsy in one manufacturer’s chain block may not be identical to another. It is important when ordering replacement chain, that the chain and the gypsy are compatible.

Chain blocks with multiple falls are often very heavy on the opposite side to the block. It is a good practice to mouse the block to the head sling, to prevent the hook from dropping out of the head sling when the weight is released from the block.

Maintenance

Inspect the brake lining material for signs of wear and have it replaced if necessary, ensuring the retaining rivets (if any) are well countersunk.

Check the pawl for sharpness and alignment, the pawl spring for effectiveness, and the ratchet teeth for sharpness and wear.

Check the bearing bushes for wear and have them renewed if necessary.

Remove the gear case and inspect the gears for wear on the shafts, and also for bending, breakage, wear, and misalignment of teeth.

Check the load chain for wear and for stretch and the load sheaves for excessive wear. If the load chain does not fit accurately it should be replaced before using the block.

Inspect the load chain guide for movement. This guide should be the fixed type not a small roller. The purpose of the guide is to guide the load chain, free of turns, on to the gypsy. If a roller guide is fitted, hang the block up and while lowering the empty hook, gently twist the ascending chain as it approaches the guide roller. If it jams, a new guide must be fitted.

Check the hooks for opening out due to overloading or misuse. Examine the hook yokes, ball bearing swivels and anchorages of chain to clevis pins.
Where a chain block needs major overhaul or repair, advice should be sought from the supplier about the work to be carried out, and should be done by people who are competent.

Chain blocks must be lubricated lightly. If too much grease is pumped into a chain block the grease could cover the brake and the chain block would fail.

Do not leave a chain block soaking in oil. The oil will saturate the brake.

**Pull lifts**

There are two types of lever operated chain pullers:

1. those fitted with bush roller chain
2. those fitted with calibrated chain.

A load supported by a bush roller chain pull lift should either be in guides or fixed into a position where side pull cannot be placed on the chain.

Do not extend the handle to give extra leverage. Doing this will overload the pull lift.

Inspection and maintenance is similar to chain blocks.

There are two types of FSWR lever operated pullers:

- the drum type
- the creeper type.

The drum type has a safety ratchet and pawl. The pawl must be held by hand when lowering. Do not tie the pawl back because this can cause control to be lost.

The FSWR used in these winches must be the type recommended by the manufacturer.

The inspection of the FSWR and the anchorages must be done daily to ensure that the winch is safe to hold the load. A complete inspection must be done monthly, with particular attention to the hoist rope.

Creeper type lever operated pullers have an advantage over drum type pullers because they have unlimited drift.

Without gears, pawls and ratchets, the design enables the rope to pass through the unit in a straight line and is not wound on a drum.
Two pairs of forged steel jaws control the lifting and lowering of the load by a hand lever. The weight of the load actuates the jaws. The wire rope is at all times held by one pair of jaws while the other pair having been opened by cams, is moved by the lever for the next gripping or pulling motion. This method draws a wire rope of any length through the unit.

**Caution:** The rope can slip through these types of pullers because of the constant diameter in the cam gripping mechanism and because FSWR reduces in diameter under constant loading.

**Operation**

1. Place the hook on the ground, hold the machine at an angle and push down on the clutch release ‘P’ towards the anchoring hook until it is seated in the notch.
2. Pull the rope through the machine until the required length is reached.
3. Close clutch ‘P’.

Forward or lifting motion. Place the handle on the lever ‘L1’, then pull and push alternatively.

Reverse or lowering motion. Place the handle on ‘L2’, and work with the same motion.

Release, pull and push alternatively on ‘L2’ to slacken the rope, then declutch ‘P’.

**Spreader beams**

Spreader beams are devices which spread the load evenly for a given lift. They are generally made to suit a particular job. Most have a central lifting point for the crane or lifting medium, and have two or more lugs underneath to take the load slings.

All spreader beams must be suitable to lift the particular load and must be branded with the WLL. The WLL must include the weight of the load plus all lifting gear (slings, shackles etc).

Some spreader beams are fitted with offset lugs on the top and are designed to raise loads level even though they are heavy on one end.

For example, there are types of spreader beams used in power stations with sliding lifting lugs used to fit the rotor into the stator. This is done by sliding the lugs along the spreader until the rotor is level.

There are loads such as pre-stressed concrete beams which are designed to take downward forces only. This is opposite to the forces imposed by lifting in the centre.

There are two methods of overcoming this problem:

1. Use slings of sufficient length so that the beam can be lifted near the ends and still have a safe angle. For this method to be successful the crane or lifting medium has to have enough drift to place the beam into position.
2. Use a spreader beam of sufficient length and strength to lift the beam. This method is the best if drift is a problem.
Equalising gear

Equalising sheaves are load supports, which transfer the load from one single point to two others by means of FSWR. Chain and fibre rope are rarely used. There are several different types of equalising gear, which all do a similar job.

Equalising sheaves transfer the weight on the single point equally to the two points which take half the load each.

If the two points are of unequal capacity, the load on the single point should never exceed double the capacity of the weakest of the two other lifting points.

If one of the two lifting points remains stationary and the other hoists up, the sheave is then a hauling sheave not an equalising sheave. Friction must then be taken into account when working out the weight on the hauling part.

If the capacity of the crane is equal to the load imposed on the crane then the capacity could be exceeded by the additional load due to friction in the sheave system.

Equalising sheaves are often used on bridge or gantry cranes which have a four part purchase with two hauling parts attached to the hoist drum. The opposite or stationary side passes over an equalising sheave.

The function of the equalising sheave is to move as the hoist block swings sideways. The part of FSWR that passes over the sheave has abrasion and fatigue. It takes half of the weight of the hoist block at all times. It also takes half the weight of the load, plus half of the weight of the hoist block when the crane is lifting. It is the hardest working piece of rope on the crane and must not be overlooked by maintenance personnel.
Jacks

Jacks are used when it is not suitable to use a crane or hoist to raise or lower a load.

Car jacks have no rated WLL and should not be used as load lifting jacks.

Preparation

Packing under jacks should be independent of other packing. All wedges should be driven home well, and spiked in position if they are left for any time.

To prevent a load that is higher than it is wide from overturning make sure it is supported by side guys or toms. Adjust the guys and toms as the load is lifted.

Do not exceed the WLL branded on jacks. Where possible use a jack that has a larger capacity than is needed to allow for a possible malfunction.

Jacks should be placed on a timber pad and have a timber pad placed on the head to prevent slipping.
Screw or bottle jacks should be followed up by packing very closely, as the pull in the tommy bar in the screw head can cause the jack to shift.

Examine the condition of the pawl, the teeth of the ratchet, and the handle. Make sure that they are in good condition before lifting.

Test the operation of the quick release before lifting a load.

**Lifting**

The head of the jack is designed to take the greatest load. Lift on the head when the load can be lifted either on the head or the toe of the jack.

Care should be taken when lifting with geared, or platelayer jacks. Lifting on the head should not be carried out with this type of jack unless special precautions are carried out to ensure stability. When lifting on the head a 600mm to 1m space is needed to place these types of jack in position.

Look out for the head making contact with projections or the jack kicking out when lifting on the toe, especially when lowering.

Make sure the load is kept steady while raising the load. Do not lift both ends of the load simultaneously.

Use the lowest gear when lifting a load near to the maximum capacity of the jack.

The lift must be vertical. If the jack shows signs of tilting, pack the load, release the jack and reset.

Do not extend the jack handle to increase leverage because this will overload the jack.

Take care when releasing the ratchet from the pawl during lowering. Control can easily be lost with the likelihood of injury.

**Hydraulic jacks**

Use the correct oil and make sure the oil reservoir is full and free from dirt or grit.
Make sure the plunger rubbers and ram rubbers are a good fit, softened in neatsfoot or hydraulic oil, and immersed when not in use.

The release valve should operate satisfactorily or be adjusted by a competent person.

All worn rams, pistons, plungers, gears, ratchets, etc should be discarded and replaced.

**Fixed cantilevered beams**

Cantilevered beams (needles) bolted down to floor beams and held by counterweighting or other means are often used for single whip beams hoists, to support a block and tackle, or a chain block.

A cantilever must be set up so that no more than one third of the length protrudes beyond the outer point of support. An engineer should make the calculations for steel beams. For timber needles see the tables that follow.

![Diagram of cantilevered beams](image)

<table>
<thead>
<tr>
<th>Depth (mm)</th>
<th>Width (mm)</th>
<th>Projection from Support in mm or metres (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>300 mm</td>
<td>450 mm</td>
</tr>
<tr>
<td>100</td>
<td>75</td>
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<td>100</td>
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</tr>
<tr>
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<td>175</td>
<td>0.85</td>
</tr>
<tr>
<td>200</td>
<td>75</td>
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<tr>
<td>300</td>
<td>200</td>
<td>3.05</td>
</tr>
</tbody>
</table>

*SAFE WORKING LOADS IN TONNES AT ENDS OF CANTILEVERED OREGON NEEDLES*

*(To obtain safe working loads for ordinary hardwood multiply values given below by 2)*
Counterweighting Cantilevered Beam

Formula for determining uplift

\[ \text{Uplift} = \frac{\text{Total weight} \times \text{Projection}}{\text{Inboard distance}} \]

Example

Weight to be lifted = 2 tonne
Projection = 1 metre
Inboard distance = 2 metre
Safety Factor = 3

\[ \text{Uplift} = \frac{W \times P}{L} = \frac{2 \times 1}{2} = 1 \text{ tonne uplift} \]

Formula for determining counterweight

\[ \text{Counterweight} = \frac{W \times P \times SF}{L} \]

\[ = \frac{2 \times 1 \times 3}{2} \]

\[ = \frac{6}{2} = 3 \text{ tonne counterweight} \]
Chapter 8 Slinging and working loads

There are many variables in working out the safe method of slinging a load and placing it into position. These include the load weight, size, where the load is to be slung, the sling size, wind, rain and where the load is to be placed.

To ensure a safe lift the rigger or dogman should discuss the placement of the load and the capacity of the crane at that radius with the crane operator. It is then time to sling the load, tie on a tag line where necessary and then guide the crane operator to lift, move and place the load safely.

WLL tables are available for all types of slings and rope. Make sure that you consult the correct table before lifting.

Working load limit

The working load limit (WLL) of a sling is the maximum load that load limit may be lifted by that sling making a straight lift. The load factor for a straight lift = 1.

The WLL can be calculated by dividing the guaranteed breaking strain (GBS) by a safety factor. In general rigging work the safety factor for FSWR is 5.

Below are the rule of thumb methods for calculating the WLL of FSWR, natural fibre rope and chain.

For the exact WLL consult the tags on the FSWR or chain or the relevant WLL tables. If there is no tag on FSWR it must be assumed that it has been made from 1570 MPa steel wires.

<table>
<thead>
<tr>
<th>Method of Loading</th>
<th>Direct Loaded</th>
<th>Choke Hitch</th>
<th>Basket Hitch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Included angle</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0°</td>
<td>1.00</td>
<td>0.75</td>
<td>0.60</td>
</tr>
<tr>
<td>45°</td>
<td>1.35</td>
<td>1.10</td>
<td>1.00</td>
</tr>
<tr>
<td>60°</td>
<td>1.73</td>
<td>1.45</td>
<td>1.35</td>
</tr>
<tr>
<td>90°</td>
<td>1.90</td>
<td>1.57</td>
<td>1.45</td>
</tr>
<tr>
<td>120°</td>
<td>1.60</td>
<td>1.30</td>
<td>1.20</td>
</tr>
<tr>
<td>Loading factor</td>
<td>1.00</td>
<td>0.92</td>
<td>0.87</td>
</tr>
<tr>
<td>0.50</td>
<td>0.75</td>
<td>0.70</td>
<td></td>
</tr>
</tbody>
</table>

WLL for 6 x 24 (15/90) - 1570 Grade - Galvanized

<table>
<thead>
<tr>
<th>Normal working load - tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
</tr>
<tr>
<td>9</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>11</td>
</tr>
<tr>
<td>12</td>
</tr>
<tr>
<td>13</td>
</tr>
<tr>
<td>14</td>
</tr>
<tr>
<td>15</td>
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<td>16</td>
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<td>18</td>
</tr>
<tr>
<td>20</td>
</tr>
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<td>22</td>
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<td>24</td>
</tr>
<tr>
<td>26</td>
</tr>
<tr>
<td>28</td>
</tr>
<tr>
<td>32</td>
</tr>
</tbody>
</table>

A safe working load chart for 6 x 24 - 1570 Grade - Galvanized Steel Wire Rope
Working load limit of flexible steel wire rope (FSWR)

To calculate the WLL in kilograms of FSWR, square the rope diameter (D) in millimetres (mm) and multiply by 8.

Formula: \[ \text{WLL (kgs)} = D^2 \text{ (mm)} \times 8 \]

For example:
Rope diameter (D) = 12mm
\[ \text{WLL (kgs)} = D^2 \text{ (mm)} \times 8 = 12 \times 12 \times 8 = 1152 \text{kgs} \]
\[ \text{WLL (t)} = 1.15 \text{ tonnes} \]

The above equation can be reversed to calculate the diameter (D) in millimetres of FSWR needed to lift a given load. To do this divide the load (L) in kilograms by 8 and find the square root of the result.

Formula: \[ D \text{ (mm)} = \sqrt{\frac{L \text{kgs}}{8}} \]

For example:
Load = 1152kg
\[ D \text{ (mm)} = \sqrt{1152} \div 8 = \sqrt{144} = 12 \text{ (mm)} \]
Therefore an FSWR sling of at least 12mm is required to lift a 1152kg load for a straight lift.

Working load limit of chain

The WLL of chain is determined by the grade (G).

Do not use a chain to lift if it does not have a manufacturer’s tag that gives details of the WLL. Return it to the manufacturer for WLL assessment and retagging.

To calculate the WLL of 80 grade lifting chain in kilograms square the diameter (D) in millimetres (mm) and multiply by 32.

Formula: \[ \text{WLL (kgs)} = D^2 \times 32 \]

For example:
Chain diameter, 10mm. Grade T (80)
\[ \text{WLL} = D^2 \text{ (mm)} \times 32 = 10 \times 10 \times 32 = 3200 \text{kg s} \]
\[ \text{WLL (t)} = 3.2 \text{ tonnes.} \]

The above equation can be reversed to calculate the diameter (D) in millimetres of chain needed to lift a given load. To do this divide the load (L) in kilograms by 32 and find the square root of the result.

Formula: \[ D \text{ (mm)} = \sqrt{\frac{L \text{kgs}}{32}} \]

Load = 3200kg
\[ D \text{ (mm)} = \sqrt{3200} \div 32 = \sqrt{100} = 10 \text{ (mm)} \]
Therefore a Grade 80 chain, 10mm in diameter is required to lift a load 3200kg for a straight lift.

Warning: The above formulas must not be used for any other load lifting chain which is less than Grade 80 (t).
To calculate the WLL of grade 30 or 40 lifting chain in kilograms, square the diameter (D) in millimetres (mm) and multiply the grade (G) by 0.3.

**Formula: WLL (kgs) = D²(mm) x G x 0.3**

*For example:* Chain diameter, 10mm. Chain grade 30

\[
\text{WLL} = D^2 \text{ (mm)} \times G \times 0.3 \\
= 10 \times 10 \times 30 \times 0.3 \\
= 900 \text{kgs}
\]

WLL (t) = 0.9 tonnes

**Working load limit of natural fibre rope**

To calculate the WLL of natural fibre rope in kilograms square the rope diameter (D) in millimetres (mm).

**Formula: WLL (kgs) = D²(mm)**

*For example:*

Diameter = 25mm

\[
\text{WLL (kgs)} = D^2 \text{(mm)} \\
= 25 \times 25 \\
= 625 \text{kgs}
\]

WLL (t) = 0.625 tonnes

The above equation can be reversed to calculate the diameter (D) in millimetres of fibre rope needed to lift a given load. To do this find the square root of the load in kilograms.

**Formula: D (mm) = \sqrt{\text{Load (kgs)}}**

Load = 200kgs

\[
D (\text{mm}) = \sqrt{200} \\
= 14.14 \text{ (mm)}
\]

Therefore a 15mm diameter fibre rope sling is required to lift a 200kg load for a straight lift.
Working load limit of flat webbing and round synthetic slings

Flat webbing and round synthetic slings are labelled with the WLL. Do not lift if the label is missing. Return the sling to the manufacturer for assessment and relabelling. Synthetic slings are colour coded. (See table below.)

<table>
<thead>
<tr>
<th>Colour No Stripes</th>
<th>Colour</th>
<th>Vertical</th>
<th>Choke</th>
<th>Basket</th>
<th>30°</th>
<th>60°</th>
<th>90°</th>
<th>120°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Violet 1</td>
<td>1</td>
<td>0.8</td>
<td>2</td>
<td>1.9</td>
<td>1.7</td>
<td>1.4</td>
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<tr>
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<td>2</td>
<td>1.6</td>
<td>4</td>
<td>3.8</td>
<td>3.4</td>
<td>2.8</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>Yellow 3</td>
<td>3</td>
<td>2.4</td>
<td>6</td>
<td>5.7</td>
<td>5.1</td>
<td>4.2</td>
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<td></td>
</tr>
<tr>
<td>Orange 4</td>
<td>4</td>
<td>3.2</td>
<td>8</td>
<td>7.6</td>
<td>6.6</td>
<td>5.5</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>Red 5</td>
<td>5</td>
<td>4.0</td>
<td>10</td>
<td>9.5</td>
<td>8.5</td>
<td>7.0</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Brown 6</td>
<td>6</td>
<td>4.8</td>
<td>12</td>
<td>11.4</td>
<td>10.2</td>
<td>8.4</td>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td>Blue 8</td>
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<td>16</td>
<td>15.2</td>
<td>13.6</td>
<td>11.2</td>
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<tr>
<td>Olive 10</td>
<td>10</td>
<td>8.0</td>
<td>20</td>
<td>19.0</td>
<td>17.0</td>
<td>14.0</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>Grey 12</td>
<td>12</td>
<td>9.6</td>
<td>24</td>
<td>22.8</td>
<td>20.4</td>
<td>18.8</td>
<td>12.0</td>
<td></td>
</tr>
</tbody>
</table>

**Label for a flat webbing synthetic sling**

**Label for a flat webbing synthetic sling according to lifting capacity**

Indicator stripes – each stripe represents 1 tonne WLL – safety factor 8:1

Load factors and slinging

The lifting capacity of a sling for a straight lift is the WLL. Once the WLL has been altered due to a particular slinging method such as an increase in the angle between two legs or a reeve it is then referred to as the safe working load (SWL).
The lifting capacity decreases as the angle between the legs of the sling attachment increases. Different methods of slinging will also alter the lifting capacity.

For example, a reeved sling around a square load will halve the lifting capacity of a sling. This gives a load factor of 0.5.

Riggers must know the load factors for each method of slinging shown below.

**Single sling**

- **Direct Load**: Load Factor = 1
- **Rectangular Load**: Load Factor = 0.5
- **Round Load**: Load Factor = 0.75

**Basket hitch**

- **Single Sling Vertical Legs**
  - Load Factor = 2
  - Load Factor = 1
- **Include Angle Between Legs**
  - 30°: 1.93
  - 60°: 1.73
  - 90°: 1.41
  - 120°: 1.00

**Endless sling or grommet**

- 45°: 1.38
- 60°: 1.30
- 90°: 1.06
- 120°: 0.75

**Multiple slings**

- 30°: 1.03
- 60°: 1.73
- 90°: 1.41
- 120°: 1.00

A simple rule of thumb for a good safe working angle is to make sure that the horizontal distance between the points of attachment of the load does not exceed the length of the slings.

This will ensure that the angle between the two legs of the sling does not exceed 60°. At 60° the slings will lift only 1.73 the WLL of one sling.

The recommended maximum angle between the two legs of a sling is 90°. The recommended maximum angle between the vertical and any leg of a sling is 45°. At 90° the slings will lift 1.41 times the WLL of one sling.

When slinging a rigid object with a multi-legged sling it must be assumed that only two of the sling legs are taking the load. Additional legs do not increase the SWL of the sling assembly. Therefore each leg has to be capable of taking half of the weight of the load.

The SWL of a multi-legged sling assembly is assessed on the diagonally opposite legs, which have the largest included angle.
The SWL of slings decreases as the angle between the slings increases or if the slings are nipped or reeved. All factors must be considered when determining which sling is the correct one to lift a given load.

Remember that the rule of thumb method of working out the SWL of slings is not completely accurate. For an accurate SWL refer to the manufacturer's load charts.

Common sling arrangements

**Single-part, single-leg slings**

<table>
<thead>
<tr>
<th>Direct Load</th>
<th>Choke Hitch</th>
<th>Basket Hitch</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Diagram" /></td>
<td><img src="image2" alt="Diagram" /></td>
<td><img src="image3" alt="Diagram" /></td>
</tr>
<tr>
<td>Round load</td>
<td>Rect. load</td>
<td>Round load</td>
</tr>
</tbody>
</table>

<p>| Double-part, single-leg slings |</p>
<table>
<thead>
<tr>
<th>Direct Load</th>
<th>Choke Hitch</th>
<th>Basket Hitch</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image4" alt="Diagram" /></td>
<td><img src="image5" alt="Diagram" /></td>
<td><img src="image6" alt="Diagram" /></td>
</tr>
<tr>
<td>Round load</td>
<td>Rect. load</td>
<td>Rectangular load</td>
</tr>
</tbody>
</table>

**Two-leg slings**

<table>
<thead>
<tr>
<th>Direct Load</th>
<th>Choke Hitch</th>
<th>Rectangular load</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image7" alt="Diagram" /></td>
<td><img src="image8" alt="Diagram" /></td>
<td><img src="image9" alt="Diagram" /></td>
</tr>
<tr>
<td>Single wrap</td>
<td>Double wrap</td>
<td></td>
</tr>
</tbody>
</table>

**Three-leg and four-leg slings**

<table>
<thead>
<tr>
<th>3-leg assembly</th>
<th>4-leg assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image10" alt="Diagram" /></td>
<td><img src="image11" alt="Diagram" /></td>
</tr>
</tbody>
</table>
Sample calculations

In the examples below all the load and reeve factors are for FSWR. The arithmetic is set out so that calculations can be easily worked out on a calculator.

1. To calculate the maximum weight of load that can be lifted multiply the WLL of the sling(s) by the angle factor by the reeve factor.

   **Formula:** Max load = WLL (of sling) x angle factor x reeve factor.

   For example: The WLL of each leg of a two legged sling is 8 tonnes, the angle between the two sling legs is 60˚ and they are reeved around a square load. This means a load factor of 1.73 for the angle and another factor of 0.5 for the reeve.

   | Sling WLL | 8 tonne |
   | Angle factor | 1.73 |
   | Reeve factor | 0.5 |

   Therefore:

   \[
   \text{Max load} = 8 \times 1.73 \times 0.5
   \]

   \[
   = 6.92 \text{ tonnes}
   \]

   6.9 tonnes is the maximum weight that can be lifted

2. To calculate the WLL of multi-legged slings needed to lift a load divide the weight of the load by the load factor.

   **Formula for a calculator:** WLL = weight ÷ load factor

   Formula can be written: \[\text{WLL} = \frac{\text{weight}}{\text{load factor}}\]

   For example: The weight of the load to be lifted is 20 tonnes and the angle between the legs of a two legged sling is 60˚. This means that the load factor is 1.73 for the angle.

   | Weight | 20 tonnes |
   | Load factor | 1.73 |

   Therefore:

   \[
   \text{WLL} = \frac{20}{1.73}
   \]

   \[
   = 11.56 \text{ tonnes}
   \]

   Therefore, use a sling with a lifting capacity greater than 11.56 tonnes.

3. To calculate the WLL of a sling needed to lift a load divide the load by the angle factor and divide by the reeve factor.

   **Formula for a calculator:**

   \[\text{WLL} = \frac{\text{weight}}{\text{angle factor} \times \text{reeve factor}}\]

   Formula can be written:

   \[\text{WLL} = \frac{\text{weight}}{\text{angle factor} \times \text{reeve factor}}\]
For example: Two slings have a 60° angle between them and are both reeved around a 4 tonne square load. This means a load factor of 1.73 for the angle and 0.5 for the reeve.

<table>
<thead>
<tr>
<th>Weight</th>
<th>4 tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angle factor</td>
<td>1.73</td>
</tr>
<tr>
<td>Reeve factor</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Therefore:

\[
\text{WLL} = \frac{4}{1.73} \div 0.5 = 4.62 \text{ tonnes}
\]

Therefore, use a pair of slings each with a lifting capacity greater than 4.62 tonnes.

4. To calculate the WLL of the sling needed to lift a load divide the load by the angle factor and divide by the reeve factor.

**Formula for a calculator:**

\[
\text{WLL} = \frac{\text{weight}}{\text{angle factor} \times \text{reeve factor}}
\]

Formula can be written:

\[
\text{WLL} = \frac{\text{weight}}{\text{angle factor} \times \text{reeve factor}}
\]

For example: Two slings have a 60° angle between them and are reeved around a 20 tonne round load. This means a load factor of 1.73 for the angle and 0.75 for the reeve.

<table>
<thead>
<tr>
<th>Weight</th>
<th>20 tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angle factor</td>
<td>1.73</td>
</tr>
<tr>
<td>Reeve factor</td>
<td>0.75</td>
</tr>
</tbody>
</table>

\[
\text{WLL} = \frac{20}{1.73} \div 0.75 = 15.41 \text{ tonnes}
\]

Therefore, use a sling with a lifting capacity greater than 15.41 tonnes.

5. To calculate the diameter (D) in millimetres (mm) of FSWR needed to lift a load (L) of 5 tonnes as a straight lift, convert tonnes into kilograms, divide by 8 and then find the square root of the answer.

**Formula:** \(D \text{ (mm)} = \sqrt{\frac{\text{load}}{8}}\)

Formula can be written: \(D \text{ (mm)} = \sqrt{\frac{\text{Load}}{8}}\)

\[
D \text{ (mm)} = \sqrt{\frac{5 \times 1000}{8}} = \sqrt{625} = 25
\]

Therefore, a 25mm diameter FSWR is needed for the lift.

**Weight of the load**

Do not lift if the weight of a load is not stamped on the load or the delivery docket or it is not possible to calculate the weight.

It may be possible to calculate the weight of a load from the weighbridge certificate from the delivery vehicle.

Be careful of the load weight stamped on the load or delivery docket.
Timber for example, can be 50 per cent heavier when wet. In foundries when large castings are raised from a mould there can be suction created by the sand adding substantially to the weight. Pipes are often weighed down by sludge.

Fuel and water tanks may not always be empty. Check for this. When lifting a load for the first time watch the lifting equipment carefully for signs of strain in case the stated weight is incorrect. The operator can confirm the weight of a load using a crane load indicator, if one is fitted.

See ‘Areas and Volumes’ page 215, for the formulas for calculating the volume of varying shaped objects and the ‘Tables of Masses’ on page 219.

**Direct lifting**

Direct the crane operator to position the head of the boom, jib or the bridge directly over the load. The load hook must be positioned directly above a load before slinging and lifting.

Always lift vertically. If the boom, jib or bridge is not directly over the load, the load will begin to swing dangerously as soon as it is raised.

Dragging a load can put undue strain on the lifting gear and crane boom especially if the load is dragged from the side.

**General slinging**

Make sure that there is suitable packing or lagging at all sharp edges of steel beams, and other hard materials.

Use packing to prevent the sling from coming into contact with sharp edges. This will lengthen the life of the sling and prevent damage to the slings.

Make sure that packing or lagging is secure so that it will not fall out when the slings go slack. Before lifting a load make sure that it is not caught or trapped in some way.
Machinery, plant, personnel or material work boxes and fuel containers with lifting lugs must have the WLL clearly marked.

All loose loads delivered to a site that could be hazardous should be strapped or wrapped.

For example:

- Loads of pipe, metal, timber, purlins and wall girts should be strapped before lifting.

Spreaders are recommended for lifting lengths of timber, pipe or steel. If a spreader is not available – double wrap before lifting.

Do not bash the eye of a sling down at the nip point. This practice will decrease the SWL and damage the sling.

**Structural steel**

Loads of structural steel (universal beams, RSJs) on trucks must have restraining spikes fitted in the truck to prevent them from falling out. Removing the chains or straps if there are no restraining spikes in place is very dangerous. Structural steel can be very dangerous. When a load arrives on site walk around the truck and check that the steel has not shifted into a dangerous position for lifting after the load binder chains were secured.
Many serious accidents have occurred as load binding chains were removed from steel beams. Deep beams that are narrower in width than height are unstable and can inflict especially severe injuries.

Always lift bundles of steel reinforcing, beams, pipes and purlins level. Do not lift it vertically or at a slope. It is not possible to make the inside section in a bundle tight enough to prevent them falling out if the bundle is at an angle. Steel reinforcing can kill if it falls.

As the load is lifted keep hands well away. Steel beams tend to snap together or roll up as the sling bites into the nip.

**Loose items**

Loads of loose items such as scaffold clips must be raised in properly constructed boxes branded with the SWL.

Do not lift loads of this kind in 200 litre drums unless they are in a properly constructed lifting frame with a solid metal base, because:

- these drums have no rated lifting capacity
- it may not be possible to know the condition of the base of the drum (they have usually been discarded because they are unfit to hold liquid)
- the holes cut into the sides for the sling or hooks can pull through under the weight
- the sharps edges of the holes can cut through a sling.

**Rubbish bins**

Rubbish bins should have proper lifting lugs and be branded with the WLL. Rubbish bins that are overloaded must not be lifted. Where rubbish can be blown out or spill from a bin, secure the load before lifting (especially in windy conditions).

Sling rubbish bins with a four legged sling. To tip the bin, release the two front slings and raise the bin with the two back slings.

Do not stand behind a bin when tipping rubbish out. It will whip back suddenly as soon as it is clear of the ground.

**Handling steel plate**

Steel plate can be lifted with:

- plate clamps that are designed to increase the purchase on the plate as the plate is lifted
- hooks or shackles where there are lifting holes in the plate.

Do not use home made type plate clamps or plate dogs. Remember that steel plate can injure or kill.
Use a spreader beam if the angle between the two legs is likely to be more than 60°

![Image of spreader beam]

Steel plate can be lifted vertically or horizontally.

Lifting vertically:

- use a plate clamp where a sling cannot be attached and there is no lifting hole. An example is the dished and flanged end plate for a pressure vessel
- **Note:** It can be difficult to remove or attach a sling where plate is stored vertically in a rack or is to be fed into bending rolls
- as a plate touches the ground and the tension is released from the slings a single hook can come out of the hole causing the plate to fall. To prevent this lift with a hook put through a ring attached to short length of chain that is shackled to a plate clamp
- always make sure that the tension remains in the slings until the plate is in place.

Lifting horizontally:

- it is recommended that a minimum of four plate clamps and a spreader beam are used for lifting steel plate horizontally. For horizontal lifts use appropriate plate clamps. Use a spreader beam for long thin plates to prevent dangerous flapping, sagging and vibration.

![Image of correct set-up for lifting steel plate vertically]

Pallets

A wide variety of loads are delivered on pallets. Before a palleted load is lifted from a truck check that:

- the pallet is free from defects
- the load is secured so that nothing can fall off
- the load is properly slung.
The WLL of a standard hardwood pallet is 2000kg. The WLL can be dramatically reduced if there are any missing boards or any other defects. **Note:** Some pallets are designed for packaging not lifting.

Do not lift a pallet that has defects. To lift a load on a damaged pallet raise the load just enough to slide an undamaged pallet underneath. Then lower the load and sling properly before lifting and moving the load to the desired place.

If no spare undamaged pallets are available send the load back to the supplier to be re-palleted.

Always raise palleted bricks inside a brick cage to prevent loose bricks falling.

**Loading formwork**

When placing concrete out of a kibble onto formwork spread the flow out. Dumping the whole load in one spot can overload the formwork especially if it is also taking the weight of workers and vibrating equipment. Formwork is only designed to take concrete spread out evenly over the whole area.

Make sure that the concrete is poured gradually. The sudden release from a kibble attached to a mobile or tower crane can cause a ‘whip back’ and the kibble will bounce dangerously.

**Turning over loads**

When turning over a load such as a steel beam the sling must be attached to the hook on the side of the load that is to be lifted. This will ensure that it will be raised on a diagonal through the centre of gravity.

It is then a simple matter to lower the hook, turning the beam over in a safe and controlled manner.

It is important that the beam is slung so that when the beam is lowered the nip will pull against the eye.

Structural steel members such as universal beams and RSJs have a high centre of gravity and a narrow base when standing on their flange. If a sling is nipped incorrectly the beam will flop, topple over and possibly break the slings.

The same principles apply when turning over all loads.

**Correct method of turning over a load**

![Diagram of correct method of turning over a load]

Turning over a steel bin
Chapter 9 Selection and use of mobile cranes

Before commencing a job with a mobile crane, go to the work site with the supervisor and the crane operator and assess the crane suitability for the whole job. Assess access, room, soil, lift capacity and lifting equipment.

Decide where to set up and how to set up.

**Mobiling**

Some mobile cranes are better suited than others to travel over rough surfaces. Always check the load chart and the manufacturer’s recommendations before mobiling.

Cranes are more likely to overturn ‘offroad’. Before leaving the road check:

- for potholes and soft or rough ground
- for overhead obstructions
- for powerlines
- for personnel working in the area
- blind corners
- traffic flow
- underground services.

Always check grassy surfaces for potholes hidden by long grass. Walk over the whole area before guiding a crane across.

Make sure spring lockouts (where fitted) are set before mobiling a load.

Do not direct the operator to slew unless the surface is firm and level. Booms are not made to withstand sideways forces.

Slewing can be very dangerous if the crane is attached in any way to another crane or tackle. (The whole operation must be under the control of one person.)

The load should be connected to the crane by a tail rope to prevent sway that could cause the crane to overturn. Do not mobile heavy loads with crawler cranes unless the ground is firm and level.

Take extreme caution walking a load into position with the load high and close to the boom. The load can swing back and hit the boom causing it to collapse as the crane moves forward.

When a crane is used as a winch make sure that the crane is secured in position and immobile.

All mobile cranes with wire rope luffing gear must have a luffing overwinding limit device.

The load must be secured in a fore and aft position unless the load is too long. Long loads must be secured in a diagonal position with the boom fore and aft.

Warning lights (where fitted) must be turned on when the crane is moving.

Travel slowly to prevent excessive swing.

Always carry the load as close to the ground as possible.

Do not direct the load higher until it is almost in position.
Avoid travelling the crane over potholes, depressions, soft ground or across a slope, road cambers or shoulders, rail tracks, or any objects or dunnage wood, which could destabilise the crane or load.

Observe traffic rules, watch intersections, and avoid pedestrians. Instruct the operator to use the warning horn or whistle when approaching pedestrians or workers.

Warn everyone in the area of your intention before moving the load. A person can be easily knocked from a structure or crushed by a moving load.

General rules for mobiling up and down slopes:

- take the slope and angle of the boom into account when moving up or down a slope
- the load must face uphill

The load must always face uphill as close to the ground as possible
• when mobilising on a slope with the boom facing uphill ensure that the boom angle does not become too close to vertical. This is to prevent the boom toppling over backwards
• do not travel across a slope with a load
• crawler cranes are very dangerous on sloping ground. Direct the operator to boom down before mobilising a crawler crane up a slope. Once the crane reaches the top the operator must boom up to compensate
• where necessary use another crane to steady heavy crawler cranes when they are travelling downhill.

**Crane safety**

Make sure that the WLL of the hook is at least equal to the maximum load that can be safely lifted by the crane at the given radius and boom position.

Check the hook block for corrosion in the shank and for distortion, cracks and wear in the hook.

Make sure that the hoist rope is completely without twists and turns before lifting where the hook block is supported with multiple falls of rope.

Keep well clear of the lower hoist block sheaves to prevent fingers or hands from jamming in the sheaves.

Make sure that all tyres are inflated to the correct air pressure.

When lifting heavy loads the boom will pull down as it takes the weight thus putting a forward swing into the load when it is raised. To allow for this, take the strain then boom up or alternatively position the hook slightly closer to the crane.

![Always stand well clear of a slewing crane](image)

Make sure that when lifting broadside with a mobile crane on a slope, the downside wheels are raised by solid packing so that the crane chassis is level.

Always stand clear of loads being lifted or handled.

Make sure that slewing cranes are clear of all obstacles, loads and people. Bystanders can become jammed between cab, counterweight and chassis.

For cranes of less than 5 tonne capacity, the lower hoist block must be safeguarded to prevent injuries to hands or fingers.
Swinging from the high side to the low side without altering the boom angle increases the radius – can cause overturning.

The side loads on the boom caused by working on a slope can result in boom collapse.

Swinging from the low side to the high side with a high boom angle can cause the boom to collapse back over the crane.
When lifting a load on a floating vessel carry out the operations quickly and cleanly. When placing a load onto a floating vessel ‘inch’ the load slowly into place to prevent the vessel surging.

Crane hoist falls must not be secured to floating vessels for towing or mooring purposes.

**Electrical hazards**

Always maintain a safe distance from electrical wires when travelling with the boom raised.

![Caution - the boom will spring up after the load is released](image)

The head of a long boom will spring up when the load is released. Make sure there is a safe distance from any electrical conductors or other obstructions before releasing the load. Do not set cranes up close to any electrified equipment or apparatus unless there are safeguards to ensure the safety of persons using the crane.

All types of crane must not approach closer than:

- 3 metres from distribution lines on poles
- 6 metres from transmission lines on towers.

**Caution:** In some cases transmission lines can be found on poles.

Keep a look out for possible contact with electrical equipment at all times while operating or travelling the crane. If the crane could come within any of the above distances to electrical apparatus during operation, an observer must be appointed to keep watch and if necessary to warn the dogman.

Advise the crane operator if the crane is in close proximity to electrical equipment. If unsure about the voltage maintain a distance of 6 metres from wires.

Where possible de-energise electrical equipment or use buffers or stops to prevent any part of the crane from coming close to electrical equipment. This is the responsibility of the contractor and the local electricity supplier.
Always use a 16mm dry natural fibre rope as a tag line. Some synthetic fibre rope can conduct electricity in some circumstances.

Use dry natural fibre rope tag lines to control a load near to power lines

(a) Distribution lines on poles

(b) Transmission lines on towers

* Distance 6 metres unless designated otherwise by electricity supply authority

Dimensions in metres
Outriggers

Outriggers are hinged or sliding beams that are usually secured with locking pins or check valves. They must be secured when they are retracted.

Outriggers should be packed to keep the crane level and stable when in use. General rules for packing under outriggers:

- outriggers should be fully extended wherever possible
- make sure that the ground under the packing is firm and can bear the load
- the packing must cover as much area as possible to distribute the load
- the base layer of packing should be laid closely together and be at least 75mm thick
- the top layer of packing must be at right angles to the direction of the outrigger beam and at least 200mm wide
- the packing should be hardwood free from defects. Where Oregon is used, beware of cracks
- the packing must be ‘pigstyed’ (each layer at right angles to the next)
- check the condition of the jacks and packing regularly during crane operation - packing will often loosen up during initial use as the ground settles.

Consult the load radius (or boom angle) indicator and load chart to find the maximum load that can be lifted:

- when the crane is on outriggers
- when it is not on outriggers.

If the ground is soft, large timber mats should be used to provide stability

In cases where operation on slopes cannot be avoided, the operating area should be built up to give a level base
The load chart on the crane must display the maximum load that can be lifted in all areas of operation. These may typically include:

- the working zones of slewing cranes
- with any length of boom or jib
- at any radius of the load from the centre of the crane
- with no packed outriggers at the ends
- with no packed outriggers at the sides
- with the crane stationary on outriggers
- during mobilizing.

To tighten packing under non-hydraulic outriggers, raise the boom high and slew the boom broadside, then tighten the packing under the boom. Repeat for the other side.

Slewing must be carried out slowly. Slewing places great strain on the boom, clutch, pinion and races. The strain is greater still if the load develops excessive swing.

It is important that the area of the base of the outrigger packing is large enough to safely take the load. To make an estimate of the area needed use the formula below.

The formula for calculating the area of each outrigger base of lattice boom cranes in square metres:

\[
\text{Area of base} = \frac{W \times R}{B \times N \times V}
\]

For a calculator:

\[
\text{Area of base} = W ÷ R ÷ B ÷ N ÷ V
\]

\(W\) = Load plus half the mass of the boom in tonnes
\(R\) = Distance from load to back wheel support in metres
\(B\) = End of outrigger to back wheel in metres
\(N\) = Number of outriggers on the loaded side
\(V\) = Bearing pressure of soil
Use the table below for estimating the load bearing pressure (V) of different soil types.

<table>
<thead>
<tr>
<th>SOIL TYPE</th>
<th>Pressure (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft clay or loam</td>
<td>10</td>
</tr>
<tr>
<td>Ordinary clay and dry sand mixed with clay</td>
<td>20</td>
</tr>
<tr>
<td>Dry sand and dry clay</td>
<td>30</td>
</tr>
<tr>
<td>Hard clay and firm coarse sand</td>
<td>40</td>
</tr>
<tr>
<td>Firm coarse sand and gravel</td>
<td>50</td>
</tr>
<tr>
<td>Shale rock and sandstone</td>
<td>80</td>
</tr>
<tr>
<td>Hard rock</td>
<td>200</td>
</tr>
</tbody>
</table>

Use the diagrams to understand load distribution and failure modes:
- **Stability tipping failure**
- **Overload at long radius**
- **Load OK at short radius**
- **Strength structural failure**
- The load must always face uphill as close to the ground as possible
For example:

A load of 10 tonnes on a 2 tonne boom is to be lifted 7 metres from the back wheel support. There are two outriggers four metres from the support. The soil type is soft clay.

Area of base = \[
\frac{11 \times 7}{4 \times 2 \times 10}
\]

or

\[
11 \times 7 ÷ 4 ÷ 2 ÷ 10
\]

= 0.96 sq m

NB: Where the boom is used over one outrigger the area of the packing must be increased by 40 per cent.

Locomotive cranes

Always chock the wheels and apply the travelling brake when operating locomotive cranes on a slope, however slight.

Make sure that the outriggers are fully extended and properly packed before lifting.

Use running lights and warning flags.

Fit a derailing stop at the front and back of the crane, or open any suitably located switch points to divert run-away trucks.

Make sure that the crane is as level as possible. If necessary, the crane outriggers (where fitted) should be packed.

Watch out for indications of possible derailment.

Do not use the crane boom to assist rerailment in the event of a derailment. Severe overloading may result. Instead use mechanical or hydraulic jacks and packing, or another crane of suitable capacity.

Do not use rail clamps in place of outriggers to prevent the crane overturning, as they are only suitable for preventing the crane from moving along the track. If the crane overturns the rails and sleepers may also overturn if rail clamps are used.

Please note: For lengthening or shortening the boom on mobile cranes see Chapter 20 Rigging cranes and hoists. For multiple crane lifting see Chapter 18 Multiple crane lifting.
Chapter 10 Packing, securing and moving loads

Packing

Packing must be able to support the load and the base of the footings of packing should be hard and level. If the footing is earth, a layer of sand should be spread over the area. Make sure that the base area of packing is large enough to support the load.

Check that there are no services such as large diameter pipes, tanks and cellars under the packing, especially if a heavy load is to be placed on the packing.

Do not place bearers in line above one another, as the packing can roll and collapse.

During lifting operations, keep filling the gap with packing until larger bearers can be inserted. Follow up packing must be adjusted as the load rises.

Pigsties or cribbing

Pigstying is an effective method of supporting a load with criss-crossed timber packing. Each layer is set at 90° to the layer below.

The footing base must be large enough to support the load and the main load support bearers must be at right angles to the load.

Sleepers which are all slightly different sizes are often used for pigstying. To ensure there is no movement the second layer must be packed with wedges or thin packers (gluts).
Parbuckling

Parbuckling is a method of using two parts of rope to unload drums or cylindrical objects from trucks, or to roll them up or down inclines.

NOTE: For heavy loads it is recommended that one or two completed turns be taken round the object with the parbuckling rope. For exceptionally heavy loads two separate parbuckling ropes and purchases should be used, one at each end of the object.

Attach one end of each part to an immoveable object. Take a round turn around the cylinder and secure the free end to another suitable anchorage for slackening away as the load is allowed to move away. To maintain control over heavy objects use a purchase or tackle.

When using only one parbuckle rope make sure that the load can be lowered evenly. If two parbuckle ropes are used both must be slackened evenly.

Use parbuckle rope in the centre to start the load moving and also to act as a restrainer when the load is rolling.

Please note:
• the rope must be strong enough and long enough to do the job
• skids or bearers must be rigidly fixed
• all persons must be kept away from both front and rear of the load.

Rolling objects

Rollers can be used where the loads are bulky or heavy, and there is no room to lift the load into position by crane. The surfaces underneath should be level and hard. Sole planks may be used to provide a level surface if the ground is uneven.

Types of rollers:
• steel scaffold tube for light loads
• solid steel bar for heavy loads
• timber rollers or logs for ‘bush jobs’.
Timber bearers should be placed on the rollers and the load landed on bearers giving the rollers two even surfaces. The bearers must be of sufficient thickness to clear any projections from under the load. Alternatively, a special cradle may be used.

Use at least three rollers to ensure that the load does not become unbalanced and topple off. Place rollers at an angle to change direction of movement.

Hands and feet must be kept clear from the rollers while the load is moving.

**Skidding**

Skidding is where the load slides into place on skids set up on rails. To skid a heavy load set up well greased rails strong enough to support the load on sleepers.

Loosely bolted fish plates must be used to join the rails together. Each rail must be packed above the next rail in the direction of movement.

The sliding shoes should be constructed of steel channel sections slightly turned up on the ends of the web and slightly turned outwards on the ends of the flange.

Timber bearers should be placed across the rails on the shoes at various positions to suit the balance of the load. The bearers must be strong enough to support the load in the centre.

When the load is in motion care must be taken to ensure that the shoes and bearers travel evenly.

Skids should be packed level to prevent the load from working or toppling sideways.

Where necessary, a restraining purchase should be fitted to the rear to obtain better control of the load.
Steel wedges

When driving steel wedges take care that follow up packing is inserted, as the wedges can fly out.

When driving wedges keep well clear of the rear of the wedge as they fly out with extreme force. Secure the wedge with a lanyard, especially when working at a height.

When driving more than one wedge try to synchronise the blows on each. If steel wedges are fixed, extreme care must be taken when withdrawing them, as they fly out with great force.

Be careful of the fingers when placing or removing wedges or packings. Hold packing by the end and keep fingers well clear.

Grind off all burrs or mushroom heads on steel wedges as they fly off and cause serious injury.
Skates

Skates are a method of moving heavy loads with a set of small rollers fixed into a solid frame which are set in bearings and run very freely. They are built to hold a specific safe working load which should not be exceeded.

Prior to use:

- sweep clean the area in the direction of travel so that there are no obstructions to jam the skates
- ensure that the surface is strong enough to take the weight of the load displaced over the small area of the skate, or skates, and that the skates will not damage the surface
- ensure that the skates are placed under the load in a position so that there is even loading on every skate and that the load is level. If this cannot be done bearers must be placed under the load to ensure even loading
- ensure that there are personnel to keep watch for the load shifting dangerously while it is moving
- ensure that all skates run freely and that there is no damage to them.

Do not move a load on skates quickly. Use a restraining purchase at the rear to ensure that the load does not ‘get away’.

Skates can be reversed so that the skates remain stationary and the load runs over them. During this procedure make sure that the load does not run off the skates and topple over.
Part two

Basic rigging
Chapter 11 Steel erection

Introduction

The use of structural steel in the construction of multi-storey buildings was very common until the development of concrete reinforced design. Over recent years, however, structural steel design has started to make a comeback in multi-storey work. Portal frame construction is also widely used for low rise factories and warehouses. Structural steel is used extensively in the construction of power stations, smelters, refineries, bridges, transmission towers, communications towers and other industrial projects.

Certification

Those engaged in (or directly supervising) steel erection must hold a Basic Rigging certificate or equivalent old certificate.

Where steel erection involves multiple crane lifting operations or the use of load equalising gear, the Intermediate Rigging certificate (or equivalent old certificate) is required. The erection of permanently guyed structures (such as some communications towers) requires the Advanced Rigging certificate (or equivalent old certificate).

Trainee riggers who can produce a properly maintained logbook which details at least 25 working days of practical rigging experience in the erection of steel structures greater than 4m in height, are entitled to a major reduction in the amount of practical skills assessment needed to qualify for the Basic Rigging certificate.

Riggers must be familiar with the common erection methods and be able to recognise the typical hazards associated with this type of work. They must be able to read and understand construction drawings and specifications. They must also have the skills necessary to use the tools and equipment needed to erect steel and they must be able to work safely and confidently at heights.

Steel erection

Structural steel is basically a skeleton, designed to support a building. The first section must be fully plumbed and wind braced to ensure stability for the rest of framework.

As erection progresses, the wind bracing must be fitted. In some ‘A-Frame’ or ‘Saw tooth’ type buildings, which are long and narrow, the building may have to be guyed for support until each wind brace bay is erected.

Columns should be guyed to prevent the holding down bolts from pulling out causing the column to collapse. The concrete in the plinth that the column stands on is usually green.

Guys that are left on overnight must be FSWR guys. Fibre ropes shrink when they are wet and stretch when they are dry, and are therefore dangerous to use as guys.

The foreman or a competent person should ensure that every column base is level using a theodolite or a dumpy level before starting to erect the columns. Bush jobs could use a spirit level.

There should be a packer (elevation pad) underneath every column. If the column bases are not level the steel will not be plumb. It can be very difficult to wedge up steel especially if the steel is heavy.

Steel packers approximately the same height as the elevation pad should be placed adjacent to each holding down bolt. Use steel wedges if necessary for plumbing purposes.
The mass (weight) of any steel must be known for lifting into place. When ordering cranes to raise columns, a second crane may be required to ‘float’ in the base.

When raising a column with two cranes at the column head each crane should be capable of lifting the total weight of the column. If this is not possible, equalising gear must be used.

To ensure that columns hang vertically they should be slung as near to the top as possible.

When lifting columns with a reeved sling ensure that the sling is wrapped around twice then nipped (round turn). As the sling is wrapped around, incline the sling toward the nip, stopping the sling from slipping when the column becomes vertical.

The column must be packed to prevent the sling from being damaged by the sharp edges of the column. The packing has to be tied or secured to prevent it from dropping out when the slings slacken as the column is landed.

Heavy columns which are erected and spliced in the air must have scaffold brackets or bearers fitted before erecting the column.
Beams and girders

The mass (weight) of each beam or girder must be known.

Make sure that the crane is capable of lifting the beam to the required height. That is, check the crane drift before lifting.

Ensure that the correct size slings are used and see that the beam is adequately packed. Ensure that the packing will not drop out when the weight is released from the slings.

Lift the beam level unless it is intended to be canted. Take special care with warren or lattice beams, because the sharp edges of gussets can easily cut through slings.

Attach tag lines to each end of the beam to control it during the lift, even when setting steel on multi-storey jobs. Short hand lines at either end will allow the top hands to control the beam more easily.

If a crane has to be boomed out to land a beam the crane must be capable of lifting the beam at that radius. Booming out with a load in the air is dangerous especially if the load is heavy. Lift the beam as close as possible to its final position.

The end of a beam nearest to rigid steel must be fixed first, then if necessary adjust the steel at the other end. The old saying ‘get the first podger hole and let your mate worry’ is not good practice.

Field bolted beams must be bolted on diagonally opposite sides to prevent the beam from rolling.

Position the beam onto the podger when lowering so that if the crane over runs slightly, the top hands have control. It is dangerous to set the podgers while raising the beam. If the crane operator over runs slightly the sling could be overloaded and broken.

When setting steel beams into the web of other beams make sure that the crane operator ‘inches’ the load very slowly allowing reaction time for the crane operator to stop.

Do not use shifting spanners for tightening bolts when working aloft. Use proper set or ring spanners (preferably the podger type).

Do not work on wet or wet painted steel. Do not set steel in gale force winds.
Tapered drifts should be held by hand when being driven in to stop them being driven right through.

Hammers should have a restraining lanyard to stop them from being dropped from aloft.

Spliced columns have to be aligned directly above one another when being positioned.

When landing a beam experienced riggers will push a drifting beam across and drop their podgers in.

To lift a beam at the centre by two cranes with a mass greater than the capacity of either crane, use a properly rigged, equalising bridle or equalising beam.

The WLL must be stamped on all lifting gear including equalising beams, shackles, rings and hooks.

Before lifting bowstrings, turnbuckles and rigging screws should be fitted to long beams which may flex excessively. The screws must be fitted with a locking device or preventer lashings.

**Roof trusses, lattice girders, purlins and girts**

Check the following before attempting to lift roof trusses into position:

- the mass (may have to be calculated)
- the truss points must be properly bolted or riveted.

In all cases slings must be attached to panel points.
Roof trusses or lattice girders must not be left standing unsupported in an upright position. They should be secured by lashing or tomming to a building column or another suitable anchorage.

Lifting puts a force on a roof truss that is the opposite to those the truss was designed to take. The bottom chord is only designed to take tension.

When lifting by the top chord, the bottom chord is in compression and can buckle and bend. To stop this strengthen the bottom chord with a strongback or bow strings. Bending in saw tooth trusses which are used mostly for short spans is not as great.

Trusses should always be lifted at the panel points. Make sure that the slings are protected by packing to stop them being cut by the sharp edges of the gusset plates.

Principal high pitched gable trusses should be slung directly at the apex.

Flat pitched gable roof trusses are particularly dangerous to lift. They should be bridled and slung with a central vertical sling. The mass should be evenly distributed to the slings and the crane must have a greater drift.

To maintain control, attach the holding down bolts and fit tag lines to the ends before lifting the truss into its final position.

Fit temporary guys to the apex of the first truss. Four guys should be fitted if the truss exceeds 10m in length. Do not remove the guys until the wind bracing is fitted.

Finish the first bay completely before continuing erection of the rest of the building.

When pulling up the purlins and braces by hand, pull up the purlins first so that the braces can then be fitted underneath. Braces which are fitted first get in the way when trying to pull up the purlins.

Fit the bottom girts first to allow standing room. The girts can be lifted using a gantline or tackle slung off the eaves girder.

Wedge open the angles with wooden wedges to help the top hands enter the braces onto the gusset plates when using double angle knee bracing. The wooden wedges should be lashed to the bracing so that they cannot fall if they drop out.

Do not use both hands to force or podger any steel into place when working aloft.

**Bolts, nuts and washers**

There is a huge variety of fastenings available for structural connections. The rigger must know which fastenings have been specified by the structural designer for the various members. This involves a careful reading of the drawings and specifications.

Riggers must also be able to recognise different grade, diameter and length fasteners by visual inspection. If the wrong bolts are used the strength or stability of the steel structure can be seriously affected.
Bolts

Structural bolts are generally categorised by their nominal diameter, overall length and thread length. The nominal bolt diameter in millimetres is designated with the letter M followed by a number. For instance, an M 16 bolt has a nominal diameter of 16mm.

High strength structural bolts have their heads marked ‘8.8’ (for the steel property class). They also carry three radial lines and the manufacturer’s identification or trademark.

Nuts

High strength structural nuts can be identified by the three arcs indented or embossed on the non-bearing faces. With some brands of double chamfered nuts, the markings may appear on both faces.

Washers

Washers can be either flat round or square taper. Flat round washers designed to be used with high strength structural bolts and nuts are manufactured with three protruding nibs around their perimeters.

Square taper washers are used less frequently in modern structural design, but are still generally available. They are usually manufactured with taper angles of either 5° (for use with taper flange channels) or 8° (for use with taper flange beams or RSJs).

Further information

Further information on the specifications and allowable tolerances for structural bolts, nuts and washers is given in AS 1252:High strength steel bolts with associated nuts and washers for structural engineering.

Torquing bolts and nuts

The fitting of additional bolts and the correct tensioning of all bolts should be carried out once the structural members have been set in place and field-bolted. This is often done by a ‘follow-up’ crew while the steel-setting crew moves on to the next stage of the erection sequence.

Tools used during the consolidation of the structure include tension wrenches and impact wrenches (commonly referred to as rattle-guns). Impact wrenches can be electrically powered or pneumatic. ‘Gunning-up’ can be very dangerous unless the necessary precautions are taken and the recommended operating procedures are strictly followed.

Caution: Using an impact wrench for long periods of time can cause hand damage called ‘white knuckle’.

When using impact wrenches, observe the following rules:

• the socket and tool should be kept in line
• do not hold the socket
• do not use a worn out socket.
Working aloft

Background

In the past, steel erectors were often expected to work at heights with nothing to protect them from falling except a sense of balance and a lot of luck. Shinning up and sliding down steel columns, walking the top flange of narrow beams, running purlins up roof trusses and riding crane lifted loads were often regarded as standard work practices.

Not surprisingly, this lead to high fatality and injury rates among steel erectors.

Since the introduction of modern occupational health and safety laws by the Australian States and Territories, the old methods of working at heights are no longer acceptable.

Minimising the risks

Careful planning can and should reduce the amount of work needed to be carried out at heights. Where space permits and cranes of sufficient capacity are available, entire sections of the structure can be prefabricated on the ground. Using remote release shackles wherever possible can also reduce the need to work at heights.

On large scale industrial projects and bridges, it is often possible to fix scaffolds to structural members or sections of the structure before they are lifted into position. Despite these and other measures, many of the rigger’s tasks need to be carried out at heights.

Wherever working aloft is necessary, the work method and means of access should minimise the risk of falling, and the risks to other people in the vicinity.

The area below the work should be barricaded or cordoned off to prevent unauthorised access by other workers or the general public. Where this is not possible, overhead protection decks such as temporary gantries, covered ways, cantilevered catch platforms, perimeter safety screens or debris nets may be necessary.

All hand tools (such as podgers, ring-spanners, drifts and hammers) should be securely stowed on a purpose designed rigger’s belt constructed from sturdy leather, canvas webbing or synthetic webbing. Where safety harnesses are used, these generally incorporate loops for the stowing of tools. Bolts, nuts and washers should be kept in a pouch attached to the belt. One handed flogging hammers should be fitted with wrist straps.

There are many ways of providing steel erectors with a safe working platform and safe means of access which can prevent dangerous falls.

These include the use of:

- elevating work platforms (EWPs) such as scissor hoists, travel towers and boom lifts
- scaffolds
- portable ladders
- crane lifted work boxes
- industrial safety nets
- safety line systems.

Safety line systems require a high degree of planning, training and supervision and rely heavily on the steel erector always ‘doing the right thing’ and not taking short cuts. For these reasons, they should only be used where none of the other methods are practicable.
The static line should be located at least 2.1 m above the beam, as stated on page 142, and lanyards should be connected to the rear D-ring between the shoulder blades.

Elevating work platforms

EWPs should be designed and manufactured to meet the minimum requirements of AS 1418.10 *Elevating work platforms*. The design of all powered boom-type EWPs or any powered EWP designed to lift people more than 2.4m must be registered with a State or Territory regulatory authority.

Providing there is a suitable supporting surface and there is sufficient access, EWPs can provide a very effective working platform for steel erection. There are various types available including self-propelled scissor hoists (some of which have cantilevered rolling platform sections), manually powered cherry pickers, trailer-mounted or truck-mounted travel towers and self-propelled boom lifts.

Your employer must make sure you have been properly trained in the use of the particular type of EWP to be used. Make sure you have read and understood the machine’s operating instructions and are aware of its limitations before you use it for the first time. Make sure all the necessary checks have been carried out before each use.

Power operated boom type EWPs with a maximum boom length of 11m or more require a certificate of competency to operate without direct supervision. The boom length is the greater of the vertical distance between the EWP’s supporting surface and the underside of the workbasket at its highest possible elevation or the horizontal distance between the boom’s centre of rotation and the outer edge of the workbasket at the greatest possible radius.
Note: With the introduction of the nationally uniform certificates, some States and Territories have allowed a phase-in period for this certificate class. If in doubt, check with the local certifying authority.

Observe the following rules when using an EWP:

- make sure the supporting surface has enough load-bearing capacity for the EWP
- do not overload the platform or basket
- do not use the EWP on ramps or inclines which are steeper than the supplier’s recommendations
- where fitted, outriggers should be fully extended with pads bearing evenly and the EWP levelled before being elevated
- for self propelled EWPs, make sure the area of operation is free from obstructions and traps such as holes, penetrations, drains or upstands. Where these cannot be removed make sure they are securely barricaded or guarded
- whenever you are elevated, make sure another person who is competent to operate any override controls is always in the immediate area so you can be quickly retrieved in an emergency. Never work in total isolation from another person
- make sure you maintain the recommended clearances from powerlines
- do not climb out of, or into the EWP while it is elevated unless the unit has been specifically designed for this and the supplier’s information allows it
- do not try to gain extra height by climbing up the guardrailing, placing planks on the guardrailing or placing ladders, trestles or boxes on the platform
- do not use the EWP as an anchorage for lifting gear unless it has specifically designed attachments for this
- make sure everyone in the basket of a boom type EWP is wearing a safety harness attached to the anchorages provided within the basket. This may save your life in the event of a boom failure. Do not disconnect your lanyard until the basket has been fully lowered.

Further information on the selection and safe use of EWPs is given in AS 2550 Cranes-Safe use Part 10, Elevating work platforms.

Scaffolds

Scaffolds should be designed and constructed to comply with the minimum requirements of AS 1576 Scaffolding. The design of prefabricated scaffolding systems (including modular, frame and towerframe types) must be registered with a State or Territory regulatory authority.

As a general rule, the erection of a scaffold from which a person or object could fall more than 4m must be carried out or directly supervised by a person holding the appropriate scaffolding certificate. However, fabricated hung scaffolds and suspended scaffolds may also be erected by persons holding the Advanced Rigging certificate (or equivalent old certificate).

There is a wide variety of scaffold types ranging from simple trestle scaffolds to highly complex tube and coupler arrangements. They are all capable of providing a stable and safe temporary working platform provided the right type of scaffold is selected for the particular work.
Steel erectors can often make use of scaffolds which have been set up for other work tasks such as wall cladding, bricklaying, concreting, roof work or services installation.

Scaffolds can also be provided specifically for the setting of steel and associated consolidation tasks such as welding, insulation and sheeting. These may include bracket scaffolds attached to large structural members, perimeter safety screens, formwork shutters or large storage tanks, trestle scaffolds for low level work, cantilevered or spurred scaffolds projecting from the face of the structure, purpose designed hung scaffolds, and suspended scaffolds such as swing stages, work cages and boatswain’s chairs. One of the most common forms of scaffolding used during the erection of low rise portal frame buildings and modern structural design multi-storey construction is mobile prefabricated tower frame scaffolds.

Observe the following rules when using scaffolds:

- make sure the scaffold has been completed and is ready for use. Carefully read all tags or notices attached to the scaffold. Make sure it has been provided with properly secured means of access such as single ladders or temporary stairways
- on a mobile scaffold, make sure the lower access ladder is clear of the supporting surface
- make sure the operational area for a mobile scaffold is a hard, flat surface free of penetrations or obstructions which could destabilise the scaffold during relocation
- do not place a mobile scaffold closer than 1m to a slab edge, penetration or step down unless a fixed barrier is in place to prevent it crossing that point
- if the supporting surface for a mobile scaffold is sloped, make sure the scaffold is fitted with adjustable castors with brakes and use the adjustment to level the scaffold before use. Where the surface gradient exceeds 50, separate adjustable baseplates or similar must be used to take the load off the castors while the scaffold is in use
- make sure all approaches, access points and platforms have effective lighting without glare or deep shadows
- do not interfere with a scaffold by removing ties, braces, guardrailing, platform planks, toeboards or other members. Any alterations needed to the scaffold must be carried out or directly supervised by a person with the appropriate certificate of competency
- apply the wheel brakes to the castors of a mobile scaffold before use. Do not release the brakes while anyone is on the scaffold
- do not climb up the framework of the scaffold. Use the access provided
- make sure the access ladder of a tower frame scaffold is always on the inside of the scaffold with the access opening in the working platform protected by a hinged trapdoor, sliding hatch or similar
- make sure that, wherever a person or object could fall more than 2m, rigid guardrails, midrails and toeboards are securely fixed to the edges of all platforms and ladder landings
- do not attach shade cloth or other sheeting to a scaffold unless you know it has been designed for the extra deadloading and windloads
- do not use the scaffold as an anchorage for lifting gear unless it has been designed for the additional loading
- do not overload the working platforms. If you are unsure of the scaffold’s duty classification, assume it is light duty. The maximum allowable light duty loading is 225kg per platform per bay. This includes the weight of persons and materials
- any materials and equipment deposited on working platforms should be positioned to maintain clear unobstructed access along the full length of the platform at all times
• maintain platforms in a tidy condition by frequently removing surplus material and debris
• where platform decking units are constructed from aluminium gridmesh and the material or tools you are using could fall through the gaps in the gridmesh, cover the platform surface with non-slip sheets of plywood
• do not try to gain extra height by climbing on the guardrailing, placing planks across the guardrails or placing a step ladder or trestle on the working platform
• do not move a mobile scaffold while anyone is on it unless the scaffold has been specifically designed to allow for this
• when relocating a scaffold by crane, make sure it is slung from the base and that the slings are long enough to enclose the scaffold. Additional scaffold tubes may need to be fixed to provide suitable lifting points. For large scaffolds, a purposelydesigned lifting frame may be required to prevent the scaffold from distorting during lifting. Make sure all members are secure against dislodgment and all loose materials have been removed from the platforms.

Further advice on the selection, use and inspection of scaffolds is given in AS 4576 Guidelines for Scaffolding. Guidance on the erection of fabricated hung scaffolds and suspended scaffolds is given in Chapters 21 and 22 of this Guide.

Portable ladders
Portable ladders should be designed and constructed to meet the minimum requirements set out in AS 1892 Portable ladders.

Portable ladders are available in two grades – Industrial and Domestic. Never use a domestic grade ladder for industrial use because it is not required to be as robust and strong as an Industrial Grade ladder.

Ladders can be constructed from steel, aluminium, timber or reinforced fibreglass and are generally classified as being one (or a combination) of the following types:

- **Single ladders**, available in lengths of up to 9m.
- **Extension ladders**, in two or more stages and available in maximum working lengths of up to 15m.
- **Stepladders**, available in lengths of up to 5.5m.
- **Trestle ladders**, used to support scaffold planks and available in lengths of up to 5m.

Trestle ladders are not generally suitable for steel erection but the other types of portable ladders can often be used for unslinging beams and for bolting up structural members.

Ladders can be checked for serviceability by:

- taking each end of the ladder in turn and trying to push the stiles apart and then together. Movement indicates insecure rungs or loose tie rods
- laying the ladder flat, raising one end and attempting to push one stile while pulling the other. If the stiles move relative to each other, the rungs are loose
- tapping timber rungs with a mallet. A dull sound indicates a defective rung.

Damaged or unsound ladders should not be used until they have been repaired and passed re-inspection.

Do not use a ladder with any of the following faults:

- timber stiles warped, splintered, cracked or bruised
- metal stiles twisted, bent, kinked, crushed or with cracked welds or damaged feet
• rungs, steps, treads or top plates which are missing, worn, damaged or loose
• tie rods missing, broken or loose
• ropes, braces or brackets which are missing, broken or worn
• timber members which, apart from narrow identification bands, are covered with opaque paint or other treatment that could disguise faults in the timber.

When using portable ladders, observe the following rules:
• place single and extension ladders at a slope of four to one, and set up step ladders in the fully opened position
• do not handle or use ladders where it is possible for you or the ladder to make contact with power lines. In particular, metal or metal-reinforced ladders must not be used in the vicinity of live electrical equipment
• do not set up a ladder within the arc of a swinging door
• single and extension ladders should be footed by another person or secured top and bottom
• do not use a step ladder near the edge of an open floor or penetration. If the ladder topples, you could fall over the edge
• do not set up ladders on scaffold platforms or EWPs to gain extra height
• always have two hands free to ascend and descend the ladder. Any materials or tools which cannot be safely stowed on your belt should be independently transferred or hoisted to the work location
• always face the ladder when climbing or carrying out work
• your feet should never be higher than 900mm from the top of a single or extension ladder, or the third tread from the top plate of a step ladder
• do not have more than one person on the ladder at any time
• do not work over other people
• make sure there is no danger of crane lifted loads trapping or striking you
• do not overreach. Your belt buckle should be within the ladder’s stiles throughout the work
• do not use a ladder for work involving restricted vision or hot work (such as welding or oxy-cutting)
• the use of power tools on a ladder should be limited to tools which are easily operated one handed
• when working from a single or extension ladder, make sure you can brace yourself at all times.

Further advice on the selection and use of ladders is given in AS 1892.4 Selection, safe use and care of portable ladders.

Crane lifted work boxes

Crane lifted work boxes are often suitable for very high work or isolated parts of the project where it is difficult or impractical to provide scaffolds or EWPs.

The work box must be specifically designed for the purpose of lifting people. The work box design must be registered with a State or Territory regulatory authority.

The work box must be stamped or be provided with a stamped metal data plate, securely and permanently attached to it in a prominent position, and providing the following information:
• the maximum hoisted load (kilograms)
• the safe working load (kilograms)
• the tare mass (kilograms)
• minimum allowable (rated) crane capacity (kilograms)
• identification reference.

The work box must also be marked permanently and legibly with letters and numerals not less than 25mm high in a colour contrasting with the background, with its safe working load in kilograms.

The work box must be painted in high visibility colours. The lifting slings must be permanently attached to its lifting lugs with moused shackles, or similar. An access door, if fitted, must only open inwards and be provided with a means to secure it shut.

The number of people supported in the work box must not exceed the number specified on the side of the box and, in any event, should not be more than three.

At least one person in the work box must hold a dogging or rigging certificate (or equivalent old certificate).

Any crane used to lift people in a work box must be:
• fitted with a safety hook
• equipped with controls that return to neutral and stop the crane when released
• equipped with power lowering
• equipped with a lockout control to prevent free fall
• fitted with an uplimit switch on the hoist motion
• fitted with a downlimit switch where the work box is to be lowered below the crane’s supporting surface.

The following rules must be observed when using crane lifted work boxes:
• use the work box solely for lifting persons and their equipment. Structural members are to be independently lifted into position
• the crane operator must remain at the controls throughout the operation
• all crane movements must be carried out under power
• when the work box is at the maximum intended radius, the crane’s SWL must be at least twice the total load of the work box, or 1.5t, whichever is the greater
• there must be an effective means of instant communication between the dogman or rigger in the work box and the crane operator
• where a mobile crane is used, it must not travel while anyone is in the work box
• every person in the work box must wear a safety harness which is attached to the crane hook or hoist rope termination or to purpose designed anchorages within the work box
• where it is necessary to carry oxyacetylene cylinders or any flammable liquids, these should be in the minimum necessary quantities, correctly secured and housed in a compartment separate to the work box. Make sure a suitable fire extinguisher is carried.

Climbing in and out of work boxes at heights can be a dangerous practice. However, where there is no alternative the work box must be securely attached to the structure before anyone enters or exits.
Safety nets

Industrial safety nets are suitable for some types of structures such as bridges and very high portal frames. They can provide an effective means of fall protection while allowing the steel erectors freedom of movement on the structural framework. Guidance on the installation and maintenance of safety nets is given in Chapter 14.

Safety line systems

Safety line systems involve the use of safety harnesses and can include various methods of anchorage including static lines, life lines and fixed anchorage points for inertia reels or lanyards.

The use of these systems as a primary means of fall protection is not generally recommended and should only be considered where none of the other methods mentioned previously are practical. Guidance on the installation and use of safety line systems is given in Chapter 15.
Chapter 12 Cantilevered crane loading platforms

Introduction

Cantilevered crane loading platforms (CCLPs) are temporary platforms which are often used during the construction or demolition of multistorey buildings and structures so that materials and equipment can be shifted to or from floor levels.

The platform is generally cantilevered from the face of the building to allow loads to be directly raised or lowered by tower cranes or mobile cranes.

CCLPs can also be used for other purposes such as catch platforms to contain falling debris at the building perimeter and as supporting structures for scaffolds constructed at the building perimeter. They are sometimes setup in a simply-supported mode such as over penetrations or voids, for use as loading platforms, access platforms or protection decks.

CCLPs are available in a variety of designs including fully fabricated and demountable types. They may have either fixed platforms or rolling platforms. Their needles can be anchored to the supporting structure in several ways, such as through bolting, bolting into cast in inserts, or reveal propping. Reveal props may be purpose designed, integral components or they may be general purpose adjustable building props laced together with scaffold tubes and couplers.

Certification

The installation and dismantling of CCLPs must be carried out (or directly supervised) by a person holding either the Basic Rigging certificate or the Intermediate Scaffolding certificate (or equivalent old certificates).

Whenever a CCLP is located or removed by a crane, the slinging and load direction must be controlled by a person with a Dogging or Rigging certificate (or equivalent old certificate).

The propping of CCLPs with adjustable building props and scaffold tubes and couplers or other types of scaffolding equipment must be controlled by a person with an Intermediate Scaffolding certificate.

The platform

The platform needles should be positively secured against lateral displacement.

A minimum of two signs stating both the maximum uniformly distributed load and the maximum concentrated load that the platform can carry must be in clear view on the platform.

The platform decking should be flush with and abutting the floor slab, otherwise suitable ramps should be fitted.

There should not be any gap between the platform and the site handrails.

Platforms located on the side of a building facing a public roadway should not extend beyond the line of the overhead protection provided for the public.
Relocation of crane loading platforms

The floor area where the platform is to be moved to, and the floor area where the platform is to be moved from, should be barricaded to prevent unauthorised persons from entering into the area while the change is made.

Perimeter fencing must be removed while the change is made.

No person should work near the unfenced perimeter edge unless attached to the building by a safety harness.

The area below the platform relocation must be barricaded and spotters provided where necessary.

Clear all loose objects from the platform before the platform is lifted by the crane.

Perimeter fencing (handrails) should be replaced immediately after moving the platform.

All bolts must be placed back in the respective vacant holes when erecting or dismantling.

The lifting position must be clearly marked with signs painted on the platforms.

The lifting lugs should be engineer designed to lift the platform.

Props must be correctly secured at the top and also at the base by bolting, welding, or other suitable securing method to stop any lateral displacement.

The tare weight of the platform must be displayed on the platform.

Some platforms have a rubbish bin inserted under the platform deck. The rubbish bin must be removed and emptied before the platform is shifted.

A waterproof sheet with instructions should be attached to the platform showing all operational and safety instructions of how to use, and lift the platform.

Use

Before the platform can be used:

• all bolts or connectors must be secured and tightened in position
• all props must be plumb and have the rear ties in position
• adjustable props must be adjusted to ensure minimal adjustable jack extension
• rear handrails must be in position
• the side panels and gates must be positively fixed in position.

Gates must be closed at all times except for long loads. All platforms must be kept clean and clear of loose materials.

Platforms should only be used in the manner for which they were designed. Any alterations or different use of the platforms should be to an engineered design.
Rolling platforms

Rolling CCLPs are platforms which can be rolled inside the building and back out again for ease of loading and unloading.

The two braces at the front of the platform, and the two locking pins on the left and right side must be in position and secured at all times for lifting, transporting and use as a loading platform.

The tie bar at the rear of the platform is to be used at all times when lifting or transporting the platform.

The spreader bar under the platform is to be secured and in position at all times.

Move the platform deck forward until it connects with the end of the beam. Secure the left and right side locking pins. Close the gates and place the left and right brace in position. To move the platform backwards, reverse the procedure.

Further information

For further information on the installation of CCLPs, refer to the supplier’s design specifications and recommendations for the particular type and model.

The general guidance for the erection of cantilever scaffolds given in AS 4576 Guidelines for Scaffolding, can also be applied to CCLPs.
Chapter 13 Erection of hoists and mast climbers

Introduction

Riggers are required to erect, dismantle and carry out maintenance on various types of hoist. These are the external guided cantilevered platform materials (one or two barrow) hoist and the mast climbing work platform. Both types are widely used in the building and construction industry but can also be used effectively in other industries.

Certification

The installation, dismantling and maintenance of cantilevered platform materials hoists and mast climbers must be carried out or directly supervised by a person holding either a Basic Rigging certificate or an Intermediate Scaffolding certificate.

The Basic Scaffolding certificate can only be used where the WLL of the hoist does not exceed 500kg. A Basic Rigging or Advanced Scaffolding certificate is needed where the WLL is over 500kg.

The cantilevered platform (one or two barrow) materials hoist

Cantilevered platform materials hoists run up and down the outside of the tower and are powered by electricity or an internal combustion engine. They are designed for the erection of small multistorey buildings and should be designed and constructed to comply with AS 1418.7 Builder’s hoists and equipment.

The working height of the platform is 30 metres or less and some have a maximum height of only 16 metres. Check the manufacturer’s specifications.

Under no circumstance can these hoists be used to carry passengers. Only certificated personnel carrying out erection, dismantling and maintenance can ride on the platform of a materials only hoist. There must be a notice on the platform clearly displaying the words - NO PERSONS RIDING.

Set up

The hoist must not be set up over a trench or excavation. When setting up near a trench the distance between the base of the tower and the edge of the trench must be greater than the depth of the trench.

The hoist must not be set up on bricks. It must be set up on solid timber packing. Where outriggers and screw jacks are fitted they must be tightened to maintain the hoist in a vertical position.

At the base of the tower the handrail must be set back at least 600mm from the working platform to stop people from leaning over and being hit by the platform coming down.

There must be an effective gate in the handrail such as a moveable or sliding rail to allow access to the platform.

On the floors above, a handrail must be placed 600mm from the edge of floors to prevent people falling off. Do not stand inside this barrier unless the platform is at your level.

There must be an overhead guard for the protection of the driver. The hoist must not be set up in front of any access way to a building unless it is blocked off.

The gap between the platform and building floor must be secured and made of solid timber or metal. The gap must be no less than 25mm and no more than 100mm. Do not use loose bridging plates.
If the hoist goes past any window or opening in the building, the opening must be blocked off to prevent people leaning out and being struck by the platform. Two barrier chains or gates must be in place on either end of the platform.

The tower must be guyed or tied every 6m and have no more than 3m free standing above the top tie, irrespective of the working height of the platform. The guys must extend diagonally from the four corners of the tower and the platform must not foul any guy rope. Guy ropes must be at least 9mm in diameter for hoists to 500kg capacity and at least 12mm for more than 500kg (and 6 x 19 construction).

Ties must be at least the same strength as the guys and rigid enough to stop the tower flexing. Fibre rope guys must not be used because they shrink when wet and stretch when dry.

**Electrical**

If the electrical power lead from the main box is loose it must be tied up clear of the ground. There have been many serious and fatal accidents because of leads lying in wet ground becoming entangled in, or severed by, equipment. All electrical equipment must be protected against water.

**The wire hoisting system**

All materials only hoists (cantilevered platform and tower) use a wire rope hoisting system for raising and lowering the platform.

There must always be at least two turns of wire rope on the hoist drum. The wire must be fixed mechanically. It must be at least 6 x 19 construction flexible steel wire rope (FSWR) and have no condemnable defects.

The hoist wire must lie neatly on the drum. Do not allow the wire to show loose turns. In the event of a rope failure there is a cam or a gripper to stop the platform from falling.

A top limit switch must be installed to stop the platform approaching closer than 1.5m from the head sheave on the hoist. A floor indicator must be installed where the platform travels more than six floors or 15m or if the driver’s view is obstructed.

**Working load limit**

The working load limit (WLL) must be displayed on the platform. The hoist WLL will be either a ‘Single barrow 250kg’ or a ‘Double barrow 500kg’. Do not allow the load to exceed the WLL.

**Pre-checks**

Prior to operating the hoist, carry out the following pre-checks:

- make sure that the hoist ties are in place and the tower has secure foundations. Check that the tower is vertical
- the hoist rope must lie neatly on the drum
- the lead from the power source must be secured well clear of the ground and in good order
- the tower guides must be clean and rust free.
Mast climbers

Design and construction

Mast climbing work platforms should be designed and constructed to comply with AS 1418-10 *Elevating work platforms*. The design must be registered with the local regulatory authority.

Mast climbing work platforms are available for use as either freestanding single or multiple tower units tied to the supporting structure as they are erected.

The supplier’s information for a particular mast climber should:

- confirm that the design has been registered with the local regulatory authority
- include sufficient instructions to enable the rigger or scaffolder to erect, alter and dismantle the unit safely within its design limitations
- include testing requirements, pre-operational checks and servicing requirements.

Any variation to the supplier’s recommendations should be to an engineered design.

Before preparing to set up a site for mast climbers, the distance from electric power lines must be known. If the distance is too close the power must be re-routed, the wires covered or the power cut off.

The ground must be checked to ensure that there are no underground services such as large drainage pipes directly under where the base or outriggers are to be situated.

If a mast climber is to be situated on a suspended concrete slab, the capacity of the concrete slab must be checked to ensure that it will take the total weight of the loaded machine. The floor must be supported by propping down the required number of floors, if the concrete is not strong enough. The builder or person in charge must be able to produce an engineer’s certificate regarding the strength of the concrete slab.

If the mast climber has to sit on bare ground, the bearing pressure of the ground must be checked to ensure that adequate packing is provided to support the machine.

The area should be level or the base packed so that it is level before the mast is placed and erected.

The site where erection is to take place should be barricaded or roped off to prevent unauthorised persons entering the area.

- the WWL and NO PERSONS RIDING signs must be in place and readable
- the attachment points for the barrier must not be bent or damaged.
Erection

The manufacturer’s manual should be carefully studied before erection starts.

Loose fitting clothes or ties should not be worn as they could be entangled in the moving parts.

Platforms must not be erected or dismantled in high winds.

Base units are fitted with lifting lugs which must be used according to manufacturer’s recommendations for the various lifting methods used for cranes, fork lift trucks etc.

The base can be either placed with mast outwards for free standing or with the mast inwards where the mast is tied to the building.

The outriggers must be extended and locked as per manufacturer’s recommendations for the actual setup of the machine. Packing must be placed under the screw jack feet to distribute the load required for local ground conditions.

The manufacturer’s recommendations should be checked for the free standing height and jack loadings of various models.

A free standing mast should not be used in high winds. The mast must be anchored at the top to ensure stability because high winds can occur suddenly. The building must be checked to ensure that it can withstand the forces of reaction that may occur in high winds.
If the building is not strong enough to support the mast at the top tie position, the anchor (tie) should be lowered to a point where there is enough strength to provide adequate support. The top anchor is usually designed so that it can be removed and turned over the top of the mast if the platform is to be driven to the top.

The platform should be lowered to the lowest position when it is not in use.

**Anchoring of masts**

Masts which exceed the maximum freestanding height must be tied to the building. When ties are used the base must be placed so that the mast is toward the building.

Tie spacing must be according to the manufacturer’s specifications or engineer’s design.

The building must be capable of taking the forces imposed by the mast climber at the anchoring points.

The base does not have to be set up on a mobile frame, it may be set up anywhere to suit a particular need.

If the machine is to be set up on needles on the outside of a building, the set up must be done according to an engineered design.
Chapter 14 Industrial safety nets

Introduction

Industrial safety nets are sometimes used as an effective means of fall protection for those working at heights where it is not practicable to provide scaffolds or temporary guardrailings. When combined with overlay nets of finer mesh size, they can also be used to contain falling debris.

Certification

The installation or dismantling of industrial safety nets must be carried out or directly supervised by a person with either a Basic Rigging or a Basic Scaffolding certificate or old equivalent.

Although safety nets can be attached to, or supported from scaffolds, they are often secured directly to the structural framework of buildings, bridges, towers and similar structures.

The advantages associated with safety nets include their ability to provide a comparatively inexpensive means of protecting people from injury due to falling or falling debris without adding considerable loads to the supporting structure.

Their advantage over individual fall arrest systems such as safety harnesses is that they allow unrestricted movement for workers.

The disadvantages are that safety nets can suffer from damage or misuse and are vulnerable to cutting, chafing and damage from sparks. Nets should not be used where they are likely to be exposed to chemicals.

Manufacture

Safety nets should comply with the design, manufacturing and test requirements of BS 3913, Industrial Safety Nets.

They are manufactured from synthetic fibre knotted lines with a 100mm mesh size. These lines are attached to perimeter cords. Safety nets are usually available in sizes of 4m x 3m or larger, and nets can be joined to cover larger areas.

The label attached to each net will state a maximum fall distance for which the net has been designed. This will be either 1m or 6m.

Installation

Prior to the installation of a safety net, the intended configuration, method of attachment and strength of the supporting structure should be verified as adequate by a competent person such as an engineer experienced in structural design. The verification should be in writing and retained on site until the net has been dismantled.

In particular, where nets are to be cantilevered from scaffolds, the scaffold must be designed for the additional loads and additional ties to the scaffold's supporting structure may be required.

The installation design should include detailed information regarding the exact positioning of the net, the fixing and tensioning methods and the erection and dismantling procedure.

Where possible, fabrication of the net assembly should be carried out on the ground or on an adjacent floor and lifted into place with a crane, hoist or purchase.
Nets should be installed as close as possible to the working levels and in no case further below than the maximum fall distance stated on the net's label.

**Typical arrangement of outrigged or perimeter nets**
The gap between a net and the building or structure should be as small as practicable, but never greater than 200mm.

Nets should not be stretched taut when erected. They should have an unloaded sag of between one quarter and one fifth of the length of the shortest side.

Sufficient clearance should be maintained at all times below the net to allow for stretch when a person falls into the net. This clearance should be at least two thirds of the length of the shortest side or 2m, whichever is greater.

When erected, nets should project beyond the outermost working point a horizontal distance of at least two fifths of the maximum fall height plus an extra 2m.

Nets should be sited so that a person who has fallen can be quickly rescued. For example, nets erected adjacent to a working platform, floor or other access point are easily accessible. Where this is not possible, it may be necessary to cut the net to quickly and safely retrieve a fallen person. Where there is any possibility of debris falling into the net, the installation design should allow debris clearance which does not require walking in the net.

Nets should be securely attached to the supporting framework using tie cords, hooks, rings or thimbles equally spaced at intervals not more than 750mm along each side and at the corners. They should be fixed to the border cords and adjacent mesh cords of the net.

Where cords are wrapped around sharp edges they should be packed to prevent damage.
Use and maintenance

A net which is used for the safety of persons should never be subjected to a loading test. The net should incorporate test cords which can be removed and tested in accordance with BS 3913.

After a net is put into use, these tests should occur at regular intervals dictated by site conditions, but in any event, at least every three months.

The test cords should not be used for any other purpose and should remain fixed to the net until they are required for testing. A record of the test results should be kept.

Nets should be thoroughly examined on both sides by a competent person immediately before they are erected. When a net is spread out for examination, particular care should be taken to avoid it coming into contact with cement mortar or other corrosive substances.

The net supporting framework and all anchorages should be inspected by a competent person immediately following erection, at weekly intervals, and immediately following any incident which may affect the strength of the net.

It is important that nets are kept free of all debris which may cause injury to persons falling into them.

The following situations should be avoided wherever possible:

- dragging the net over rough surfaces
- contact of cords with sharp edges
- stacking materials on the net
- accumulation of debris in the net
- persons jumping or throwing objects into the net
- sparks or flame from welding or oxy-cutting, hot gases from blow torches and hot ashes from chimneys or furnaces
- chemical attack
- the supporting framework being struck by moving loads
- unauthorised interference with any part of the net assembly.

Expert advice from the supplier or a competent person should be sought where there is any doubt regarding the suitability of the net following contamination or severe shock loading. Expert advice should also be sought on the serviceability of any net which has been in use for two years or more.

Damaged nets should be repaired only by specialists.

When they are not in use, safety nets should be stored under cover where they are protected from the weather and strong sunlight.
Chapter 15 Safety line systems

Safety line systems are used to prevent falls from multi-storey buildings when work has to be carried out in the absence of safety screens or handrails.

The installer designs the system based on the number of persons on the line at any given time taking into account whether or not energy absorbing lanyards are to be used and any other restrictions on the use of the line system.

Riggers and other users of the systems must also be aware of all the restrictions on the system.

Permanent installations must have any restrictions on the use of the system shown on sign posts at the access points.

Certification

The installation of safety line systems may be carried out or directly supervised by a person with either a Basic Rigging or a Basic Scaffolding certificate or old equivalent.

Specifications

The safety line system may be purpose designed or the following specifications may be used.

Single spans

For single spans of four to six metres, where no more than two people are on the line at any one time, and both persons are using lanyards with energy absorbers rated at 600kg (6kN) or less the specifications are:

• FSWR 10mm diameter (minimum)
• sag – approximately 50mm per meter, ie 6m span – 300mm sag
• anchorage – capable of supporting an imposed load of 4t (40kN)
• tensioning turnbuckles – minimum 16mm diameter threaded section.

Multiple span

The specification for multi-span systems are the same as a single span system with the following exceptions:

• sag for two or three continuous spans – approximately 30mm per meter, ie 6m spans = 180mm sag
• sag for four or more spans – no minimum sag required but the line should not be over tensioned
• corner supports or intermediate supports where the FSWR is not free to slide through the support end anchorages (ie they should be capable of supporting an imposed load of 4t).
Static line spans

The static line is the supporting safety line attached to the inside of the perimeter columns. The line should be supported at each column or in accordance with an engineer’s specification.

The line should be placed to eliminate the risk of tripping. Where practicable the line should be located no less than 2.1 metres above the floor of the work area. The point of attachment to the safety line system should be within reach of the user standing on the floor.

Anchorages and lines between supports should be positioned on the inside face of columns where practicable and used to anchor static lines, or the static line may pass through a cavity tube cast in concrete for that purpose.

Static lines between supports must be free of obstructions to allow uninterrupted movement for persons who may be attached to the line.

If a line passes around a column, corner, or other sharp edge, it should be packed to prevent damage to the line.

Do not use bulldog grips on static lines.

Tensioning should be achieved by turnbuckles or other appropriate means such as wire rope pullers and creeper winches.

If ratchet and pawl devices such as creeper winches are used for tensioning, remove them from the system after tensioning is completed.

Joining static lines

One method of joining static lines:
• terminate one end with a thimble and three double saddle clamps and allow a 200mm tail
• the second line should be passed through using a second thimble and three evenly spaced double saddle clips allowing a 200mm tail and shackle between each rope end
• line joins should be located at or adjacent to supports or anchorage points
• lapped joins on lines must not be used under any conditions.
Line systems for vertical travel

When using vertical lifelines (droplines) or other vertical fall arrest systems in connection with work from boatswain’s chairs or ladders, only one person should be attached to any one lifeline. Vertical lifelines should comply with AS 1891-3 Fall arrest devices.

Termination of static lines

The termination of the static line should be by eye and thimble. Where practicable ends should be secured by one of the following methods:

- double saddle clamps with a minimum of three equal spaces with a minimum 200mm tail past the last clamp
- hand splice with thimble eye
- machine splice with thimble eye
- suitable wedge sockets
- purpose designed fittings such as swaged or pressed fittings.

Lines and fittings may be secured directly to anchorage points with dee or bow shackles which should have a minimum WLL of 2t. The pin of the shackle should be moused (lashed) to the shackle.

Installation of anchorage points

Anchorage points used should be located as high as equipment permits, as it is safer to work below the point of anchorage.

The span between the intermediate supports of static lines should not exceed the engineer’s or supplier’s specification. All bolts should comply with AS 2317-1984 Collared eyebolts.

The following types of anchorages are acceptable when used in concrete:

- Cast-in anchors (in situ). A wall tie (shee bolt) purpose designed. An engineer designed anchorage
- Chemical and friction type anchors. Chemical and friction type anchorages should be positioned so the load from a fall is taken in shear. They should be proof tested in tension to at least one third of the design load prior to use. Collared eye bolts should be used.

All anchorages should be visually checked prior to use.

Turnbuckles

Only framed turnbuckles of an open type design which allow visual inspection of the condition and extension of the threaded sections should be used.

The frame should be locked or moused to the eye bolt to prevent slackening due to vibration, shock or spin in the line attached. Hook type turnbuckles should not be used. Only clevis or eye type should be used on lifelines.

Harnesses, lanyards and equipment

Body type harnesses and lanyards which comply with AS 1891 Industrial safety belts and harnesses should be used. The harness should be connected to the lanyard or lifeline at the top dorsal position.
If a life line and rope grab device is used on steeply sloping surfaces, the user needs to have the device located in front. This will allow safe manual operation of the mechanism.

Do not connect into a single D-ring on the side of the harness belt. Both side D-rings may be used for pole straps if a fall of 600mm or more is not possible. Do not use waist type belts.

Safety harnesses should be selected and used in accordance with AS 2626 *Industrial safety belts and harnesses – Selection use and maintenance*. Always follow the manufacturer’s information and advice, if available.

There should be a minimum of slack in the lanyard between the person and the attachment to the anchorage. The length of the lanyard should restrict the fall distance to a maximum of 1.8m.

Where an anchorage point is above the harness connection point a 1.8m lanyard will achieve this result. Where the anchorage point is below the harness connection point a shorter lanyard, or other means of restricting the fall distance may be required.

Do not use home made lanyards. Do not join lanyards together. If extra reach is needed use an inertia reel or similar equipment.

Do not connect lanyards with inertia reels. Snap hooks or other connectors should have a locking device and be compatible with all anchorages.

Those using safety harnesses should not work alone. In the event of a fall it is vital that the person is rescued as soon as possible to prevent further injury by the harness restricting blood flow.

To reduce injuries caused by a fall, energy absorbers should be used as part of the lanyard.

Equipment used with static lines should be compatible with the original system specification, such as manufactured travellers or energy absorbing lanyards.

**Inertia reels**

Inertia reel systems can be used to arrest falls where workers are required to carry out their work near an unprotected edge. They must comply with AS 1891.3 *Fall arrest devices*. 
Inertia reels are not designed for continuous support but become effective in the event of a fall. They should not be used as working supports by locking the system and allowing it to support the user during normal work. Inertia reels may be less effective for certain applications, e.g., stopping a person from sliding down an inclined surface.

When inertia reel anchorages are located lower than head height or a person is located at a horizontal distance from the anchorage, the line of the inertia reel will strike an edge if the person falls from the structure. The damage this may cause to the line could result in its failure. To avoid this, inertia reels should be used in accordance with the manufacturer’s instructions.

Inertia reels may be connected to a static line with a snap hook fitted with a locking device.

**Pendulum effect**

This is a potential hazard connected with the use of individual fall arrest systems. The pendulum effect may also occur if the positioning of the inertia reel allows for a significant length of unsupported line connected to the user.

Swing down can occur if an inertia reel is extended out diagonally so that the line makes an extreme angle with the perimeter edge of the structure. In this situation, the forces generated in an arrested fall over the edge will cause the line to rotate back along the perimeter edge until it reaches a position directly in line with the inertia reel and at right angles with the perimeter edge.

As the line moves back in this way, the unsupported section lengthens, dropping the attached worker further than the original (arrested) fall distance. If the length of the unsupported line equals the height of the building then the worker will hit the ground. Even if the worker does not reach the ground they may collide with obstructions on the side of the building.

To eliminate the pendulum effect place the inertia reel anchorage point square to the position of the line at the perimeter edge. A mobile anchorage helps here.
Chapter 16 Handling pre-cast concrete

Introduction

Pre-cast concrete is commonly used in a wide range of modern building and construction projects. Pre-cast concrete includes pre-tensioned beams, pre-cast concrete floor and facade panels.

Certification

The placement of pre-cast concrete must be carried out or directly supervised by a person holding a Basic Rigging certificate or old equivalent.

Work associated with tilt up panels is covered under the Intermediate Rigging certificate but excluded from the Basic Rigging certificate. For tilt up panels see Chapter 17.

Pre-stressed concrete beams

Pre-stressed concrete beams are designed so that stressing strands allows the concrete to hold a given load over a larger span.

The strands are often put into the beam in an inverted arc. When placed into position the beam is usually slightly arched, which allows the beam to straighten out when it is loaded.

Pre-stressed concrete beams are very sensitive to the direction in which they can be loaded. They are generally designed to take forces in a vertical downward direction only and have little or no resistance to forces in any other direction. Turning a pre-stressed beam on its side or upside down can cause it to collapse particularly when it is suspended.

Transfer beams

A different hazard applies to a special class of post-tensioned pre-stressed beams known as transfer beams. These are usually located at the first floor level of multi-storey buildings and are designed to transfer loads from the upper storeys to more widely spaced supports below to create large open spaces at ground floor level.

During the construction phase, the tendons in these beams are partially stressed in progressive stages to balance the loads as they increase over the construction period. Final stressing and grouting occur when the building reaches full height.
If no action is taken to reverse the effects of this procedure during demolition, the beam will tend to bow upward an increasing amount as the load from above is reduced. This can lead to local failure of the structure at, or just below, the working level. A reverse bending failure and collapse of the beam well below the working level can cause a collapse of the entire structure.

Riggers must be extremely careful when choosing the slings and lifting equipment because of the dangers associated with handling pre-stressed concrete beams.

The beams should be lifted by their ends, and from as near as possible to the position where they are to be placed.

It is recommended that a spreader beam is used to lift the beams to avoid having slings at an excessive angle. Spreader beams should be properly designed by an engineer to the length required and the weight of pre-stressed concrete beams.

**Pre-cast concrete facade panels**

Pre-cast concrete facade panels should be delivered to the site sitting on a frame so that they only require one erection crane and can be top lifted. If they are to be stored on site they should be stored on frames. They should not be erected in high winds.

Although they are usually erected by specialist contractors, riggers should be aware of the hazards.

The lifting inserts must be cleaned out to ensure that the lifting media can be fully bolted.

The lifting media (lugs etc) must be to an engineered design.

Panels should be lifted with a spreader beam so that the pull on the inserts is direct.

The angle between the slings during lifting should not be more than 60˚.

Do not work under the panel to put slings around it, if an insert pulls loose.

Contact the panel manufacturer and/or designer to have the insert positively fixed (welded) to the reinforcing steel if it is loose.

People who work outside a handrail, or if a handrail is removed, must be attached to a lifeline and be wearing a safety harness.

One person is to be in charge of the crane when lowering a panel into position.

The crane operator must be instructed to lower as slowly as possible when lowering a panel into final position.

When lowering panels by radio, if any person under any circumstances cuts across the channel, operations must stop until their reason for cutting across is discussed. If that reason is not safety they must be informed not to repeat an extreme safety breach.

Operations must cease immediately if the radio channel being used for giving directions for lowering a panel is cut into from a person not involved in the operation.
Part three

Intermediate rigging
Chapter 17 Tilt up panels

Introduction

Tilt up panels are widely used in the construction of low rise factories, warehouses and blocks of flats.

Concrete wall panels are cast horizontally, either on site or in a casting yard. They are crane lifted into position and fixed with temporary bracing until the structure becomes fully self-supporting.

Tilt up panels are designed as vertical members. If a panel is incorrectly rigged, it can be overstressed or may even break when it is being lifted from the horizontal to the vertical position.

Certification

The rigging of tilt up panels must be carried out or directly supervised by a person holding the Intermediate Rigging certificate (or equivalent old certificate). The use of load equalising gear, which is also frequently applied during tilt up panel erection, is also covered by the Intermediate Rigging certificate.

Panel design and casting

The design and casting of tilt up panels should comply with AS 3850.2 Guide to design, casting and erection of tilt up panels, which requires the panel design to be certified by an engineer.

Rigging gear

Rigging gear used in the erection of tilt up panels includes lifting inserts, lifting clutches, spreader beams, equalising sheaves, slings, bracing inserts, panel braces, bracing anchors and shims.

Riggers involved in tilt up erection need to know the following:

• lifting clutches should be proof tested to their WLL every 6 months
• the minimum safety factor on the WLL of lifting inserts and bracing inserts is 2.5
• the minimum safety factor on the WLL of panel braces is 2
• the locking pins of adjustable panel braces must be fitted with retaining devices to prevent them being knocked out
• the information available on site regarding panel braces must include their WLL at zero extension and their WLL at their maximum possible extension
• the maximum load on any expansion anchor used to secure a panel brace must not exceed 65 per cent of the first slip load (or 0.65 x first slip load)
• deformation controlled expansion anchors are not recommended to fix braces to the floor
• where chemical anchors are used to fix braces, they must all be individually proof tested to their WLL
• when spreader beams and equalising sheaves are used, the minimum lengths of the slings must comply with the formulas shown in the following illustrations
• the maximum height of shims under a panel edge should not exceed 40mm
• the minimum width of shims under a panel edge should be 100mm or the thickness of the panel, whichever is the lesser.
Common rigging configurations

2 x 1
Minimum C + 300 mm

2 x 2
Minimum 2D

4 x 1
Minimum 3C + D

Minimum 4.5D or 4.5E whichever is the greater

2 x 4
Minimum 3D

4 x 2
Minimum 2D

Edge lift

NOTES:
1. Dimensions on slings are total length through pulley
2. The lifting insert supplier may specify a maximum value for this angle
Shop drawings

Carefully examine the shop drawing for the panel before it is rigged. The shop drawing should indicate the type of rigging configuration needed, the position of lifting inserts, bracing inserts and fixing inserts and floor to panel connection points. The drawing will also specify where strongbacks or additional bracing is needed during lifting and erection.

(a) examples of strongback applications

(b) light duty strongback - timber

(c) heavy duty strongback - steel

Strongbacks
Riggers must be able to read and understand shop drawings. In particular, riggers must know the following symbols used on shop drawings:

- an outlined triangle – indicates a lifting insert
- a blocked-in triangle – indicates a bracing insert
- a blocked-in circle – indicates a fixing insert
- a screw-thread – indicates a panel-to-floor connection.

**Job planning**

Before lifting tilt up panels, observe the following rules:

- select a crane with sufficient capacity and drift
- make sure the crane is fitted with a load weight indicator which has been calibrated in accordance with the manufacturer’s instructions
- confirm that the crane’s supporting surface will take the erection loads
- make sure the site is cleared for crane access and mobility, with sufficient room for the crane’s outriggers and for the panel bracing, and sufficient clearance from overhead powerlines
- confirm that the concrete has been cured to reach its specified strength
- clean out all lifting, bracing and fixing insert recesses
- check the orientation and location of the lifting inserts
- refer any wrongly located lifting or fixing inserts to the certifying engineer
- check that shims have been set to the correct height and location
- check that the rigging configuration is as specified on the shop drawing and check that the slings are the correct length for that configuration
- wherever possible, secure the braces to the panel before it is lifted.

**Lifting panels**

When calculating the total load on the crane, allow for the weight of the panel, the weight of any braces and strongbacks and the weight of spreader beams, equalising sheaves and other lifting gear.

The effect of suction will increase the load on the crane when a panel is being lifted from its casting bed. Therefore, multiply the dead load of the panel by 1.4 in loading calculations for the start of the lift.

The centre of gravity will be at a greater working radius when a panel is face lifted than when it has been secured in position. To allow for this, add at least 1.5m to the final panel position when calculating the crane’s working radius. This may need to be increased for very tall panels.

Make sure all site personnel are at a safe distance from the panel when it is being lifted from the horizontal to the vertical. When taglines are used to control panel swing, work well clear of the panel edges because it may slew sideways.
Make sure the lifting and placing method will not endanger the crane operator or the crane if a sudden failure of the panel or the rigging gear were to occur.

Panels have a large surface area which can catch the wind. Do not attempt to lift a panel if the wind conditions will prevent control of the panel during all stages of erection.

**Fixing panels**

Braces should be fixed to the panels before lifting. Where this is not possible, make sure the panel is held firmly and safely by the crane while braces are attached.

Each panel should have at least two braces of equal capacity at right angles to the panel face.

At regular intervals during the erection process, re-check the tightness and security of the braces and their anchorages.

Do not remove the braces from a panel until it has been fully incorporated into a self supporting structure.

Unless otherwise specified in the drawings, the maximum tolerance on the alignment of a panel fixed in its final position is 5mm.
Rotating panels from truck trays

Large wall panels are often delivered to the site on racks where space restrictions prevent on site casting. This requires the panel to be edge lifted from the rack and rotated through 90 degrees.

Panel rotation can be carried out by using both the main hook and the auxiliary hook of a mobile crane provided the rigger is fully aware of the dangers which can arise and has observed the precautions detailed below.

If the wrong type of crane is used, panel load control will not be maintained during the rotation.

The auxiliary winch and the rooster sheave can be easily overloaded, and the panel itself or its lifting inserts may be overstressed if the proportion of load carried by the auxiliary hook is not properly estimated.

Make sure the crane manufacturer or supplier has confirmed its suitability for panel rotation when selecting a crane. In particular, make sure the crane has independent drive facilities for the main winch and the auxiliary winch. Cranes which use a shared drive between winches should not be used because safe control of panel rotation is very difficult to achieve.

The capacity of the auxiliary winch needs to be at least 75 per cent of the combined weight of the panel and any attachments.

The capacity of the main winch needs to be at least 100 per cent of the combined weight of the panel and any attachments.

The following rules should also be observed:

• use the main winch to rotate the panel by raising the hoist rope, not lowering
• make sure the included angle between the main hoist rope and the auxiliary hoist rope is not more than 45 degrees
• rig the crane so that in its final position the panel is fully supported from the main winch
• make sure the combined weight of the auxiliary hook block and lifting gear is not more than 200kg
• make sure the distance from the auxiliary winch rope’s lifting point to the end of the panel is not more than one quarter of the panel length.

Make sure there are no cut outs in the half of the panel closest to the main winch rope’s panel lifting point.
Chapter 18 Multiple crane lifting

Introduction

The use of two or more cranes to move and position loads can be very hazardous and should not be considered where a single crane is capable of doing the job.

There are, however, occasions when multiple crane lifts are necessary. They are often required during the construction and assembly of oil and gas rigs and in the construction of bridges and large scale industrial projects such as power stations, smelters and refineries.

Certification

The person with direct responsibility for coordinating and directing a multiple crane lift must hold an Intermediate Rigging certificate or equivalent old certificate.

For very complex lifts, the advice of an experienced structural engineer may be required to properly plan the operation, but the certificated rigger must maintain immediate supervision at all stages.

Planning and coordination

The importance of careful planning and the need for a thorough briefing of all personnel involved in the lift cannot be overstated. Many multiple crane lifts have come to grief through oversights, wrong selection of cranes, incorrect siting of cranes and misunderstandings between crew members.

If the weight of the load, its centre of gravity and the weight of the lifting gear is not known in advance, they must be carefully calculated.

Whenever possible, a ‘dummy run’ should be staged prior to the lift to check that the cranes can perform all stages of the operation within radius while maintaining sufficient clearance from obstructions and powerlines. This exercise should also be used to confirm that the agreed communication method is understood and is suitable.

Crane selection and siting

Whenever possible, select cranes of equal capacity and similar characteristics. This will make the synchronisation of crane movements easier to achieve. This does not necessarily apply to all designed lifts planned in accordance with Section 6.26 and Appendix D of the 2002 edition of AS 2550.1.

Each crane must have additional capacity over and above its share of the load at all times during the operation. This is to allow for the possibility of the hoist ropes deviating from vertical or other loads transferred through imperfect synchronisation of crane movements. The minimum capacity requirements for each crane are:

• when two cranes are used – 20 per cent greater than the share of the load
• When three cranes are used – 33 per cent greater than the share of the load
• when four or more cranes are used – 50 per cent greater than the share of the load.

Crane siting must be carefully considered so that crane movements are reduced to the minimum necessary. The crane siting can be limited by the nature of the worksite, the position of obstructions and powerlines, or the existing position of tower cranes.
Wherever possible, site the cranes to avoid slewing motions. Always use luffing up in preference to luffing down. Luffing down is dangerous because it can easily lead to the load swinging one or more of the cranes outside the safe operating radius. Wind loading adds to the dangers of luffing down.

Where the cranes are required to pick and carry, they must be aligned in the same direction. If they are out of alignment, the movement of one crane can push or pull the other cranes and stability may be lost.

**Calculating load share**

Where the load to be lifted is beyond the capacity of any of the selected cranes, equalising gear may be required to ensure that each crane supports its correct portion of the load.

Equalising gear is needed when the cranes are close together, such as for lifting large columns and similar objects. It also acts as a lever.

When the cranes are of differing capacity, the load to be lifted should be slung away from the centre of the equalising beam so that the load taken by each crane is proportional to its capacity. The load is slung closer to the end of the equalising beam supported by the larger capacity crane, to increase its share of the load and reduce the part of the load carried by the second crane.

**Sample calculation**

To calculate where to sling a particular load on the equalising beam when lifting with two cranes of unequal capacity.

Mass of the column to be lifted = 19t
Mass of the equalising beam = 1t
Capacity of crane ‘A’ = 16t
Length of the equalising beam = 8m

1. Mass of the load + mass of the equalising gear.
   \[ 19 + 1 = 20t \]

2. Multiply total by 1.2 (to add 20 per cent factor)
   \[ 20 \times 1.2 = 24t \]

3. To find sling point:
   Distance from crane A = total length – crane A \times \frac{total length}{total load}
   \[ = 8 - \frac{16 \times 8}{24} \]
   \[ = \frac{8}{2.67} \text{metres} \]

Find the next designated lifting point away from crane A. For the purpose of this example the lifting point is 3m from crane A.

4. To find the required lifting capacity of crane B:
   \[ \text{Capacity of crane B} = \frac{\text{total load} \times \text{distance from crane A}}{\text{total length}} \]
   \[ = \frac{24 \times 3}{8} \]
   \[ = 9 \text{ tonnes} \]
5. To ensure that each crane is lifting its correct share of the load calculate the actual load on each crane without the 20 per cent factor.

\[
\text{Crane A} = \frac{\text{load} \times \text{distance from crane B}}{\text{total length}} = \frac{20 \times 5}{8} = 12.5 \text{ tonnes}
\]

\[
\text{Crane B} = \frac{\text{load} \times \text{distance from crane A}}{\text{total length}} = \frac{20 \times 3}{8} = 7.5 \text{ tonnes}
\]

Use the load gauge check to ensure that each crane is lifting its correct share of the load.

Directing a multi-crane lift

When directing a multi-crane lift, observe the following rules:

- assess the weather conditions and make sure the lift is conducted during stable low wind conditions
- ensure that all crane hoist ropes remain vertical at all stages
- only one motion should be undertaken at a time
- avoid slewing movements wherever possible
- use luffing up in preference to luffing down
- ensure all crane movements are carried out at slow speeds
- where available, use appropriate instruments to monitor the angle of the load, how vertical the rope is, and the force in each hoist rope
- in pick-and-carry operations, make sure the axis of each crane remains fully aligned with each other
- where you cannot observe all necessary locations, post dogmen or riggers to observe and report on the progress of the lift.
Chapter 19 Demolition rigging

Introduction

The practical skills needed to carry out rigging work associated with demolition are essentially those used in general rigging. However, the rigger involved in this type of work must have a thorough understanding of the additional precautions and rules of thumb needed to safely carry out the rigging operations.

Typical demolition rigging includes the dismantling of lift cars, the cutting and removal of large structural beams and the use of winches to fell columns, walls and towers.

In some States, the person with overall responsibility for the demolition of certain types of buildings and structures must be licensed as a demolisher with the regulatory authority. If in doubt, check with the local authority.

Certification

The person carrying out, or directly supervising rigging work in connection with the demolition of structures must hold an Intermediate Rigging certificate (or equivalent old certificate).

Cranes and rigging gear used in demolition

All power cranes used for hoisting and lowering demolished material must be fitted with a load weight indicator and a hoist limiting (anti two block) device.

A crane which has been used for lifting products of demolition or for swinging-ball demolition must be thoroughly inspected before being returned to general duties.

Flexible steel wire ropes used as felling ropes must have a minimum diameter of 12mm.

Grade 80 chains used as felling chains must have a minimum diameter of 8mm.

Estimating loads and forces in demolition rigging

The actual loads and forces applied to cranes, winches and rigging gear in demolition work are much more difficult to assess than in general rigging.

In demolition things are not always as they seem to be, so nothing should be taken for granted. The weight of particular structural members is often uncertain, the centre of gravity may not be as it appears and long term deterioration may have reduced their strength or the strength of their connections.

Structural members are often subjected to unknown forces caused by the structure shifting out of alignment, poor fabrication or poor construction methods.

Wherever practicable, test samples should be cut and weighed using the crane’s load weight indicator. This will help to make your loading estimates more accurate.

All load estimates of in-situ members and materials must be increased by 50 per cent when calculating the SWL for cranes, winches, and all rigging gear. This means the SWL must always be at least 1.5 times the estimated loads.

For example, a crane with a load chart rating of 15t at a given radius must not be used to lift a load estimated at anything greater than 10t. If a pair of slings is fixed to a beam with an estimated weight of 6t, the sling assembly must have a SWL of at least 9t.
Cutting and removal of beams

Large structural beams are often demolished by slinging them to a crane, winch or chainblock and then cutting them free with cutting torches (gas axes).

There are several dangers with this type of operation if it is not carefully planned and controlled. The freeing of a beam end may cause sudden impact loading on the crane or other rigging gear. When a beam end is cut free, it will often suddenly and violently spring in an unexpected direction. A freed beam may suddenly tilt because its centre of gravity is not where the rigger thought it was.

The risks involved in cutting and removing beams can be minimised if the rigger observes the following rules:

- to allow for unusual centres of gravity, use long slings so that they can be fixed as far apart as possible while maintaining a narrow angle between the sling legs. Alternatively, use a spreader beam
- when a crane is used, position it so it can take the load at the minimum possible radius. This will help to prevent a swinging beam taking the crane out of its safe operational radius
- before a beam end is cut free, it should be secured with temporary guys (such as fibre ropes and tackles) to control unexpected springing or shifting out of level
- make sure the crane or other lifting devices have slowly taken up the slack on the slings before the beam is cut through. This will reduce impact loading and uncontrolled movement
- make sure everyone who is not needed during the operation is kept out of the area. No one should ever be below the beam during the cutting and removal
- make sure the person cutting the beam is safely supported, has the necessary PPE and is positioned so that if the beam springs, they will not be struck or jammed
- after the first end is cut, make any necessary adjustments to the rigging system before directing the second end to be cut. Never cut both ends at the same time
- keep a close check on the adjacent structural members throughout the operation for any sign of unexpected movement or overstressing. If this is apparent, cease the operation immediately, remove everyone from the area and immediately report the situation to the person supervising the demolition project.

Felling with winches, ropes and chains

One form of demolition rigging is felling columns, walls and towers by pulling them over. Winches which can be used for this type of work include electrically or pneumatically powered general purpose winches, truck or crane mounted power take off winches and manually powered winches, including drum types and creeper types. Tracked mobile plant may also be used to pull felling ropes and chains.

Ropes, chains, shackles and other load bearing gear must be carefully inspected for damage before each use. Unserviceable equipment can easily result in failure under load, causing the hauling rope to whiplash dangerously or structural collapse to occur in an uncontrolled or unintended manner.

General guidance

Make sure there is sufficient clear space in the direction of collapse to contain all collapsing material within the site confines.

Check that the area where the collapsing materials will fall is strong enough to withstand the impact without collapsing. When in doubt, seek advice from the person supervising the demolition project.
Make sure the collapse will occur well clear of all site personnel and will not be fouled by any obstructions.

Check that the winch is correctly aligned to the load so that it will pull the structure in the intended direction.

Check all winch anchorages and fixings to ensure they will safely take the estimated loads and prevent movement of the winch. Vehicle mounted winches should be set up on a hard, level surface. Vehicle brakes should be applied and wheels chocked. Additional means of securing the vehicle may also be needed.

Never fell structural members by snatch loading. Always apply the tension gradually.

Make sure all sharp edges are covered to prevent damage to hauling ropes and slings.

Make sure the horizontal distance from the winch to the demolition work is at least 1.5x the vertical distance from the winch to the highest part of the structure to be felled.

Once pulling has started, no one must be closer to the sides of the rope or chain than three quarters of the horizontal distance from the winch to the load.

Once the collapse has been completed, make sure the slings, hauling rope and other gear involved in the operation are carefully inspected for signs of overstressing or damage.

**Reinforced concrete columns**

The following procedure should be used for freestanding square or rectangular reinforced concrete columns:

1. secure the ropes or chains around the top of the column. Use a fixing method which will ensure they don’t become dislodged at any stage of the pulling
2. remove the concrete cover on all sides of the base of the column and enough to expose the vertical reinforcing bars
3. cut through all exposed reinforcing bars, except those closest to the direction of fall
4. steadily apply tension to the felling ropes or chains so the column hinges over on the uncut reinforcing bars
5. when the column has been felled, cut the remaining reinforcing bars.
Masonry walls
The following procedure should be used for long masonry walls:

1. where necessary subdivide the wall into separate panels small enough for the capacity of the winch and rigging equipment. This can be done by cutting vertical slots through the wall

2. the felling ropes or chains should be attached to the wall panels at a height no more than half the unsupported height above the intended cut off level. Strongbacks such as C-section channels may be needed to ensure that all of the panel is felled in a single operation

3. attach felling ropes or chains to all of the subdivided panels before starting to demolish any of them. Make sure all free ends are left at a safe distance from the wall. This avoids the need for anyone to approach the wall once the demolition of the panels has started

4. fell each panel separately

5. once all panels have been felled, remove the ropes or chains.

Concrete walls
Cast-in-situ reinforced concrete walls of 200mm or more thickness usually have two reinforcing grids; one in each face. Walls with two grids can be felled in the same way as reinforced concrete columns.

Walls less than 150mm thick generally have only one reinforcing grid. This may be centrally located or towards one face. For walls with one grid, its location should be determined at the cut off level.

Walls with only one grid should be felled in the same way as masonry walls, with the reinforcement cut after the wall is lying flat. Walls with a single grid which is close to one face should be felled towards the reinforced face.

Tilt up panel structures
Buildings which have reinforced precast panel walls, including tilt up panel types, should be dismantled in the reverse sequence to their original erection.

Do not commence the dismantling and removal of wall panels until the nature and condition of their fixings to the rest of the structure and of the jointing between panels has been determined.

Where the wall acts as bracing to other parts of the structure, temporary replacement bracing must be installed prior to removal of those wall panels.

If the original inserts are intended to be used to lift and lower a wall panel, a careful examination of their condition and the condition of the surrounding material must be made. If there is any doubt regarding their adequacy, use another slinging method or provide back up slings.

Multistorey buildings
During the demolition of multistorey buildings, rigging may be needed to provide temporary support or bracing to parts of the structural framework to maintain stability at particular stages of the demolition process.

In general, free standing columns and walls above floor levels are to be demolished before demolition of the floor.
**Precast wall panels**

Where the building facade incorporates precast wall panels, the relevant guidance given above for tilt-up panel structures should be followed.

**Lifts**

When demolishing a lift use the following procedure:

1. support the lift car by shoring or other suitable means so that it is independent of its hoisting cable
2. make sure all lift door openings are barricaded
3. check that electrical power to all areas of the lift machinery has been disconnected
4. do not allow lift counterweights to free fall from the upper levels. Where applicable, lower counterweights to a convenient level before disconnecting them
5. unwind lift cables in a controlled manner
6. before removing lift machinery and lift cars, make sure protection decks have been installed in the lift shaft at not less than the two levels immediately below the work.

**Lattice towers and masts**

Where electricity transmission line towers are to be demolished, the transmission-line cables must first be deactivated and then removed in a way which prevents unbalanced lateral loading on the tower at the cable attachment points.

**Caution:** Suspended cables must not be cut under any circumstances.

When demolishing a guyed mast, first remove all freestanding portions of the mast down to the level of the guys. Make sure each set of guys is progressively slackened and removed in a way which prevents the remaining portions of the mast from becoming unstable. The mast may require temporary bracing before the lowest level of guys is slackened.

![Diagram of lattice tower](image)

*Felling of lattice towers and masts*
Felling unguyed towers and masts

Attach the ropes or chains to node points incorporating horizontal bracing near the top of the structure.

Position the winch at right angles to the face of the structure nearest the direction of fall.

Before cutting any member, tension the hauling rope enough to relieve the dead load from the furthest legs of the structure.

While maintaining the tension on the hauling rope, have the back legs of the structure cut through or disconnected near ground level.

As soon as possible after the back legs are freed, remove all personnel and equipment from the area around the structure. Make sure the tension on the hauling rope is held steady and not increased until everyone is out of the area.

Felling can now continue. Disconnect the remaining legs from their footings after the felling has been completed.

Pre-stressed concrete members

Riggers involved in the demolition of reinforced concrete structures need to be able to recognise pre-stressed structural members and understand the special hazards associated with their removal.

Pre-stressing is used to provide concrete members with a far greater load-bearing capacity than similar sized normal reinforced members.

Pre-stressed members will not be found in structures built before 1950. Buildings built between 1950 and 1960 may have pre-stressed floor sections. Structures built after 1960 may include major pre-stressed structural members.

Pre-stressing methods

Pre-stressed structural members have tendons embedded along their length. These tendons are stretched before the member is placed into service so it can take the loads of the structure.

The tendons may be high tensile wires from 5mm to 7mm in diameter arranged singly or in groups, high tensile steel cables 9mm to 15mm in diameter arranged singly or in groups, or single high tensile steel bars 19mm to 38mm in diameter with threaded ends.

Members can be pre-stressed in two basic ways. They can be pre-tensioned or post-tensioned.

Pre-tensioned members have their tendons tensioned with hydraulic jacks. The tendons are anchored in their stretched condition before the concrete is poured. Once the concrete has cured and bonded around the tendons, the anchorages are removed and the slack ends of the tendons are cut off flush. This method is generally used in the construction of precast members.

Post-tensioned members are usually formed up in-situ, with the tendons lying loose in tubes or ducts which have steel anchor plates at each end. The tendons pass through one or both of these anchor plates.

After the concrete is cured, hydraulic jacks are used to tension the tendons against the anchor plates. Once the tensioning is complete, the ducts are pumped full of liquid cement grout under pressure. This is intended to help bond the tendons and protect them from corrosion.
Unbonded tendons usually have provision for retensioning or releasing the load in the tendons. Where pavement slabs and footing beams are directly supported on the ground the ducts may be packed with grease, which means they remain unbonded.

**Recognising pre-stressed members**

Pre-stressed members can often be easily identified by their length, slenderness or camber.

Most concrete beams with spans greater than 9m and slabs with spans greater than 8m will be prestressed. Suspended pre-stressed members are usually more slender than normally reinforced members. Precast floor sections that have been pre-stressed will often have a slight upward camber.

Post-tensioned members generally have a surface recess on one or both ends to allow the tendon anchorages to be protected with a mortar covering. This covering is usually a different colour to the concrete and hairline cracks are frequently visible around the recess.

The cut ends of pre-tensioned tendons are usually covered with a protective cement render. Light scabbling of the rendered face should reveal their presence.

**Hazards**

The demolition of structures incorporating pre-stressed members can be very hazardous. The rigger responsible for the slinging and removal of pre-stressed members must be aware of the potential problems so that the rigging method selected can prevent them from occurring.

Post-tensioned members with unbonded or badly bonded tendons are the most dangerous. If a tendon is cut or an anchor plate is damaged, the member may suddenly lose its strength and collapse. This can be prevented by propping under the entire length or area before any tendon is cut.

There are also several other dangers which are often beyond the rigger’s competence to identify and control. Therefore, ungrouted post-tensioned members should never be demolished without consulting a structural engineer or the supplier of pre-stressing equipment.

Maintain the orientation of the beam when pre-stressed beams are removed. The beam has been stressed to take load, including its own selfweight, in a particular direction. If the beam is turned over or upside down, the forces in the beam will be acting in a different way. This may be enough to cause sudden and catastrophic collapse of the beam.

The structure above any post-tensioned transfer beam should not be demolished without consulting a structural engineer or the supplier of pre-stressing equipment. Unless special counter measures are taken, the demolition and removal of the upper floors and the consequent reduction in the imposed loads can cause the transfer beams to fail and may even trigger a collapse of the entire structure.

**Unattended free standing structural members**

The stability of partially demolished structures can be severely affected by high winds and heavy storm conditions. Therefore the planning and control of the demolition sequence must ensure that freestanding elements of the structure are not left in a hazardous condition when work ceases.

The following general rules should be observed:

- a freestanding masonry wall must not be left outside working hours without lateral support if its height is greater than 15 times its least overall plan dimension
• a freestanding reinforced concrete column must not be left outside working hours without lateral support if its height is greater than 20 times its least overall plan dimension

• a freestanding uncased steel column must not be left outside working hours without lateral support if its height is greater than 25 times its least overall plan dimension.

Further information

Further information can be found in AS 2601 – *The demolition of structures* and AS 2550.1 *Cranes – Safe use, Part 1: General requirements*. Codes of practice dealing with demolition work may be approved for use in some States and Territories. Specific regulations dealing with demolition may also apply. If in doubt, check with the local regulatory authority.
Chapter 20  Rigging cranes and hoists

Certification

An Intermediate Rigging Certificate or old equivalent, is necessary to perform the rigging of:

- external guided cantilevered platform (personnel and materials) hoists
- hoists with jibs
- self climbing hoists
- mobile crane booms
- tower cranes.

Cantilevered platform (personnel and materials) hoists

The cantilevered platform (personnel and materials) hoist is the most commonly used hoist in the construction industry. It uses a rack and pinion driven by at least two electric motors to raise and lower the platform.
Setup

When the cage is at the top landing there must be no less than 1.5m to the top of the rack. When the cage is stopped by the final stopping devices there must be no less than 1.2m to the top of the rack.

The final section (or tower module) must be fitted above the top section of rack and must not be less than 1.5m in height. The final section must not be fitted with a rack.

When the cage is sitting at its lowest point on fully compressed buffers there must be at least 600mm between the underside of the cage and the floor of the pit.

The landings and the inside of the cage must have effective protective mesh fixed to a steel pipe or angle iron frame work.

Door entrances must have at least 2m overhead clearance. Doors must have 9mm square, 2.5mm wire mesh over a steel frame. The doors must not deflect more than 25mm under forces exerted in normal working conditions. (1kg over 1m²)

Doors must be no more than 150mm from the edge of a landing. They must fit flush with the surrounding mesh enclosure to form an effective guard. The clearance between the floor of the cage and the landing must not be greater than 50mm.

Car construction

Cars must have a steel frame and be fully enclosed on the sides, top and gates. It must not deflect more than 25mm under forces exerted during normal working conditions.

The gate ends and the sides must be covered with steel or timber up to 1.2m. Above this must be covered by 30mm square, 3mm steel wire mesh. If there is less than 100mm from the cage to moving parts the mesh size must be 10mm square.

The gate in the cage must sit fully within the floor line of the cage and the door counterweight must have an enclosure to slide into. The cage must measure no less than two metres from the floor to the ceiling.

The car roof has a hinged trap door with an electrical interlock. It must be strong enough to withstand material falling from above. There must be a ladder inside the cage at all times to provide access to the trapdoor.

Lighting

The cage must have lighting that allows for safe operation and maintenance of the hoist. In addition to the light inside the cage there must be a permanently wired hand lamp for use on the roof. There must also be an emergency light that will operate in the event of the failure of the main light.

Load plate

A load notice plate must be displayed in the cage with the following details:

<table>
<thead>
<tr>
<th>Maximum Load Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials kg</td>
</tr>
<tr>
<td>Passengers kg</td>
</tr>
<tr>
<td>Combined materials &amp; passengers kg</td>
</tr>
</tbody>
</table>
Car door and landing interlocks

There must be a gate on each floor fitted with a lock which can only be released from inside the car.

Each door must be interlocked so that the hoist will not operate unless all doors are closed and locked.

Locks must be enclosed by metal cladding, be weatherproof, fail safe and bolted to the door frame.

The gate on the lowest landing can be opened by key by the hoist operator from the landing, if the cage is within 230mm of the landing.

Working limit switches at the top and bottom prevent the cage overrunning. Limit switches must be metal clad and weatherproof and the cams must be constructed of steel.

In the event of failure of the working limits there is also a full current limit switch which will cut off all power to the hoist if the hoist travels beyond the top or bottom landing.

If any of the full current limit switches are tripped they must be reset and checked by a qualified electrician.

Electrical

All wiring must be insulated with PVC and where the wiring enters switch gear the PVC must not be distorted.

All metal armouring for cables and other electrical equipment must be earthed by wire no less than 2.5mm². All earth wires must return to one place and be clamped together.

If an earth fault does occur the control current wiring must be arranged so that the power to the hoist is cut off.

The control fuse must have the maximum current capacity clearly marked. Fuses must be replaced by a qualified electrician.

Roof controls

Roof controls must be used by riggers or other authorised persons only. Hoist controls must be shrouded to prevent accidental activation of the manual reset emergency stop button.

The controls inside the cage must be inoperative when the roof controls are in use. When the hoist is operated from the roof for maintenance or repairs the controls must be switched over to the installation setting.

Pre-checks

Prior to operating a hoist for repairs or maintenance carry out the following pre-checks:

• make sure that there are no obstructions such as pipes in the path of the hoist platform
• make sure that the lift car alarm and communication system are functioning
• take the hoist on a check run to check the operation of the stopping limits. Show caution when approaching the top or bottom landings
• test the operation of all gates including the trap door. Make sure that the hoist will not operate while the trap door or any of the gates are open
• make sure that the rack and pinion are well greased and that the teeth are in good order
• the switch that controls the operation of the cage must be inside the cage and return to the stop position when it is released, although control may be switched to an alternate switch on the roof for rigging uses.

The internal guided platform (materials) hoist

Internal guided platform (materials) hoists run up and down inside the tower in guides and use a wire rope hoisting system to raise the platform. A jib can be attached to tower hoists to raise long loads.
There are two types of tower hoist:

- internal guided platform (materials) hoist
- superduty tower hoist.

The platform is hoisted and lowered inside the tower and held in position by two timber or steel guides. The platform is hauled up and down by a wire rope that runs up the tower over a sheave system and down to the platform.

The tower is encased in wire mesh to prevent people being hit by the moving platform. There are openings at each floor to gain access to the platform which are guarded by gates or barriers. There is a signalling system so that people on other levels can communicate with the driver.

**Tower set up**

The tower must be tied to the building or guyed to the ground every 9 metres. There must be no more than 6m free standing between the top guy or tie and the top of the tower.

Guys must extend from the corners of the tower. They must be at least 12mm diameter and 6 x 19 construction FSWR. Fibre rope must not be used.

There must be access to the top platform for maintenance of the rope sheaves. The area must have securely fixed closely boarded 38mm planks and be enclosed by a 1m high handrail.

An inclined ladder must provide access to the top platform. Ladders between the landings must not be more than 6m.

The tower must be completely enclosed by 1.2mm wire – 50mm mesh up to 1.8metres in height, 20 mm closely boarded timber or light gauge steel sheet.

The gap between the edge of the platform and the inside of the tower must not exceed 50mm. The timber runners or guides must be at least 100mm x 75mm oregon or hardwood. They must be bolted to each horizontal brace and to the cat head bearers.

The runners and corner posts must rest on a steel plate of at least 300mm x 50mm. It must be secured with countersunk bolts.

**Gates**

If the hoist is serving higher than three storeys, gates and lights must be installed on each floor. Gates must be at least 1.8 metres high and made of 2.5mm wire, 50mm mesh.
Gates can hinge outward or slide horizontally or vertically. They must have a fixed stop to prevent them closing beyond the correct position and an effective latch to make sure that they remain closed.

All gates must be wired so that when any gate is open, two red lights will show at the driving station and when all the gates are closed, one green light will show.

**Hoist winch**

The hoist rope runs from the winch drum under the first lead sheave at ground level up to the top of the tower and then down to the platform.

![Diagram of hoist winch](image)

**Foot diversion sheave (guards removed)**

The rope will not lie neatly onto the winch drum unless the correct ‘fleet’ angle is formed from the foot diversion sheave to the outside of the drum from the centre of the drum. (The first lead sheave on a tower hoist is called the foot diversion sheave.)

There must be a covered guard-rail on both sides of the length of hoist rope between the winch drum and the first lead sheave. When the hoist takes the strain the rope can whip violently.

The nip point of the lead sheave must also be guarded to prevent a person in contact with the rope being drawn into the sheave. The anchor point for the foot diversion sheave must not put bending forces on the tower.

The winch must be secured to a frame to prevent it slipping forward. Alternatively two 150mm x 100mm shores can be placed between the winch and the tower.

Concrete hoppers should not be supported by the hoist tower.
**Working load limit**

The combined weight of the load and the platform for standard internal guided platform tower hoists must not exceed 1t.

**Typical loads:**

A wheelbarrow of concrete weighs up to 250kg.

A wheelbarrow of bricks weighs up to 216kg (45 bricks).

A pallet load of bricks weighs up to 2t. *

* Combined with the weight of a forklift truck a pallet of bricks is too heavy for any materials only hoist. Always check the combined weight.

**Super duty tower hoists**

Super duty tower hoists meet the need for a hoist with a greater load carrying capacity. The towers can be erected to a height of 150m. They have a 2.5t capacity and some have dual towers.

Dual towers can be erected so that there is a concrete tipping bucket in one tower and a platform in the other.

**Tower set up**

Towers must be fully braced against the building and must not exceed 75m where guy ropes only are used.

Towers more than 75m must be braced every 16m starting from the base. Towers of 75m or less must be guyed from each corner with 16mm diameter, 6 x 19 FSWR every 16m.

A tower must not project more than 18m above the top of the building. The projecting section of tower must be guyed in all directions.

Tube 89mm x 4.88mm must be used for towers up to 107m in height. Above 107m, the lower section must be constructed of 89mm x 5.9mm tube.

The tower structure must be of 2m high panels, 2.4m x 1.9m. Dual towers are 4.9m x 1.9m.

The section of the lower tower where the foot diversion sheave is attached must be 89mm OD hydraulic tube. It is usually painted yellow and branded FS.

**Hoisting system**

The hoist rope for a super duty hoist must be 20mm, ordinary lay and at least 1570 grade FSWR.

**Protective barriers**

The requirements are the same as the standard tower hoist.
Warning lights

The warning light system is the same as for other types of materials hoists. (See cantilevered platform, materials only)

There must be a level indicator at the driving station where the platform rises to 15m or six floors above the driving station.

Hoists operating with jibs or buckets only do not need a level indicator.

Jibs

Where long loads have to be hoisted a jib attachment can be fitted to a tower. Jibs for tower hoists are usually nine metres long with a fixed radius of 6.4 metres. The jib slewing motion is controlled by a handline.
Do not use the jib when there is a load on the platform or bucket or when the platform is off the ground.

Do not use a jib to drag or snig loads.

**Single tower (2.4m x 1.9m) WLL**

A single super duty tower hoist can raise 2.5 tonnes up to 150 metres.

The platform weighs 600kg.

Therefore the SWL = 1.9 tonnes.

**Dual tower (4.8m x 1.9m) WLL**

Where both towers of a dual tower hoist are in use the SWL of each is 1.2 tonnes.

**Lengthening the boom on mobile cranes**

Make sure that when the boom extensions are loaded onto the truck they are in sequence and properly packed.

Attach the luffing bridle to the end of the boom with a sling.

Lower the boom into line with the extension. Make sure that the level of the truck is lower than the horizontal level of the boom. This will allow the top joint pins to be inserted first.

When the top pins are in place raise the boom until the new section is in line and then insert the bottom pins. The boom can now be raised and the process repeated if necessary.

If a boom is 18 metres or longer a second crane and trestle supports must be used for boom changes.

Make sure that correct slinging procedure is used for attaching boom sections to the assisting crane.

Fit the pins from the inside to the outside when connecting sections of boom.

Stay out from under the boom. Do not knock out the bottom pins first.

Do not stand under the boom to insert or remove pins. This is very dangerous. Do not permit any person to stand under the boom.

Before raising the boom check every pin, bolt, and shackle connection on the boom and jib pendants and rope anchorages. Make sure that all fittings are in good order, tight and secure.
Until the boom is solidly supported on its blocking never touch the top pins ahead of the pendulums. The boom will drop.

Caution: Never walk, work, lean or place any part of your body under the boom when it is being assembled, dismantled, shortened or lengthened. If necessary, use a long bar to knock the far side pins out.

Many operators and riggers have been killed when dismantling or shortening booms and the main cause is usually failure to follow the procedures specified by the manufacturer. Work on jibs involves the same hazards.

Never touch any (top or bottom) pin on any boom section located between the pendant attachment points and the crane.

If a set of lower pins (located between the pendant attachment points and the crane) is removed, the boom will jackknife down when the last pin is pulled.
**Tower cranes**

Tower cranes are widely used in the construction of multi-storey buildings and high rise industrial projects. There are two main types of tower crane:

- luffing boom
- hammerhead.

Both of these can be climbing, fixed or rail mounted. Climbing tower cranes can be internal or external to the building structure. Fixed and rail mounted cranes do not climb.

The most common type of tower crane used in Australia is the luffing boom type which can be either rope assisted hydraulic luffing type or entirely rope luffing. They are usually powered by diesel motors mounted on the machine deck at the top of the tower.
The hammerhead crane which has a horizontal jib is less common in Australia but widely used in Europe. They are usually powered by electric motors and have a crab which travels along the jib to achieve the required radius.

Tower crane design should comply with AS 1418.4 Tower cranes and designs must be registered with a State or Territory regulatory authority. Each individual tower crane must also be registered.

The addition or removal of sections of external climbing tower cranes must be carried out by riggers with an Intermediate Rigging Certificate (or old equivalent). The complete erection and dismantling of tower cranes is done by rigging crews who have undertaken specialist training in particular types of crane.

**General safety**

Tower cranes consist of a square tower which is bolted to a concrete foundation, support beams or a rail carriage. The slewing platform, hoist, mast and jib are mounted on the tower. For external climbing the climbing frame is fitted around the top of the tower. For internal climbing the rams and beams are fitted within the base of the tower.

All potential hazards should be considered before erecting a tower crane on site. The installation of the crane should be well planned and carried out in accordance with the manufacturer’s instructions. The sequence of installing the jib (or boom) sections and counterweights is critical. Using an incorrect sequence could result in a collapse.

Engineers consider the type of soil and rock under the crane, the crane’s capacity and various radii before deciding on the exact site.

There is a maximum free standing height which is designed by the manufacturer. This should not be exceeded without the manufacturer’s and engineer’s approval.

During the erection, climbing or alteration of a tower crane the following rules should be observed:

- use barricades or other effective means to prevent unauthorised access to the operational zone
- use lanyards to restrain tools when working at height
- use a safety harness whenever there is a risk of falling
• make sure the each boom connection pin is fitted with chain or wire rope attached to both the boom and the pin head

• the effects of windloading must be taken into account including the funnelling effects between adjacent buildings. Large sections of tower cranes should only be handled in calm conditions

• the sequence of erection and dismantling must be carried out in strict accordance with management’s instructions

• tower erection bolts must be of the type specified by the manufacturer and be correctly torqued to their recommendations

• all loose tools, nuts and bolts must be removed from the crane or effectively stored after erection and before operation.

External climbing tower cranes

External climbing tower cranes are self climbing and are tied to the building or structure and are climbed by adding sections to the top of the tower. Riggers must know how to add and remove the tower sections. Use the sequence below as a general guide:

1. when adding sections unload and place sections close to the crane at the foot of the tower so there is no need to slew the crane to pick up another section

2. install the monorail if it is not already in place

1. Crane lifts additional tower section and suspends it from extendable monorail. Bolts of top tower section are removed at A.

2. Hydraulic ram lifts top section of crane and climbing frame.

3. Additional tower section is drawn into the climbing frame and bolted at B and A.

To climb down, the reverse procedure is followed.
3. connect the climbing hoses from the climbing control on the machine deck to climbing rams in climbing frame. Take directions from the fitter as it may be necessary to stop the engine.

Slewing motions may not be available during the climbing process, because some cranes use the slew pump to supply the necessary oil pressure for the climbing rams. This is a simple matter of taking the slew hoses off the slew motor and fitting them to the climbing rams controlling the oil flow with the slew control

4. lift the section and hang it on the monorail by transferring from the crane hook onto a four legged sling attached to the trolley on the monorail. Ensure that the sling legs are the correct and equal length so that the section can run freely when pulled into the aperture at the correct height

5. lock the counterweights and make sure that the jib is right up

6. remove the tower section bolts and ensure that the fitter has connected hoses before trying to climb

7. the rigger in charge must direct the driver to balance the crane by luffing the jib out or travelling the crab. The driver should make note of the radius or crab position so it is possible to return to this point

8. the crane is now ready to climb. The rigger in charge, the dogman controlling the climbing valve and the driver in the cabin in charge of the throttle must all be in radio contact

9. at the signal, 'rams down' the crane will start to lift. The tower sections may jam in the climbing frame. It may be necessary for riggers to adjust the guides in the climbing frame several times during climb to ensure the frame slides freely over tower sections. Do not simply increase pressure to force it through

10. once the crane has reached the full extent of the rams (full climbing height), the section can now be pulled into the space and bolted into place. Please note: on some cranes raising the tower to the required height will need four climbing cycles of the rams

11. the rams are then retracted to protect the piston shafts, keep them out of the way and return oil to the reservoir

12. once retracted, disconnect the hoses if necessary and coil them out of the way on the machine deck (usually under hoist drum)

13. counterweights can now be reconnected and the limits reset if necessary

14. the mono-rail may have to be removed, depending on design.

Removing a section is essentially the reverse of the above sequence.
Internal climbing cranes

Internal climbing cranes sit in the lift well, stairwell or in a well especially designed into the building. The climbing and erection method of the crane is designed into the building because a working crane subjects the building structure to great stresses.

1. The telescopic sections of beams A and C are retracted.

2. Crane, tower and climbing frame, to which beams A and C are attached, are lifted by hydraulic rams.

3. Telescopic sections of beams A and C are extended to support the crane. Telescopic sections of beams B are retracted. Hydraulic cylinders lift beam B to the level of beams A and C. Telescopic sections of beam B are extended.

Engineers’ certificates must be checked to ensure that floors are of sufficient strength to take the total weight of the crane, the support structure and all loadings imposed by the crane working.

If the lift shaft is not used, the floor reinforcing is left protruding through the cut out section of the floor. The hole can later be formed up and poured, sealing the hole after the crane is raised higher.

The tower sits inside the building (typically 5 or more sections in the building) as the building is erected around the crane. The crane is jacked up from the floor it is sitting on by extending the climbing rams pushing the completed crane up. When the bottom of the tower reaches the required height (usually the next floor or a level cast into the lift well), flippers (feet) are pushed out and the crane is settled on to its new level. Rams are then retracted and settled on to the same floor ready for next climb.

When the crane is sited in the lift well, holes to take the flippers and beams are cast into the walls of the lift or stair well as part of the design of the building.

Internal climbing cranes are usually taken down from the roof or top slab by a special recovery crane or by large mobile cranes. Removal of the tower crane should be planned before erection begins.

Please Note: As a result of a tower crane fatality on 5 August 2001, WorkSafe Victoria has issued two Alerts setting out additional requirements to be observed for the jumping of luffing boom tower cranes that incorporate sliding counterweights. These are:

- Alert 6/2001, Precautions in Jumping Tower Cranes, and

The information contained in these Alerts is additional to the advice provided on tower crane rigging on pages 174 to 178. They can be accessed at [www.workcover.vic.gov.au](http://www.workcover.vic.gov.au)
Part four

Advanced rigging
Chapter 21 Fabricated hung scaffolds

Introduction

Fabricated hung scaffolds are purpose designed temporary structures which are anchored to a permanent structure to support a working platform. Unlike suspended scaffolds, they are not capable of being raised or lowered while in use.

They are usually installed as a static structure, but are sometimes hung from girder trolleys or mobile suspension rigs so they can be horizontally travelled.

Fabricated hung scaffolds are usually constructed from structural steel, aluminium or timber components. Typical working platforms include checkerplate, gridmesh or timber flooring.

This type of scaffolding is used during the erection of large structures such as power stations, to provide platforms for steel erection and consolidation and to provide temporary access ways between parts of the unfinished structure. They are also used during the construction of oil and gas rigs and are often slung under bridges for maintenance and repair work.

Fabricated hung scaffolds are either fixed to structural members on the ground prior to lifting, or are independently lifted into position by cranes, winches, chain blocks or fibre ropes and tackle blocks.

Certification

The installation and dismantling of fabricated hung scaffolds must be carried out or directly supervised by a person holding either an Advanced Rigging certificate or an Advanced Scaffolding certificate (or equivalent old certificate).

Hung scaffolds which are not fully fabricated, such as those constructed from tubes and couplers, require the Advanced Scaffolding certificate (or equivalent old certificate).

Design and construction

Design compliance

The design of a fabricated hung scaffold and the strength and condition of the supporting structure should be verified in writing by a competent person such as a structural engineer as complying with the minimum requirements of AS 1576.1 Scaffolding-General requirements.
The written verification should specify the duty classification of the working platform and specify the method(s) of anchorage to the supporting structure.

Before installing the scaffold, make sure you have sighted the written verification and have carefully read any of the limitations and conditions attached.

**Duty classifications**

Fabricated hung scaffolds are classified as:

- **light duty** – with a maximum allowable live load of 225kg per platform per bay and a minimum platform width of 450mm
- **medium duty** – with a maximum allowable live load of 450kg per platform per bay and a minimum platform width of 900mm
- **heavy duty** – with a maximum allowable live load of 675kg per platform per bay and a minimum platform width of 1m
- **special duty** – with a maximum allowable live load as specified in the design verification (but greater than heavy duty) and a minimum platform width as specified (but at least 1m).

Platforms used for through access of person and materials must be designed to at least heavy duty specifications, but the platform width can be reduced to 450mm (for persons and hand-tools only) or 675mm (for general materials movement).

**Platform construction**

The platform of a fabricated hung scaffold must be closely decked with an even, slip resistant surface which is free of trip hazards. The platform must be secured so as to prevent uplift or dislodgment.

As a general rule, the platform should be horizontal. In some cases, the scaffold may be designed to have a sloping platform (such as for continuous access under sloping structural beams).

The maximum allowable slope on a working platform is 7° (1:8). For access platforms, the slope may be increased to 20° (1:3), provided that the full width of the platform surface is cleated to prevent people from slipping. Cleats should be 25mm thick by 50mm wide and should be secured at intervals of 450mm.

Edge protection is required at the open sides and ends of all platforms from which a person or object could fall more than 2m. Edge protection includes guardrailing and toeboards.

Guardrailing must be constructed from rigid components. Fibre rope, chain and steel wire rope is not permitted. The height of the guardrail must be not less than 900mm and not more than 1100mm above the platform surface.

Toeboards may be timber or metal kickplates. They must extend at least 150mm above the platform surface and any gap between a toeboard and platform must not exceed 10mm.

The gap between the guardrail and the toeboard must be protected by either a midrail or infill such as meshed screens or construction grade plywood sheets.

Where a midrail is used and material stacked near the platform edge extends past the toeboard, additional infill (such as extra toeboards fixed above the existing toeboards) must be fitted to prevent the possibility of any material being knocked over the platform edge.
Access to the working platform

A safe means of access must be provided to the working platform. Where direct access at the same level from the existing structure is not available, means of access such as ladders, stairways or ramps must be incorporated.

Portable ladders used for access must be single ladders. Extension ladders are not suitable as access ladders. Ladders must be industrial grade. Domestic grade ladders are not to be used.

Access ladders must be fixed at a slope not less than 61 and not more than 4:1. They must be secured against movement in any direction and they must extend above landings by at least 900mm.

Scaffold anchorages

A fabricated hung scaffold can be fixed to the supporting structure in a variety of ways, such as by using integral rigid hanging supports which can be yoked around or bolted to the overhead structure, or by hanging the scaffold with lifting slings and shackles. Hanging supports can be vertical or angled, depending upon the particular design and the location of the support points.

The safety factors for slings supporting scaffolds are higher than the safety factors for general rigging.

The maximum load supported by a flexible steel wire rope must not exceed one sixth of its minimum guaranteed breaking strain (compared to one fifth for general rigging). This means the normal rigging rule of thumb used to calculate allowable load on a flexible steel wire rope cannot be used. Instead of 8 x diameter squared, use 7.5 x diameter squared.

The maximum load on a chain supporting a scaffold also cannot exceed one sixth of the breaking strain.

Any sling or hanging member which directly supports the scaffold is performing the function of a scaffolding standard. In calculating the maximum load on a standard, you need to include the portion of the scaffold's selfweight supported by the standard (the dead load) and a portion of the maximum permissible duty classification (the live load).

To allow for uneven platform loading, it is always assumed that a standard is supporting at least one third of the duty live load on each platform and in each bay it serves.

For example, an intermediate standard in a run of heavy duty scaffold one bay in width, supports two longitudinally adjacent bays. If this scaffold has a single full length working platform, the intermediate standard is assumed to be supporting a live load of 675kg x 113 x 2 bays = 450kg.

Where the scaffold is to be hung from girder trolleys to provide horizontal travel, make sure the assembly of trolleys has been longitudinally and transversely fixed together with rigid tie bars and plan bracing so that the hanging standards remain vertical and the trolleys do not move out of alignment with each other.

Make sure the open ends of the girders supporting the trolleys have been fitted with through-bolted stops to prevent the trolleys running off the ends. Trolleys must have a WLL greater than the total loads they are required to support. Never use a trolley with a WLL of less than 500kg.

Further information

For further information about hung scaffolds see AS 4576 Guidelines for Scaffolding.
Chapter 22 Suspended scaffolds

Introduction

A suspended scaffold has a suspended platform that can be raised and lowered during normal use. It is generally suspended from temporary overhead supports by flexible steel wire ropes to which scaffolding hoists are fixed.

Types of suspended scaffolds include swing stages, double rope suspended platforms, work cages and boatswain’s chairs.

Suspended scaffolds are often used to carry out work for short periods on the sides of tall buildings or structures. They are also used inside lift shafts, large boilers and chimneys.

Suspended scaffolding should be designed to comply with AS1576.4 Suspended scaffolding.

A typical traversing swing stage scaffold

1. Counterweights
2. Traversing track
3. Through bolted stop to prevent trolley from leaving track
4. Trolley
5. Rigid tie bar
6. Suspension rope
7. Traversing rope
8. Scaffolding hoist
9. Cradle
10. Tubular suspension rig

Note: Secondary ropes and second person omitted for clarity
Certification

The erection, alteration and dismantling of a suspended scaffold must be carried out or directly supervised by a person holding either the Advanced Rigging certificate or the Advanced Scaffolding certificate (or equivalent old certificate).

The erection, alteration and dismantling of suspension rigs for a suspended scaffold constructed from tube and coupler scaffolding requires the Advanced Scaffolding or the Intermediate Scaffolding certificate (or equivalent old certificate).

Scaffolding hoists and protective devices

The design and manufacture of scaffolding hoists should comply with AS 1418.2 Serial hoists and winches. The design of a power operated scaffolding hoist must be registered with an Australian regulatory authority.

Scaffolding hoists are usually electrically powered, but pneumatically powered models and hand operated models are also available.

Scaffolding hoists can be either a drum type hoist, where the FSWR is stored on the winch drum, or a climber type hoist, where the winch climbs a suspension rope and the rope tail hangs below the hoist.

Electrically powered scaffolding hoists must be fitted with load limiting devices set at no more than 1.25 x the WLL of the hoist. This is because modern electric scaffolding hoists can have an ultimate stalling torque which is far greater than their rated capacity.

A load limiter will prevent the hoist toppling the suspension rig or destroying the suspension rope if the scaffold is jammed by an obstruction while it is being raised.

There must be a protective device for each scaffolding hoist, supporting the cradle. They can be built into the hoist unit or independently mounted above the cradle. They act as an emergency brake if the suspension rope is severed inside the scaffolding hoist. Depending upon the make and model, they can act directly on the suspension rope above the hoist or they can be rigged to an independently anchored secondary rope.

Each scaffolding hoist and protective device must have a data plate which includes:

- the type, model and serial number
- the manufacturer’s name or identification mark
- details of the FSWR to be used, including rope diameter, grade and construction
- the rated load
- reeving requirements, where applicable
- power supply requirements, where applicable.

Suspension ropes and secondary ropes

Make sure that suspension ropes and secondary ropes are the correct diameter and the correct construction for the particular scaffolding hoist or protective device. Suspension ropes used with climber type hoists often have unusual rope constructions which give them enough flexibility and durability to bend over the small diameter sheaves inside the hoist. If the wrong construction of rope is used, the sheaves can ‘chew up’ or sever the rope.
The WLL of a suspension rope intended for use with a hand operated scaffolding hoist must not be more than one seventh of its GBS. The WLL of a suspension rope intended for use with a power operated scaffolding hoist must not be more than one tenth of its GBS.

Suspension ropes and secondary ropes should be each marked with a recorded identification number. They should have a swaged and thimbled eye at one end and no part of the rope construction should be removed to facilitate swaging. Ropes used with climber type hoists should be bullet-headed to help reeving.

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</tbody>
</table>

For drum type scaffolding hoists, make sure there are at least three full turns of rope on the drum when the scaffold is at its lowest point. The flange of a fully loaded winch drum should extend at least two rope diameters above the built up rope to prevent the rope jumping over the drum flange.

There should be at least 1m of spare rope when climber type scaffolding hoists are at the lowest point. Excess rope should be carefully coiled and tied to hang freely below the scaffold, or inserted into a rope winder to avoid kinking. Do not fix the rope ends back to the scaffold as this may cause kinking or birdcaging and can lead to rope failure.

Do not use bulldog grips on suspension ropes or secondary rope because they can damage the ropes.
Cradles

The internal width of a cradle must not be less than 450mm.

As a general rule, a swing stage cradle should not exceed 900mm in width. Cradles for double rope systems should have a width not less than 900mm and not more than 1.7m.

Work cages should have a width not less than 750mm and not more than 1.5m. Stabilising sheaves mounted on workcages for suspension ropes and secondary ropes should be at least 2m above the cage floor.

A sign clearly displaying the WLL must be fixed to the inside of the cradle. Articulated cradles should have a WLL sign on the inside of each bay. Multi-tiered cradles should have a WLL sign on the inside of each bay at each level.

Safe access should be provided between the levels of a multi-tiered cradle. Such access should be:

- protected on both sides with securely fixed mesh
- fitted with hinged trapdoors or sliding hatches
- installed in a manner which provides clear access at least 450mm in width along each working platform.

Where access between the levels of a multi-tiered cradle is not provided, each scaffolding hoist must be capable of being operated from each level, including the operation of the manual descent facility on power operated hoists.

Where netting is used to prevent debris falling from a cradle, it should be galvanised wire mesh with wires at least 1.5mm thickness spaced at no more than 25mm apart. It must be securely fixed between the guardrail and toeboard on all sides and ends of the cradle.

Electrical equipment

All electrical equipment and controls should comply with AS 3000 Electrical installations. Central control boxes, where fitted, should be fully enclosed, lockable, shatterproof and weatherproof and should include:

- socket outlets for scaffolding hoists
- an emergency stop button
- a power on light
- a Type I or Type II residual current device complying with AS 3190 Approval and test specification-Residual current devices.

All operating buttons and levers should be the spring loaded ‘dead-man’ type.

The control box should be removable for safety and security. When in use, it should be securely attached to the inside of the cradle guardrails on the side of the cradle away from the working face.

Electrical cables should be purpose designed and should only be suspended from built in thimbles. Do not use electrical cable with an outer covering damaged so that the insulation covering the wires is exposed.

The main supply cable should be plugged into the control box with separated yokes leading to the scaffolding hoists.
Pneumatic equipment

Pneumatic equipment and supply hoses, where used to power the scaffolding hoists, should be the type and capacity recommended by the hoist supplier. Air hoses should only be suspended from built in thimbles with an effective bending diameter of at least 8 times the nominal internal diameter of the hose.

Incoming air should pass through a suitable filter and lubricator fitted as close as possible to the hoist’s air motor. Each motor must have its own filter and lubricator set and a second motor must not be able to draw air through another motor’s filter and lubricator.

Oil used in lubricators should be the type recommended by the lubricator manufacturer and should be maintained at the recommended level.

General construction

Suspended scaffolds and suspension rigs should be erected or altered according to their design specifications. At the completion of the installation or alteration, the competent person in control of the work should issue a written statement of completion to the person in charge of the workplace. The statement should be retained until the scaffold is further altered or dismantled.

To protect those passing below, install a catch platform that has been designed for a uniformly distributed load of not less than 500kg per square metre and is long and wide enough to trap any falling debris, or a guardrail or fence.

Take precautions to prevent damage to the suspended scaffold or its supporting structure by traffic, cranes or other plant.

Where there is any likelihood of debris falling from above the cradle, install overhead protection. Independently supported catch platforms may be used. Meshed or solid overhead debris protection fixed to the cradle should be used only where debris would not cause instability of the suspended scaffold.

Install safe entry and exit points for persons using the suspended scaffold. The approaches to the suspended scaffold should be illuminated by either natural or artificial light.

Where access and egress is not at the ground or from a protected landing, safety harnesses and lanyards should be provided for all those entering and leaving the cradle. Where harnesses are used during entry and exit, a suitable tying method should be used to secure the cradle against movement. Anchorage points for harnesses should also be provided and be capable of withstanding a force of at least 1.5t.

Those working on a suspended scaffold must be protected from coming into contact with unprotected electric wires or dangerous plant or substances.

Use lateral restraints to prevent instability of the cradle during use. Instability may come from the work procedures or from wind.

Restraints include:

- lanyards
- tensioned wire rope systems
- removable ties
- fan units
- suction units.
There should be a reliable and efficient communication system between the cradle and outside. Communication systems include persons being in sight of the cradle or chair at all times at a distance from which hand signals, whistles, bells or radio can be used effectively.

There should be means of rescuing those in the cradle in the event of an emergency, such as crane safety boxes or rescue services.

Materials or equipment in the cradle must not be in excess of the rated load of the suspended scaffold.

The cradle should be maintained in a tidy condition with unobstructed access along the entire length.

Suspension ropes and secondary ropes should not be contaminated with construction materials resulting from work activities.

Purpose made weatherproof covers should be fitted to all scaffolding hoists when not in use to minimise contamination of the hoist mechanism by construction materials.

**Construction and operation**

An assessment of the supporting structure in relation to the intended loads should be made by a competent person prior to the erection of a suspended scaffold.

A copy of the statement of assessment or design should be made available to the person erecting, altering or dismantling the suspended scaffold.

**Suspension rigs**

The outboard end of a needle should never be lower than the inboard end. A beam spanning between only two supports should always be horizontal.

A needle or supporting beam should always be mounted with the greater dimension vertical.
Typical suspension rigs

(a) Counterweight

Line through centre of gravity

Fulcrum point

Inboard

Lever arm

Outboard

Needle

Projection length

(b) Counterweights

Inboard

Outboard

(c) Check fitting

Inboard

Outboard
Anchored needle suspension rigs

Anchorage design should take into account the nature of the material in which the anchorage is fastened. Anchorage bolts should be provided with lock nuts or other suitable means to prevent loosening.

Friction anchors and chemical insert anchors should not be used in tension in anchorage systems.

The design of the suspension rig should take into account any likely lateral forces including wind forces and surge.

Reveal propped needle suspension rigs construction

The suspension rig should incorporate at least two rows of uprights fixed with ledgers and transoms and be provided with longitudinal, transverse and plan bracing systems.

The needles should be positively fixed under or to the reveal props. In the case of needles that are rolled steel joists or universal beams, close fitting U-heads may be used.

Counterweighted needle suspension rigs

They should not be used to stabilise a needle attached to two or more suspension ropes.

Counterweights should be secured to the suspension rig in such a manner that they cannot be displaced or removed without the use of a tool. Counterweights should be placed directly on the needles or on the innermost supporting components to the needles.

A beam that spans between only two supports is often used to support a suspended scaffold in a shaft, boiler or chimney, or through grid mat flooring and like situations. The supporting beam should be fixed or located to prevent the possibility of dislodgment or slippage.

The built up framework on a suspension rig should be purpose built to engineering principles or constructed from scaffold tubes and couplers tied together with braced ledgers and transoms, to form a rigid and stable structure under working conditions.

Overhead fixing

The maximum rope tension applied to a shackle, strap, bolt, sling, chain, trolley, beam clamp or other device used to attach a suspension rope or secondary rope to overhead support should not exceed 80 per cent of the WLL.
The maximum rope tension applied to a choked sling should not exceed 40 per cent of the WLL.

Where a strap is used around a needle or supporting beam it should be made to an engineered design.

Shackles may be used to secure suspension ropes and secondary ropes to suspended scaffold tubes, beam clamps and various other devices. The pin should be moused to the body of the shackle with wire to prevent accidental unwinding.

Chains or slings supported over a beam with sharp edges should be protected with beam chaffers.

A positively fixed stop should be fixed at the end of each needle to prevent ropes from sliding off.

A check coupler should be fitted on either side of the suspension point of suspended scaffold tube needles to prevent movement.

In the case of a steel or aluminium beam, a bolt not less than 12mm diameter should be fitted through the needle with pipe washers.

**Traversing tracks and trolley**

Traversing tracks are suspended beneath needles or simply supported beams to help horizontal movement of a suspended scaffold. The ends of the traversing track should be fitted with through bolted stops to prevent any trolley running off the track.

Trolleys to support suspended scaffolding must have a rated working load hoisting of at least 500kg.

Trolleys supporting a swing stage should be connected with a spacer tie at the same centre to centre distance as the suspended scaffolding hoists to prevent spreading.

Trolleys supporting a double rope suspended scaffold should be rigidly connected longitudinally and transversely, and plan braced to prevent twisting.

To prevent cradles from colliding on the traversing track or excessive load on the rig and structure, fit a buffer zone with intermediate stops to the traversing track.

Ropes used for horizontal movement of a suspended scaffold should be at least 12mm diameter fibre rope.

**Calculating maximum rope tension**

For electrically powered suspended scaffolding hoists the maximum rope tension should be assessed as the sum of:

- the mass of the suspension rope
- any stabilising weights attached to the suspension rope
- the rated working load of the scaffolding hoist as limited by the load limiting device.

For pneumatically or manually powered suspended scaffold hoists, the maximum rope tension should be the sum of:

- the mass of the suspension rope
- any stabilising weights attached to the suspension rope
- the self-weight of the scaffolding hoist
- any secondary rope device
• that portion of the cradle weight supported by the rope
• the rated live load of the cradle taking into account grouping of live loads.

The ratio of stability for cantilevered suspension rigs

The ratio of stability of a suspended scaffold incorporating a cantilevered suspension rig must be no less than 3. The ratio of stability is:
• the sum of the moments acting on the inboard portion of the suspension rig, divided by
• the sum of the moments acting on the outboard portion of the rig.

The formula for calculating the number of counterweights needed on each needle of a cantilevered suspension rig is:

No of counterweights
\[
= \frac{3 \times \text{rope tension (kg)} \times \text{outboard (mm)}}{\text{inboard (mm)} \times \text{mass of each counterweight (kg)}}
\]

For a calculator:

\[
3 \times \text{rope tension x outboard ÷ inboard ÷ counterweight mass}
\]

For example:

<table>
<thead>
<tr>
<th>Counterweights</th>
<th>25kg each</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max rope tension</td>
<td>700kg</td>
</tr>
<tr>
<td>Outboard</td>
<td>900mm</td>
</tr>
<tr>
<td>Inboard</td>
<td>3600mm</td>
</tr>
</tbody>
</table>

Therefore:

\[
3 \times 700 \times 900 \div 3600 \div 25 = 21 \text{ counterweights per needle}
\]

Include these factors in calculations of the inboard moments:
• the self-weight of the inboard portion of the suspension rig, including any counterweights
• the design load of anchorages and props
• the strength of the supporting structure
• the distance between the fulcrum and the inboard distance to the centre of the counterweights in position.

Consider these factors in calculations of the outboard moments:
• the self-weight of the outboard portion of the suspension rig, including trolley tracks and trolleys
• the mass of secondary ropes, traversing ropes, electrical cables and compressed air cables
• the distance between the fulcrum and the suspension rope attachment points
• the maximum rope tension
• where suspended scaffolds incorporate trolley tracks the most adverse horizontal position of the cradle should be considered when calculating the ratio of stability.
Inspections and records

Six monthly inspection and test notations should be maintained in the maintenance workshop or base office and include:

• date of service and test
• list of parts replaced or repaired
• test load and rated working load of the hoist in kilograms
• statement that the hoist passed the test
• name and signature of servicing or testing person.

Each protective device should be returned to a maintenance shop for a thorough inspection and maintenance program at periods nominated by the manufacturer and not exceeding six months. The program should include a test where the device is loaded with a static load equal to the rated working load of the scaffolding hoist, plus a factor of 1.25, to allow for the effect of impact. It should show no sign of change.
Chapter 23 Gin poles and derricks

Introduction

The gin or derrick pole is an apparatus used for raising loads which is now not widely used in erection work. Its function has been replaced by mobile, derrick or tower cranes.

It consists of a vertical pole or derrick, stayed or guyed and often fitted with a several part purchase. It is capable of being leaned slightly forward or sideways as necessary and may be tracked along to a new position.

Certification

The rigging of gin poles, guyed derricks and sheer legs must be carried out or directly supervised by a person holding an Advanced Rigging Certificate (or old equivalent).

Set up

The greatest advantage of the derrick pole is the simplicity of rigging.

Timber poles are square or sometimes circular oregon or other suitable timber varying in cross section from 150mm$^2$ to 450mm$^2$ and in length from 6m to 25m or greater.

A solid bar is usually fitted through the pole near the top.
Single or twin reversed head slings are rove around the mast above this bar. The edges of the pole are protected by corner battens. A bolster is secured below this bar. Headslings hang over the bolster and are shackled into the headlock of the purchase. The bolster prevents the headlock from binding into the pole.

The pole is fitted with one front guy or stay, one each side, and one or sometimes two, backstays.

It is recommended to fit five stays, so that one stay can be used as a lazy guy when shifting the position of the others for the purpose of tracking the pole.

The stays or guys should have an eye splice at the top end. A round turn is taken around the pole head and the guy shackled in position. A rope yarn seizing is then fitted to prevent slackening.

A single block and gantline is also fitted to the pole head for a boatswain’s chair to provide access in case adjustment and greasing is necessary.

The lead from the top block of the main purchase is taken through a lead block which is shackled to a sling rove around the heel of the pole.

Heel lashings are fitted to the pole to secure it in position. At least one of these lashings must be opposite the direction of pull on the lead rope.

If the pole is to be leaned forward a front heel lashing is fitted and if it is leaned sideways a side heel lashing should also be fitted.

If the pole is to be leaned sideways the guy opposite the lean will take the strain/weight.
Lifting

Make sure that the pole is set up in the position for a lift on firm packing and footing.

For tracking purposes set the pole up on one or more planks or timbers. A steel dished tray should be fitted under the heel of the pole and hooked to a tracking purchase. Sometimes a wooden slide is used. The pole must lean in the direction of the tracking purchase, and a controlling rope must be secured to the heel as a follower.

As the pole is moved along, the guys and follower are slackened and adjusted in order to keep the pole as near to vertical as possible. Maintain complete control over the rear stay when it is being slackened for the purpose of tracking the pole.

Make allowance for the additional compressive loads placed on the pole by the pull in the lead rope and the pull in the backstays.

To calculate the total compressive load on the pole:

1. estimate the load on the lower block, which includes the load to be lifted and the mass of the block, shackles, slings, packing, etc

2. calculate the load or pull in the rope leading from the top block to the first lead sheave, as follows:
   
   Becket or static load = \frac{\text{Total load on lower block}}{\text{No. of parts of rope supporting the lower block}}

   The load in lead rope = \frac{\text{Becket load} + (\text{Becket load} \times \text{No of sheaves in purchase} \times 5\% \text{ friction})}{\text{No of parts of rope supporting the lower block}}
   = \frac{2.1 \times 5}{20}
   = \frac{2.625}{20}

3. add 1. and 2. together to get load applied to pole by purchase, ie Purchase load = Load on lower block + load in lead rope

4. total load on pole is approximately 1.125 x the purchase load. (0.125 or 1/8 of the mast head load is added to compensate for the weight of the back guy).

Example:

1. Mass of load and gear = 10.5t.
   
   Purchase consists of 3 sheaves at the top end and 2 sheaves at the bottom block = 5 part purchase.

2. Becket or static load = 10.5 = 2.1t.

   Load in lead rope = 2.1 + (2.1 \times 5) \div 20
   = 2.1 + 0.525
   = 2.625

3. Purchase load applied to top to pole = (10.5 + 2.625)
   
   Total load on the pole = 13.125 \times 1.125
   = 14.765t.
   
   Size of 15mm pole = 350mm square oregon.

Where excessive bending or ‘whip’ of the pole could develop due to age or excessive length, a set of three bowstrings should be fitted at the back and sides to strengthen the pole.
Guy loads

To calculate the loads in the back guys of derrick or gin poles:

1. calculate the total load at the pole head as shown above
2. multiply this load by the forward rake or ‘lean’ of the pole
3. divide the above result by the shortest radius measured from the heel of the pole to the back guy. The shortest radius is perpendicular (at right angles) to the back guy and is found by running a square along the back guy on the sketch until it meets the heel of the pole.

The result is the actual load in the guy.

Gin or derrick poles – rules for use

• where the distance from the back guy anchorage to the heel of the pole is equal to 1.5 x the pole height, the load in the guy is approximately 1/8 of the total pole head load
• where, measuring horizontally, the backstay anchorage is less than 1.5 x the height of the pole from the base of the pole, engineering calculations must be obtained for the pole and guy sizes
• the maximum forward lean is 1:10 measured from the vertical
• wire ropes must be at least 6x19 construction and have a breaking tensile strength of not less than 1570 Grade
• if more than one back guy is used make sure that the load is equalised
• all stays, guys, lashings, windlasses, etc, which are secured or led over sharp edges or hard materials, or secured to columns and piers should be properly lagged. Wrapping a bag around the rope itself is useless.
Splicing gin or derrick poles

To splice gin poles or masts together make a butt joint secured with steel or timber splice plates and bolts. Do not use separate plain steel plates without angle reinforcement.

**Derrick pole joints**

- **Butt joint for heavy poles**

Note: Angles welded to plates

- **Joint for poles not exceeding 300 mm square**

Note: For poles 400 mm square the plates should be 12 mm thick and the angles 100 mm x 100 mm x 12 mm. The total number of 20 mm diameter bolts used in that case should be 20.

Lapped joints may be used with clamp plates for light loads. For heavier loads an additional tom should be fitted.

Timber poles should only be painted with clear transparent paints, varnishes or oils, so that defects are not hidden.

The splicing of steel lattice frame poles should be calculated by an engineer.

<table>
<thead>
<tr>
<th>Oregon Size in mm</th>
<th>SAFE TOTAL LOAD AT POLE HEAD IN TONNES</th>
<th>Oregon Size in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Length of Pole in metres</td>
<td>4.5</td>
</tr>
<tr>
<td>100 x 100</td>
<td>tonnes</td>
<td>1.05</td>
</tr>
<tr>
<td>150 x 150</td>
<td>tonnes</td>
<td>3.0</td>
</tr>
<tr>
<td>200 x 200</td>
<td>tonnes</td>
<td>6.5</td>
</tr>
<tr>
<td>250 x 250</td>
<td>tonnes</td>
<td>12.0</td>
</tr>
<tr>
<td>300 x 300</td>
<td>tonnes</td>
<td>18.5</td>
</tr>
<tr>
<td>350 x 350</td>
<td>tonnes</td>
<td>26.5</td>
</tr>
<tr>
<td>400 x 400</td>
<td>tonnes</td>
<td>-</td>
</tr>
<tr>
<td>450 x 450</td>
<td>tonnes</td>
<td>-</td>
</tr>
</tbody>
</table>

**Note:** This table assumes maximum slope of pole one in ten (1:10) from vertical, and that the horizontal distance between foot of pole and anchorage of back guy shall not be less than one and one-half times the length of the pole.
Sheerlegs

A sheerleg is where twin timber poles form an A-frame with the base measurement of approximately one-third of the height. A pair of sheerlegs should lift approximately double the load of a derrick or gin pole of similar size and length provided the head lashings or bolt, headslings and guys are of adequate strength.

The timbers are crossed at the head, leaving 600mm to 1m projecting beyond the cross which may be bolted, or lashed with a FSWR round lashing.

The headslings should be draped over the cross, one eye hanging on either side. The two eyes are shackled together attached to the top block of the purchase.

The lead from the top block of the purchase is taken through a strongly secured lead block clear of the hook and load, and then to the winch. Caution: The sheerlegs can dislodge if the lead block is attached to the heel of one leg.

A rope is sometimes fitted across the base between the heels of the legs to prevent spreading. A more usual method is to set the heels in shoes secured to a soleplate, or on a substantial footing.

Heel lashings secured in both directions are necessary. At least one of the heel lashings must be opposite to the direction of pull on the lead rope.

One front guy and one back guy should be fitted, and if necessary, a purchase shackled to each.

It is unsafe to fit more than one guy to the front or back of the sheerlegs as one guy may receive more load than the other, resulting in one leg lifting and losing its footing.

Sheerlegs may be tilted forward or backward as required, but the angle of tilt must not exceed 15° from the vertical.

It is clear that the greater the angle of lean, the greater the thrust on the heel tackle and thus all heel tackle must be soundly secured to prevent kicking.

Permanent sheerlegs must be fitted into special base pivots.

This table assumes:

• the distance between feet of poles equals one-third of length
• the distance from feet of poles to anchorage of back guy is not less than one and one-half times the length.

Back guys for sheerlegs

The maximum forward lean should be 1:3 measured from the vertical.

The distance from the heels to the anchorage of the back guy should not be less than 1.5 x the length of the legs.

Wire ropes must be at least 6x19 construction with a tensile strength of at least 1570Mpa.

Guys and connections should be designed by the engineer for loads greater than 5t.

If more than one guy is used care must be taken to equalise the loads.
Tripods

Tripods are used for loading materials into trucks, or pipes into trenches and so on. A properly set up tripod can raise loads up to three times that of a derrick or gin pole of similar size and length.

Two legs in the form of an A-frame, often with hand winch and bearers bolted across the base, are splayed at the head to take the third leg between. A heavy bolt is fitted completely through the three legs at the apex. A purchase or chain block is hooked into a U-shackle suspended from this bolt.

Steel caps must be fitted above or stitch bolts below the main bolt to prevent the timbers from splitting under the load.

Make sure that:

- all legs make a similar angle to each other. The load to be lifted is directly under the lifting tackle. It is easy to overturn a tripod by pulling sideways upon the suspended load
- the feet are securely set on substantial ground or packing
- heel rope spans are secured between all three legs
- the angle of spread of the tripod legs should not exceed 30° from the vertical.

This table assumes that the distance between the feet of the poles does not exceed half the height where the height is the distance between the heel and the crutch.

<table>
<thead>
<tr>
<th>Total load on top of Sheerlegs</th>
<th>Vertical height from base to top bolt or top connection</th>
<th>Diameter of Wire Rope Back Guy</th>
</tr>
</thead>
<tbody>
<tr>
<td>tonnes</td>
<td>m</td>
<td>mm</td>
</tr>
<tr>
<td>0.5</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>1.0</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>2.0</td>
<td>12</td>
<td>16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WORKING LOAD LIMIT IN TONNES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oregon Size in mm</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>tonnes 100 x 100</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>3.50</td>
</tr>
<tr>
<td>300</td>
</tr>
</tbody>
</table>
Guy derricks

Guy derricks are rarely used in building work. They can be used where ample space is available to set up and to move.

They are usually constructed of steel lattice or tubular steel but may be of timber.

The mast is rotated on a ball and socket footing which must be safely anchored in position to prevent movement in any direction.

The derrick is usually fitted to a hinge at the base of the mast although in some cases to a hinge very much higher up the mast.

A guy pendant and rope tackle is fitted to each side of the derrick to control its movement. Frequently a bullwheel is provided, and slewing carried out by means of a power winch.

A swivel is fitted to the mast head to which the stays are attached by means of a spider. This allows the derrick and mast to revolve as one unit.

Six stays (often eight), fixed at equal angles are used to plumb the mast. The stays are rigidly anchored, and fitted with turnbuckles to enable constant adjustment to take up slackness. The turnbuckles should be locked to prevent slackening. The anchorages should be properly lagged if they are of steel.

Anchor the stays 1.5 x the height of the mast, from the footing. Mast stays should have the strength to support the mast loads.
The luffing gear from derrick head to mast head is a several part purchase. The number of parts is determined by the hook load. The lead together with the hoist rope lead is taken to the base of the mast (usually through a hole in the ball and socket joint) to the lead sheaves and then to the winch. In temporary rigs the hoist lead is sometimes taken direct to the lead sheaves at the base of the mast and then to the winch.

The main defect of the guy derrick is the tendency of the stays opposite the derrick to stretch under load. This results in the mast being thrown out of plumb, placing heavy loads on the stays, and making slewing difficult. Therefore stays must be continually kept taut in order to keep the mast plumb.

The derrick may need to be lowered and dipped under the nearest stay, or the stay let go and reset before slewing. The heel of the mast must be set up on a support with the strength to support the mast load plus the weight of mast and derrick with side thrust.

Another type of guyed derrick has the derrick hinged two-thirds of the way up the mast. These require particularly strong masts because of the bending forces.

In building construction the building framework is erected as high as the crane can reach. The crane is then lifted up several floors and re-set in position.

Stays must be of adequate strength, kept taut and kept clear of all obstructions and the mast must be kept plumb.

Correct procedure for the erection of derricks is to make the stays complete with spliced eyes to a length equal to 1.25—the height of the mast. Additional lengths may then be shackled on as required.

The stays are too large in diameter to be bent around rectangular stanchions and similar anchorages without sustaining serious damage. For this reason only lighter bowsing ropes or slings should pass round anchorages.

Insert heavy straining screws between the bowsings or slings and the eyes of the stays. If necessary use heavy wedge sockets to shorten the main stays.

Do not use single base bulldog grips on the stays.

**Marine type derrick**

The marine type derrick was once extensively used in building work. It is similar in rig to the guyed derrick but uses part of the building structure in place of the guyed mast.

A goose-neck swivel is used for securing the heel of the derrick to a base which is clamped to a column.

Care should be taken to ensure that the goose-neck support is secured against any vertical or sideways movement, as thrust in both directions is very great. To prevent slip, a piece of thin plywood, or brake lining may be inserted between bracket and column and stops welded to the bracket.

The luffing tackle should be positively secured to a properly constructed anchorage attached to a column, etc. Alternatively, two head slings long enough for one round turn may be used. The two head slings should be rove in opposite directions around the column. The column should be well lagged to protect them. A wire rope lashing with sufficient turns and back hitched to prevent movement of the shackle in any direction may also be used.

Wire rope lashings should only be used as a temporary measure. The turns of the lashing tend to ride or bend in the bow of the shackle. Consequently, one or more parts are jammed, cannot equalise, and thus receive excessive loads which will ultimately cause failure with perhaps disastrous results.
When using a wire rope luffing purchase, care must be taken to ensure a free and true lead to the lower lead block at all positions of the derrick.

A natural fibre rope luffing purchase may be used only if it has the strength to sustain the load plus the weight of the derrick, and if a FSWR preventer topping lift is used and permanently secured.

The boom must never be left under load supported only by fibre ropes as the ropes may be damaged by sparks, acid, weather etc or become unstranded.

The lifting purchase must be able to safely sustain the hook loads.

The boom head should be protected, shackles moused and lead blocks hung up. Guys, pendants and tackles must be properly secured and of sufficient number to enable proper control of the derrick.

In the table below the maximum ratio of length to diameter does not exceed 60.

<table>
<thead>
<tr>
<th>Capacity of crane in tonnes</th>
<th>Minimum boom diameter mm</th>
<th>Length of boom in metres</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6</td>
<td>7.5</td>
</tr>
<tr>
<td>1/2</td>
<td>110</td>
<td>125</td>
</tr>
<tr>
<td>1</td>
<td>120</td>
<td>140</td>
</tr>
<tr>
<td>2</td>
<td>_</td>
<td>_</td>
</tr>
<tr>
<td>3</td>
<td>_</td>
<td>_</td>
</tr>
<tr>
<td>5</td>
<td>_</td>
<td>_</td>
</tr>
<tr>
<td>7</td>
<td>_</td>
<td>_</td>
</tr>
<tr>
<td>10</td>
<td>_</td>
<td>_</td>
</tr>
</tbody>
</table>
Chapter 24 Span ropes and flying foxes

Introduction

A flying fox is an apparatus which is used to traverse a span while maintaining a load at a constant height.

A flying-fox consists of a more or less horizontal fixed overhead steel cable (called the ‘main cable’). A trolley or ‘fox’ which runs on the cable is used to raise, lower and transport loads.

A flying fox consists of only a single span. There is only one main cable which is supported at the extreme ends. One end is often much lower than the other such as when materials are raised or lowered from a cliff or gorge.

Certification

The rigging of flying foxes and cableways must be carried out or directly supervised by a person holding an Advanced Rigging certificate (or old equivalent).

Installation

The natural curves and slopes of the main cable make it necessary to control the fox by an endless rope or equivalent device. The endless control or ‘traverse’ rope should only be omitted upon the advice of an engineer.

This is partly because the pull of the hoisting rope tends to move the fox into unexpected positions. This movement can be sometimes offset by reeving the hoisting rope to relieve the fox of forces which move it along.

The main cable bends under the wheels of the fox as the load travels. If there are too few wheels the bending action may become localised greatly reducing the safety of the cable. Foxes usually have four or more wheels so that the bend in the main cable is spread over a considerable length.
When measured at the bottom of the treads the diameter of the wheels should be eight times the diameter of the main cable, though in large foxes carrying loads of 10t or more they may be as small as six diameters.

In most applications there should be no more than about 2.5t of load on each wheel although in bridge building, loads of double this figure are quite usual.

The ‘no load’ sag of the main cable, measured vertically at half span from a straight line joining the respective ends of the span should be about one-twentieth of the span, when the unloaded fox is at half span.

The ‘pull’ or tension in the main cable under maximum working load should not exceed one-sixth of the breaking strength of the cable.

For large permanent cableways such as those used in dam construction a maximum working load of one-quarter (or even less) is common, but this is not recommended for rough temporary cableways.

Where the span exceeds about 200m, fit carriers, in the form of steel links or loops to support the hoisting rope from the main cable. Without the carriers the unsupported hoisting rope will sag and interfere with the control of the lifting hook, and may make it impossible to lower an empty hook.

The carriers have a wheel running on the main cable. As the fox traverses the span it leaves behind a carrier at each of the points the hoisting rope is to be supported. The carriers are unshipped from the fox, and located where required by an overhead rope known as a ‘button rope’ because of the various stops or buttons attached to it for engaging carriers.
The fox collects the carriers on the return trip and transports them until they are needed again.

Where spans are less than about 200m the bottom block (hook block) is made heavy enough to overcome the pull and drag of the ropes whilst being lowered without any burden.

In bridge work it is often necessary to raise and lower loads not directly below the main cable. The poles supporting the main cable should be inclined sideways to bring the fox immediately above the load.

Preventer ropes must not be clamped to operating ropes by bulldog grips, but by properly constructed double-seated clamps.

**Span ropes**

Span ropes must have a minimum safety factor of six allowing for reeving, sharp bends at anchorages and point of load attachment.

The sag should never be less than five per cent of the length of span. The greater the sag the less the tension in the rope.

\[
\text{Tension in span rope} = \frac{W \times L}{4 \times S}
\]

The span should be securely anchored at both ends and if standing guys are used, these should be of sufficient strength to match the span rope and suitably protected and anchored.

Sheaves of fox block should be at least ten times the diameter of the span rope, with close fitting cheeks. Running control lines should lead as close to line of span as possible.
Appendix (i) Personal safety equipment and first aid

Riggers often have to wear helmets, gloves, eye protection, face masks and respirators and steel capped boots to protect themselves from injury.

It is the responsibility of your employer to provide the necessary protective equipment. It is the responsibility of riggers to wear and use the equipment properly and where and when necessary.

Safety helmets

Safety helmets with chin straps must be worn wherever there is a risk of objects falling from above and on any work site where the hard hat sign is displayed.

Helmets should comply with AS 1801 Industrial safety helmets.

Gloves

Riggers should wear close fitting pigskin gloves to protect hands from:

- heat and abrasion
- molten metal
- sharp edges.

Special purpose gloves may be required for protection against chemicals including acids, alkalis, solvents, fats and oils.

Eye protection

Wear eye protection that conforms to AS 1337 Eye protectors for industrial applications if you are likely to be exposed to:

- physical damage caused by – flying particles, dust, molten metal
- chemical damage caused by – toxic liquids, gases and vapours, dusts
- radiation damage caused by – sunlight, visible light, infra red, laser.

Respiratory protection

Riggers should wear a face mask that conforms to AS 1716 Respiratory protective devices if you are likely to be exposed to:

- toxic gases and vapours
- irritating dusts, such as silica.

Inhalation of some chemical vapours and gases can cause death or a wide range of unpleasant symptoms including narcosis and headaches.

Common dusts such as silica can cause lung disease later in life and is found wherever there is excavation, ie building sites, road works, tunnelling and mining.
**Hearing protection**

Hearing damage is likely if you are exposed to long periods of industrial noise above 85 decibels. This is the noise level of a large truck or loader.

A chainsaw for example has a noise level of about 92 decibels.

If you think it is likely that you are being exposed to dangerous noise levels ask your employer to provide you with hearing protectors complying with AS 1270 Acoustics – Hearing protectors.

**Footwear**

Riggers should be careful to choose footwear which are comfortable, gives maximum grip and provides protection from pinching, jamming and crushing.

A range of lightweight flexible boots with steel or plastic caps is available that comply with AS 2210 Safety footwear.

**Sun protection**

Riggers spend a great deal of time exposed to direct sunlight. To prevent permanent damage caused by ultra violet rays always wear a hat, long sleeves, long trousers and use UV cream when working outside.

**First aid**

Riggers work in a high risk industry. Not only are there many minor injuries but there are also serious injuries where the injured person will need first aid to restore breathing, heart beat or to stem blood flow.

Know the location of the first aid room and the nearest first aid kit. There should be a first aid kit on every alternate floor of a multi-storey building site or within 100 metres of any part of the workplace.

The standard first-aid symbol in Australia is a white cross on a green background.

First-aid kits on construction sites should have a carrying handle. There should be a notice near to the first-aid room with the name(s) of those in the workplace who hold an approved occupational first-aid certificate.

It is recommended that riggers take the time to do an approved first-aid certificate course.
Appendix (ii) Communication and signals

Two way radios

An effective means of communication when out of line of sight from the crane operator and other crew members on site is two way radio.

It is important that the two way system provides clear and immediate signals without interference.

The two types of two way radio are conventional and trunked.

For mobile cranes the rigger should stay in line of sight from the crane driver ready to use hand signals if the radio fails.

Conventional radio

Great care is taken when allocating frequencies to make sure that there are no other operators using the same frequency in the area. It is not possible, however, to control radio users in the field who may be using a frequency in the wrong area.

Always use a good quality system from a reputable company with a properly allocated frequency for the area.

Interference on your frequency can be a safety hazard. Stop using the system if there is interference, until the system is checked or a new frequency allocated.

Trunked radio

Trunked radio is a computer controlled two way system that locks other radio users out of your frequency. No other operator can cut in and overpower your signal.

With trunked radio it is possible to have several separate groups on one site communicating by radio without interfering with each other. Trunked radio is recommended for large sites.

Directions for crane or hoist operators

Riggers must give crane or hoist operators clear signals when directing crane movements. The noise of the crane motor and distortion over the radio can make it difficult to hear directions.

The following are the standard directions for crane operators:

- Hook movement: ‘Hook up’ and ‘Hook down’
- Boom Movement: ‘Boom up’ and ‘Boom down’
  - ‘Boom extend’ and ‘Boom retract’
- Slewing: ‘Slew left’ and ‘Slew right’
- OK to raise: ‘All clear’
- Do not move: ‘Stop’

Speak clearly and say the name of the part of the crane to be moved first – then the direction of movement.
<table>
<thead>
<tr>
<th>Motion</th>
<th>Hand Signal</th>
<th>Whistle, bell or buzzer signal</th>
<th>Motion</th>
<th>Hand Signal</th>
<th>Whistle, bell or buzzer signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hoisting raise</td>
<td><img src="image" alt="Hoisting raise" /></td>
<td>2 short **</td>
<td>Hoisting down</td>
<td><img src="image" alt="Hoisting down" /></td>
<td>1 long ___</td>
</tr>
<tr>
<td>Luffing boom up</td>
<td><img src="image" alt="Luffing boom up" /></td>
<td>3 short ***</td>
<td>Luffing boom down</td>
<td><img src="image" alt="Luffing boom down" /></td>
<td>4 short ****</td>
</tr>
<tr>
<td>Slowing right</td>
<td><img src="image" alt="Slowing right" /></td>
<td>1 long ___ 2 short **</td>
<td>Slowing left</td>
<td><img src="image" alt="Slowing left" /></td>
<td>1 long 1 short ___</td>
</tr>
<tr>
<td>Jib-trolley out: telescoping boom extend</td>
<td><img src="image" alt="Jib-trolley out: telescoping boom extend" /></td>
<td>1 long ___ 3 short ***</td>
<td>Jib-trolley in: telescoping boom retract</td>
<td><img src="image" alt="Jib-trolley in: telescoping boom retract" /></td>
<td>1 long 4 short ****</td>
</tr>
<tr>
<td>Travel and traverse</td>
<td><img src="image" alt="Travel and traverse" /></td>
<td>Not applicable</td>
<td>STOP</td>
<td><img src="image" alt="STOP" /></td>
<td>1 short ___</td>
</tr>
</tbody>
</table>

Creep speed: Appropriate hand signal for motion with hand opening and close

Signals
Appendix (iii) – Areas and volumes

Areas

Area of a square = length x width
For example:

\[ 2 \text{m} \times 2 \text{m} = 4 \text{ square metres} \]

Area of a rectangle = length x width
For example:

\[ 2 \text{m} \times 5 \text{m} = 10 \text{ square metres} \]

Area of a circle = diameter\(^2 \times .79\)
For example:

\[ 3 \text{m} \times 3 \text{m} \times .79 = 7.1 \text{ square metres} \]
Area of a triangle = base x height ÷ 2
For example:
3m x 3m ÷ 2 = 4.5 square metres

Volumes

Volume of a cube = length x height x width
For example:
3m x 3m x 3m = 27 cubic metres

Volume 27 cubic metres

Volume of a rectangular solid = length x height x width
For example:
2m x 4m x 6m = 48 cubic metres

Volume 48 cubic metres
Volume of a cone or pyramid = area of base x height ÷ 3

For example (pyramid):

\[2m \times 2m \times 1.5m ÷ 3 = 2 \text{ cubic metres}\]

\[\text{Volume 2 cubic metres}\]

For example (cone):

\[3m \times 3m \times .79 \times 4m ÷ 3 = 9.5 \text{ cubic metres}\]

\[\text{Volume 9.5 cubic metres}\]

Volume of a sphere = diameter\(^3\) x 0.53

For example:

\[3m \times 3m \times 3m \times 0.53 = 14.3 \text{ cubic metres}\]
Calculating the weight of a load

To calculate the weight of a load, if it is unknown, you must multiply the volume of the load by the unit weight of the material.

For example:

A rectangular stack of hardwood 3 metres long – 1 metre high – 0.5 metre across.

*Volume of rectangular solid = length x width x height*

\[3\text{m} \times 1\text{m} \times 0.5\text{m} = 1.5 \text{ cubic metres}\]

*Unit weight of hardwood is 1120kgs per cubic metre*

\[1.5 \times 1120 = 1680\]

Therefore the total weight of the load is 1680kgs.
### Appendix (iv) – Tables of masses

<table>
<thead>
<tr>
<th>Item</th>
<th>Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid (crated maximum)</td>
<td>200kg</td>
</tr>
<tr>
<td>Ale, beer, 160 litre</td>
<td>250kg</td>
</tr>
<tr>
<td>Aluminium, cu m</td>
<td>2.7t</td>
</tr>
<tr>
<td>Aluminium ingot</td>
<td>1.5kg</td>
</tr>
<tr>
<td>Asbestos cement sheet, plain, 2m x 1m</td>
<td>18kg</td>
</tr>
<tr>
<td>Ashes, coal, cu m</td>
<td>800kg</td>
</tr>
<tr>
<td>Asphalt, 200 litre, drum</td>
<td>200kg</td>
</tr>
<tr>
<td>Barbed wire, coil</td>
<td>50kg</td>
</tr>
<tr>
<td>Blue metal, cu m</td>
<td>2.0t</td>
</tr>
<tr>
<td>Beer (see Ale)</td>
<td></td>
</tr>
<tr>
<td>Bitumen, 200 litre, drum</td>
<td>200kg</td>
</tr>
<tr>
<td>Bolts, various, bag</td>
<td>50kg</td>
</tr>
<tr>
<td>Brass, cu m</td>
<td>8.5t</td>
</tr>
<tr>
<td>Bricks, common, 1,000</td>
<td>4t</td>
</tr>
<tr>
<td>Bronze, cu m</td>
<td>8.5t</td>
</tr>
<tr>
<td>Cast iron, cu m</td>
<td>7.2t</td>
</tr>
<tr>
<td>Cast steel, cu m</td>
<td>7.9t</td>
</tr>
<tr>
<td>Clay, cu m</td>
<td>1.9t</td>
</tr>
<tr>
<td>Cement, 1 bag small</td>
<td>20kg</td>
</tr>
<tr>
<td>Cement, 1 bag large</td>
<td>40kg</td>
</tr>
<tr>
<td>Coal, 1 cu m</td>
<td>864kg</td>
</tr>
<tr>
<td>Concrete, cu m</td>
<td>2.4t</td>
</tr>
<tr>
<td>Copper, cu m</td>
<td>9.0t</td>
</tr>
<tr>
<td>Copper, 3mm thick, sq m</td>
<td>27kg</td>
</tr>
<tr>
<td>Doors, 50</td>
<td>1t</td>
</tr>
<tr>
<td>Dog spikes, 100</td>
<td>50kg</td>
</tr>
<tr>
<td>Drums, empty 200 litre</td>
<td>13kg</td>
</tr>
<tr>
<td>Earth, 1 cu m</td>
<td>1.9t</td>
</tr>
<tr>
<td>Fat, tallow, etc (44 gal barrels) 200 litre</td>
<td>200kg</td>
</tr>
<tr>
<td>Fencing wire, coil</td>
<td>50kg</td>
</tr>
<tr>
<td>Fibrous plaster, sq m</td>
<td>9kg</td>
</tr>
<tr>
<td>Fibre board, sq m</td>
<td>0.6kg</td>
</tr>
<tr>
<td>Fibro cement sheets –</td>
<td></td>
</tr>
<tr>
<td>Flat –</td>
<td></td>
</tr>
<tr>
<td>4.5mm thick, sq metre</td>
<td>7kg</td>
</tr>
<tr>
<td>6mm thick, sq metre</td>
<td>11kg</td>
</tr>
<tr>
<td>Corrugated –</td>
<td></td>
</tr>
<tr>
<td>standard, sq metre</td>
<td>11kg</td>
</tr>
<tr>
<td>deep corrugations, sq metre</td>
<td>12kg</td>
</tr>
<tr>
<td>Compressed –</td>
<td></td>
</tr>
<tr>
<td>15mm thick, sq metre</td>
<td>26kg</td>
</tr>
<tr>
<td>Fish bolts, 24mm dia</td>
<td>1kg</td>
</tr>
<tr>
<td>Fish plates, 4-hole</td>
<td>13kg</td>
</tr>
<tr>
<td>Fish plates, 6-hole</td>
<td>18kg</td>
</tr>
<tr>
<td>Galvanised flat iron 0.5mm sheet</td>
<td>7kg</td>
</tr>
<tr>
<td>Glass, 10mm thick, sq metre</td>
<td>27kg</td>
</tr>
<tr>
<td>Granite, cu m</td>
<td>2.6t</td>
</tr>
<tr>
<td>Grease (44 gal) 200 litre</td>
<td>200kg</td>
</tr>
<tr>
<td>Gypsum, cu m</td>
<td>2.3t</td>
</tr>
<tr>
<td>Gypsum, 1 bag</td>
<td>50kg</td>
</tr>
<tr>
<td>Hardwood (see Timber)</td>
<td></td>
</tr>
<tr>
<td>Hermatic ore, cu m</td>
<td>5.4t</td>
</tr>
<tr>
<td>Hemp, bale</td>
<td>300kg</td>
</tr>
<tr>
<td>Ice, cu m</td>
<td>930kg</td>
</tr>
<tr>
<td>Iron, cast m</td>
<td>7.25t</td>
</tr>
<tr>
<td>Iron, ore, cu m</td>
<td>5.4t</td>
</tr>
<tr>
<td>Jute, bale</td>
<td>150kg</td>
</tr>
<tr>
<td>Kerosene (44 gal) 200 litre</td>
<td>200kg</td>
</tr>
<tr>
<td>Lead, cu m</td>
<td>11.4t</td>
</tr>
<tr>
<td>Lead, 3mm thick, sq m</td>
<td>34kg</td>
</tr>
<tr>
<td>Lead, pig or ingot</td>
<td>36kg</td>
</tr>
<tr>
<td>Lime (stone), 12 bags</td>
<td>1t</td>
</tr>
<tr>
<td>Lime (stone), cu m</td>
<td>2.6t</td>
</tr>
<tr>
<td>Lime, hydrated, 1 bag</td>
<td>22kg</td>
</tr>
<tr>
<td>Nails, case</td>
<td>50kg</td>
</tr>
<tr>
<td>Netting, wire 1m roll, 50m</td>
<td>25kg</td>
</tr>
<tr>
<td>Oils, all types (44 gal drum) 200 litre</td>
<td>200kg</td>
</tr>
<tr>
<td>Paint (except red and white lead) 4 litre</td>
<td>0.4kg</td>
</tr>
<tr>
<td>Palings, H.W. 1.5m sawn, 400</td>
<td>1t</td>
</tr>
<tr>
<td>Palings, H.W. 2m sawn, 360</td>
<td>1t</td>
</tr>
<tr>
<td>Particle board 18mm thick, sq metre</td>
<td>12kg</td>
</tr>
<tr>
<td>Petrol (44 gal) 200 litre</td>
<td>200kg</td>
</tr>
<tr>
<td>Pig iron</td>
<td>50kg</td>
</tr>
<tr>
<td>Pipes –</td>
<td></td>
</tr>
<tr>
<td>Stoneware –</td>
<td></td>
</tr>
<tr>
<td>100mm 55m</td>
<td>1t</td>
</tr>
<tr>
<td>150mm 32m</td>
<td>1t</td>
</tr>
<tr>
<td>225mm 20m</td>
<td>1t</td>
</tr>
<tr>
<td>300mm 15m</td>
<td>1t</td>
</tr>
<tr>
<td>Cast iron, 3.6m long, lined – 80mm nominal inside dia</td>
<td>18kg/m</td>
</tr>
<tr>
<td>100mm pipe</td>
<td>28kg/m</td>
</tr>
<tr>
<td>150mm pipe</td>
<td>54kg/m</td>
</tr>
<tr>
<td>200mm pipe</td>
<td>84kg/m</td>
</tr>
<tr>
<td>225mm pipe</td>
<td>115kg/m</td>
</tr>
</tbody>
</table>
300mm pipe .......... 148kg/m

Steel, galvanized –

<table>
<thead>
<tr>
<th>N.B.O.D.</th>
<th>O.D.</th>
<th>Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>13.5mm</td>
<td>0.7kg/m</td>
</tr>
<tr>
<td>10</td>
<td>17mm</td>
<td>0.9kg/m</td>
</tr>
<tr>
<td>15</td>
<td>21mm</td>
<td>1.28kg/m</td>
</tr>
<tr>
<td>20</td>
<td>27mm</td>
<td>1.69kg/m</td>
</tr>
<tr>
<td>25</td>
<td>34mm</td>
<td>2.5kg/m</td>
</tr>
<tr>
<td>32</td>
<td>42mm</td>
<td>3.2kg/m</td>
</tr>
<tr>
<td>40</td>
<td>48mm</td>
<td>3.8kg/m</td>
</tr>
<tr>
<td>50</td>
<td>60mm</td>
<td>5.3kg/m</td>
</tr>
</tbody>
</table>

Copper, 13g internal diameter – approx.

<table>
<thead>
<tr>
<th>O.D.</th>
<th>Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.7mm</td>
<td>0.35kg/m</td>
</tr>
<tr>
<td>16mm</td>
<td>0.5kg/m</td>
</tr>
<tr>
<td>25mm</td>
<td>0.8kg/m</td>
</tr>
<tr>
<td>38mm</td>
<td>1.25kg/m</td>
</tr>
<tr>
<td>50mm</td>
<td>1.7kg/m</td>
</tr>
</tbody>
</table>

Pitch and tar, (44 gal) 200 litre 200kg

Plywood 6mm, 2m x 1m 7kg

Plasterboard (Gyprock) 13mm thick –

sq metre ........................................ 27kg

Rails, steel (masses are branded on side) –

<table>
<thead>
<tr>
<th>Height mm</th>
<th>Base width mm</th>
<th>Masses</th>
</tr>
</thead>
<tbody>
<tr>
<td>157</td>
<td>229</td>
<td>192kg/m</td>
</tr>
<tr>
<td>152</td>
<td>165</td>
<td>86kg/m</td>
</tr>
<tr>
<td>157</td>
<td>146</td>
<td>73kg/m</td>
</tr>
<tr>
<td>173</td>
<td>140</td>
<td>59kg/m</td>
</tr>
<tr>
<td>137</td>
<td>127</td>
<td>41kg/m</td>
</tr>
<tr>
<td>94</td>
<td>94</td>
<td>22kg/m</td>
</tr>
<tr>
<td>65</td>
<td>60</td>
<td>10kg/m</td>
</tr>
</tbody>
</table>

Water, fresh, 1 litre 1.0kg

Weatherboards, rusticated –

Hardwood, 180mm x 25mm x 200m 1t

Woolpacks, pack average 150-160kg

Zinc, cu m ........................................ 7.0t

Zinc, ingot ...................................... 26kg
Appendix (v) Glossary

Below is a glossary of terms used in this guide and general rigging terms.

ACID: Substance which when concentrated will burn the skin. Neutralises and the opposite to alkali. Examples include battery acid, sulphuric acid and hydrochloric acid.

ALKALI: Substance which when concentrated will burn the skin. Neutralises and the opposite to acid. Examples include, caustic soda and potash.

AS: Australian Standard followed by a number which denotes a particular publication.

ANGLE FACTOR: The factor by which the WLL of a multi-legged sling is de-rated to give its SWL at a particular angle between the sling legs.

ANTI-TWO-BLOCK DEVICE: See hoist-limiting device.

BS: British Standard followed by a number which denotes a particular publication.

BACK HOOKING: A method of slinging using slings with hooks where the sling is passed around the load and the hook is secured back onto the ring or hook above the load.

BACK SPLICE: A splice in the end of a fibre rope to prevent it from unlaying.

BALD EYE: An eye in a rope which is not protected by a thimble. It is also called a ‘soft eye’.

BARROW HOIST: See cantilever platform materials hoist.

BASKET HITCH: A method of securing a sling around an object by bringing both eyes back together with an angle factor = 1.

BAYONET: A jib extension used with the auxiliary winch on a hydraulic boom crane and often extending from a fly jib to increase the crane’s operating radius and drift.

BEARING JOINT: A bolted joint in steel erection designed to allow for some joint slip for alignment.

BECKET: An anchorage point on a sheave block when reeing a tackle or purchase.

BECKET LOAD: The load in any fall of rope in a multiple fall tackle or purchase. It equals the total load being lifted divided by the number of falls supporting the load.

BEND: A tie made in fibre rope to create a temporary eye (such as a bowline bend) or to join ropes (such as a sheet bend).

BIGHT: The middle portion of a length of rope. For example, a ‘bowline on the bight’ means a bowline formed in the middle of a rope.

BILL: The lower end point of a hook.

BIRDCAGING: A rope defect, springing or enlargement of a FSWR – usually in Lang’s Lay.

BLACK WIRE: See bright wire.

BLOCK: An appliance which supports one or more sheaves.

BLOCK AND TACKLE: A sheave block or blocks used with fibre rope.

BOATSWAIN’S CHAIR: A suspended scaffold where the platform is a chair or similar device suitable for use by one person.
BODY BELT: A safety belt designed to be worn around the waist and which does not have shoulder straps or leg straps.

BOOM: A member attached to and cantilevered from the crane structure from which the load is suspended. Can be luffed or sleeved while the crane is handling a load.

BOOM BUTT: The end of the boom nearest to the crane.

BOOM HEAD: The end of the boom furthest from the crane.

BOOM LIFT: See boom type elevating work platform.

BOOM TYPE ELEVATING WORK PLATFORM: A powered telescoping device, hinged device or articulated device or any combination of these used to support a platform on which personnel, equipment and materials may be elevated to perform work. Also known as ‘cherrypickers’.

BORDEAUX CONNECTION: A fitting used to connect a chain to FSWR where the connection is required to pass over a sheave.

BOTTLE SCREW: See rigging screw.

BOW SHACKLE: A shackle with bowed sides.

BOWSING: See frapping.

BOWSTRING: A rope tensioned to a structural member to prevent it from distorting during lifting.

BREAKING FORCE: See guaranteed breaking strain (GBS).

BRIDGE CRANE: A powered crane consisting of one or more bridge beams mounted at each end to an end carriage that can travel along elevated runways. It may be cabin controlled or remote controlled (such as pendant control).

BRIGHT WIRE: Uncoated steel wire used in the construction of FSWR. Also known as ‘black wire’.

BRITISH DOCKS SPLICE: Orthodox 5 tuck eye splice in FSWR.

BUSH ROLLER CHAIN: Chain constructed with parallel flat links and cylindrical rollers, such as bicycle and motorcycle drive chains.

BUILDER’S HOIST: A hoist incorporating a mast or guides which is used on building and construction projects. It includes a cantilever platform materials hoist and a personnel and materials hoist.

BULLDOG GRIP: A wire rope grip consisting of a U-bolt, two nuts and a saddle.

CCLP: Cantilevered crane loading platform.

cm: Symbol for centimetre.

CABLE LAID ROPE: Three hawser laid fibre ropes laid up together in an opposite lay to form one rope. Cable laid ropes are often used for moorings.

CABLE PULLING STOCKING: A device used as a temporary join for two ropes where the join needs to pass over a sheave. It is used to haul a new rope onto a crane.

CALIBRATED CHAIN: Short link chain with parallel link sides constructed to very exact link lengths so it can ride smoothly over a gypsy. Commonly used on chain blocks. Also called ‘pitched short link chain’.
CANTILEVER: A beam, structural member or similar which is anchored at one end and which is free at the other end.

CANTILEVER PLATFORM MATERIALS HOIST: A powered builder’s hoist which has the lift platform cantilevered from the hoist tower. It moves materials only, up and down the face of a building or structure. Also called a ‘barrow hoist’.

CANTILEVERED CRANE LOADING PLATFORM: A temporary loading bay cantilevered from the face of a building or structure to land or lift crane-handled loads.

CAPSTAN WINCH: See warping drum.

CAT HEAD: The sheave assemblies on the top mast section of a builder’s hoist or the top of the A-frame on a tower crane.

CENTIMETRE: A unit for measuring distance. 10mm equals one centimetre. 100cm equals 1m.

CHAIN BLOCK: A geared portable appliance used for hoisting a load suspended on a chain.

CHAIN PULLER: A geared portable appliance incorporating a load chain which is operated by a lever handle.

CHERRY PICKER: See boom type elevating work platform.

CHOKE HITCH: A method of securing a load to a sling or a sling to an anchorage by reeving the sling back through its eye, or fixing the eye back to the sling leg with a shackle.

CIRCUMFERENCE: The distance around the outside edge of a circle.

CLEVIS: An eye with a removable pin.

CLIMBING FRAME: An internal or external frame used to lift the crane from the tower sections of a tower crane for climbing up or down.

COME-ALONG: See chain puller or creeper winch.

CRADLE: The part of a suspended scaffold that incorporates the working platform.

CRANE: An appliance intended for raising and lowering a load and moving it horizontally, but excluding industrial lift trucks, earthmoving machinery, amusement structures, tractors, industrial robots, conveyors, building maintenance equipment, suspended scaffolds and lifts.

CRANE CHART: See load chart.

CRAWLER CRANE: See track mounted crane.

CREEPER WINCH: A portable manually operated winch for hoisting or haulage where an FSWR is moved through the winch by a gripping jaw mechanism.

CRIBBING: See pigsty.

CROSBY CLIP: See bulldog grip.

CUT SPLICE: A splice joining two fibre ropes which incorporates an eye.

DEAD END: The tail of a rope which does not take load.

DEAD LOAD: The self weight of a crane, hoist or scaffold before it is loaded.
DEBRIS NET: A fine mesh net usually laid over an industrial safety net in order to catch small light items of falling debris.

DEE SHACKLE: A shackle with parallel sides, resembling the letter D on its side.

DERRICK CRANE: A slewing strut-boom crane with the boom pivoted at the base of a mast which is either guyed (guy-derrick) or held by backstays (stiff-leg derrick). Can luff under load.

DIAMETER: The distance across a circle measured through its centre.

DIVERTING SHEAVE: A sheave set up to change the direction of the lead rope between the winch and the head sheave.

DOG KNOTTING: A method of finishing a splice in a fibre rope by halving each strand and knotting each half to the adjacent half strand. It prevents the splice from loosening during use.

DOGGING: The application of slinging techniques, including the selection or inspection of lifting gear, or the directing of a crane or hoist operator in the movement of a load when the load is out of the operator’s view.

DOMESTIC GRADE LADDER: A portable ladder designed and manufactured for light loads and intended for use by home handymen. It is not intended for industrial work.

DOUBLE BASE CLAMP: A wire rope grip with two or more bolts along a split barrel to minimise damage to the FSWR.

DOUBLE ROPE SUSPENDED SCAFFOLD: A scaffold where the cradle is suspended using two hoists and two suspension ropes at each support point.

DOUBLE THROAT WIRE ROPE GRIP: A wire rope grip which uses a saddle on each side to minimise damage to the FSWR.

DOUBLE WRAP: A method of slinging where the sling legs are passed twice around the load with the eye choked back to the sling. Often called a round turn.

DRAGLINE: A crane fitted with a bucket or scoop which is thrown outwards and retrieved by a drag cable arrangement.

DRIFT: 1. A steel handtool consisting of a tapered shaft which is used to align bolt holes in structural steel connections. It is sometimes driven in with a flogging hammer to ‘drift’ the bolt holes into alignment.

OR 2. The distance between the upper and lower blocks of a tackle or purchase. The drift determines the maximum height a load can be lifted.

DROIT: A brandname for excavators and loaders.

DRUM: The cylinder of a winch around which the rope is wound and stored. It may be plain or grooved.

DUAL COVERAGE: Work which can be performed by someone who holds either the appropriate class of rigging certificate or the appropriate class of scaffolding certificate, because the work is within the scope of both types of certificate.

DUAL LIFT: See multiple crane lift.

DUCK: A light canvas material similar to calico.

DUNNAGE: Packing under loads to allow the removal or placing of slings.
EOHTC: Electric overhead travelling crane – an electric powered bridge or gantry crane.

EWP: Elevating work platform.

EGG RING: The main (or master) ring to which the legs of a chain sling assembly are attached.

ELEVATING WORK PLATFORM: A telescoping device, scissor device or articulating device used to support a working platform.

END SPLICE: See back splice.

EQUALISING BEAM: A lifting beam which can be used with two cranes to ensure that each crane is supporting its correct portion of the load.

EQUALISING SHEAVES: Sheaves used to equalise the load.

EXTENSION LADDER: A portable ladder constructed in two or more stages which can be adjusted to vary the height of the ladder.

EYE SPLICE: A splice in the end of a rope which forms an eye.

EYEBOLT: A lifting ring fixed to a threaded rod which can be screwed into a load or anchorage.

FC: Symbol used to indicate a fibre core in the construction of an FSWR.

FSWR: Flexible steel wire rope.

FW: Filler wire. It is used in some FSWR constructions to space and support the main wires in a strand.

FABRICATED HUNG SCAFFOLD: A pre-assembled scaffold hung from another structure but which is not capable of being raised or lowered when in use. It is sometimes used for large steel erection projects.

FACTOR OF SAFETY: The ratio of the minimum breaking load (or GBS) to the WLL or actual working load. For example, an FSWR with a safety factor of five has a WLL which is one fifth of its GBS.

FALLS: The separate parts of rope in a purchase or tackle.

FELLING: Various methods of demolition where a winch or earthmoving equipment is used to drag over a part of the building or structure.

FERRULE: A metal collar used in an FSWR eye splice to hold the rope parts together.

FLEET ANGLE: The angle formed from the centre line of the drum to the centre of the first lead sheave then back to the inside centre of the drum flange.

FLEETING: A method of moving an object by using two hoists, purchases or tackles to lift, haul and lower the load.

FLEMISH EYE: A method of forming an eye in FSWR by separating and re-marrying the strands without tucks.

FLOGGING HAMMER: A hammer designed to be held in one hand for driving drifts, cold chisels and the like. Commonly used in steel erection.

FLY: A secondary jib mounted at the head of the crane’s main boom or jib, increasing the crane’s operating radius and drift. Also called a ‘goose neck’.

FLYING FOX: An arrangement where a rope is suspended between two tower structures and which supports a carriage (or ‘fox’) from which a load may be raised, traversed and lowered.
FRAPPING: A lashing where several turns are passed around parts to pull a rope tighter. Also called a ‘bowsing’ lashing.

GBS: Guaranteed breaking strain.

GANTLINE: A fibre rope reeved through a single sheave block.

GANTRY CRANE: A powered crane with one or more bridge beams. The beams are supported at each end by legs mounted on travelling end carriages. They have a crab with one or more hoisting units that are able to travel across the bridge beam or beams. Used where there is no supporting building for the crane.

GEARED JACK: A geared mechanical device used to raise or lower loads.

GERMAN JACK: See geared jack.

GIN POLE: A guyed derrick without a pivoted strut-boom. It can raise and lower a load and a limited amount of slewing can be achieved by adjusting the guys.

GIN WHEEL: A purpose designed single sheave tackle block often used as a gantline during the erection and dismantling of scaffolds.

GIRDER CLAMP: An appliance designed to be fixed to the lower flange of a universal beam or RSJ to provide an anchorage for a sling, suspension rope, purchase or tackle.

GIRT: A horizontal structural member in a wall of a steel structure which supports the wall cladding sheets.

GOOSE NECK: See fly.

GUARANTEED BREAKING STRAIN: The load (or force) stated by the rope manufacturer as the rope’s breaking load when tested to failure in a new condition. The ratio between the GBS and the WLL is the factor of safety.

GRADE: Indicates the strength of chain, FSWR or other items manufactured from steel. The higher the grade of steel, the higher the tensile strength.

GROMMET: An endless sling constructed with a single rope strand layed up onto itself.

GUN TACKLE: A fibre rope tackle which uses an upper block with two sheaves and a lower block with two sheaves (two double blocks).

GUY: A tensioned rope fixed at one end to a mast, tower or structure and anchored some distance from the base to stabilise the structure.

GUYED DERRICK: A derrick (or derrick crane) stabilised by guys.

GYPSY: A sheave with pockets formed into its groove to take a load chain, such as on a chain block.

HAMBONE: See wedge socket.

HAMMERHEAD CRANE: A tower crane with a counterweighted horizontal boom which supports a traversing crab for hoisting.

HAMMERLOCK: An attachment for joining hooks or rings to a chain.

HANDY BILLY: A fibre rope tackle where one block has two sheaves and the other block has three sheaves (double and treble blocks). It is also called ‘light gin tackle’. 
HAWSER LAID: A fibre rope construction which uses three strands.

HEAD BLOCK: The top block in a purchase, tackle or block at the head of a crane boom or hoist.

HEADACHE BALL: A spherical overhauling weight.

HEAVY DUTY WORKING PLATFORM: A scaffold platform with a duty live load capacity of 675kg per bay. This is three times the capacity of a light duty platform.

HEAVY GIN TACKLE: A fibre rope tackle where the upper block has three sheaves and the lower block has three sheaves (two treble blocks).

HELIX: The spiral put into a rope construction.

HIGH STRANDING: Rope damage indicated by one strand sitting up higher than the others in a portion of the rope.

HITCH: A tie made in a fibre rope to fix it to an anchorage or to a load. Common examples include the clove hitch, rolling hitch, becket (or buntline) hitch and timber hitch.

HOIST: An appliance used to raise or lower a load with no horizontal movement.

HOISTING: Raising or lowering a load.

HOIST-LIMITING DEVICE: A device used in a crane or hoist to stop the winch or warn the operator before the hook block jams into the head block (two-blocking) while the hook is being raised. It is also called an 'anti-two-block device'.

HOOK BLOCK: The lower block on a crane which incorporates a hook for slinging loads.

HYDRAULIC BOOM CRANE: A crane which has a boom which luffs using hydraulic power and usually also telescopes using hydraulic power.

IWRC: Wire rope core in the construction of an FSWR.

IWS: Wire strand core in the construction of an FSWR.

INBOARD: The portion of a needle or other cantilevered beam between the fulcrum and end anchorage or centre of the counterweights.

INDUSTRIAL GRADE LADDER: A portable ladder designed and manufactured for general industrial use. This is the type of ladder for use in rigging work.

INDUSTRIAL SAFETY NET: A purpose designed net intended to catch a person falling from a building or structure.

INERTIA REEL: A self-locking device with a retractable line intended for use with a safety harness.

JACK: An appliance which is placed under a load to raise or lower it.

JIB: A member attached to the crane structure from which the load is suspended. It can not be luffed while the crane is under load. **Please note:** In the past, ‘jib’ was often used to mean the same thing as ‘boom’.

JIB TROLLEY: A crab or saddle from which the load is suspended and which can traverse along the jib.

JOCKEY SHEAVE: A diverting sheave which can freely run along the length of an axle to reduce the fleet angle of the lead rope.
kg: Kilogram.
kPa: Kilopascal.

kN: Kilonewton.

KERNMANTLE CONSTRUCTION: A method of constructing synthetic fibre rope where a plaited sheath is laid over a parallel or twisted core. Kernmantle ropes are used with abseiling equipment and emergency rescue lines.

KIBBLE: A crane lifted vessel normally used for hoisting and pouring wet concrete.

KIDNEY BELT: See body belt.

KINKING: Damage to a rope indicated by a sharp permanent twist.

KILOGRAM: A unit for measuring mass (or weight). One litre of water weighs one kilogram. There are 1000kg in a tonne.

KILONEWTON: A unit for measuring force. One kilonewton is approximately equivalent to a weight of 100kg.

KILOPASCAL: A unit for measuring pressure or stress. One kilopascal is approximately equal to 100kg per square metre.

KNEE BRACE: A diagonal brace used to stiffen a column in a steel structure.

L: Indicates Grade 30 mild steel chain.

LH: Indicates left hand lay in a rope construction.

LL: Indicates Lang’s lay in an FSWR rope construction.

LANG’S LAY: A construction method for FSWR where the rope strands are laid in the same direction as the wires.

LANYARD: A short length of synthetic fibre rope used to attach a safety harness or body belt to an anchorage.

LATTICE BOOM CRANE: A crane with an open-web boom, usually in sections. It does not telescope. Sometimes called a ‘pin-jib crane’

LAY: The way a rope is constructed.

LEAD BLOCK: A block which diverts the line of pull in a winch hauling rope.

LEAD ROPE: The portion of rope between the lead block and the winch drum.

LEFT HAND LAY: A method of rope construction where the strands are laid up in an anti-clockwise direction. Sometimes called an ‘S twist’ because the strands run the same direction as the central part of the letter S.

LEVER HOIST: See Chain puller.

LIFELINE: A vertical, or near vertical rope to which a safety harness can be attached using a device that will grab the lifeline if the wearer slips.

LIFTED LOAD: See live load.
LIFTING CLAMP: See plate clamp.

LIGHT DUTY WORKING PLATFORM: A platform on a scaffold with a duty live load capacity of 225kg per bay.

LIGHT GIN TACKLE: See ‘handy billy’

LIVE LOAD: The load being lifted (also called the ‘lifted load’) or the load of persons and materials supported by a scaffold platform in each bay.

LIVE ROPE: A moving rope.

LOAD BINDER CHAIN: Chain designed for securing loads to the trays of trucks. It is not designed for lifting.

LOAD CHART: A manufacturer’s notice fixed to a crane or hoist which specifies the SWLs in all normal operating configurations. It is also called a ‘load plate’ or ‘crane chart’.

LOAD FACTOR: The fraction of a sling assembly’s WLL created by a particular slinging method. It includes the angle factor and the reeve factor.

LOAD LIMITING DEVICE: Used with a power-operated scaffolding hoist, which cuts the hoist motor at a pre-set load to avoid overloading the rope or the suspension rig.

LOAD WEIGHT INDICATOR: A device which indicates the weight of the load being lifted.

LOCOMOTIVE CRANE: A crane designed and intended for use on railway tracks.

LONG SPLICE: A method of joining two ropes so that they can travel over sheaves without obstruction.

LOWER BLOCK: The bottom block in a tackle or purchase from which the load is suspended.

LUFF TACKLE: A fibre rope tackle where the upper block has two sheaves and the lower block has a single sheave (single and double blocks).

LUFFING: Raising or lowering the boom head of a crane.

M: The symbol used to indicate the diameter of a structural bolt in millimetres. For example, M16 indicates a 16mm bolt.

m: A metre – the unit for measuring distance.

mm: Millimetres. 1000mm equal one metre.

MPa: Megapascal.

MSDS: Material safety data sheet.

MAN AND MATERIALS HOIST: See personnel and materials hoist.

MANILA: Natural fibre used for rope construction. Has a creamy brown appearance when new.

MARLIN SPIKE: A tapered hand tool used to prise open the strands of an FSWR during splicing or during rope inspection.

MARLINE: Tarred hemp cordage used for seizings, mousings and whippings. Also called ‘small stuff’.
MAST CLIMBER: A hoist with a working platform used for temporary purposes to raise personnel and materials to the working position. It has a drive system mounted on an extendable mast which may be tied to a building.

MATERIALS HOIST: A builder’s hoist used for raising and lowering materials (not personnel) including a cantilevered platform materials hoist.

MATERIAL SAFETY DATA SHEET: Manufacturer’s or supplier’s information about a substance, including any hazards associated with its transportation, storage and use.

MECHANICAL LOADSHIFTING EQUIPMENT: When used in connection with rigging, this term includes specified cranes, hoists, cableways, flying foxes, winches, blocks and purchases which incorporate sheaves, jacks and airbags.

MEDIUM DUTY WORKING PLATFORM: A platform on a scaffold with a duty live load capacity of 450kg per bay. This is twice the capacity of a light duty platform.

MEGAPASCAL: A unit for measuring pressure or stress. 1000 kilopascals equals 1 megapascal. 1 megapascal is approximately equal to 100 tonnes per square metre.

MOBILE CRANE: A crane which can travel over a supporting surface without the need for fixed runways or railway tracks and which relies on gravity for stability.

MOBILE SCAFFOLD: An independent free standing scaffold mounted on castors.

MOBILING: Moving a mobile crane over its supporting surface while it is under load.

MULTI-LEGGED SLING: A sling assembly with more than two sling legs.

MULTIPLE CRANE LIFT: The movement of a load where the load is suspended from two or more cranes.

NR: Symbol used to indicate non-rotating rope.

NEEDLE: A cantilevered structural member that supports a scaffold or load.

NIP: The point at which a rope or sling is gripped by a hitch.

NON-ROTATING ROPE: FSWR in which adjacent layers of strands are laid in opposite directions, ie alternatively right hand and left hand, to prevent the rope from spinning under load. Commonly used as a crane hoist rope.

NON-SLEWING MOBILE CRANE: A mobile crane which has a boom or jib that cannot be slewed. It includes an articulated type mobile crane and a locomotive crane.

OL: Symbol used to indicate ordinary lay rope construction.

ON RUBBER: The operation of a truck mounted or rough terrain mobile crane without the aid of outriggers.

OPEN WEDGE SOCKET: See wedge socket.

ORDINARY LAY: A method of FSWR construction where the strands are laid in the opposite direction to the outer layer of wires. Referred to in North American manuals as ‘regular lay’.

OUTBOARD: The portion of a needle or other cantilevered beam between its fulcrum and its outermost attachment point.

OUTRIGGER: A stabilising extension for a mobile crane.
OVERHAULING WEIGHT Counterweight to overhaul the self-weight of an unloaded hoisting rope.

OVERWOUND: Rope winding on and off the top side of a winch drum.

P: Symbol used to indicate Grade 40 chain.

PARBuckling: A method of moving a large cylinder up or down a ramp using one or more ropes to haul it or control its descent.

PARCelling: Covering a splice with strips of duck or canvas before serving.

PARACHUTE HARNESS: See ‘safety harness’.

PARTS OF ROPE: See ‘falls’.

PENDANT: A rope used to provide support to a length of crane boom or jib.

PENDANT CONTROL: A hand held set of motion controls attached to a crane or hoist by an extension cable to provide remote operation. Particularly used with some types of bridge cranes and power operated chain blocks.

PERSONNEL AND MATERIALS HOIST: A powered builder’s hoist which hoists personnel, goods or materials.

PIGSTY: A method of placing bearers on top of each other at right angles to provide a stable temporary support for a load.

PIN-JIB CRANE: See ‘lattice boom crane’

PITCHED SHORT-LINK CHAIN: See ‘calibrated chain’.

PLATE CLAMP: A purpose designed appliance for lifting steel plate and similar items.

PLATE SHACKLE: A shackle with two side plates used to connect boom pendants.

PODGER SPANNER: A spanner with a tapered handle used to field bolt structural steel members.

POWER TAKE-OFF WINCH: A winch powered by the engine of the vehicle to which it is attached.

PORTAL BOOM CRANE: A powered jib or boom crane mounted on a portal frame that is supported on runways allowing the crane to travel. Commonly used in waterside ports.

PREFORMED ROPE: FSWR where the spiral of the strands and wires is formed before the rope is laid up.

PROOF-COIL CHAIN: Unmarked chain of uncertain grade and construction.

PROTECTIVE DEVICE: A device used with a suspended scaffold which will arrest the descent and support a cradle or boatswain’s chair in the event of a failure of a suspension rope or scaffolding hoist.

PURCHASE: A series of sheaves reeved up to form a mechanical advantage in the FSWR.

PURLIN: A longitudinal member spanning between roof trusses or beams to which roofing sheets are fixed.

RL: See ‘ordinary lay’

RSJ: Rolled steel joist.

RADIUS: The distance between the centre of a circle and its outside edge.
REEVE: To thread rope through lifting gear such as sheaves or put one eye through the other for slinging.

REEVE FACTOR: The factor by which the WLL of a sling is adjusted to give its SWL for a particular manner in which the sling is reeved.

REGULAR LAY: See ‘ordinary lay’

REMOTE-RELEASE SHACKLE: A purpose designed shackle with an operating rope enabling it to be disconnected by a person standing below the lifting point. Often used to lift columns during steel erection.

RIGGING: The use of mechanical loadshifting equipment and associated gear to move, place or secure a load including plant, equipment or members of a building or structure and to ensure the stability of those members, and for the setting up and dismantling of cranes and hoists, other than the setting up of a crane or hoist which only requires the positioning of integral outriggers or stabilisers.

RIGGING SCREW: An enclosed device with an anchorage point and a threaded rod in each end. Used to tension an FSWR or to provide fine adjustment to a sling assembly.

RIGHT HAND LAY: A method of rope construction where the strands are laid up in a clockwise direction. Sometimes called a ‘Z twist’ because the strands run in the same direction as the central part of the letter Z.

ROLLED STEEL JOIST: A structural steel member with an I-section, now largely superceded by universal beams (UB’s) and universal columns (UC’s).

ROOF RIG: See ‘suspension rig’.

ROOSTER SHEAVE: The head sheave for the auxiliary winch on the top of the boom head of a hydraulic boom crane.

ROUGH TERRAIN CRANE: A mobile crane designed to operate on unimproved natural terrain and disturbed terrain of construction sites.

ROUND SLING: An endless synthetic fibre sling constructed with a circular cross-section.

RUNNING GEAR: Flexible ropes which run over sheaves or drums and the gear used with such ropes.

S: The symbol used to indicate seale construction in an FSWR.

S TWIST: See ‘left hand lay’

SF: The symbol used to indicate seale filler wire in the construction of an FSWR.

SW: The symbol used to indicate seale warrington construction in an FSWR.

SWL: Safe working load.

SAFE WORKING LOAD: The maximum load which may be applied to a crane, hoist, rope, chain or sling for particular conditions of use.

SAFETY HARNESS: A body harness to which a lanyard or inertia reel can be attached to protect a person from falling or arrest a fall.

SAFETY HOOK: A hook provided with a safety latch across its throat intended to prevent a sling being accidentally dislodged.

SAFETY LINE: A horizontal rope or webbing anchored to two or more points of a building or structure and tensioned to provide an anchorage for a person wearing a safety harness to attach a lanyard or inertia reel.
SAFETY NET See ‘industrial safety net’.

SAG ROD: A stiffening member fixed between purlins or girts, generally at their mid span.

SEALE: A multi-layered strand construction method in FSWR where equal sized wires in one layer are laid over an equal number of smaller equal sized wires in the next layer.

SEALE WARRINGTON: A multi-layered strand construction method in FSWR where a seale laid layer is laid over a warrington laid centre.

SCAFFOLD: A temporary structure specifically erected to support access platforms or working platforms.

SCAFFOLDING HOIST: A serial hoist used with a suspension rope to raise and lower a cradle or boatswain’s chair during normal operation.

SCISSOR HOIST: An elevating work platform where the platform is raised and lowered using a scissor mechanism.

SECONDARY ROPE: A rope sometimes used on a suspended scaffold which does not normally support the cradle but which is rigged for use with a protective device.

SEIZING: A lashing for holding two ropes, or two parts of a rope together. Common types include round, square, flat, racking, throat and end seizings.

SENHOUSE SLIP: A tongued quick release device for chains or ropes. Often used to secure the anchor of a vessel.

SERVING: Winding marline, twine or annealed wire tightly around a rope, usually to protect a splice from damage and to protect the user’s hands from cuts.

SHEAVE: A grooved wheel or roller over which a rope or chain passes.

SHEERLEGS: A derrick like appliance consisting of two legs in an 'A' formation, with a sheave block fixed to its apex and the framework stabilised with guys.

SHORT SPLICE: A method of joining two ends of fibre rope. It is used where the spliced section does not have to travel over a sheave.

SHROUD LAID: A method of constructing a fibre rope using four strands layed around a core.

SIMPLY SUPPORTED BEAM: A beam which is fixed at each end.

SINGLE LADDER: A non-self supporting portable ladder whose length cannot be adjusted.

SINGLE WHIP: A fibre rope tackle where both the upper and lower blocks have single sheaves (two single blocks).

SISAL: Vegetable fibre obtained from the sisal plant. Sometimes used to construct natural fibre ropes.

SLEWING: The rotation of a crane’s boom or jib in the horizontal plane.

SLEWING CRANE: A crane with a boom or jib which has slewing capability.

SLEWING MOBILE CRANE: A powered mobile slewing crane. It does not refer to a front-end loader, backhoe, excavator or similar equipment when configured for crane operation.

SLING: Detachable lifting gear made from FSWR, natural fibre, chain, or synthetic fibre.
SNATCH BLOCK: A sheave block with a drop side to permit the bight of a rope to be placed or removed without reeving it through.

SNATCH LOADING: The sudden application of power to lift a load, causing large impact forces on the load and the running gear.

SNIGGING: Dragging a sling or dragging a load.

SNOTTER: A fibre rope sling.

SPANISH WINDLASS: A dangerous method of twitching tight the parts of a rope by placing a bar between them and taking several turns.

SPREADER BAR: A rigid member used to connect two trolleys from which a scaffold is suspended. It keeps the suspension points aligned when the cradle or working platform is traversed.

SPREADER BEAM: A beam with a central lifting attachment and with slinging points at each end. Used to reduce the angle of slings or to sling loads with large surface areas or to reduce the strain on a load.

SPECIAL DUTY WORKING PLATFORM: A platform on a scaffold designed for live loads greater than 675kg per bay.

SOCK: See ‘cable pulling stocking’.

SOFT EYE: See ‘bald eye’.

STANDING GEAR: Ropes such as guys and stays which do not run or work over sheaves or drums, and the gear used with such ropes.

STATIC LINE: See ‘safety line’.

STEP LADDER: A self-supporting portable ladder of fixed length having flat steps or treads and hinged back legs.

STIFF-LEG DERRICK: A derrick crane stabilised by rigid backstays and sleepers.

STOCKING: See ‘cable pulling stocking’.

STRAND: A number of wires or fibres layed in a spiral which are then layed up with other strands to form a rope.

STRETCHING SCREW: See ‘tumbuckle’.

STRONGBACK: A temporary member fixed to a load to strengthen or stiffen it during lifting.

STROP: An endless sling.

STUD-LINK CHAIN: Chain constructed with a stud across the centre of each link. Commonly used for marine purposes, the stud prevents the chain from jamming when it comes out of ships’ lockers. Unsuitable for general lifting purposes.

SUPER DUTY HOIST: A materials tower hoist with a WLL greater than one tonne. It is sometimes constructed as a dual tower with a materials platform in one tower and a concrete bucket in the other.

SUSPENDED SCAFFOLD: A scaffold incorporating a suspended platform which can be raised and lowered in normal use, including a boatswain’s chair.
SUSPENSION RIG: The portion of a suspended scaffold (including a trolley track) which is mounted at a higher level than the cradle and which supports and positions the cradle. Sometimes called a ‘roof rig’.

SUSPENSION ROPE: A rope used in a suspended scaffold to support a cradle.

SWAGED FITTING: A metallic fitting attached to FSWR using radial pressure to form an eye.

SWING STAGE: A suspended scaffold with a single row of suspension ropes.

SWIVEL: A rotating item of lifting gear which can rotate without spinning the rope, hook or load.

SYNTHETIC FIBRE: Manufactured fibre used in the construction of fibre ropes and slings, such as polyamide (nylon), polyester, polyethylene, polypropylene, etc.

T: Symbol indicating Grade 80 chain.

t: Symbol for tonne.

TFB: Tapered flange beam

TACKLE: Fibre rope reeved through sheaves to form a mechanical advantage.

TAGLINE: A fibre rope attached to a suspended load to control the load during lifting.

TAPERED FLANGE BEAM: A largely obsolete type of steel I-beam. UB’s are now generally used.

TARE WEIGHT: The unloaded weight of a crane, lifting box or other container. It is also called the ‘self-weight’.

TELESCOPING: The extension or retraction of a crane’s boom or jib by the movement of the boom or jib sections during normal operation. A feature of most hydraulic boom cranes.

THIMBLE: A grooved piece of metal, circular or pear-shaped, used to protect an eye splice. It forms a ‘hard eye’.

TONNE: A unit for measuring mass (or weight). 1000kg equals 1 tonne.

TOWER CRANE: A boom or jib crane mounted on a tower structure.

TRACK-MOUNTED CRANE: A mobile crane mounted on a crawler track base. It is not usually fitted with outriggers.

TRAVEL: Movement of a complete crane along a surface or track.

TRAVEL TOWER: A boom-type EWP mounted on a truck tray.

TRAVERSE: Movement of a crab or other part of a crane along runways forming part of the crane structure, or horizontal movement of a scaffold platform hung from or suspended from a trolley track.

TRAVERSING ROPE: A fibre rope used with a suspended scaffold or hung scaffold supported from a trolley track to provide controlled horizontal movement of the platform. Also the rope used to traverse the fox across the main cable of a flying fox.

TRESTLE LADDER: A portable hinged self-supporting ladder designed and intended to support scaffold planks.

TRUCK-MOUNTED CRANE: A mobile crane mounted on a truck-type chassis and cab system, with the crane base forming part of the truck chassis.
TUCK: A rope strand tail passed under a strand in the construction of a splice.

TURNBUCKLE: An open framed attachment with an anchorage and threaded rod at each end used to tension a rope or to provide fine adjustment.

UB: Universal beam.

UC: Universal column.

UNDERWOUND: Rope winding on and off the underside of a winch drum.

UNION SCREW: See turnbuckle.

UNIVERSAL BEAM: An I-section steel beam commonly used in steel structures.

UNIVERSAL COLUMN: An I-section steel column commonly used in steel structures.

VEHICLE LOADING CRANE: A powered slewing crane mounted on a vehicle for the principal purpose of loading and unloading the vehicle.

W: Symbol used to indicate a warrington construction in an FSWR.

WLL: Working load limit.

WALKING: Mobiling a load with track mounted cranes.

WARPING DRUM: A powered winch with a dished drum used with a fibre or wire rope which is turned around the drum using friction to lift or haul a load. Also called a 'capstan winch'.

WARRANTON: A multi-layered strand construction method for FSWR where the strand is laid up parallel with alternate large and small wires in one layer.

WEBBING SLING: A flat woven synthetic fibre sling.

WHIP UPON WHIP: A fibre rope tackle with two moveable single blocks and one fixed single block.

WHIPPING: A method of preventing the end of a rope from unlaying by securing yarn, marline, twin or wire around it. Forms of whipping used with fibre ropes include Common whipping, American whipping, West-Countryman’s whipping and Palm-and-Needle whipping.

WINCH: An appliance which provides a means of hoisting or hauling a load.

WIRE: A single continuous steel filament. In FSWR, a number of wires make up a strand, and several strands form a rope.

WIRE ROPE GRIP: A removable device incorporating nuts and bolts designed to be fixed to FSWR.

WORK CAGE: A suspended scaffold cradle supported by a single suspension rope. Usually designed for one person.

WORK BOX: A crane lifted box designed to carry personnel and provide them with a working platform. Often used to service tower crane booms and during large-scale steel erection.

WORKING LOAD LIMIT: The maximum load which can be applied under general conditions of use to a crane, hoist, rope, chain, sling or item of lifting gear.

WORMING: The laying of lengths of spun yarn into the valleys between the strands of a rope to make the rope completely circular before it is served.

Z TWIST: See right hand lay.
Appendix (vi) Sample assessment questions

Introduction

The questions in this Appendix are typical of those set for riggers’ certificate assessments and are grouped into dogging, basic rigging, intermediate rigging and advanced rigging. You will find the answers in the text of this guide.

Dogging

1. Which has the greater bearing pressure—shale or dry sand?

2. What type of tagline would you use operating near powerlines—natural fibre rope or synthetic fibre rope?

3. Which type of two-way radio is recommended for dogging on large city building sites—a trunked radio or a conventional radio?

4. What is meant by 6 x 24 FC RHOL FSWR?

5. Are the strands of a right hand lay rope laid clockwise or anti-clockwise around the core?

6. Does the lay of a rope affect the WLL?

7. Which letter is often used to mark Grade 80 chain?

8. What is the WLL of a synthetic sling colour-coded green?

9. What is the recommended maximum angle between two legs of a sling?

10. When a three legged sling is used to lift a rigid load, how many legs are assumed to be taking the weight?

11. How would you protect a sling from damage caused by the sharp edges of a load?

12. What can happen if a kibble of concrete is dumped in one spot?

13. What minimum clearance around stacked loads would you keep for truck access?

14. What is the minimum diameter FSWR you would use for two vertical slings fixed to a spreader for lifting a tank filled with water where:

   the tank’s tare weight is 200kg
   the tank diameter is 850mm
   and the tank height is 1600mm?

15. If you are using a 13mm Grade (P) four-legged chain sling with an included angle of 60 degrees between the diagonally opposite sling legs, what is the maximum load that can be lifted?

16. If you are using a pair of 14mm reeved FSWR slings with an included angle of 90 degrees to lift a universal beam which weighs 147kg per metre, what is the maximum length the beam can be?
Basic rigging

1. Is a person with a Basic Rigging certificate allowed to carry out dogging work?

2. Is a person with a Basic Rigging certificate allowed to supervise dual lifts?

3. Is a person with a Basic Rigging certificate allowed to install a safety net?

4. What identification marks would you find on the head of a high strength structural bolt?

5. What type of shackle can be used from a lower level to release the running gear from a column?

6. Would you sling a roof truss away from the panel points or at the panel points?

7. Can FSWR be safely used in a fibre rope tackle block?

8. What is the minimum groove depth in a wire rope purchase block?

9. What type of damage is caused by sheaves where the groove is too large for the rope?

10. What is a gun tackle?

11. On what side of an underwound winch drum would you fix a left hand lay rope?

12. What are the two maximum fall distances you might find marked on the label of a safety net?

13. What maximum spacing would you use between ties along the border cord of a safety net?

14. What is the maximum distance you would use between lateral ties or guys of a cantilevered platform materials hoist?

15. What is the minimum distance from the lead block to a plain winch drum which is 900mm wide?

16. Allowing 5 per cent per sheave for friction, what is the load in the lead rope when a purchase with 5 sheaves is used to lift a total load of 8t?

Intermediate rigging

1. Is a person with an Intermediate Rigging certificate allowed to plan and direct a multiple crane lift?

2. Is a person with an Intermediate Rigging certificate allowed to use load equalising gear?

3. Is a person with an Intermediate Rigging certificate allowed to erect and dismantle a cableway?

4. How often are proof tests required on lifting clutches used for tilt-slab erection?

5. What is the maximum recommended height of packing under the edge of a tilt up panel?

6. What type of indicator must be fitted to a crane used for lifting tilt slabs?

7. When lifting a tilt slab panel from its casting bed, what increase in the dead load would you allow for the effect of suction?

8. On a tilt slab shop drawing, what does a blocked-in circle mean?

9. If you are using a 2 x 2 rigging configuration with equalising sheaves to raise a tilt-slab and the distance between the anchor points for each sling is 2.4m, what is the minimum length of the slings you need?
10. Does a crane used for demolition work require a hoist limiting device?

11. What is the minimum diameter of a felling chain for demolition work?

12. How close to the sides of a felling rope can a person stand during demolition work?

13. If you are demolishing reinforced concrete columns, what is the maximum allowable freestanding height if they are left without lateral support outside working hours?

14. What is the minimum number of temporary guylines needed to control the felling of a steel column?

15. An equalising beam which is 8m long with lifting points located at each end and at every metre along its length will be used in a dual lift. The total load to be lifted is 40t. One crane has an SWL at the working radius of 25t.

(a) How far along the equalising beam from this crane's lifting point would you sling the load?

(b) What is the minimum required SWL of the second crane at the working radius?

Advanced rigging

1. What is the maximum duty live load per bay for a medium duty fabricated hung scaffold?

2. What is the minimum width of a heavy duty working platform on a fabricated hung scaffold?

3. What is the minimum distance a toeboard must extend above the top surface of a working platform on a fabricated hung scaffold?

4. Would you use a fibre rope as a guardrail on a scaffold?

5. What is the minimum and maximum height from a scaffold platform to the guardrail?

6. At the edge of a scaffold platform, what must be provided between the guardrail and the toeboard?

7. What are the minimum and maximum slopes at which a portable ladder can be pitched to provide access to a scaffold?

8. What is the minimum cradle width for a double rope suspended scaffold?

9. What is the maximum width of a swing stage cradle?

10. Can bags of sand be used to counterweight the needles of a suspended scaffold?

11. Where two trolleys are used to support a swing stage, how would you stop them spreading?

12. When a drum type scaffolding hoist is at its lowest point, how many full turns of rope should remain on the drum?

13. When a climber type scaffolding hoist is at its lowest point, what is the minimum length of spare rope?

14. What type of scaffolding hoist must be fitted with a load limiting device?
15. A swing stage cradle of one bay is set up with two electric scaffolding hoists. Each hoist has a rated working load of 500kg using 50m of suspension rope weighing 30kg per 100m. The cantilever needles have an inboard of 3m and an outboard of 500mm. Each counterweight weighs 30kg.
   (a) Calculate the maximum rope tension.
   (b) Calculate the minimum guaranteed breaking load of the suspension ropes.
   (c) Calculate the minimum number of counterweights needed at the inboard end of each needle.

16. A chain block is set up on a span rope fixed between two beams which are 25m apart. The load to be lifted is 600kg and the weight of the lifting gear and load in the hauling part is 70kg. When the span rope sag is at the recommended minimum, what is the tension in the span rope?

17. A 6m gin pole has been set up at the maximum recommended lean with the guys anchored at the minimum recommended distances from the pole foot. The lead rope is parallel to the pole. When a 6t load is lifted there is a 1.2t load in the lead rope.
   (a) Calculate the load on the back guy.
   (b) Calculate the forward lean of the top of the pole.
   (c) Calculate the distance between the pole heel and the back guy anchor.
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