SSS
S.R. & S.C. SCHEYER
A.B.N.- 80712611497

Part four

Advanced rigging

Chapter 21 Fabricated hung scaffolds

Introduction

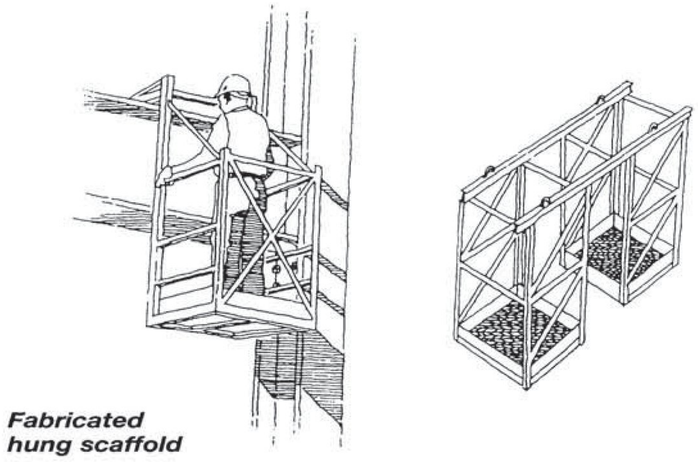
Fabricated hung scaffolds are purpose designed temporary structures which are anchored to a permanent structure to support a working platform. Unlike suspended scaffolds, they are not capable of being raised or lowered while in use.

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

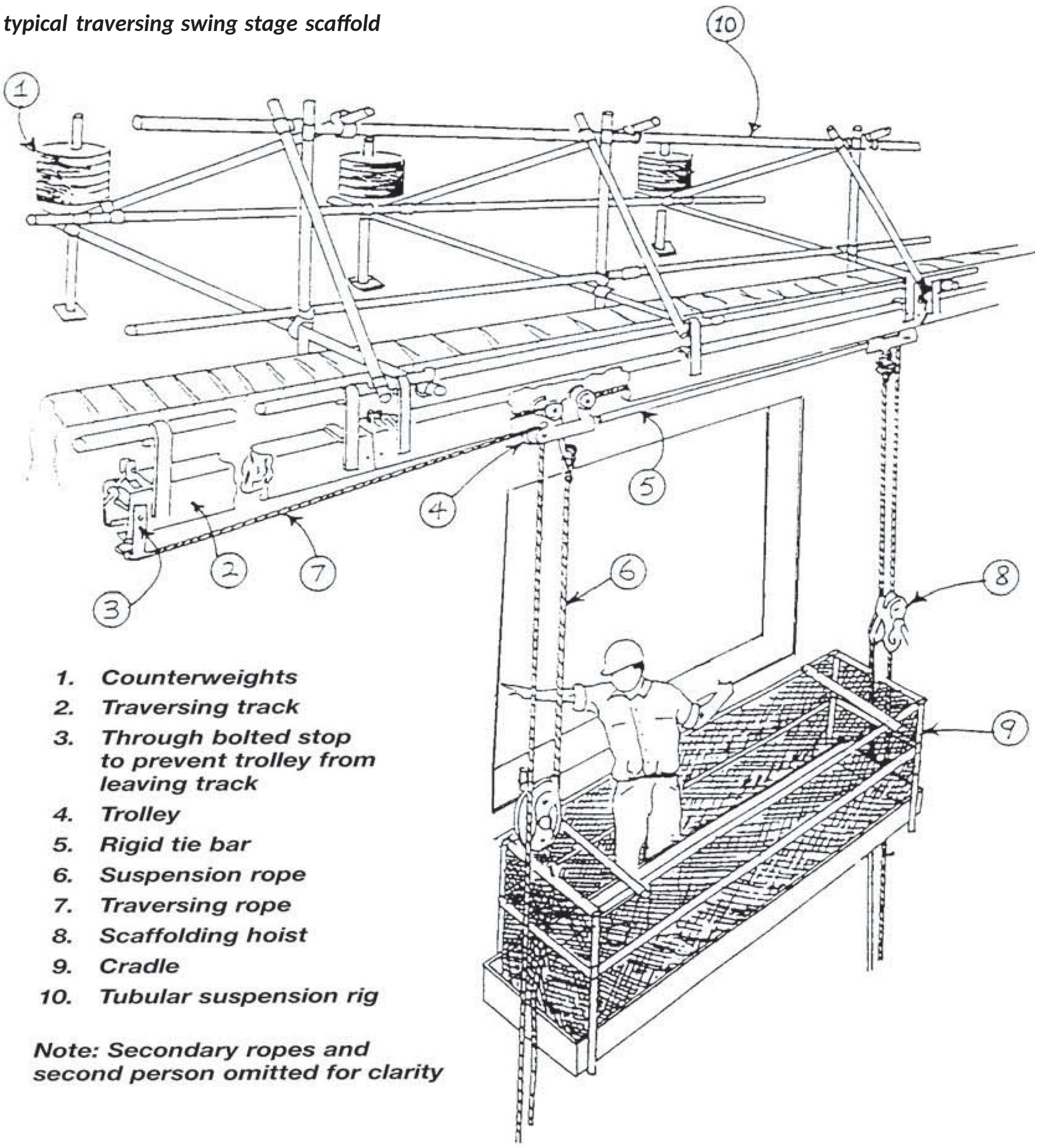
A suspended scaffold has a suspended platform that can be raised and lowered during normal use. It is generally suspended from temporary overhead supports by flexible steel wire ropes to which scaffolding hoists are fixed.

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



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:

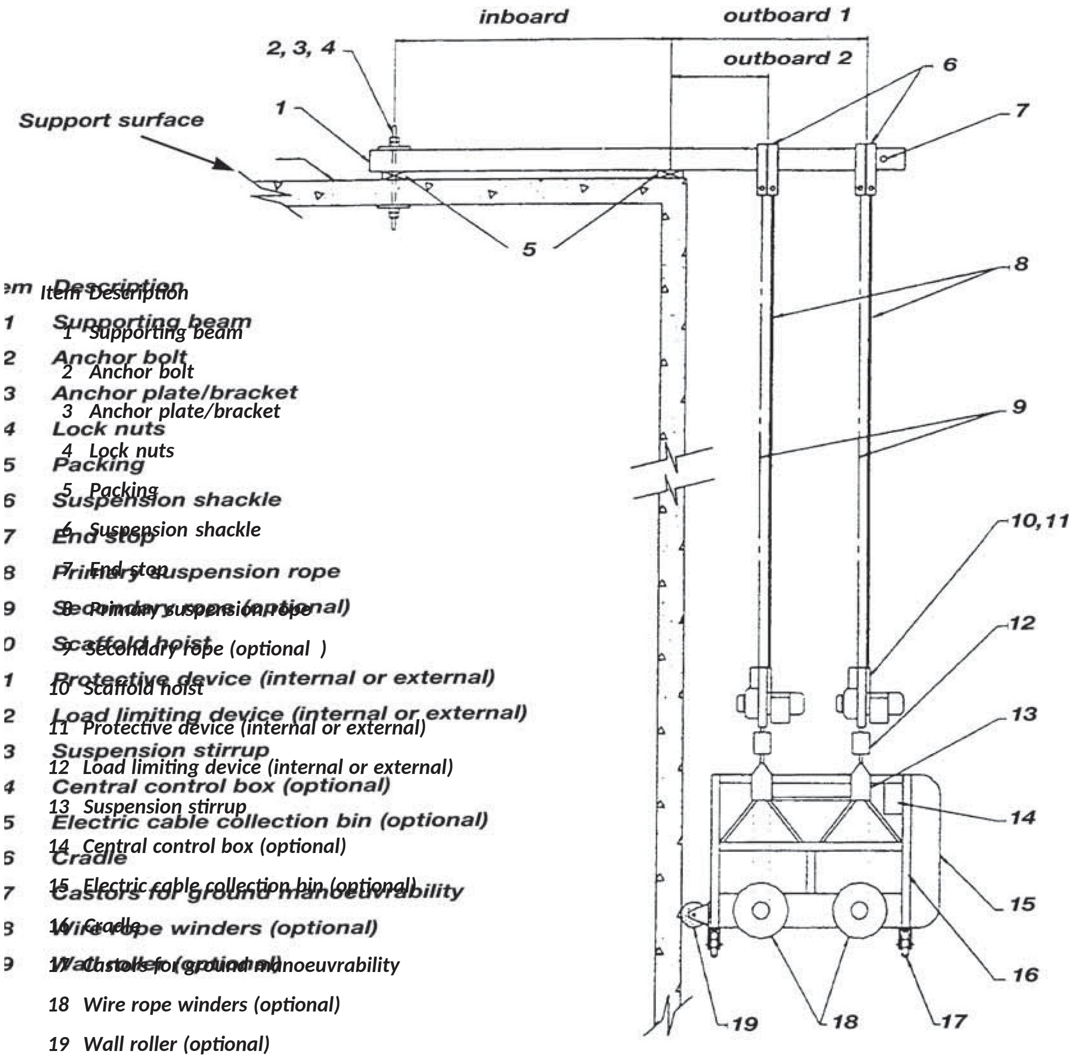
- the type, model and serial number
- the manufacturer’s name or identification mark
- details of the FSWR to be used, including rope diameter, grade and construction
- the rated load
- reeving requirements, where applicable
- power supply requirements, where applicable.

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.



Item Description

1. *Supporting beam*
2. *Anchor bolt*
3. *Anchor plate/bracket*
4. *Lock nuts*
5. *Packing*
6. *Suspension shackle*
7. *End stop*
8. *Primary suspension rope*
9. *Secondary rope (optional)*
10. *Scaffold hoist*
11. *Protective device (internal or external)*
12. *Load limiting device (internal or external)*
13. *Suspension stirrup*
14. *Central control box (optional)*
15. *Electric cable collection bin (optional)*
16. *Cradle*
17. *Castors for ground manoeuvrability*
18. *Wire rope winders (optional)*
19. *Wall roller (optional)*

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 31 90 *Approval and test specificationResidual 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.

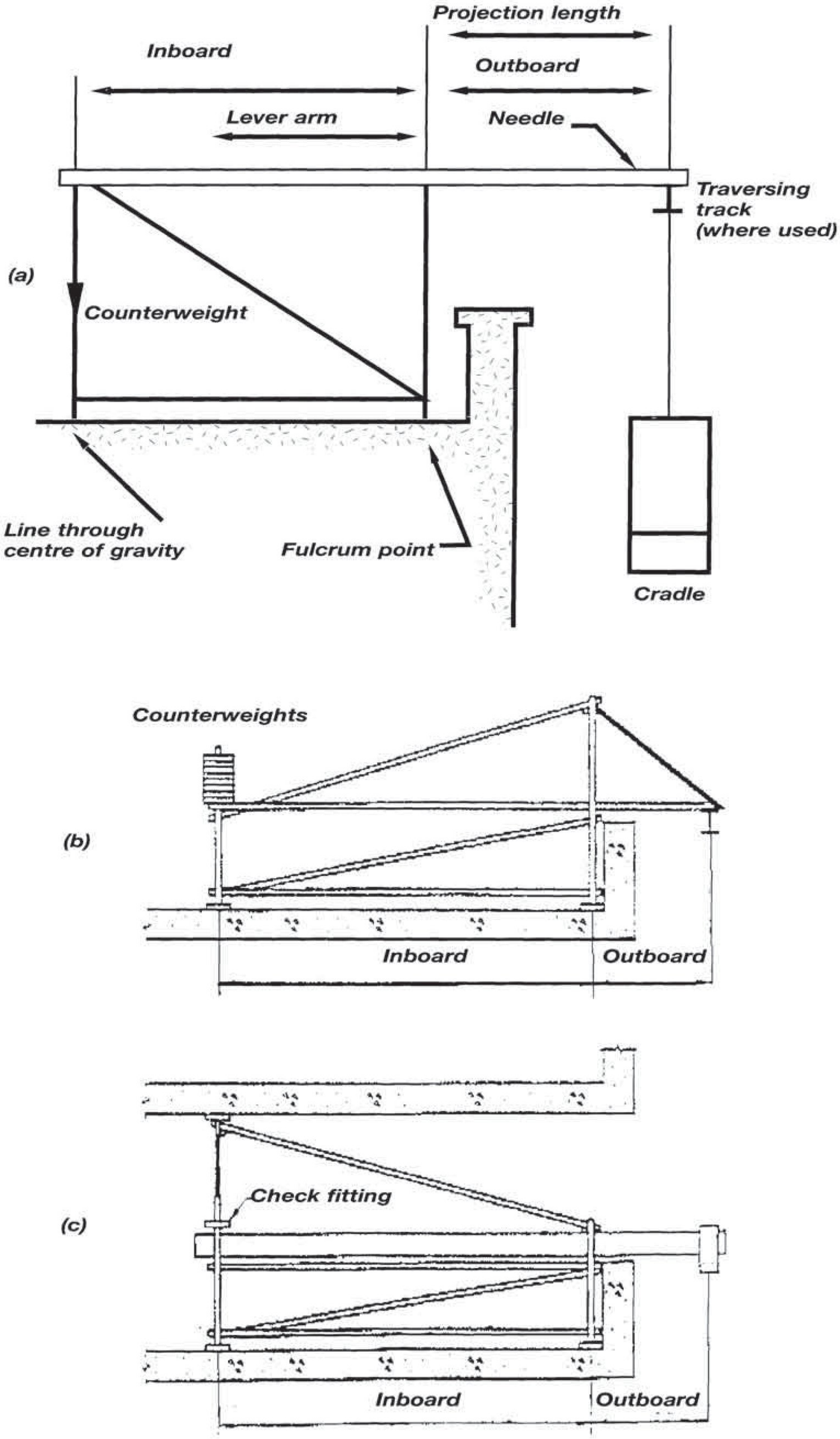
A copy of the statement of assessment or design should be made available to the person erecting, altering or dismantling the suspended scaffold.

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



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.

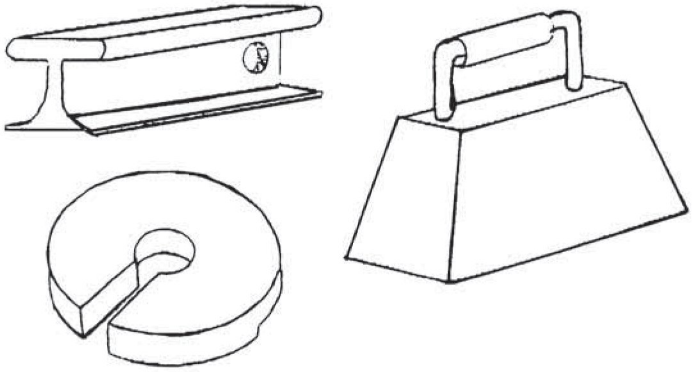
Reveal propped needle suspension rigs construction

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.



Typical counterweights for counterweighted needles

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 = 3 x rope tension (kg) x outboard (mm) inboard (mm) x mass of each counterweight (kg)

For a calculator:

3 x rope tension x outboard ÷ inboard ÷ counterweight mass

For example: Counterweights = 25kg each Max rope tension = 700kg Outboard = 900mm Inboard = 3600mm

Therefore:

3 x 700 x 900 ÷ 3600 ÷ 25 = 21 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.

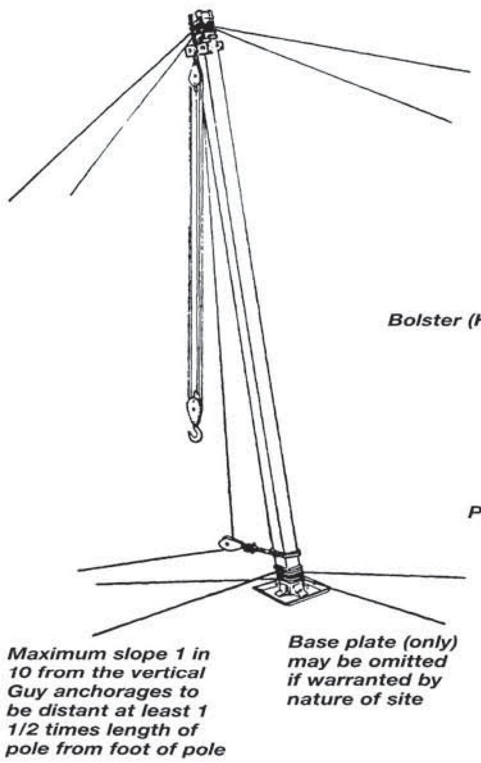
Chapter 23 Gin poles and derricks

Introduction

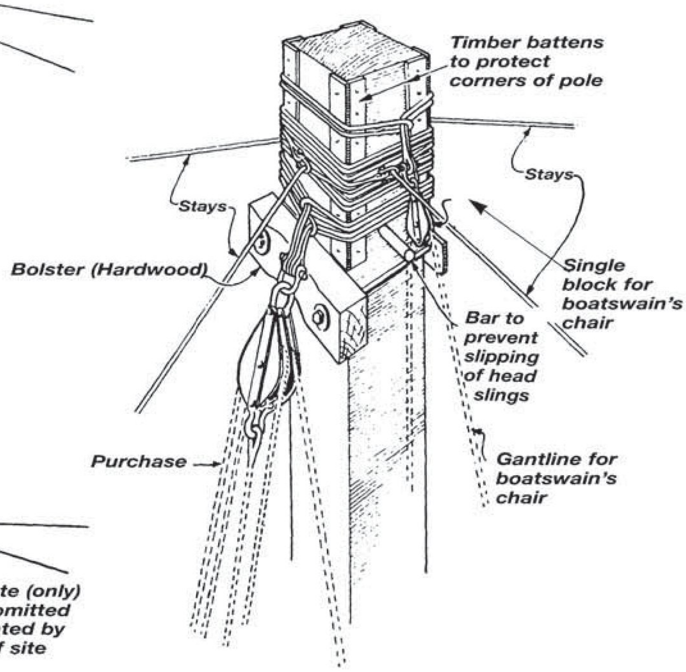
The gin or derrick pole is an apparatus used for raising loads which is now not widely used in erection work. Its function has been replaced by mobile, derrick or tower cranes.

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.

Derrick pole



Derrick pole rigging of headgear



Certification

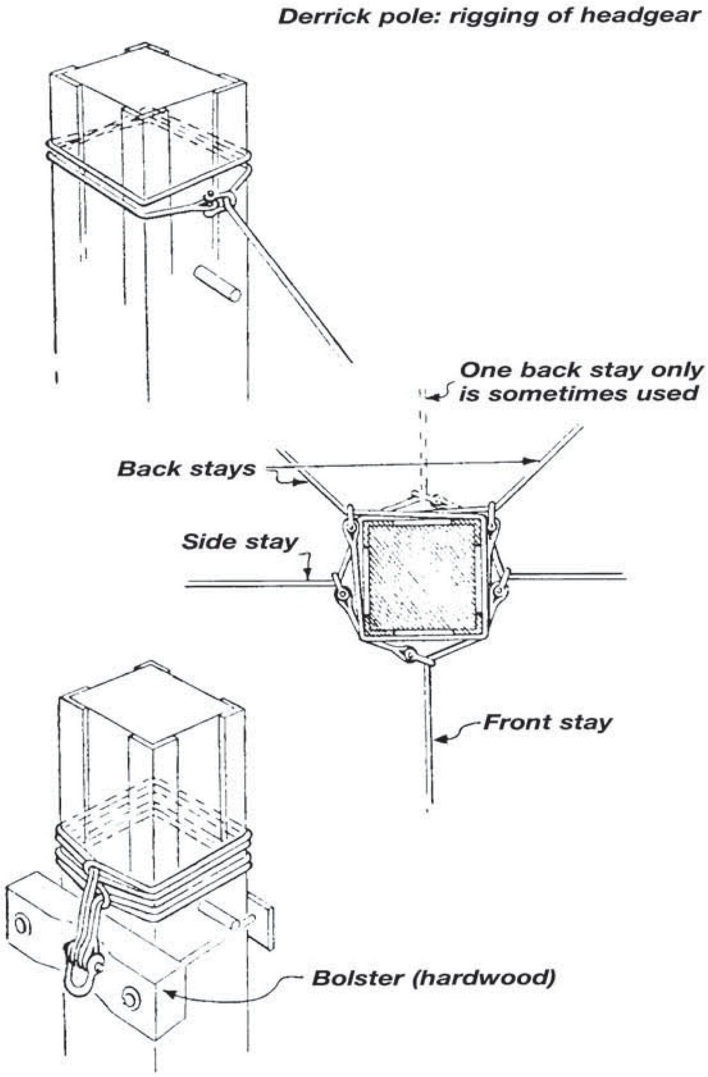
The rigging of gin poles, guyed derricks and sheer legs must be carried out or directly supervised by a person holding an Advanced Rigging Certificate (or old equivalent).

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:

$$\text{Becket or static load} = \frac{\text{Total load on lower block}}{\text{No. of parts of rope supporting the lower block}}$$

The load in lead rope = Becket load + (Becket load x No of sheaves in purchase x 5% friction)

= B.L. ÷ (B.L. x No of sheaves) x 5/100

$$= \frac{\text{B.L.} \div (\text{B.L. x No of sheaves})}{20}$$

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 = $\frac{10.5}{5}$ = 2.1t.

   Load in lead rope = 2.1 + (2.1 x 5) ÷ 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 x 1.125

   = 14.765t.

   Size of 15mm pole = 350mm square oregon.

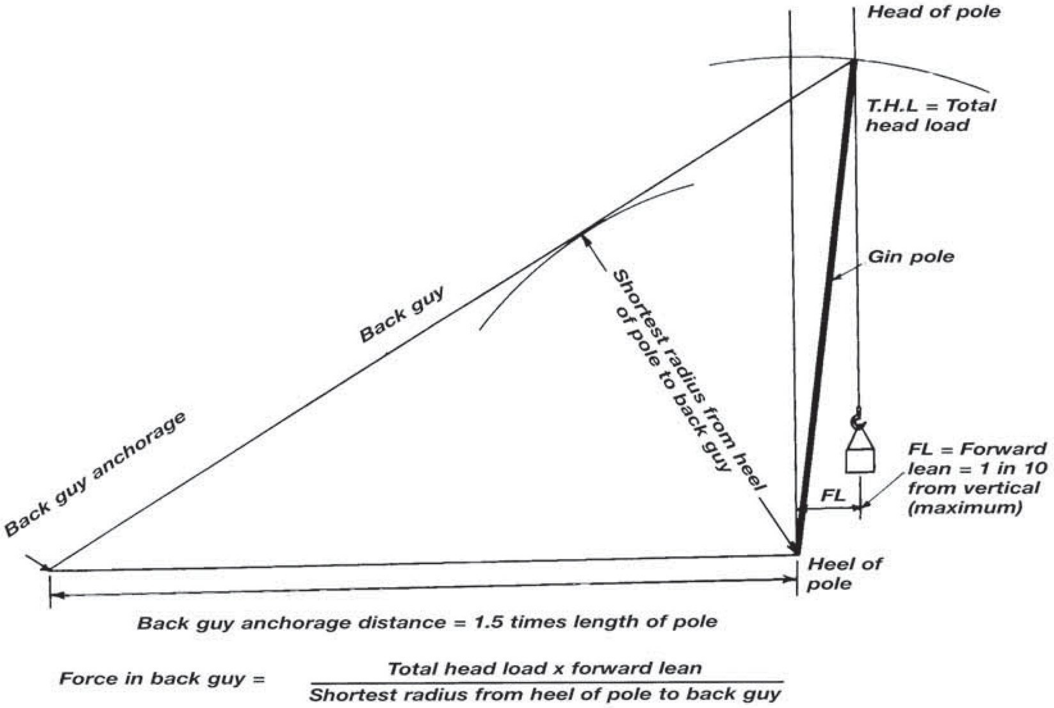
Where excessive bending or 'whip' of the pole could develop due to age or excessive length, a set of three bowstrings should be fitted at the back and sides to strengthen the pole.

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.



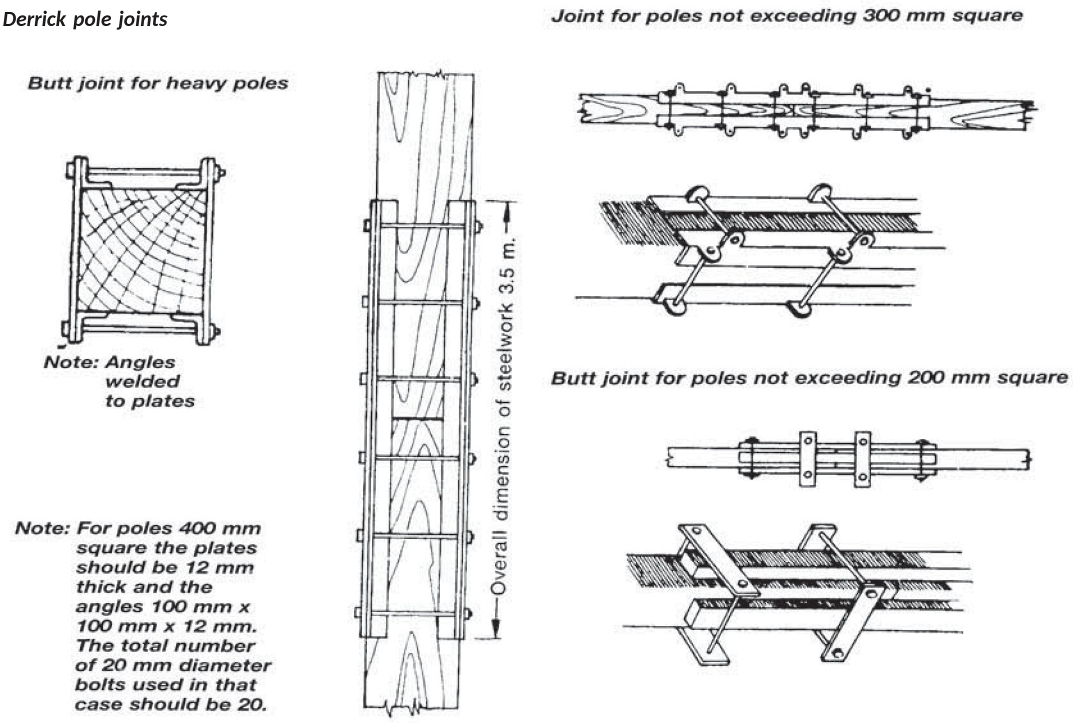
Gin or derrick poles – rules for use

- 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



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.

Oregon Size in mmm	SAFE TOTAL LOAD AT POLE HEAD IN TONNES **Length of Pole in metres**											Oregon Size in mmm
	4.5	6	7.5	9	11	12	13.5	15.0	18	21	24	
	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	
100 x 100	1.05	0.75	–	–	–	–	–	–	–	–	–	100 x 100
150 x 150	3.0	2.6	2.0	1.7	–	–	–	–	–	–	–	150 x 150
200 x 200	6.5	6.0	5.25	4.5	3.75	3.2	–	–	–	–	–	200 x 200
250 x 250	12.0	11.0	10.0	9.0	8.0	6.5	6.0	5.0	–	–	–	250 x 250
300 x 300	18.5	17.0	16.0	15.0	14.0	12.0	11.0	9.0	7.0	–	–	300 x 300
350 x 350	26.5	26.0	24.0	23.0	22.0	20.0	18.0	17.0	13.0	11.0	–	350 x 350
400 x 400	–	–	–	–	–	30.0	28.0	26.0	21.0	17.0	14.0	400 x 400
450 x 450	–	–	–	–	–	–	–	–	30.0	26.0	27.0	450 x 450

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 onethird 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 headsling 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.

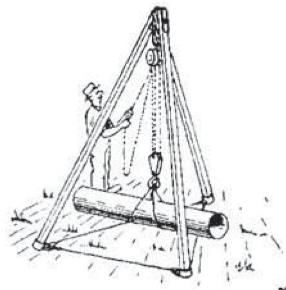
If more than one guy is used care must be taken to equalise the loads.

Total load on top of Sheerlegs	Vertical height from base to top bolt or top connection	Diameter of Wire Rope Back Guy
tonnes	m	mm
0.5	9	11
1.0	9	12
2.0	12	16

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.

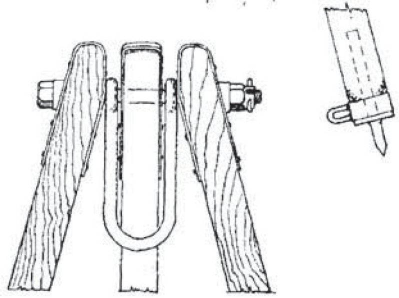
Two legs in the form of an A-frame, often with hand winch and bearers bolted across the base, are splayed at the head to take the third leg between. A heavy bolt is fitted completely through the three legs at the apex. A purchase or chain block is hooked into a U-shackle suspended from this bolt.



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.

WORKING LOAD LIMIT IN TONNES				
Oregon Size in mm	Length in metres			
	4.5	6	7.5	9.0
tonnes	tonnes	tonnes	tonnes	
100 x 100	6	3.50	–	–
150x 150	26.0	17.25	10.75	7.5
200 x 200	–	300	25.5	25.5

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.

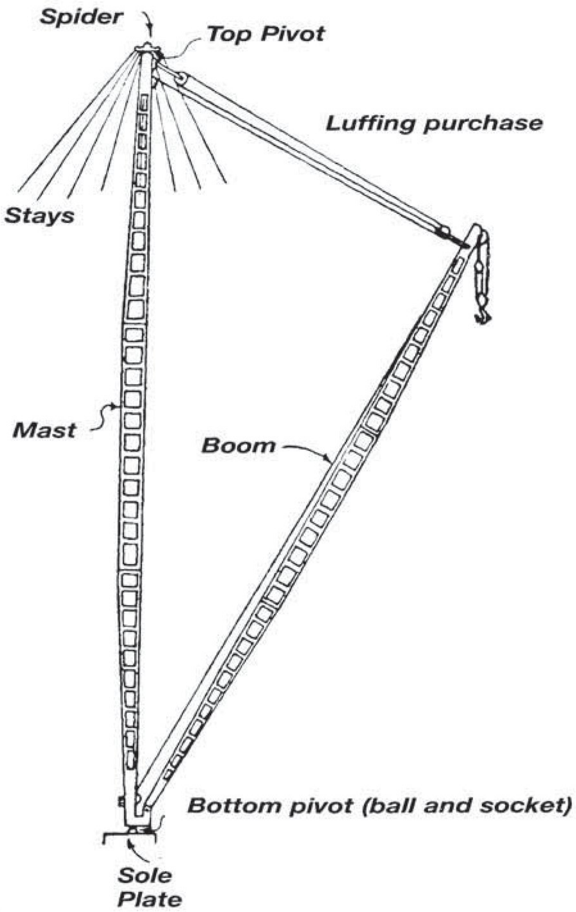
They are usually constructed of steel lattice or tubular steel but may be of timber.

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.



Guy derrick

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

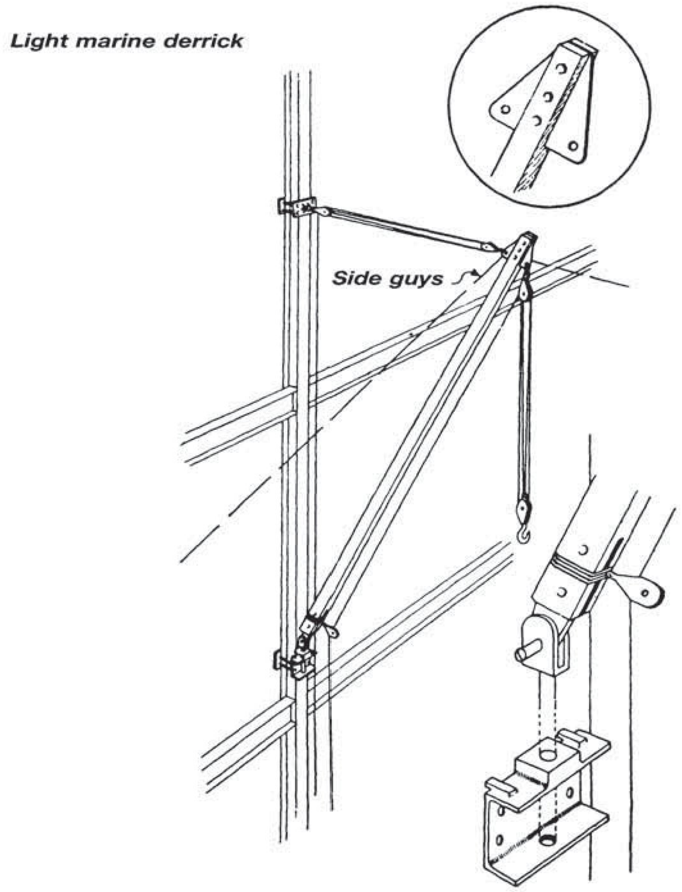
The marine type derrick was once extensively used in building work. It is similar in rig to the guyed derrick but uses part of the building structure in place of the guyed mast.

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.

Capacity of crane in tonnes	Minimum boom diameter mm Length of boom in metres						
	6	7.5	9	11	12	13.5	15
1/2	110	125	150	175	200	_	_
I	120	140	160	175	200	225	_
2	_	_	175	195	215	235	250
3	_	_	195	215	235	250	265
5	_	_	_	_	260	280	290
7	_	_	_	_	280	300	315
10	_	_	_	_	310	330	345

Chapter 24 Span ropes and flying foxes

Introduction

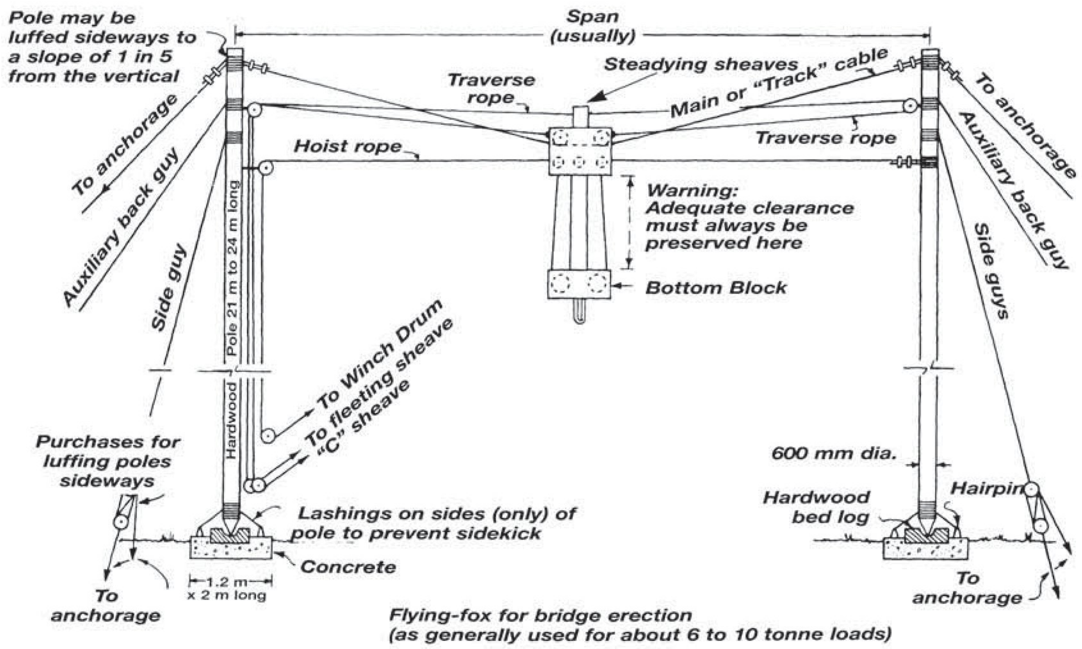
A flying fox is an apparatus which is used to traverse a span while maintaining a load at a constant height.

A flying-fox consists of a more of 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.

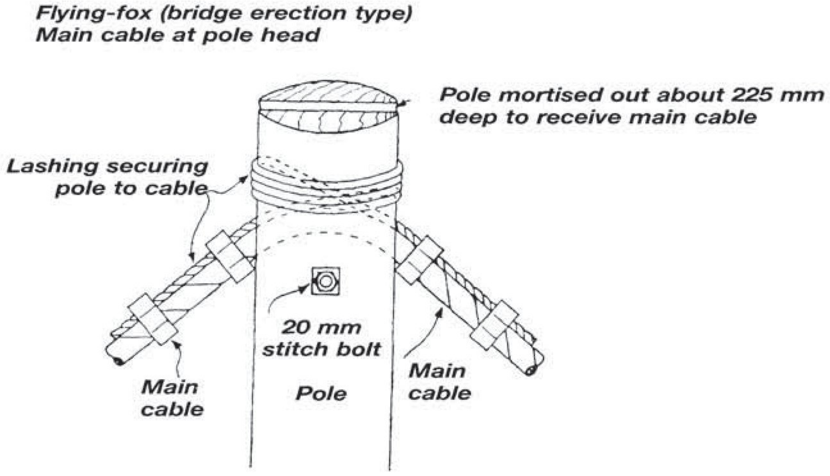
In most applications there should be no more than about 2.5t of load on each wheel although in bridge building, loads of double this figure are quite usual.

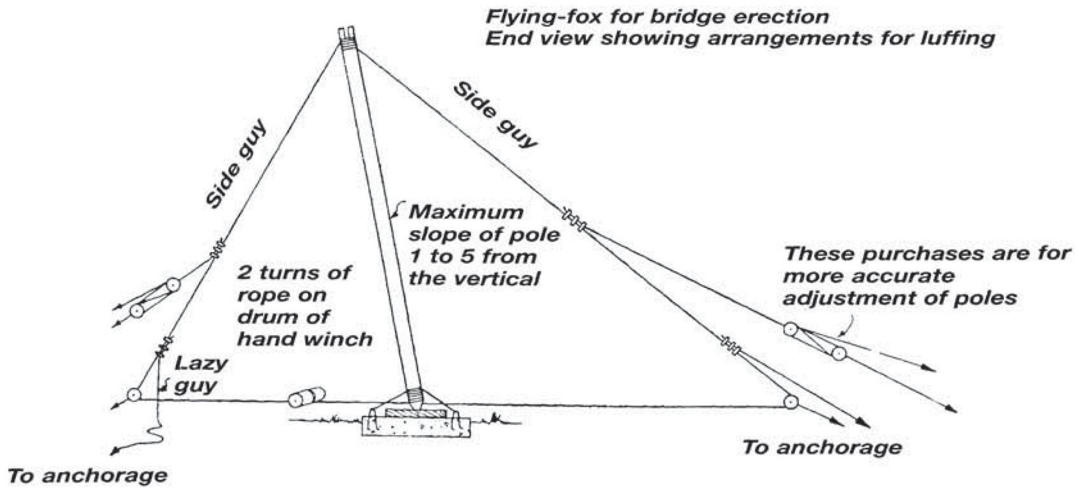
The ‘no load’ sag of the main cable, measured vertically at half span from a straight line joining the respective ends of the span should be about one-twentieth of the span, when the unloaded fox is at half span.

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.

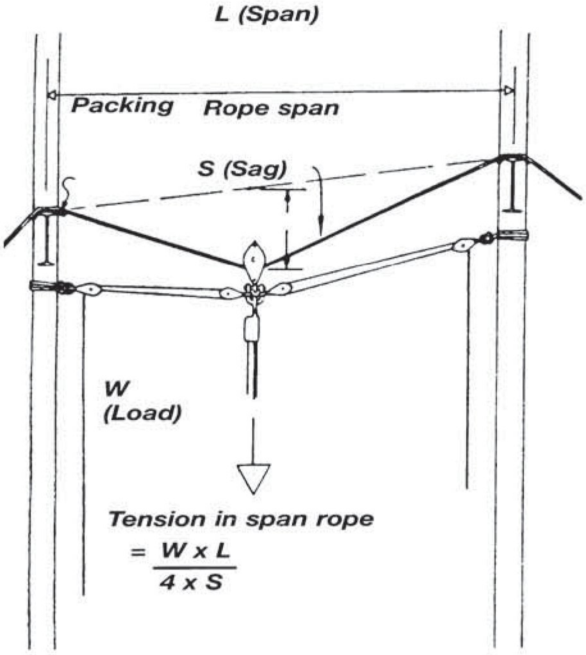
In bridge work it is often necessary to raise and lower loads not directly below the main cable. The poles supporting the main cable should be inclined sideways to bring the fox immediately above the load.

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.



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.