TRAINING MODULE FOR RIGGER (TOWER CRANE)

Prepared for:

Jabatan Keselamatan dan Kesihatan Pekerjaan
Kementerian Sumber Manusia

Prepared by:

UKM PAKARUNDING

TRAINING MODULE FOR RIGGER

Project Title:

KAJIAN PENAMBAHBAIKAN SISTEM PENGURUSAN KESELAMATAN KREN MENARA DI SEKTOR PEMBINAAN

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Abbreviation

FYK	-	Approved Firm (Firma yang Kompeten)
DOSH	-	Department of Occupational Safety and Health
OYB	-	Responsible Person (Orang Yang Bertanggungjawab)
PTW	-	Permit to Work
SWL	-	Safe Working Load
WLL	-	Working Load Limit

(1) MODULE : Training module for rigger (tower crane)

(2) OBJECTIVE: To provide training for rigger for safe lifting operations at construction site

(3) LEARNING PERIODS: 4 days (2 days lecture and 2 days practical)

(4) PRE-REQUISITE: None

(5) SYNOPSIS:

A rigger is an important personnel in a lifting team. A project manager or a lifting supervisor is responsible to appoint a competent rigger who is knowledgeable, trained in correct rigging and slinging techniques and can comply with the rules/laws and safe work procedures as emphasised by the employer as well as the authority. This module contains the required knowledge that needs to be acquired by a competent rigger. By having a competent rigger in the lifting team, the safety level for lifting operations at the construction site can be enhanced and the occurrence of accidents can perhaps be greatly reduced.

(6) LIST OF TOPICS

Chapter 1 Legislation (1 hour)

Chapter 2 Rigger in lifting team (0.5 hours)

Chapter 3 Basic calculation for load (3 hours)

Chapter 4 Load chart (1 hour)

Chapter 5 Rigging and slinging method (3 hours)

Chapter 6 Hoisting equipment (3 hours)

Chapter 7 Lifting accesories (1.5 hours)

Chapter 8 Personal protective equipment (0.5 hour)

Chapter 9 General safety (0.5 hours)

Chapter 10 Practical training (12 hours)

TOTAL LECTURE : 14 HOURS

TOTAL PRACTICAL : 12 HOURS

(7) REFERENCES (Selected):

Ronald G. Garby, IPT's Crane and Rigging Handbook (Revised Edition), 2005, IPT Publishing and Training Ltd

Donald L. Pellow, Bob's Overhead Crane & Rigging Handbook For Industrial Operations (Third Edition), Pellow Engineering Services, Inc.

Certified Sling & Supply, Chain Sling and Rigging Hardware (Reference Guide)

Nota Operator Kren Menara, Institut Kemahiran Tinggi Belia Negara (IKTBN), Kementerian Belia dan Sukan, Bachok, Kelantan, 2004.

Nota Operator Kren Menara, Institut Kemahiran Tinggi Belia Negara (IKTBN), Kementerian Belia dan Sukan, Chembong, Negeri Sembilan, 2003.

Nota Rigging and Signal, Gamuda Plant Operator School (GPOS), Shah Alam, Selangor, 2002.

Nota Rigging & Slingging Safety Course Beruntung Skill Training Centre (BSTC)

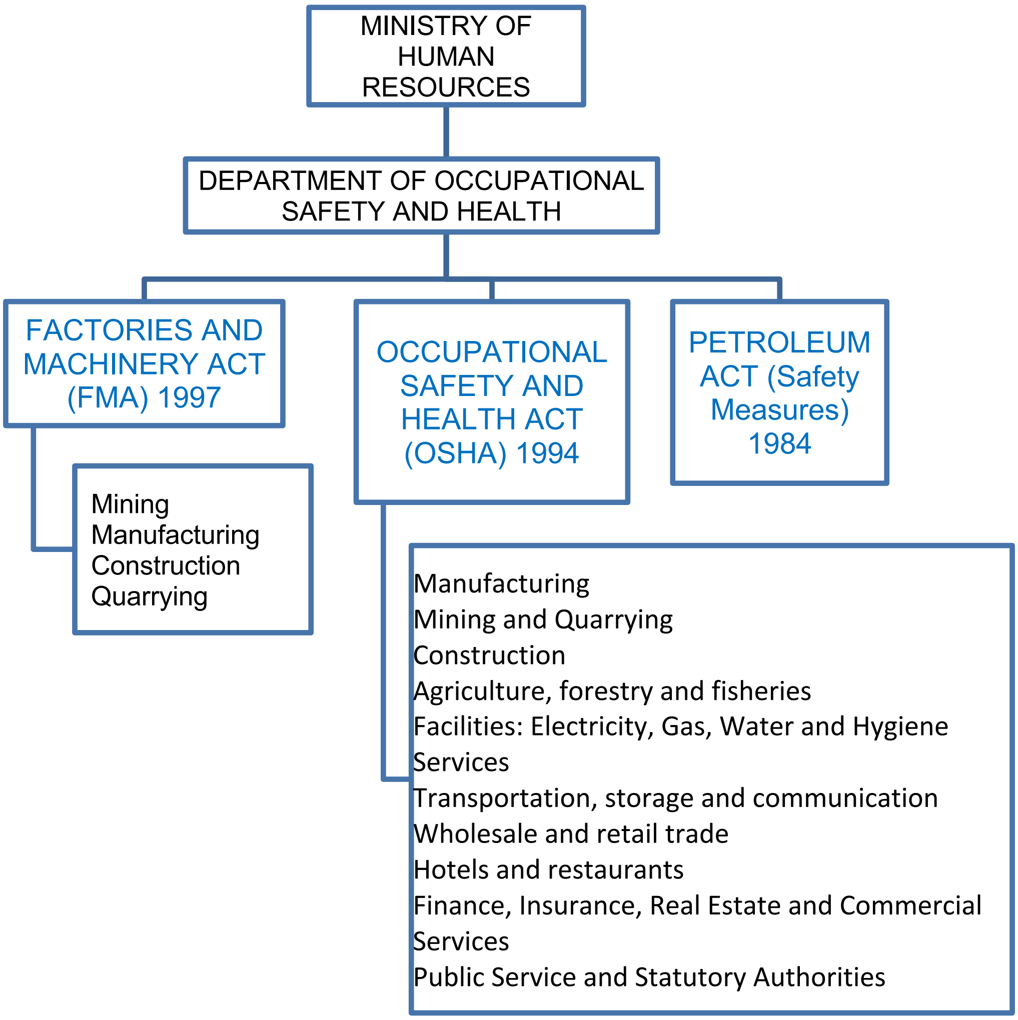
CHAPTER 1

LEGISLATION

1.1 Introduction

Any action by the enforcement authorities, whether under OSHA or the FMA, should be in accordance with the existing legislative provisions. Similarly, any directive, action and decision to be taken by DOSH must be based on clear sources of authority and stipulations of the law, whether it be OSHA or FMA and the regulations contained therein. Any unauthorized action can jeopardise the work of DOSH or its enforcement officers, especially if the case is challenged in court.

For Malaysia, the major legislations enacted to address occupational safety and health issues at the workplace are the Occupational Safety and Health Act (OSHA) 1994 and the Factories and Machinery Act (FMA) 1967, as shown in Figure 12.1. Under these Acts, there are Regulations and Rules made by the Minister and which are enforced by the Department of Occupational Safety and Health (DOSH), Ministry of Human Resources.



- Figure 1.1 Acts that apply in Malaysia

DOSH enforces all three Acts. Before a further explanation is given about OSHA 1994 and FMA 1967 (both these Acts are widely used for tower crane issues), a little clarification should be made with regard to the Petroleum Act (Safety Measures) 1984.

1.2 Petroleum Act (Safety Measures) 1984 (Act 302)

In addition to OSHA 1994 and FMA 1967, DOSH also enforces the Petroleum Act (Safety Measures) 1984 (Act 302), which is aimed at ensuring safety in the transportation, storage and use of petroleum. The Act contains provisions relating to the transportation of petroleum by road and railway; the transportation of petroleum by water; the transportation of petroleum by air; the transportation of petroleum through a piped system; the storage and handling of petroleum; the use of equipment, gadgets, materials, plants, building equipment, structures and installations; and existing equipment, gadgets, materials, plants, building equipment, structures and installations.

For the transportation of petroleum by road or railway, the owner or operator of the vehicle assigned to carry the petroleum shall take the necessary steps to ensure that the workers handle the petroleum according to the provisions under the Act and Regulations. When petroleum is transported by water, it should not be loaded or unloaded or removed except at a port or place prescribed by the Minister. The transporation of petroleum by air or through pipelines must be with the prior approval of the Minister. Furthermore, under the Act, a valid licence for the use of petroleum is required to store or operate any form of petroleum. There is also a requirement for containers or containers with petroleum to be labelled. The Act also requires residents in nearby areas to give the Minister notice within 24 hours in the case of any accident or loss of life or personal injury arising from a petroleum-related explosion or fire.

1.3 Occupational Safety and Health Act 1994 (OSHA)

The main purpose of this Act is to inculcate an attitude of concern for safety and health at the workplace, and to create effective safety measures through self-regulatory schemes, consultation, collaboration and involvement of employees, that are tailored to the industry or relevant organization. The long-term objective of this Act is mainly to produce a healthy and safe work culture among all employees and employers in Malaysia.

Aims of OSHA (Act 514)

(Part I; Section 4 Paragraphs (a),(b),(c) and (d)) Act 514)

1) To secure the safety, health and welfare of employees;

2) To protect employees and others against activities that involve risks;
3) To promote a safe and healthy workplace environment;
4) To provide occupational safety and health legislations with industrial codes of practice approved under the provisions of the Act (not limited to Acts and regulations).

Scope of Act 514

FOR EMPLOYEES:

in all sectors in Malaysia is as follows:

(a) Manufacturing
(b) Mining and quarrying
(c) Construction
(d) Agriculture, forestry and fisheries
(e) Facilities: Electricity, Gas, Water and Hygiene Services
(f) Transportation, storage and communication
(g) Wholesale and retail trade
(h) Hotels and restaurants
(i) Finance, Insurance, Real Estate and Commercial Services
(j) Public Service and Statutory Authorities

Except:

Work on ships (enshrined under the Merchant Shipping Ordinance 1952) and in the Armed Forces.

General Duties of Employers and Self-Employed Persons (Part IV)

Summary of the Relevant Provisions:

Section 15. General duties of employers and self-employed persons to their employees

It is the duty of the employer and self-employed person to ensure the safety, health and welfare of his employees while they are at work. The general duties of employers are summarised as follows:

Paragraph (1) and Paragraph (2);

(a) To provide a safe plant and system of work.
(b) The use or handling .... plant and substances;
(c) To have and provide information, instructions, training and supervision in relation to safety and health.
(d) To provide safe means of access to and egress from the workplace
(e) To maintain a safe work environment for employees.

For the purposes of this section, “employees” include independent contractors and the employees of that independent contractor.

Section 16. Duty to formulate safety and health policy

It is the duty of the employer to prepare and revise a written statement of his general policy with respect to the safety and health of his employees, and to bring it to the notice of all his employees.

Section 17. General duties of employers and self-employed persons to persons other than their employees

It is the duty of the employer and the self-employed person to conduct his undertaking so as to ensure that other persons who are not his employees are not exposed to risks to their safety or health as a consequence of his undertaking.

Section 18. Duties of an occupier of a place of work to persons other than his employees

It is the duty of the occupier of non-domestic premises to ensure that the premises, plant or substances used by persons who are not his employees are safe. This duty includes any maintenance or repairs to the place and the access to and egress from that place.

Section 19. Penalty for an offence

A person who contravenes the provisions of section 15, 16, 17 or 18 shall be guilty of an offence and shall, on conviction, be liable to:

(a) A fine not exceeding RM 50,000.00; or
(b) Imprisonment for a term not exceeding 2 years; or
(c) Both.

Section 20. General duties of designers, manufacturers, importers and suppliers with regard to plants for use at work

It is the duty of a person who designs, manufactures, imports or supplies any plant to ensure that it is so designed and constructed as to be safe and without risks to safety and health.

In this case, a plant includes any tool or device or machine (tower crane). A designer or manufacturer or importer of tower cranes can be charged under this section if he commits a related offence.

“**So far as is practicable”**

The duties set out in sections 15, 17 and 18 of OSHA are so far as is practicable. The phrase “so far as is practicable” means by giving due consideration to and taking into account four factors that are provided for in section 3(1):

(a) the severity of the hazard or risk in question;

(b) the state of knowledge about the hazard or risk and any way of removing or mitigating the hazard or risk;

(c) the availability and suitability of ways to remove or mitigate the hazard or risk; and

(d) the cost of removing or mitigating the hazard or risk.

(To further understand the meaning of the phrase ‘so far as is practicable’, please refer to the Guideliness to the General Provisions of OSHA 1994).

Investigating officers and prosecutors should also read the case of ***The Department of Occupational Safety and Health versus Sri Kamusan Sdn Bhd*** [2014] 9 CLJ 825, where the High Court of Sabah explained the meaning and the elements that need to be proved in section 15 of OSHA. Although this case was not related to a tower crane accident, the High Court’s interpretation of section 15 can be used to help investigating officers and prosecutors to understand the elements that must be proved under this provision.

The prosecution must prove:

a) That the deceased was an employee of the respondent at the time concerned;

b) That the deceased, being an employee of the respondent, was exposed to health and safety risks;

c) That the deceased, being an employee of the respondent, 'was working' at the workplace at that time; and

d) There was a causal nexus between the respondent's violation and the risk to the safety of the deceased.

(i) The prosecution must prove that the deceased 'was working' at the time in question. Section 15 (1) of OSHA states that it is the duty of the employer to ensure the safety, health and welfare of his employees at the workplace.

This means that it is the employer's job to ensure the safety, health and well-being of his employees while they are working, and not when they are not functioning or working. If it can be proven that the employee was 'not working' when the incident or accident occurred, then one of the elements in section 15 cannot be proven.

Another matter is that the court will see whether or not DOSH had issued a notice to the employer under section 48 of OSHA (Improvement or Prohibition Notice). The failure of DOSH to issue a notice under section 48 means that the workplace or equipment/plant used by the employer was safe.

In this case, DOSH did not issue a notice under section 48 of OSHA. As a statutory body, DOSH has a statutory duty under section 48 of OSHA to issue such a notice if DOSH is of the opinion that, in this case, the trailer, was unsafe. By not issuing such an important notice, it could be concluded that the trailer was safe and did not pose a threat to the life of the employee when it was being used.

Burden of Proof

The issue of the burden of proof was raised in the Sri Kamusan case. Reference was made to the case of *Work Cover Authority of New South Wales (Inspector*

Woodington) v. Australand Holding Limited and Sassall Glass & Joinery Pty Limited [2008] NSWIR Comm. 153, where the court contended that:

"As in all criminal matters, the nature of the duty imposed does not relieve the prosecution of the necessity for it to prove the employer's failure beyond reasonable doubt".

See also the case of *State Rail Authority of New South Wales v. Dawson* [1990] 37 IR 110, on pages 120-121, where the judge stated:

"Although S. 15(1) creates an absolute liability on the employer, it is still nevertheless necessary for the informant to prove, according to the criminal standard of beyond reasonable doubt, that the employer failed to meet the obligation cast on him by the section".

Therefore, based on the above cases, the Judge agreed with the respondent's argument that the burden of proof must lie with the prosecution to prove beyond a reasonable doubt, and that burden had never shifted to the respondent (employer).

Section 60 of OSHA provides that:

"In any proceedings for an offence under this Act or any regulation made thereunder consisting of a failure to comply with a duty or requirement to do something so far as is practicable, or to use the best practicable means to do something, it shall be for the accused to prove that it was not practicable to do more than was in fact done to satisfy the duty or requirement, or that there was no better practicable means than was in fact used to satisfy the duty or requirement".

In his defence, the respondent (employer) relied on section 55 of OSHA:

"It shall be a defense in any proceedings against a person for an offence under this Act or any regulations made thereunder if the Court is satisfied that the offence was committed without his consent or negligence, and he had exercised all due diligence to prevent the commission of such an offence as he should have done, in view of the nature of his function in that capacity and in all circumstances".

Based on the evidence submitted by the employer, the Judge decided that the employer was indeed present and had taken all the reasonable measures and made appropriate efforts to ensure the safety of every employee on the farm, and that the employer had taken precautionary measures against exposure to any danger by installing warning signboards around the workplace. In this case, the employer succeeded in proving that he had taken steps 'as far as is practicable' to ensure safety at the workplace.

What is meant by causal nexus? Causal nexus means a violation or negligence on the part of the employer that resulted in the risk of accident or loss to the victim. In this case, if the employer failed to provide a safe place or vehicle and that situation resulted in a risk to the safety of his employees, then there was a 'causal nexus'. Otherwise, there would be no causal nexus. 'Causal nexus' is based on the principle of causation in the Law of Torts.

General Duties of Employees (Part VI)

Section 24. General duties of employees at work

Paragraph (1) sub-paragraph (a),(b),(c) and (d), and Paragraph (2)

(a) To take care of the safety and health of himself and of other persons.

(b) To co-operate with his employer and other persons in implementing the requirements of the Act.

(c) To wear the personal protective equipment provided.

(d) To comply with instructions and measures on occupational safety and health.

A person who contravenes the provisions of this section shall be guilty of an offence and shall, on conviction, be liable:

(a) to a fine not exceeding RM 1,000.00; or

(b) to imprisonment for a term not exceeding 3 months; or

(c) to both.

Section 25. Duty not to interfere with or misuse things provided pursuant to certain provisions

A person who intentionally, recklessly or negligently interferes with or misuses anything provided or done in the interests of safety, health and welfare in pursuance of this Act shall be guilty of an offence and shall, on conviction, be liable:

(a) to a fine not exceeding RM 20,000; or

(b) to imprisonment for a term not exceeding 2 years; or

(c) to both.

The regulations under OSHA 1994 are as follows:

1. Occupational Safety and Health (Classification, Labelling and Safety Data Sheet of Hazardous Chemicals) Regulations 2013;
2. Occupational Safety and Health (Notification of Accident, Dangerous Occurrence, Occupational Poisoning and Occupational Disease) Regulations 2004;
3. Occupational Safety and Health (Use and Standards of Exposure of Chemicals Hazardous to Health) Regulations 2000;
4. Occupational Safety and Health (Safety and Health Officer) Regulations 1997;
5. Occupational Safety and Health (Classification, Packaging and Labelling of Hazardous Chemicals) Regulations 1997 (Revoked);
6. Occupational Safety and Health (Safety and Health Committee) Regulations 1996;
7. Occupational Safety and Health (Control of Industrial Major Accident Hazards) Regulations 1996;
8. Occupational Safety and Health (Employers' Safety and Health General Policy Statements) (Exception) Regulations 1995.

ORDERS:

- Occupational Safety and Health (Safety and Health Officer) Order 1997
- Occupational Safety and Health (Prohibition of Use of Substances) Order 1999

1.4 Regulations and Special Orders under the Factories and Machinery Act, 1967

The Regulations and Orders under the Factories and Machinery Act, 1967 pertaining to the safety of machinery and the construction of buildings are as follows:

1. Factories and Machinery (Exemption of Certificate of Fitness for Hoisting Machine) Order 2015;
2. Factories and Machinery (Building Operations and Works of Engineering Construction) (Safety) Regulations 1986;

3. Factories and Machinery (Notification of Fitness and Inspections) Regulations 1970;
4. Factories and Machinery (Safety, Health and Welfare) Regulations 1970 (Amended - 1983); and
5. Chief Inspector Special Order (To The Project Manager On the Management and Safe Operation of Tower Cranes) 2017.

In exercising the powers conferred on him by subsection 27(1) of the Factories and Machinery Act 1967 [Act 1391], the Chief Inspector of Factories and Machinery issued the following special orders:

Project managers must ensure that tower cranes:

(a) Have approved designs and comply with the requirements for design approval by the Department of Occupational Safety and Health;
(b) Have an installation permit and comply with the requirement for installation approval by the Department of Occupational Safety and Health; and
(c) Have a valid certificate of fitness.

The Regulations from No. 1 to No. 4 are indirectly related to the use of tower cranes, hence they are not described here. Meanwhile, the Chief Inspector Special Order (To The Project Manager On the Management and Safe Operation of Tower Cranes) 2017 is very relevant to the use of tower cranes at the sites of construction projects, and the special order makes it the primary duty of the project manager. The Order was made under the power of subsection 27(1) of the Factories and Machinery Act 1967.

The responsibilities of the project manager are as follows:

1. The project manager must ensure that the tower crane has:
   (a) An approved design and complies with the requirements for a design approval by DOSH;
   (b) A permit for its installation, and complies with the requirements for the approval of installation by DOSH; and
   (c) A valid certificate of fitness.

2. The project manager should ensure that during the operation, handling and maintenance of the tower crane:

(a) The operator who is appointed is registered with the Department of Occupational Safety and Health to operate the crane;
(b) The appointed lifting supervisor, signalman and rigger have relevant and adequate knowledge, experience and competency;
(c) A permit-to-work system is implemented;
(d) All the lifting gear is inspected and maintained according to the specifications of the manufacturer and good engineering practices;
(e) All safety devices are maintained to function properly at all times and are not easily disrupted; and
(f) Records relating to the use, inspection, maintenance and permit-to- work are kept at the construction site for checking purposes at any time..

The project manager must ensure that any person appointed by the occupier has a valid contract that is legally binding to:

(a) Carry out works to inspect, install, mount, test, maintain and dismantle a tower crane;
(b) Conduct regular inspections on each tower crane at least once a month;
(c) Carry out works to inspect, install, mount, test, maintain and dismantle a tower crane according to the specifications of the manufacturer and good engineering practices; and
(d) Perform repairs or modofications to the tower crane structure or components after obtaining the written approval of the Department of Occupational Safety and Health, and in accordance with the specifications of the manufacturer and good engineering practices.

Penalty:
"Any person who violates this special order shall be guilty of an offence and can be charged under section 8(g) of the Factories and Machinery Act 1967 (Act 139) and, if convicted, shall be liable to a fine not exceeding two hundred thousand ringgit or to imprisonment for a term not exceeding five years or to both".

However, no specific Regulations have been made under either of the two Acts (OSHA 1994 and FMA 1967) regarding the correct use or operation of tower cranes at work sites. This can be found in the following guidelines and standards:

1. Guidelines of Occupational Safety and Health (OSH) in the Construction Industry (Management) 2017;
2. Guidelines for Public Safety and Health at Construction Sites, 2007;
3. Guidelines for the Prevention of Falls at the Workplace, 2007;
4. Guidelines for the Prevention of Falling Objects at the Workplace, Department of Occupational Safety and Health, Ministry of Human Resources, Malaysia, 2007.
5. Standard Malaysia, MS 1803:2008: Cranes - Safety - Tower Cranes*;*
6. Standard Malaysia MS ISO 4310:2014 Cranes - Test code and procedures (First revision) (ISO 4310:2009, IDT); and
7. Standard Malaysia MS ISO 4306-1:2014 Cranes – Vocabulary - Part 1: General (First Revision) (ISO 4306-1:2007, IDT).

1.5 Construction Industry Development Board (CIDB) (ACT 520)

The Construction Industry Development Board of Malaysia is a department under the Public Works Ministry. The history of its establishment is as follows:

- Tabling of the Construction Industry Development Board Act in Parliament in May 1994.
- Gazetted as Act 520 in July 1994.
- Came into effect officially on 1 December 1994.

Objectives of Act 520:

1) To register contractors/workers in the construction sector according to their class/skills.
2) To accredit and certify skilled construction workers and construction site supervisors according to the methods and forms specified.
3) To conduct investigations into any offence and inspections.

Jobs that require skills and certification

1) Blaster and painter
2) Air-conditioning and mechanical ventilation specialist
3) Drywall installer
4) Ceiling installer
5) Petrochemical fitter
6) Roof truss installer
7) Precast concrete installer
8) Formwork system installer
9) Block system installer
10) Bar bender
11) Wireman
12) Bricklayer
13) Plant operator
14) **Crane operator**
15) Chargeman
16) Cable jointer
17) **Slinger and rigger**
18) Painter
19) Tiler
20) Carpenter
21) Welder
22) Plasterer
23) Plumber
24) Scaffolder

Why is it necessary for construction site workers and supervisors to register with the Malaysian Construction Industry Development Board (CIDB)?

1) To gain recognition for their skills.
2) To enhance their career opportunities.
3) To acquire opportunities to improve their skills.
4) To enjoy the benefits of protection through the Takaful scheme.

Bibliografi

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Akta Kilang dan Jentera 1967, dan Peraturan-Peraturan (Akta 139).

Akta Petroleum (Langkah-langkah Keselamatan) 1984 (Akta 302).

Nota Operator Kren Menara, Institut Kemahiran Tinggi Belia Negara (IKTBN), Kementerian Belia dan Sukan, Bachok, Kelantan, 2004.

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Nota *Tower Crane Operator*, Gamuda Plant Operator School (GPOS), Shah Alam, Selangor, 2002.

Nota Operator Kren Menara, Beruntung Skill Training Centre (BSTC), Rawang, Selangor.

Peruntukan Utama Akta Keselamatan dan Kesihatan Pekerjaan 1994, Jabatan Keselamatan dan Kesihatan Pekerjaan (JKKP).

Lembaga Pembangunan Industri Pembinaan Malaysia, Akta 520.

CHAPTER 2

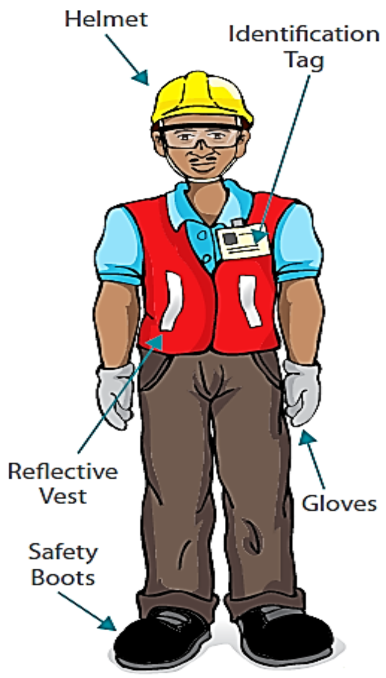
RIGGER IN LIFTING TEAM

2.1 General definition for rigger

Rigger is the person involved with the rigging and slinging works and is able to select the sling that is appropriate to the shape and weight of the load that will be lifted using a crane

2.2 Rigger responsibilities

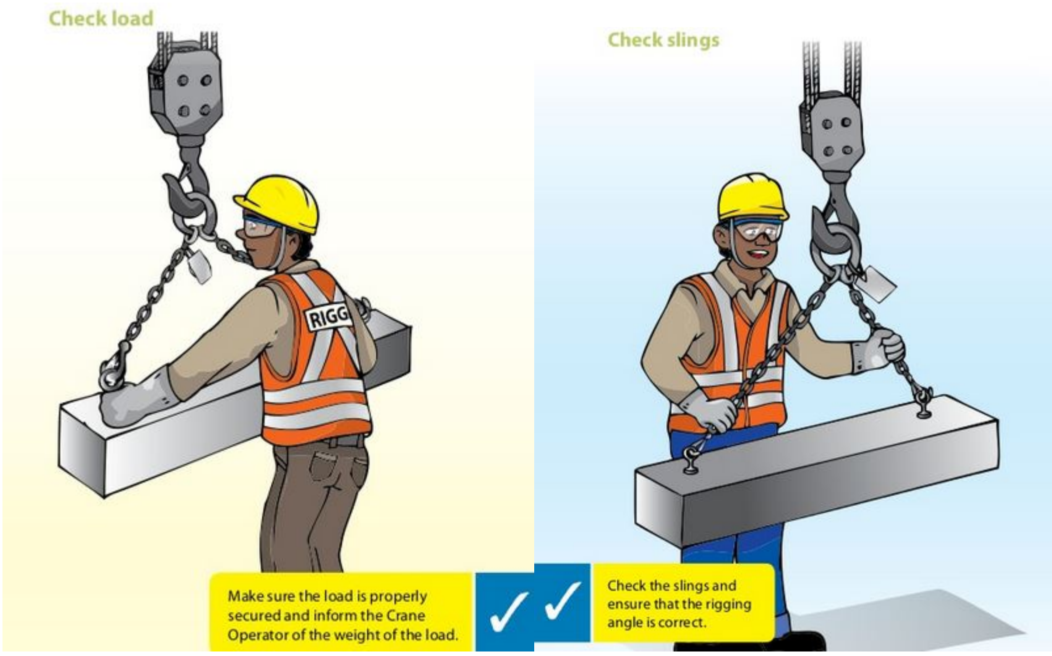
Rigger is resposible to tie and release load from crane, and utilize lifting equipments and gears properly according to operation plan. Safety wear of a rigger must be complete and visually distinct (refer Figure 1.1). A rigger must be:



Rajah 2.2 Safety gear for rigger(*Worker's Safety Handbook* 2011)

(a) Adequately trained in slinging and hoisting, able to estimate load, and safe distance, and height of lifted load
(b) Able to select suitable lifting equipments and gears that is safe for the lifting operation
(c) Able to perform visual inspection on the lifting equipments and gears before use
(d) Avoid using damaged lifting equipments and gears
(e) Record defected lifting equipments and gears in suitable documents and report to lifting supervisor
(f) Understand hand signal and verbal communication codes when communicating using hand signal or walkie-talkie respectively
(g) Understand emergency procedure and know how to react in the event of accidents during lifting operation
(h) Responsible for ensuring that he / she is able to think soundly, in good health, mentally good and able to control emotion.

(i) Riggers are those who may follow the rules and regulations as well as safe work procedures as defined by the employer and the authorities




Practice good communication within the Lifting Team
Rigger and Signalman must maintain good communication between each other at all times.


Practice good communication within the Lifting Team
LIFTING PLAN and SWP
RIGGER
Communication between Lifting Supervisor, Rigger and Signalman must be maintained at all times.


Check lifting gears
Make sure the lifting gears such as slings and shackles are well-maintained and in good working condition.


Ensure loose loads are secured
Make sure any loose items are placed in a proper receptacle or container to prevent the load from falling during the lifting operation.

Figure 2.1 Roles of rigger (pt.slideshare.net)

The safety gear of a rigger should be complete and easy to see as shown in Figure 2.2.

2.3 Parties involved with tower cranes

Parties involved with tower cranes are:

- Managing director
- Project manager
- Safety officer / Site safety supervisor
- Professional engineer
- Designer
- Manufacturer
- Approved firm (Firma yang Kompeten, FYK)
- Responsible person (Orang yang Bertanggungjawab, OYB)
- Crane importer
- Crane owner
- Lifting supervisor
- Crane operator
- Rigger
- signalman

During the lifting operation using a crane, lifting tem must consist of;

- Lifting supervisor
- Crane operator
- Rigger
- signalman

However, project managers should also monitor and have knowledge of lifting operations to ensure smoothness and the safe operation procedures conducted by the lifting team. Figure 2.3 shows the lifting operation which are cosist of lifting supervisor, crane operator, rigge and signalman.

Figure 2.3 Lifting team (krafly.com)

2.4 Responsibilities of Personnels During Lifting Operation

2.4.1 Project manager

Project managers are important personnel in the management of a construction project including the selection and determination of contractual relationships with contractors including tower crane contractors. The responsibilities of the relevant project manager are subject to the Regulations and Special Orders under the Factories and Machinery to Project Manager on the Management and Operation of the Crane Tower 2017. In carrying out the task, the project manager must ensure that the tower crane has:

(a) design approval and compliance with design approval requirements by DOSH,
(b) the letter of authorization to install the tower crane and comply with the conditions of permission from DOSH,
(c) valid qualification certificate

The project manager should ensure that during the operation, handling and maintenance of the tower crane:

(g) The operator who is appointed is registered with the Department of Occupational Safety and Health to operate the crane;
(h) The appointed lifting supervisor, signalman and rigger have relevant and adequate knowledge, experience and competency;
(i) A permit-to-work system is implemented;
(j) All the lifting gear is inspected and maintained according to the specifications of the manufacturer and good engineering practices;
(k) All safety devices are maintained to function properly at all times and are not easily disrupted; and
(l) Records relating to the use, inspection, maintenance and permit-to- work are kept at the construction site for checking purposes at any time..

The project manager must ensure that any person appointed by the occupier has a valid contract that is legally binding to:

(e) Carry out works to inspect, install, mount, test, maintain and dismantle a tower crane;

(f) Conduct regular inspections on each tower crane at least once a month;

(g) Carry out works to inspect, install, mount, test, maintain and dismantle a tower crane according to the specifications of the manufacturer and good engineering practices; and

(h) Perform repairs or modofications to the tower crane structure or components after obtaining the written approval of the Department of Occupational Safety and Health, and in accordance with the specifications of the manufacturer and good engineering practices.

2.4.2 Lifting supervisor

Lifting supervisor (Figure 2.4) is responsible for planning and supervising safe lifting operation using tower crane at worksite. Lifting supervisor is also responsible in ensuring all loads were lifted as per safety procedure, under allowable load limit and in accordance to the respective load chart of the specific tower crane. Among the responsibilities of a lifting supervisor are as follows:

Figure 2.4 Lifting supervisor (*Safe lifting* (2002))

(a) Possesses the adequate theoretical knowledge, technical and practical training, plus the experience and knowledge in lifting operations

(b) Prepares and plans for the lifting work

(c) Coordinates and executes the lifting work according to plan

(d) Brief all lifting workers (crane operator, signalman and rigger) regarding the lifting plan, risk controlling measures and safe lifting procedures prior to lifting operation

(e) Identifies types and weight of the loads to be lifted

(f) Ensures periodic inspections on the lifting appliances and lifting gear

(g) Ensures safe working load (SWL) markings for all lifting appliances and lifting gear, and with valid test certificates

(h) Ensures all crane operators are registered with DOSH, while the signalmen and riggers are adequately trained

(i) Evaluates risk and prepare controlling measure accordingly to avoid risks

(j) Attends all lifting operations

(k) If unsafe condition is reported, suitable steps must be taken to rectify the situation to ensure safe lifting operation

(l) To stop all works if lifting activities lead to unsafe condition

2.4.3 Tower crane operator

Tower crane operator (Figure 2.5) must be responsible to handle crane safely based on orders and work system provided by the owner or tower crane contractor. The responsibilities of tower crane operator are as follows:

Figure 2.5 Crane operator
(*Safe lifting* (2002))

(a) To own a log book

(b) To perform daily inspection on crane system such as handling mechanisms, controlling switches, hydraulic hose, hydraulic oil level and various others

(c) To correctly respond to the signalman and rigger during lifting operation

(d) Only giving lift to allowable loads in accordance to the load chart provided by crane manufacturer, and to ensure loads lifted do not exceed allowable load limits

(e) To ensure no lifting activities to be carried out without the risk assessment by authorised individual or parties

(f) Understand hand signal and verbal communication codes when communicating using hand signal or walkie-talkie respectively

(g) Understand emergency procedure and know how to react in the event of accidents during lifting operation

2.4.4 Signalman

Signalman is responsible to give clear signals as a mean of communicating with the crane operator after rigging is completed and the load is ready to be lifted. Signalman is also responsible to coordinate safe crane movement with the crane operator. Safety wear of a signalman must be complete and visually distinct (Figure 2.6). A signalman must:

(a) Understand hand signal and verbal communication codes when communicating using hand signal or walkie-talkie respectively
(b) Able to give instruction to the crane operator and coordinate movement of crane and load safely
(c) Able to estimate safe distance between the lifted load and the surrounding objects during lifting operation
(d) Understand emergency procedure and know how to react in the event of accidents during lifting operation

Figure 2.6 Safety gear for signalman*Worker's Safety Handbook* 2011)

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CHAPTER 3

BASIC CALCULATIONS FOR LOAD

3.1 General Formula for Calculation

(I) Basic unit of measurement for a load

Quantity	Unit	Symbol
Mass	kilogram tan	kg tan
Length	millimeter centimeter meter	mm cm m

(II) Measurement unit

a) 1 ton = 1000 kilogrammes
b) 1 metre = 100 centimetres = 1000 millimetres

(III) To convert the unit of measurement

a) Tons to kilogrammes

Example: 2 tons x 1000 = 2000 kg

b) Kilogrammes to tons

Example: 2000 kg / 1000 kg (divided) = 2 tons

c) Metres to millimetres

Example: 2 m x 1000 = 2000 mm

d) Millimetres to metres

Example: 2000 mm / 1000 (divided) = 2 m

e) Metres to centimetres

Example: 5 m x 100 = 500 cm

f) Centimetres to metres

Example: 300 /100 (divided) = 3 m

Examples of unit conversions for length:

1cm	→	**10mm**
10mm	→	**1cm**
1m	→	**100cm**
100cm	→	**1m**
1 km	→	**1000m**
1000m	→	**1 km**

(IV) Calculations Using a Calculator

If there is a decimal in the calculated figure, then, three digits should be taken after the decimal point.

123.456789012

Example:

123.456778 tons is taken as 123.456 tons (Example in the picture)

100.87651 tons is taken as 100.877 tons

100.1111 tons is taken as 100.111 tons

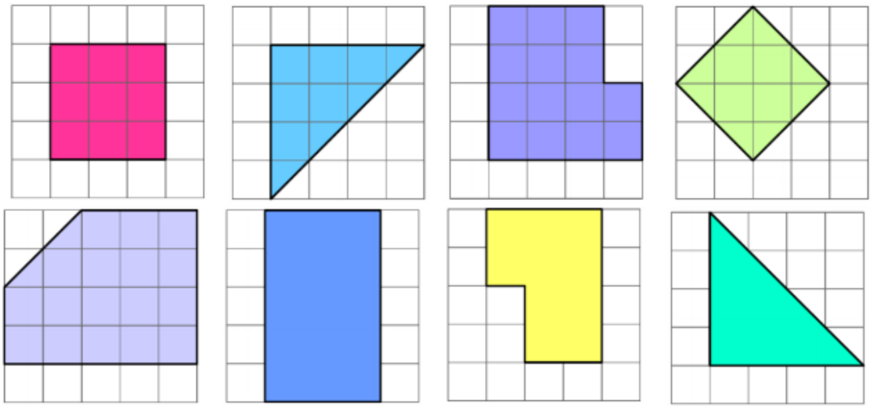
Example: 200.9999 kg is taken as 201.000 kg

Example: 200.1111 kg is taken as 200.111 kg

3.2 Calculation of Area and Volume of Various Shaped Objects

(a) Surface Area

The calculation of the surface area depends on the shape. Several basic calculations, such as the areas of squares and circles, must be known.

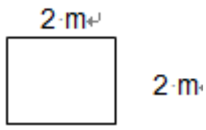


i) Surface area of a square (m2) = Length x Width

Example:

m2 = 2 m x 2 m

= 4 m2 (square metres)

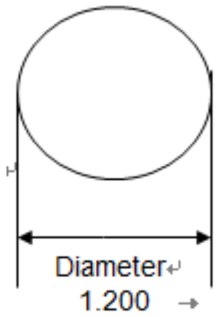


ii) Surface area of a Circle (m2) = Radius x Radius x 0.79

Example:

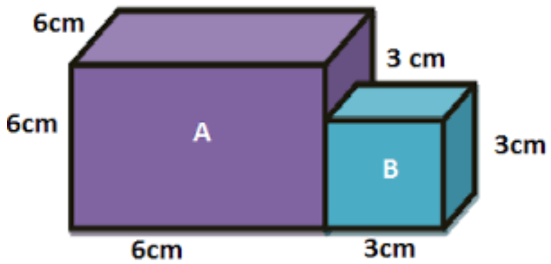
m2 = 1.2 x 1.2 x 0.79

= 1.138 m2 (square metres)

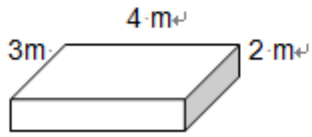


(b) Volume

The volume is the quantity of space that is taken up by a component. In this syllabus, 5 types of volumes must be known, namely:-



i) Volume of a Rectangular Object (m3) = Length x Width x Height

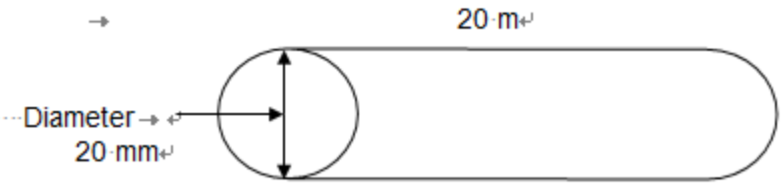


Example:

m3 = 4m x 3m x 2m

= 24 m3 (cubic metres)

ii) Volume of a Cylinder (m3) = Radius x Radius x Length x 0.79

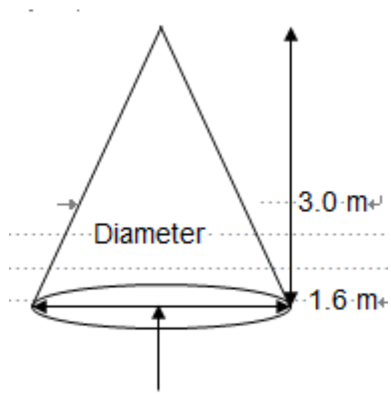


Example:

m3 = 0.02m x 0.02m x 20m x 0.79
= 0.00632 m (cubic metres)

Note: Pi (π) = 3.142 = 3.142/4 = 0.79

iii) Volume of a Cone (m 3) = Radius x Radius x Height x 0.79
(divided) 3



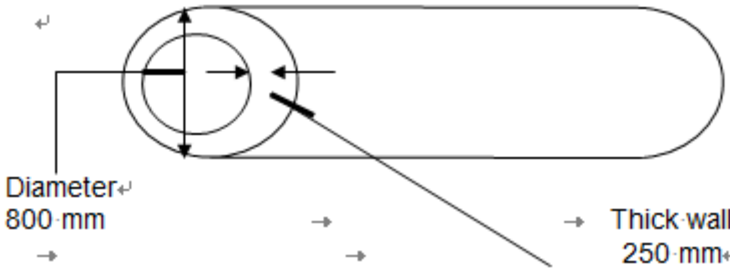
Example :

m3 = 1.6 m x 1.6 m 3 x 3.142 3.0 m
(divide) 3 Diameter

1.6 m
= 2.022 m3 (cubic metres)

iv) Volume of a Metal Pipe (m3) = Radius x Thickness x Length x Pi (π)

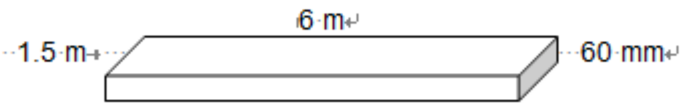
Pi = 22 /7 = 3.142



Example:

m3 = 0.8m x 0.25m x 6m x 3.142
= 3.770 m 3 (cubic metres)

v) Volume of Iron Board (m3) = Length x Width x Thickness



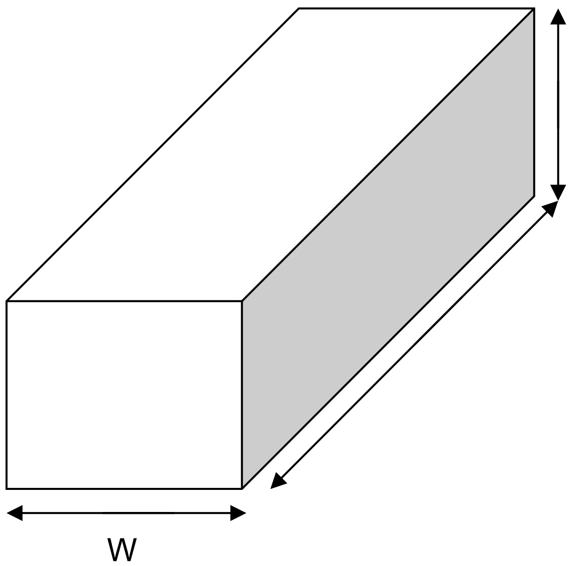
Example:
m3 = 6 m x 1.5 m x 0.06 m

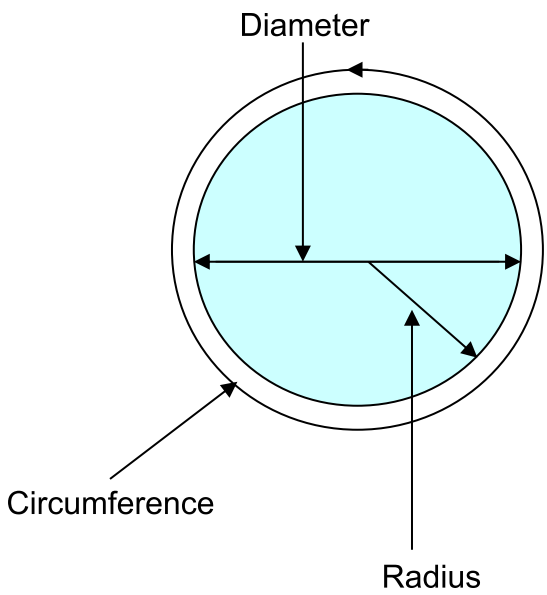
= 0.54 m 3 (cubic metres)

· Summary of Formulas

CODES FOR UNITS OF MEASUREMENT

L	Length	**mm**	Millimetre
W	Width	**M**	Metre
H	Height	**M^2**	Square metres
D	Diameter	**M^3**	Cubic metres
R	Radius	**Kg**	Kilograms
Circ	Circumference	**T**	Tonnes
Th	Thickness	**Pi**	3.142





Diameter	R x 2
Circumference	3.142 x D^2
Area of a square	L x W = m
Area of a circle	D x D x 0.79 = m^2
Area of a cylinder	3.142 x D x L = m^2
Volume of a round tank	D x D x 0.79 x L = m^3
Volume	Area x H = m^3

3.3 Basic Calculation for Finding the Weights of Objects of Various Shapes

There are several ways of knowing the weights of construction materials, among which are:

a) The weight may be marked on the item.
b) Ask your supervisor or any person who might know.
c) If the item appears in a catalogue, perhaps the weight of the item can be obtained from the catalogue that comes together with the item.
d) The weights of machines might be obtained more clearly from the business records or Operator's Manuals.
e) Through the Engineer's Manual
f) Calculations

3.3.1 Calculated weights of several materials

MATERIAL	WEIGHT
Aluminium	2.7 tonnes/m^3
Bricks, Clay, Common (2.5t/1000)	1.6 tonnes/m^3
Cast Iron	7.2 tonnes/m^3
Cement (20 bags/T)	1.0 ton (50 kg per bag)
Concrete, wet or set	2.4 tonnes/m^3
Concrete Panel (Steel reinforced)	3.0 tonnes/m^3
Petrol	0.7 tonnes/m^3
Diesel	0.8 tonnes/m^3
Earth, Loose	1.8 tonnes/m^3
Glass	2.6 tonnes/m^3
Hardwood	1.1 to 1.4 tonnes/m^3
Lead	11.3 tonnes/m^3
Road metal (Crushed rock)	1.9 tonnes/m^3
Sand, Dry	1.7 tonnes/m^3
Sand, Wet	1.9 tonnes/m^3

Softwood (average)	0.6 tonnes/m^3
Steel	8.0 tonnes/m^3
Mild Steel	7.84 tonnes/m^3
Water, fresh (1 Kg per litre) (1 m^3)	1.0 tonne/m^3 (1000 litres/m^3)
Scaffold fittings (4.9 mm thick) (Frame)	0.5 kg/m; AST Rigging Handbook, 1.5 kg/m (for Australian scaffolds)
Scaffold Tubes (tubular type) (Steel)	4.41 Kg/m
Karri Scaffold planks	7 Kg/m
Steel H-Beam	45 kg/m
Steel Pipe (20 mm thick)	2.4 tonnes/m^3; From material catalogue

3.3.2 Calculation of weight of load/mass

Throughout our study, we worked with rectangular and square shapes. The formula below is used to find the surface area:

Surface Area = Length x Breadth = m^2 (square metres)

The volume can then be calculated from the above surface area:

Volume = Surface area x Height = m^3 (cubic metres)

If the weight of the material is given, the weight of the load/mass can be calculated from the above volume:

Weight = Volume (m^3) x Weight of the material

The following makes it clearer:
Weight = Length x Breadth x Height (Thickness) x Weight of the Material = Tonnes

You should be able to calculate the measurements including the parts in metres (1.30 x 2.5 x 1.75 and so on) or in millimetres alone.

1 Meter

1000 Milimeter

mm. 0 250 500 750 1000

m 0 .25 0.5 0.75 1.0

One metre is equivalent to 1000 mm

1 mm is equivalent to one-thousandth of a metre or 0.001 metres (1/1000)
10 mm is equivalent to one-hundredth of a metre or 0.01 metres (1/100)

100 mm is equivalent to one-tenth of a metre or 0.1 metres (1/10)

Thousand Hundred Ten One (Unit)

T H T U

One metre	1. 0 0 0
One hundred millimetres	0 .1 0 0
Ten millimetres	0. 0 1 0
One millimetre	0. 0 0 1

Measurements in different units cannot be multiplied together. If two different units are to be multiplied together, the units must be converted to become the same.
Example:

1500 mm = 1.5 m
1 m and 30 mm = 1.03 m
5 m and 6 mm = 5.006 m
2072 mm = 2.072 m

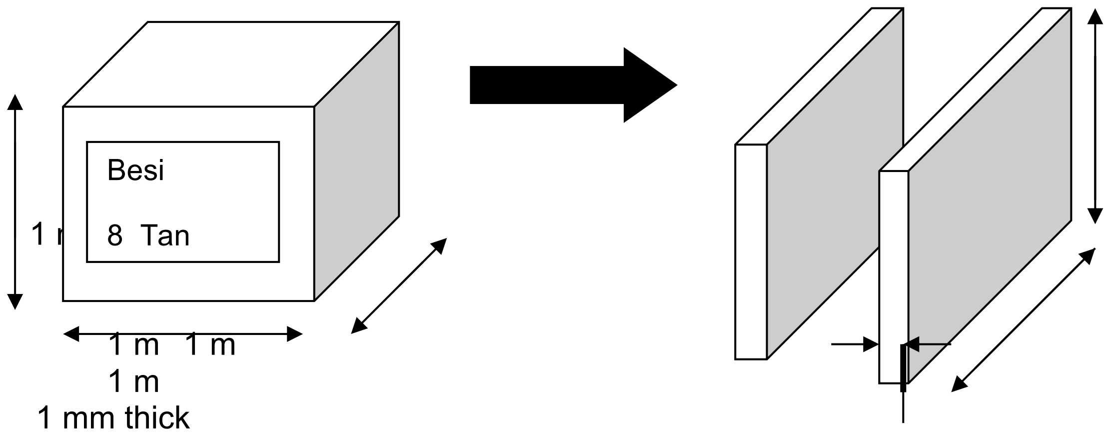
3.3.3 Tonnes to pounds

1 US tonne = 2000 Ibs.
1 (M) tonne = 2204 Ibs.
1 kg = 2.2 Ibs
1 metre = 3.28 feet

(a) Plate Formula
There are various types of weight calculations. The Plate formula is based on the thickness of an object, for example, an iron sheet.

We know that the weight of 1 cubic metre of iron is 8 tonnes or 8000 kg. We can cut the iron into 1 m^3 pieces to become 1000 small pieces, with each piece measuring 1 m x 1 m x 1 mm and weighing 8 kilograms.

8000 kg/1000 small pieces = 8 kg/piece



Each small piece of iron weighs 8 kilograms

Below is shown how these facts are used:

One piece - 1 m x 1 m x 1 mm, weighs 8 kilograms
One piece - 1 m x 1 m x 10 mm, weighs 80 kilograms
One piece - 2 m x 1 m x 10 mm, weighs 160 kilograms

Each square metre of this piece weighs 40 kilograms.

Method for obtaining the weight:

5 mm (thick) x 8 kg (weight of a 1-mm thick piece of iron) = 40 kilograms

Therefore, for 3 square metres (3 x 1 = 3 m^2) of this piece, the weight will be:

3 x 40 = 120 kilograms

The formula for calculating the weight of the iron piece is as follows:

Weight = Area (m^2) x Thickness (mm) x Weight of the material = Kg

Example:

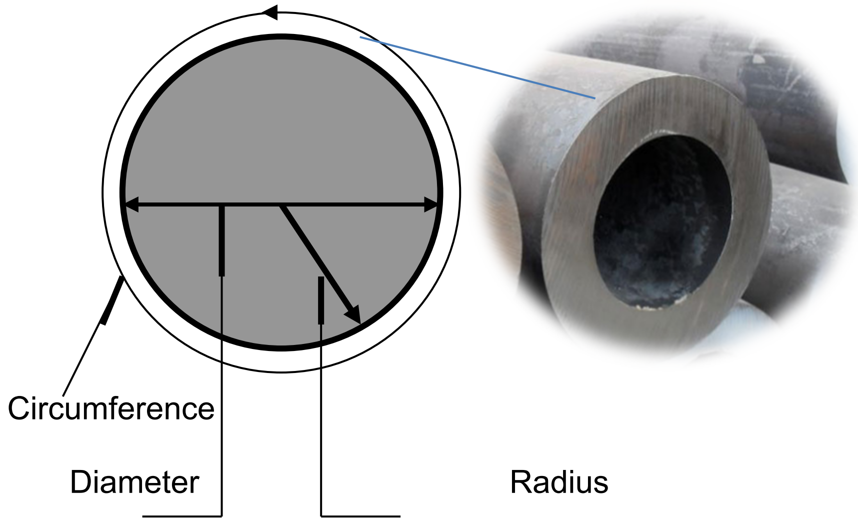
Weight = 3 x 1 x 5 x 8 = 120 kilograms

Note:
The advantage of using the Plate formula is that the thickness in mm units need not be converted to metre units or be in equivalent units in the calculation.

This formula can be used for concrete or any material produced in cubic metres.

3.3.4 Calculation of weight of load/mass for circular objects

(a) Area of circular object
Before working with circular objects, it is important to understand the 3 types of measurements that are inter-related to each other.



The radius (R) is the distance from the centre of a circle to the edge of the circle. The radius is half of the diameter.

The diameter (D) is the distance across the circle from one edge to another, passing through the centre of the circle.

The diameter is twice the radius.

The circumference is the distance around the circle along the outer edge of the circle.

Formula for calculating the area of a circle:

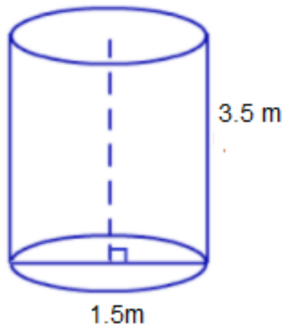
AREA = DIAMETER X DIAMETER X 0.79 = M²
OR
AREA = D X D X 0.79 = M²

Formula for calculating the circumference of a circle:

CIRCUMFERENCE OF A CIRCLE = 3.142 X DIAMETER

(b) Estimated weight of a circle

Figure 3.1: Oil Tank (http://tslack.com)



The weight of this oil tank (diagram), which is made of 3-mm thick steel, needs to be determined.
Step 1: Calculate the area of this steel tank.

This tank has two circular surfaces at both ends. Obtain the areas of both surfaces.

Total area of circular surface = D x D x 0.79 = M² x 2 (both ends) = m²

$= 1.5 \times 1.5 \times 0.79 = 1.77 \times 2 = 3.5\ m^2$

The body of the tank is made of a steel piece that has been rolled into a tube or cylinder. The area of this steel body can be calculated using the formula:

Area = Length x Breadth = m²

If we think of the body of this tank as being in the shape of a rectangle, then its length would be 3.5 m, i.e. the length of the tank.

We can obtain the circumference for the whole circle by using the following formula:

Circumference of circle = 3.142 x Diameter (D) = m

Area of the tank body = 3.142 x Diameter (D) x Length (L) = m²
(Area of a cylinder)

Total area of steel = Second area – surface areas of two ends + Area of the tank body
= $3.5 + 16.5 = 20\ m^2$

Step 2: Calculation of the weight of steel

WEIGHT = Area x Thickness X Weight of Material = Tonnes

Calculation:

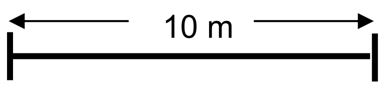
Area = $20\ m^2$
The thickness of the body of the steel tank at 3 mm must be changed to 0.003 m.

Weight of the material = 8 kg (Weight of 1 square metre piece of steel with a thickness of 1 mm)

Therefore, the Weight of the Tank = $20 \times 0.003 \times 8 = 0.48$ tonnes

EXAMPLES OF CALCULATIONS OF THE WEIGHT OF A LOAD/MASS

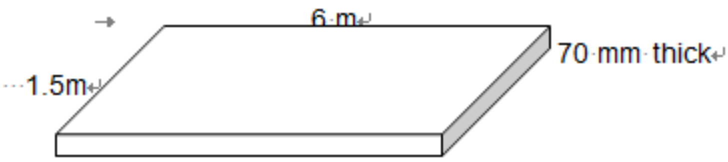
1. Find the weight of 2 iron beams, given that:



the weight of a 1-metre length = 100 kg
the length of 1 piece = 10 m

Answer: 10 m x 100 kg x 2 pieces = 2.0 tonnes

2. Find the weight of 2 pieces of iron board (Soft Iron):



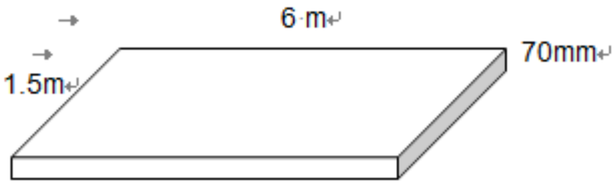
Solution:

Thickness of 70 mm = 0.07 m

Answer: 6 m x 1.5 m x 0.07 m x 7.84 tonnes = 4.939 tonnes x 2 = 9.878 tonnes

3. Find the weight of 2 pieces of iron board.

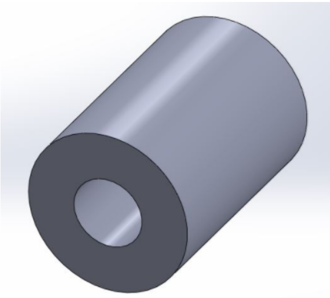
Given:
Weight of 1 square metre = 100 kilograms



Solution:
Convert the thickness of 70 mm into metres = 0.07 m

Answer: 6 m x 1.5 m x 100 kg = 900 kg x 2 = 1800 kilograms

4. Find the volume and weight of the pipe below:

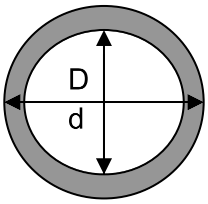


Given:

Length = 6m
Diameter = 1.5m (Diameter)
Thickness = 20 mm

Solution:

Convert the thickness of 20 mm to 0.020 m



Pi (π) = 3.142
D = 1.5 m
d = 1.5 – (0.020 + 0.020) = 1.460 m

Volume of pipe = 3.142 x Length x Outer diameter x Thickness = m^3

Volume of pipe = 3.142 x 6 m x 1.5 m x 0.02 m = 0.565 m^3

or

$$\frac{\pi (D - d^2)^2}{4} \text{ x Length}$$

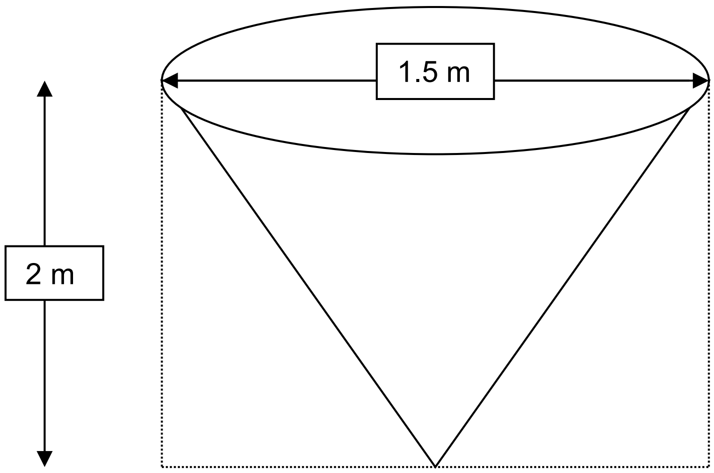
$$\frac{3.142 (1.5 - 1.46^2)^2}{4} \text{ x } 6 = 0.558 \text{ m}^3$$

Total weight of the pipe = 0.565 x 2.4 tonnes = 1.356 tonnes

Note:
The weight of the pipe with a volume of 1 cubic metre (thickness of 20 mm) obtained from the weight of the building material = 2.4 tonnes

5. Find the weight of a concrete bucket filled with concrete.

Given:
Weight of the empty concrete bucket = 300 kg
Diameter of the top surface of the concrete bucket = 1.5 metres
Height of the concrete bucket = 2 metres



Solution:

Convert the weight of the empty concrete bucket of 300 kg to 0.3 tonnes.

Use the formula for the volume of a cone
= 0.79 x Diameter x Diameter x Height
(divide) 3

or $\frac{\pi R^2 \times \text{Height}}{3}$

or $\frac{\pi D^2 \times \text{Height}}{12}$

Note:
R = Radius D = Diameter π = Pi = 3.142

Step 1

Find the volume of the concrete bucket:
Volume of concrete bucket = 0.79 x 1.5 m x 1.5 m x 2 m / (divide) 3 = 1.185 m^3

Step 2

Find the weight of the concrete:
Use the weight of wet concrete = 2.4 tonnes/m^3 (obtain from Table 1.0)

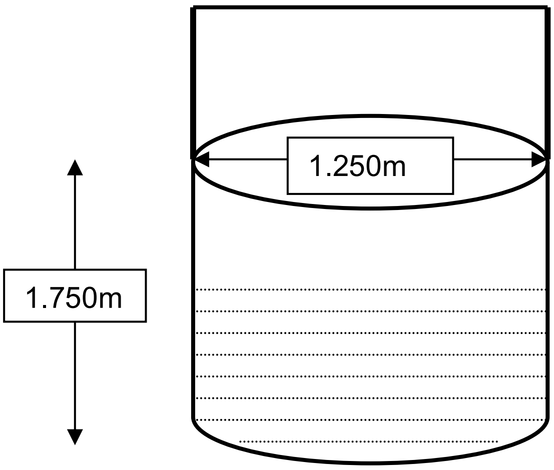
Weight of wet concrete in the bucket = Volume of concrete bucket (m^3) x 2.4 tonnes/m^3 = Tonnes
= 1.185 m^3 x 2.4 tonnes/ m^3
= 2.844 tonnes

Step 3

Find the weight of the concrete bucket filled with concrete:
Convert the weight of the empty bucket, given as 300 kg, to 0.3 tonnes

Weight of the concrete bucket filled with concrete = weight of wet concrete in the bucket + Weight of the empty concrete bucket
= 2.844 tonnes + 0.3 tonnes
= 3.144 tonnes

6. Find the weight of a bucket, ¾ of which is filled with water.
Given:
Weight of the empty bucket = 300 kilograms



Solution:

Step 1

Obtain the height of the water in the bucket, which is ¾ the height of the bucket = 1.750 m x ¾ = 1.313 m

Step 2

Obtain the volume of the water in the bucket = Diameter x Diameter X Height x 0.79 = m^3

= 1.250 m x 1.250 m x 1.313 m x 0.79 = 1.621 m^3

Step 3

Find the weight of the water in the bucket:

Weight of water in the bucket = Volume of water (m^3) x 1.0 tonne/m^3

= 1.621 m^3 x 1.0 tonne/m^3
= 1.621 tonnes

Step 4

Obtain the weight of the bucket that is ¾ filled with water.

Convert the weight of the empty bucket, which is given as 300 kg, to 0.3 tonnes

Total weight = Weight of bucket + weight of water content

= 1.621 tonnes + 0.3 tonnes
= 1.921 tonnes

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CHAPTER 4

LOAD CHARTS

4.1 Introduction

A load chart is a table that is provided by crane manufacturers giving information on the hoisting capacities of cranes. The proper use of the load chart is one of the basic competencies of a crane operator. Individuals involved in hoisting operations need to understand how to read and use a load chart correctly. Nevertheless, tower cranes have been fitted with safety devices and switches that automatically indicate any excess loading weight or moments on the crane for safety purposes. If the load chart is wrongly read or the capacity of the crane is over-estimated, accidents can occur due to damage to the crane structure and the lifting equipment leading to injury/death to other workers and members of the public.

4.2 Understanding the Load Charts of Various Crane Models

Load charts list the hoisting capacities of cranes for various boom lengths and load ranges, as shown in Figure 4.1 and 4.2. To ensure a crane operates within a safe load range, the following points should be noted:

(a) The values shown in the load chart for a crane refer to the maximum load for the crane concerned (including the lifting equipment). These values apply to a crane that is in an “as new” condition and is installed according to the manufacturer’s specifications.

(b) To determine the maximum load that can be safely lifted by a crane, the weight of the lifting equipment (wire rope, sling, etc.) and lifting gear (hook, shackles, spreader beam, hook block, etc.) must be subtracted from the maximum hoisting load of the crane.

(c) A load chart assessment only applies to a crane that has been maintained in good condition, as specified by the crane manufacturer. The boom is one of the critical elements in a crane, and it must be in perfect condition at all times.

(d) Crane operators must understand load charts for the safe handling of loads. A copy of the load chart must be displayed in the crane operator's cabin.

Radius and Capacities

Hook Reach	Maximum Capacity – Radius	ft m	13* 4*	66 20	98 30	107 32.5	115 35	123 37.5	131 40	139 42.5	148 45	156 47.5	164 50	172 52.5	180 55	189 57.5	197 60	205 62.5	213 65
213 ft 65m	26,460 lbs – 127 ft 12 000 kg – 38.8m	lbs kg	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	25,245 11 450	22,155 10 410	20,945 9 500	19,160 8 690	17,550 7 960	16,115 7 310	14,795 6 710	13,625 6 180	12,520 5 680	11,530 5 230	10,580 4 800
197 ft 60m	26,460 lbs – 136 ft 12 000 kg – 41.4m	lbs kg	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	24,440 11 540	23,345 10 590	21,495 9 750	19,820 8 990	18,320 8 310	16,955 7 690	15,720 7 130	14,550 6 600		
180 ft 55m	26,460 lbs – 144 ft 12 000 kg – 43.8m	lbs kg	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	25,395 11 520	23,415 10 620	21,625 9 810	20,020 9 080	18,520 8 400				
164 ft 50m	26,460 lbs – 150 ft 12 000 kg – 45.8m	lbs kg	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	25,065 11 370	23,150 10 500						
148 ft 45m	26,460 lbs – 148 ft 12 000 kg – 45m	lbs kg	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000								
131 ft 40m	26,460 lbs – 131 ft 12 000 kg – 40m	lbs kg	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000										
115 ft 35m	26,460 lbs – 115 ft 12 000 kg – 35m	lbs kg	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000	26,460 12 000												
98 ft 30m	26,460 lbs – 98 ft 12 000 kg – 30m	lbs kg	26,460 12 000	26,460 12 000	26,460 12 000														

*Minimum hook reach.

1-PART OPERATION

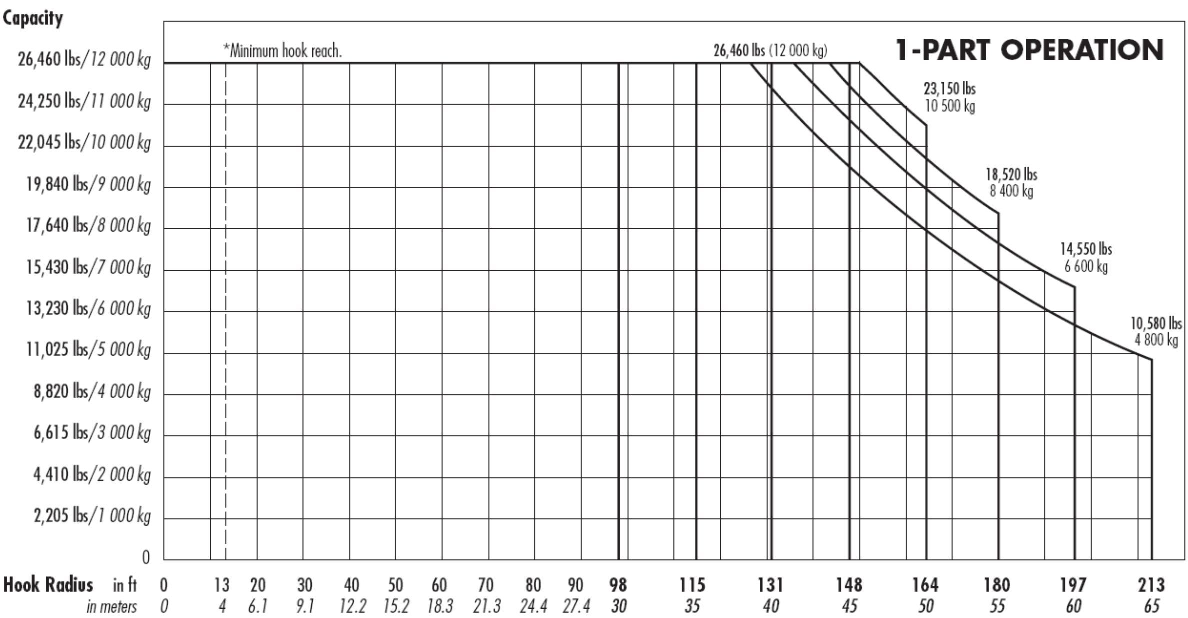

Figure 4.1 Load chart for a luffing crane (single-wire rope reeve) (Lift Director- Tower Cranes Load Chart Manual, 2013)

Radius and Capacities

2-Part Operation

Hook Radius	Jib Tip Radius	Maximum Capacity – Radius	ft / m	33 / 10	49 / 15	66 / 20	82 / 25	98 / 30	115 / 35	131 / 40	148 / 45	164 / 50	180 / 55	197 / 60	213 / 65	230 / 70	246 / 75
246 ft	252'-0"	22,050 lbs – 104 ft	lbs	22,050	22,050	22,050	22,050	22,050	19,670	16,670	14,370	12,540	11,050	9,790	8,730	7,830	7,050
75m	76.8m	10 000 kg – 31.6m	kg	10 000	10 000	10 000	10 000	10 000	8 920	7 560	6 520	5 690	5 010	4 440	3 960	3 550	3 200
230 ft	235'-7"	22,050 lbs – 117 ft	lbs	22,050	22,050	22,050	22,050	22,050	22,050	19,180	16,600	14,530	12,850	11,460	10,270	9,260	
70m	71.8m	10 000 kg – 35.6m	kg	10 000	10 000	10 000	10 000	10 000	10 000	8 700	7 530	6 590	5 830	5 200	4 660	4 200	
213 ft	219'-2"	22,050 lbs –129 ft	lbs	22,050	22,050	22,050	22,050	22,050	22,050	21,500	18,650	16,380	14,530	12,990	11,680		
65m	66.8m	10 000 kg – 39.2m	kg	10 000	10 000	10 000	10 000	10 000	10 000	9 750	8 460	7 430	6 590	5 890	5 300		
197 ft	202'-9"	22,050 lbs – 139 ft	lbs	22,050	22,050	22,050	22,050	22,050	22,050	22,050	20,460	17,990	16,000	14,330			
60m	61.7m	10 000 kg – 42.4m	kg	10 000	10 000	10 000	10 000	10 000	10 000	10 000	9 280	8 160	7 260	6 500			
180 ft	186'-0"	22,050 lbs – 148 ft	lbs	22,050	22,050	22,050	22,050	22,050	22,050	22,050	21,910	19,310	17,200				
55m	56.7m	10 000 kg – 45m	kg	10 000	10 000	10 000	10 000	10 000	10 000	10 000	9 940	8 760	7 800				
164 ft	169'-7"	22,050 lbs – 155 ft	lbs	22,050	22,050	22,050	22,050	22,050	22,050	22,050	22,050	20,500					
50m	51.7m	10 000 kg – 47.3m	kg	10 000	10 000	10 000	10 000	10 000	10 000	10 000	10 000	9 300					
148 ft	153'-3"	22,050 lbs – 148 ft	lbs	22,050	22,050	22,050	22,050	22,050	22,050	22,050	22,050						
45m	46.7m	10 000 kg – 45m	kg	10 000	10 000	10 000	10 000	10 000	10 000	10 000	10 000						
131 ft	136'-10"	22,050 lbs – 131 ft	lbs	22,050	22,050	22,050	22,050	22,050	22,050	22,050							
40m	41.7m	10 000 kg – 40m	kg	10 000	10 000	10 000	10 000	10 000	10 000	10 000							
115 ft	120'-5"	22,050 lbs – 115 ft	lbs	22,050	22,050	22,050	22,050	22,050	22,050								
35m	36.7m	10 000 kg – 35m	kg	10 000	10 000	10 000	10 000	10 000	10 000								

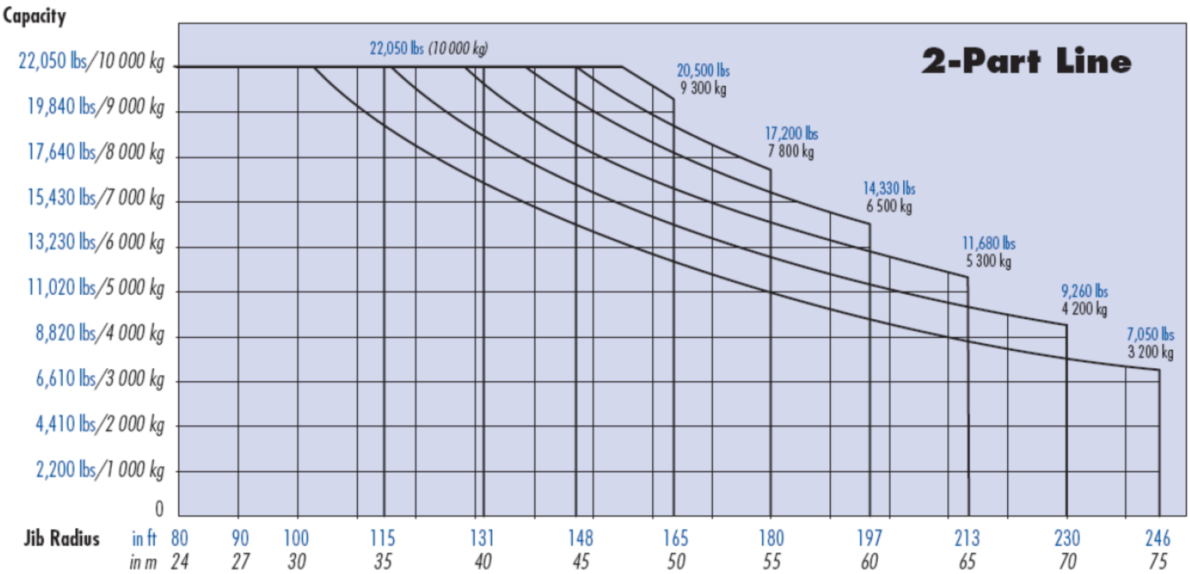

Figure 4.2 Load chart for a hammerhead crane (double-wire rope reeve) (Lift Director - Tower Cranes Load Chart Manual, 2013)

4.3 Use of Load Charts for Different Types of Cranes

Every type of crane has its own load chart. Crane operators need to know how to use these different load charts in order to avoid failure in the lifting equipment and to the crane structure. In the absence of supervision by a responsible person during load hoisting operations, operators must discipline themselves to ensure that they do not exceed the load limit specified in the load chart or by the crane manufacturer. For instant, the maximum load and specification for hammerhead tower crane model Kroll K180 is shown in Figure 4.3

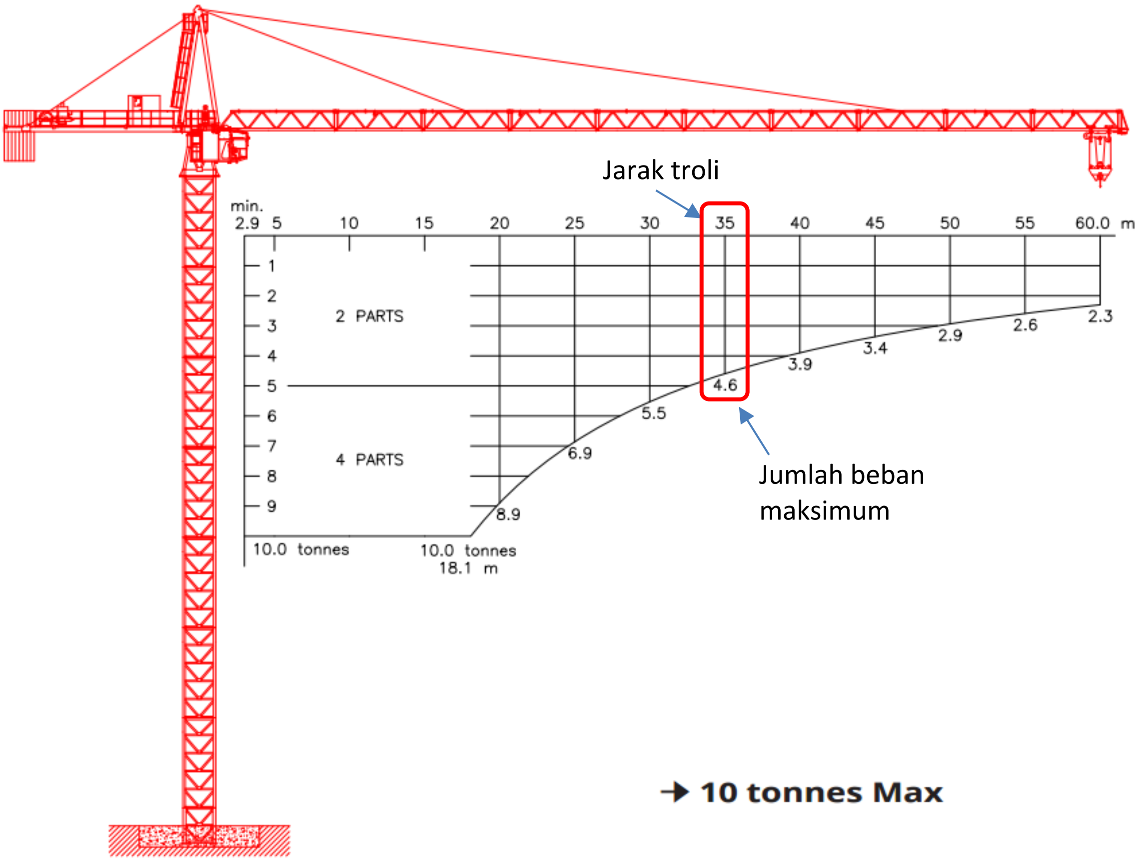

Figure 4.3 Trolley distance configuration and safe working load (www.krollcranes.dk)

The load chart and device specifications for a tower crane model BKT ZBK 80 (DIN 15018 H 1/B3) are shown in Figure 4.4.

Note: This load chart will be used in assessments by instructors at the National Institute of Occupational Safety and Health (NIOSH).

Radius and capacity

JIB	MAX CAPACITY		Radius (m) and Capacity (t)																
			18.0	20.0	22.0	24.0	25.0	26.0	28.0	30.0	32.0	34.0	35.0	36.0	38.0	40.0	42.0	44.0	45.0
L4 45.0 m	5.0 t	2.3 - 15.9	4.34	3.86	3.46	3.14	2.99	2.86	2.63	2.43	2.25	2.10	2.03	1.96	1.84	1.73	1.63	1.54	1.50
L3 40.0 m	5.0 t	2.3 - 17.9	4.96	4.41	3.96	3.59	3.43	3.28	3.02	2.79	2.59	2.42	2.34	2.26	2.12	2.00			
L2 35.0 m	5.0 t	2.3 - 18.9		4.70	4.23	3.83	3.66	3.50	3.22	2.98	2.77	2.59	2.50						
L1 30.0 m	5.0 t	2.3 - 20.1			4.53	4.11	3.93	3.76	3.46	3.20									

Speeds

	v = 22/45 m/min			KL - PU		2,6 kW
	v = 0 - 25 m/min			KL - FK		2 x 5,5 kW
	n = 0 - 0,86 min $^{-1}$			KL- WB		5,0 kW
Type KL/PU 24/5	HK - = max. 130 m 3-Layers					24,0 kW
		63 m/min	1,65 t	31 m/min	3,30 t	
		31 m/min	2,50 t	16 m/min	5,00 t	
		7,0 m/min		3,5 m/min		
380 V/50 Hz/3 Ph	Connection power - upper part of crane					42 kVA

Counter jib ballast

Jib	L 1	L 2	L 3	L 4
Ballast BG	7,65	9,00	9,45	9,45
Number	2x3,15 1x1,35	2x3,15 2x1,35	3x3,15	3x3,15

Figure 4.4 Load chart and device specifications for crane model ZBK 80

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CHAPTER 5

RIGGING AND SLINGING METHODS

5.1 Introduction

A sling is defined as a tool that is used for rigging something so that it can be suspended. In the construction sector, a sling is used for rigging loads when works to hoist, lower or suspend are being carried out by a tower crane as well as a travelling crane. There are several types of slings, and the use of each sling depends on the kind of load to be hoisted Among the slings that are commonly used at construction sites are wire rope slings, chain slings, synthetic fabric slings and fibre slings. Figure 5.1 below shows some of the slings that are usually used at construction sites.

(a) Wire rope sling

(b) Chain sling


(c) Fibre sling (www.shutterlock.co.za)


(d) Synthetic fabric sling (www.craneinstitute.com)

Figure 5.1 Types of slings that are usually used at construction sites (www.uscargocontrol.com/Lifting-Slings)

5.2 Types of rigging and slinging

5.2.1 Direct hitch

This type of sling is hitched directly with a single-leg without any bending or stretching towards the load. It is tied to the load using hooks at every place where there is a bow or eye bow attached to the load. When a sling with more than one leg is used, i.e. a 2-leg, 3-leg or 4-leg sling, and if it is not folded to become two or more slings, and is not stretched, it is still categorized as a single sling, as shown in Figure 5.2.

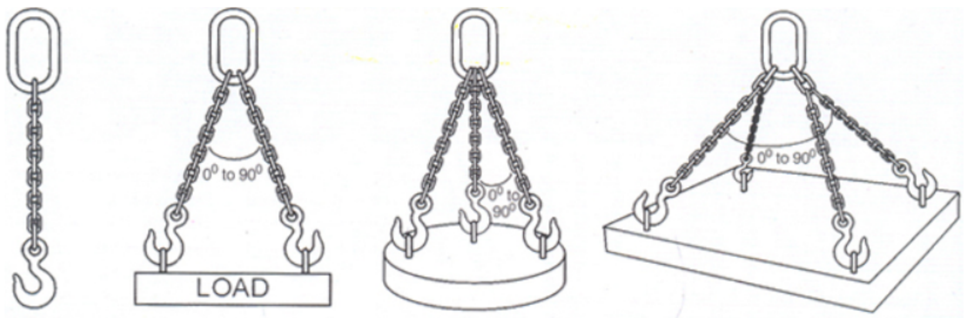
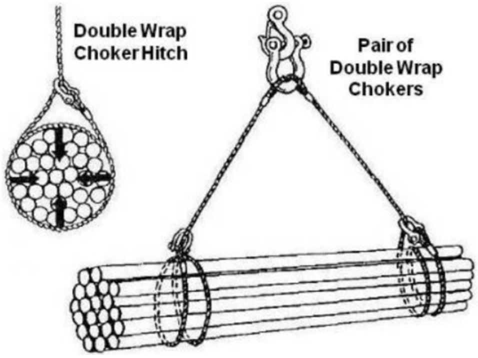


Figure 5.2 From left, direct hitch sling with one leg, two legs, three legs and four legs (www.lifttechnique.com)

5.2.2 Choker hitch/reeved hitch

In this method, the load is wrapped or choked using the same sling. This type of sling has an eye at its end, whether it is a single sling or more than one sling (Figure 5.3). When the load is hoisted, the sling that is wrapped around the load will become tighter and will experience strain. The sling can also be double-wrapped around the load to prevent the load from slipping out of the sling or being pulled out from the rigging, for example, when lifting a large number of cylindrical pipes. This type of hitch can also be used to shorten the sling.



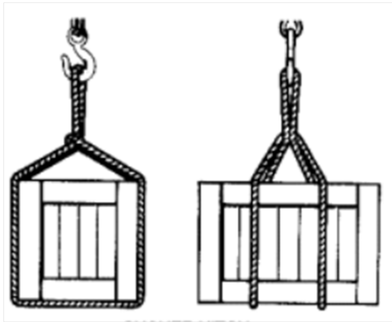


Figure 5.3 Choke/reeved hitch sling (www.practicalmaintenance.net, www.globalsecurity.org)

5.2.3 Basket hitch

This type of sling is passed around the load and both ends of the sling are joined to a hook in the hook block of a tower crane or added to the hoist beam (Figure 5.4).

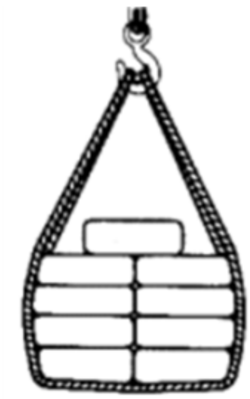


Figure 5.4 Basket hitch sling (www.practicalmaintenance.net)

5.3 Terminology for Sling

5.3.1 Working load limit

The working load limit (WLL) is the maximum load that can be applied to a lifting equipment or lifting aid to prevent damage. Every lifting equipment has its own WLL. Therefore, the lowest WLL value should be used as a reference for hoisting work if the equipment or lifting gear used has different WLL values.

5.3.2 Safe working load

The safe working load (SWL) is the old term that was used before the introduction of the WLL to determine the maximum load to prevent damage to the equipment. Most lifting equipment or lifting gear now uses the WLL label.

5.3.3 Breaking strength

The breaking strength (BS) is the actual force required to cause damage to lifting equipment.

5.3.4 Proof loading

Proof loading is the load failure limit that is determined by testing the material concerned. The safe working load value must be below the proof loading value. The sling that is used to hoist the load should have this test certificate issued by the manufacturer.

5.3.5 Safety factor

The safety factor (SF) is used to prevent any failure in all areas, especially in the engineering design. The value of the SF varies according to the lifting equipment, and it is used to calculate the WLL/SWL. Table 5.1 shows the SF values for several types of lifting equipment.

Table 5.1 Safety Factor according to type of sling

Sling type	Safety factor
All types of slings when used to lift persons	10
Synthetic fabric	8
Fibre rope	6
Wire rope	5
Chain (steel)	4

The relationship between the BS, SF and WLL is shown in Equation (4.1) below:

$$BS \div SF = WLL \tag{4.1}$$

Example:

A wire rope that is used as a sling has a minimum breaking strength (BS) of 10 tons. What is the value of the Working Load Limit (WLL) for the sling that is used?

Answer

Based on Table 1, the SF for a wire rope sling is 5. By using Equation (1) above, the WLL value can be obtained.

BS= 10, SF=5

Hence, WLL = 10 ÷ 5 = 2 tons (Maximum permissible load)

The use of the SF is very important for ensuring that there is a large gap in the load before it reaches the level where it can cause damage to the sling. Therefore, according to the above calculation, the user is only allowed to hoist a maximum load of 2 tons (=WLL). Before using the lifting equipment, make sure that every equipment has the SWL or WWL mark, which must be complied with. The notes below are very important for the knowledge of every user.

The safety margin is built into the SWL/WLL to protect the user,

IT MUST BE STRICTLY ADHERED!

5.4 Angle Factor and Load Factor

There are two main factors that can have an effect on the strength of the sling during operations, namely, the Angle Factor and the Load Factor.

5.4.1 Angle factor

The angle of the sling to the load can affect the strength of the sling.

- When the sling angle is increased, the tension in the sling also increases.
- When the tension in the sling increases, the strength capacity of the sling will be reduced.

Figure 5.5 shows the same load being hoisted using a single 2-leg chain sling at 5 different angles. The sling angle was changed from 0° to 120° and the load on the sling legs was changed from 5 tons to 10 tons. This clearly proved that the angle influences the tension as well as the strength of the sling.

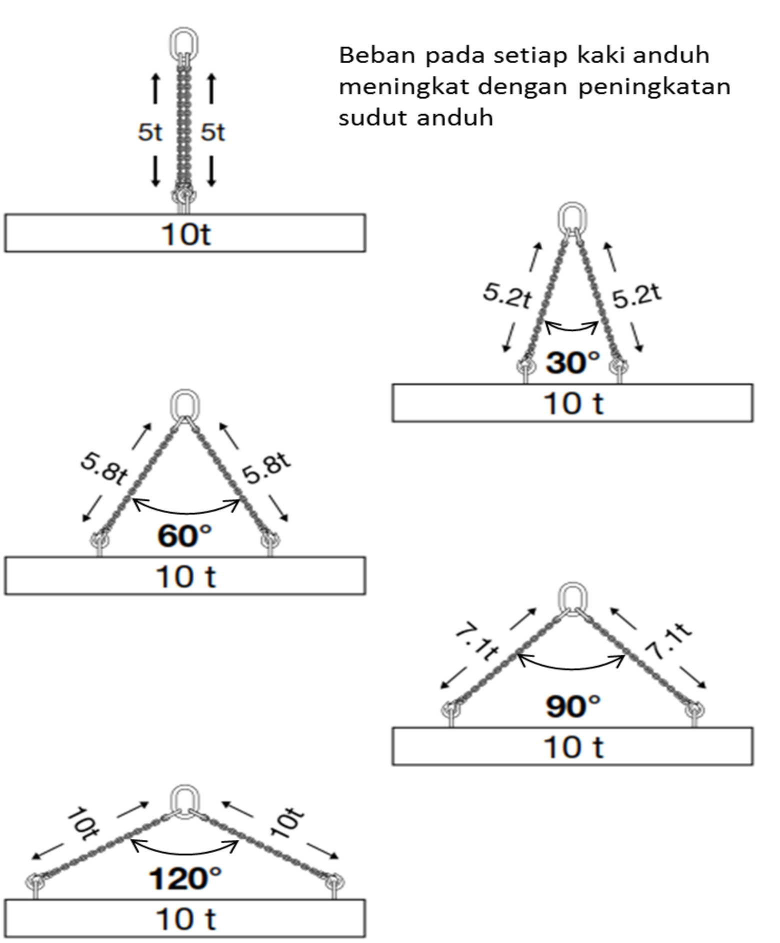


Figure 5.5 Angle factor on sling tension (Laing O`Rourke, 2008)

Table 5.2 summarises the rate of increase in the sling tension with an increase in the sling angle.

Table 5.2 Increase in sling tension with increase in the sling angle and angle factor

Sudut anduh	Peratus peningkatan ketegangan anduh	Faktor sudut
30°	3%	1.93
45°	7%	1.85
60°	15%	1.73
90°	41%	1.41
120°	100%	1.00

Methods for estimating the sling angle

During operations, the angle of the sling that is hitched to the load can be estimated if the length of the sling leg, as well as the distance between two hitches or its height, are known. The angles that can easily be estimated are 30°, 60°, 90° and 120° (Figure 4.6).

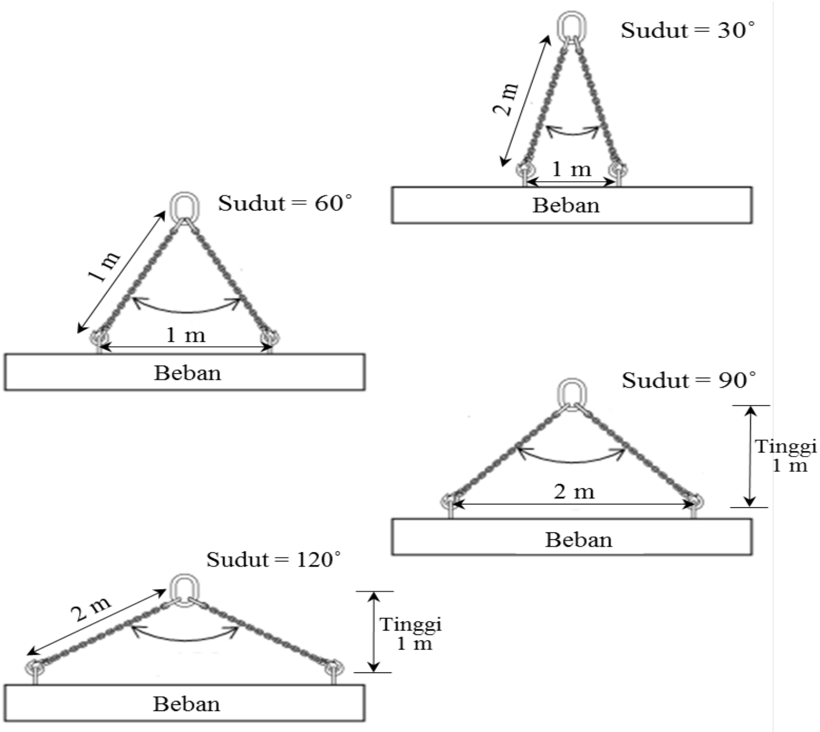


Figure 5.6 Estimate of sling angle

Nevertheless, the user must know the following:

- Best sling angle = 60°
- Maximum angle for all types of slings = 120°
- Maximum angle recommended for slings = 90°

Figure 4.7 below shows the increase in the sling tension with increases in the sling angle from 30º to 171º for lifting a load of 1 ton.

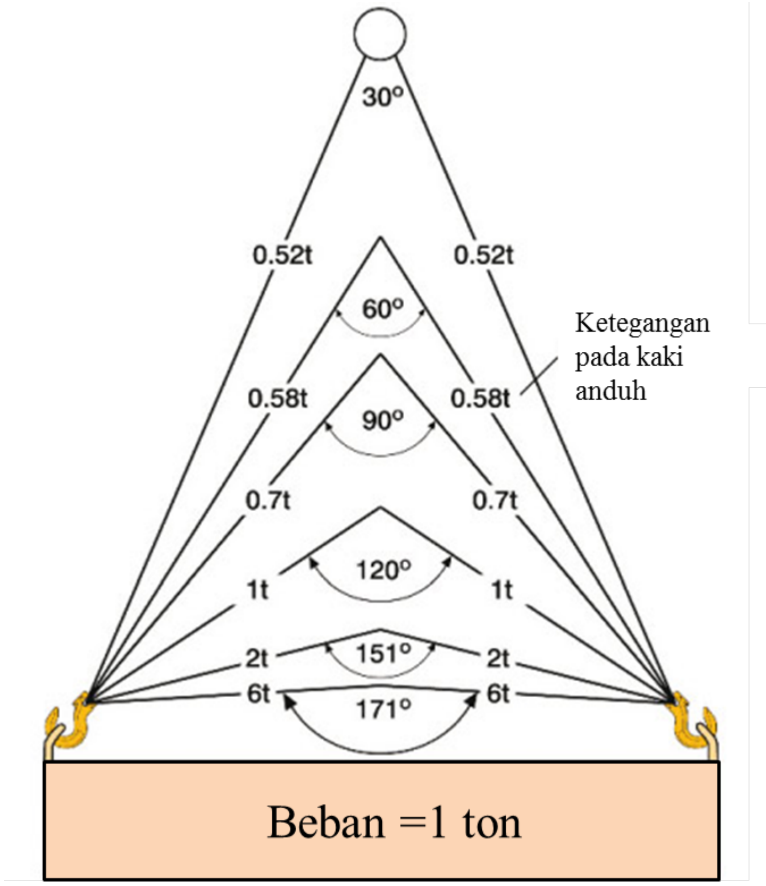


Figure 5.7 Increase in sling tension with an increase in the sling angle (www.williamhacket.co.uk)

5.4.2 Load factor

The load factor (LF) also influences the strength of the sling, where it is used to calculate the WLL/SWL. The load factor depends on the type of sling hitch as well as the shape of the load to be hoisted. Figure 5.8 shows the load factors for various types of sling hitches and different loads.

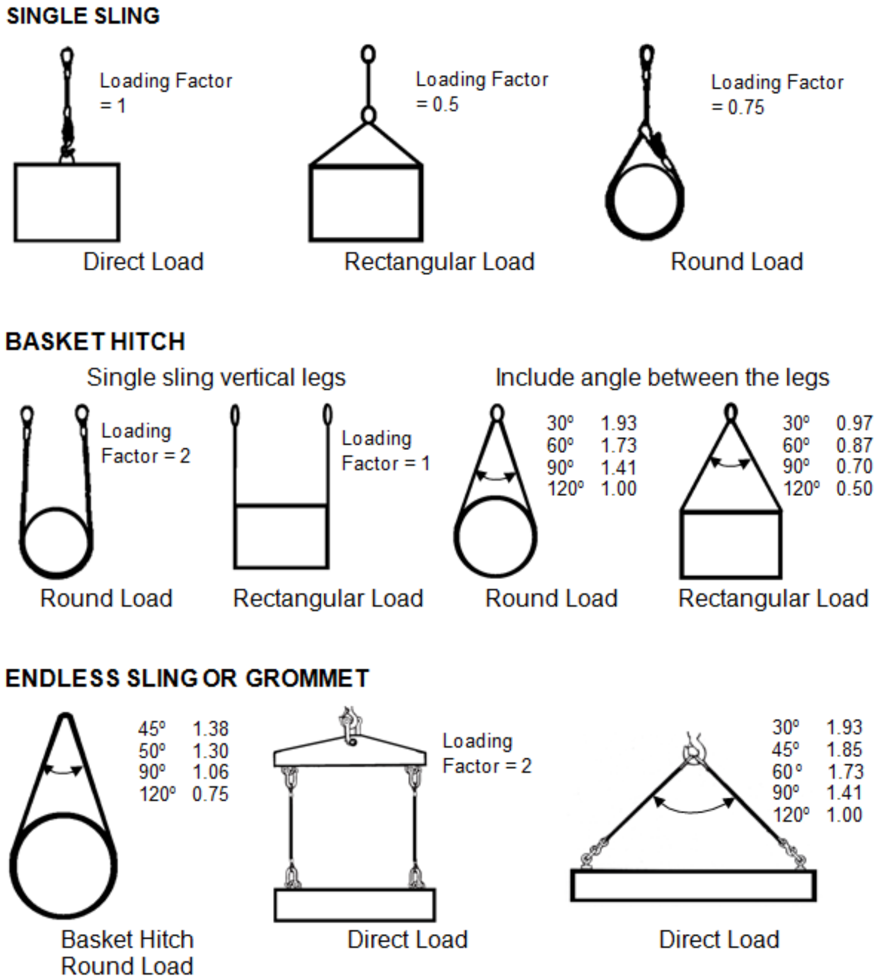


Figure 5.8 Load factors for various sling hitches and different load shapes (www.cranecrew.com)

Loss of Strength in Choke Hitch Sling

In a choke hitch, the strength of the rope used to lift the load can be reduced by as much as 50% (see Table 5.3). The rope hitch that is wrapped or knotted will reduce the strength of the rope and can lead to failure or damage when the rope is in a state of tension. Therefore, the choke hitch is the same with those types of slings that are easily hitched to form sharp bends, where the nip point of the rope must be identified (Figure 5.9).

When a rectangular load is hoisted with a choke hitch, there will be an increase in the tension in every corner of the load. Table 4.3 below shows the percentage loss in strength of the sling caused by the corners of the rectangular load. It also shows the load factor based on the shape of the load and the type of sling.

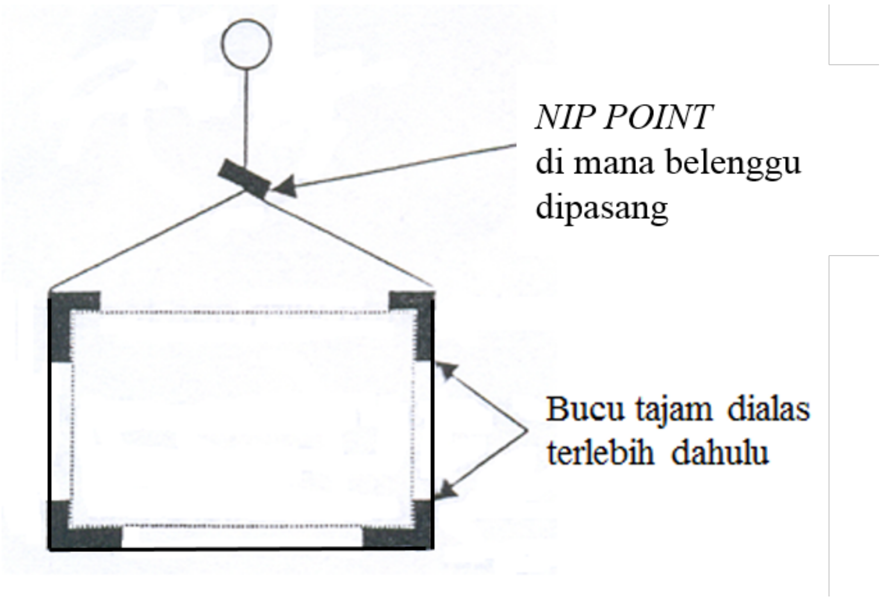


Figure 5.9 Load centre of sling

Table 5.3 The percentage reduction in the strength of a sling with a choke hitch as well as the load factor according to the type of sling and shape of the load

Jenis anduh	Beban silinder	Beban segi empat
Tali fiber	25% (F.B: 0.75)	50% (F.B: 0.5)
Tali dawai	25% (F.B: 0.75)	50% (F.B: 0.5)
Rantai Drane T	25% (F.B: 0.75)	25% (F.B: 0.75)
Kain sintetik	20% (F.B: 0.8)	20% (F.B: 0.8)

Effect of corners of rectangular loads on slings

When a basket hitch is used, the sharp corners of a rectangular load will weaken the sling (Rajah 4.8). When the corners are lined, the sling will be protected and the loss in strength of the load can be reduced. Corner liners must be used with circular or basket hitch slings, and these will reduce the loss in strength of the sling by 20%.

5.4.3 Calculation of the SWL based on the angle factor and load factor

The relationship between the angle factor, load factor and SWL/WLL is shown in Equation (4.2):

$$\text{WLL} = \text{Weight of load} \div \text{Angle factor} \div \text{Load factor} \qquad (4.2)$$

From Equation (4.2), the maximum load can be calculated using Equation (4.3) below if the value of the WLL is known:

$$\text{Maximum load} = \text{WLL} \times \text{Angle factor} \times \text{Load factor} \qquad (4.3)$$

Example 1: Rectangular load

A rectangular load weighing 4 tons is hitched to a wire rope sling with a single 2-leg hitch at an angle of 30˚, as shown in Figure 5.10. What is the value of the WLL that should be marked on the equipment to enable it to be used for lifting this load?

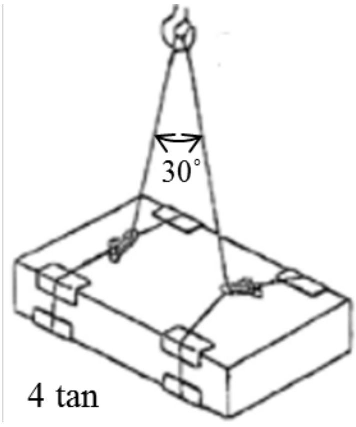


Figure 5.10 Rectangular load

<u>Answer</u>

Load = 4 tons

Sling angle = 30˚

Angle factor (Refer to Table 5.2: choke hitch at angle of 30˚) = 1.93

Load factor (Refer to Table 5.3: wire rope, rectangular load) = 0.5

Hence, W.L.L = Weight of load ÷ Angle factor ÷ Load factor

= 4 ÷ 1.93 ÷ 0.5

= 4.15 tons

Therefore, a sling with a WLL that is equal to or more than 4.15 tons can be used to hoist this load.

Example 2: Cylindrical load

A cylindrical load weighing 20 tons is hitched to a synthetic fabric sling with a single 2-leg hitch at an angle of 60˚, as shown in Figure 5.11. What is the value of the WLL that must be marked on the equipment to enable it to be used for lifting this load?

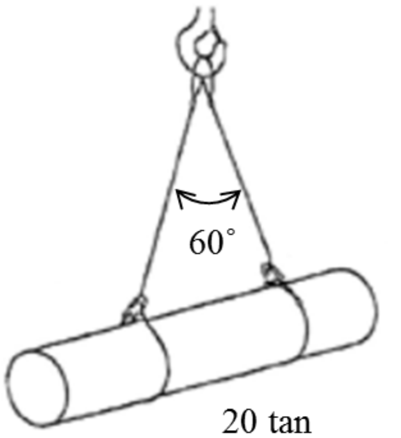


Figure 5.11 Cylindrical load with sling angle of 60˚

Answer

Load = 20 tons

Sling angle = 60˚

Angle factor (Refer to Table 5.2: choke hitch at an angle of 60˚) = 1.73

Load factor (Refer to Table 5.3: synthetic fabric, cylindrical load) = 0.8

Hence, W.L.L = Weight of load ÷ Angle factor ÷ Load factor

= 20 ÷ 1.73 ÷ 0.8

= 14.45 tons

Therefore, a sling with a WLL that is equal to or more than 14.45 tons can be used to hoist this load.

Example 3: Maximum weight for a cylindrical load

A cylindrical load is hitched to a synthetic fabric sling with a single 2-leg hitch at an angle of 30˚, as shown in Figure 5.12. What is the maximum load that can be lifted by this sling?

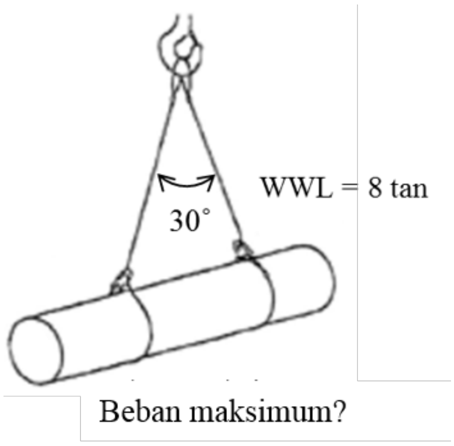


Figure 5.12 Cylindrical load with a sling angle of 30˚

Answer

WWL = 8 tons

Sling angle = 30˚

Angle factor (Refer to Table 5.2: choke hitch at angle of 30˚) = 1.93

Load factor (Refer to Table 5.3: synthetic fabric, cylindrical load) = 0.8

Hence, with reference to Equation (3)

Maximum load = WLL x Angle factor x Load factor

= 8 x 1.93 x 0.8

= 12.35 tons

Therefore, the maximum weight of the load that can be hoisted with a sling having a WLL of 8 tons is 12.35 tons.

5.5 Centre of Gravity and Equilibrium of Objects

A load (load that is being hoisted) can be balanced at a point known as the centre of gravity. This is also called the equilibrium point of an object. The shape and orientation of the object will influence the position of the centre of gravity. Therefore, it is very important for a rigger to know the centre of gravity of an object so that it will be in a stable and balanced condition when it is being hoisted by a crane. Figure 5.13 shows an unbalanced hitch that caused an object that was being lifted to swivel the moment it was hoisted. However, the object became stable after the balancing point or centre of gravity was vertically in line with the hitch source (sling hitch at the shackle).

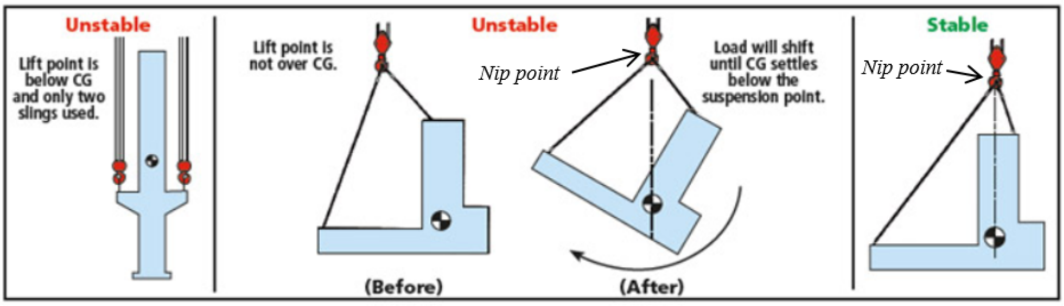


Figure 5.13 Centre of gravity and equilibrium of object
(https://www.lift-it.com/info_hitches_all.asp)

5.6 Slings selection based on load types

To ensure safety during hoisting works, the appropriate sling must be selected based on the following matters:

- Type of load to be hoisted
- Weight of the load
- Size of the load. Large-sized loads require longer slings
- Shape and orientation of the load
- Whether the load is provided with points to connect to a sling or not
- Whether the load can be easily damaged or not
- Whether the load is an individual load or is comprised of several loads hitched together

- Double hitches must be used with long slings
- Whether the load is in the form of ingots or bricks

Examples of loads that are usually hoisted as well as the use of the correct slings are shown in Figure 5.14.

a) Concrete containers must be hoisted using a single one-leg hitch sling.
b) A double hitch must be used when lifting a load of pipes or tubes.
c) A net must be used when hoisting a load in the shape of ingots or blocks.
d) Synthetic fabric slings can be used for short pipes. If the pipes are long, use two slings with a double choke hitch. A shackle is needed to join the 2 slings.
e) Special equipment is needed to lift containers, except for equipment that has been assessed and approved. This equipment comes with an ISO twistlock that is designed for the socket at each corner of the container. Never use any type of hook, shackle or other equipment that is directly connected/hitched to the container.
f) A single 4-leg hitch sling must be used to lift nets.
g) A double hitch must be used to hoist beams.

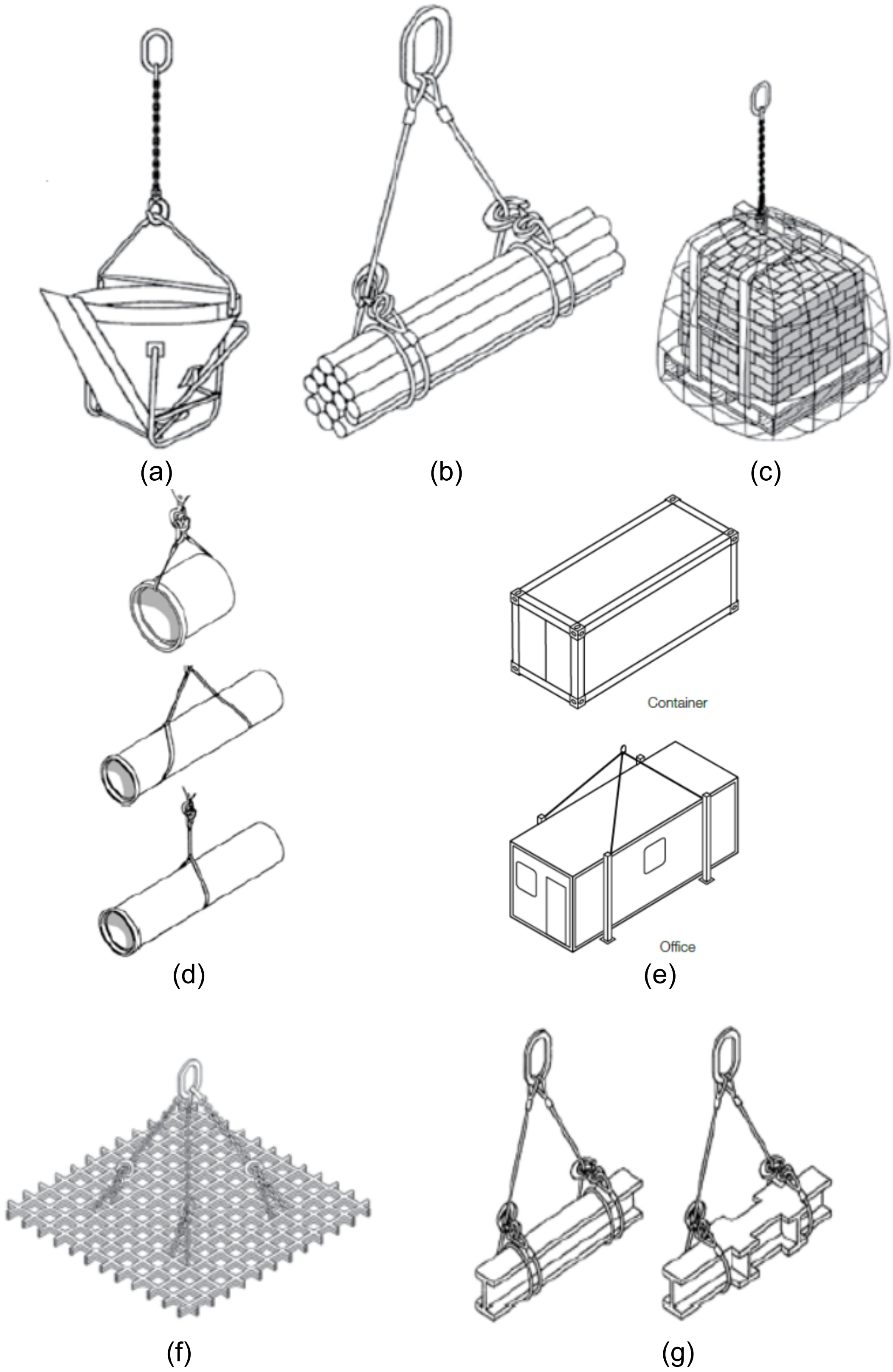


Figure 5.14 Example of a sling being used to lift a load (Laing O'Rourke, 2008)

Correct and wrong ways of using a sling

Figure 5.15 below shows the correct and wrong ways of using a sling to ensure that the load is safely hoisted.

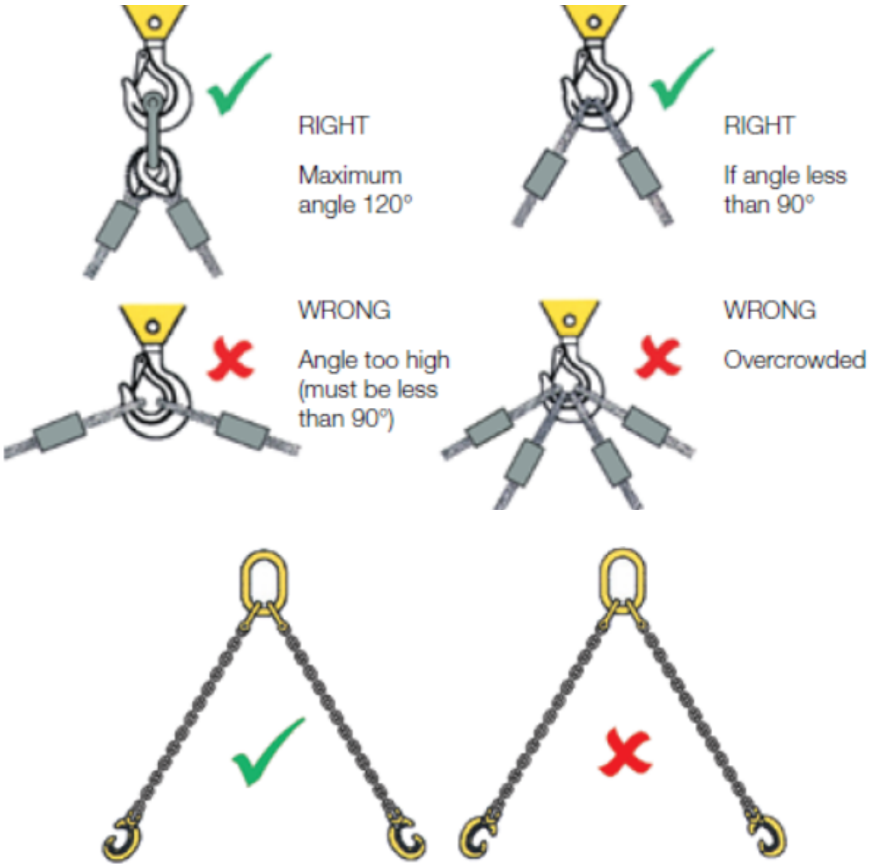


Figure 5.15 Correct and wrong ways of using a sling (Laing O'Rourke, 2008)

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CHAPTER 6

HOISTING EQUIPMENT

6.1 Introduction

Lifting equipment can be divided into three categories as follows:

1. Mechanical equipment that can raise and lower loads. For example, cranes, hook blocks, hoisting ropes and so on.
2. Equipment that connects loads to mechanical equipment for the purpose of raising and lowering. For example, ropes, slings, hooks, shackles and so on.
3. Equipment that combines the two categories of equipment mentioned above.

Detailed information regarding lifting equipment will be explained in the following chapter. This chapter describes the equipment that connects the load to the mechanical equipment.

6.2 Operating Principles for Equipment

- All lifting equipment must be made of materials that are suitable for their use. They should be tested according to the prescribed standards or conditions, and the test certificate must be identified before they can be used.
- All lifting equipment should have a safety factor that corresponds to its design.
- It is very important for the manufacturer/supplier to provide information regarding the suitable use of the equipment before it is put into operation.
- All equipment must have the SWL or WLL mark or label.

- It is necessary to select the appropriate equipment according to the compatibility of each load that is to be lifted. There are several different grades of quality of materials for the equipment, especially for hooks, links, rings and shackles. Their size also varies according to the capacity and the grade of the material.

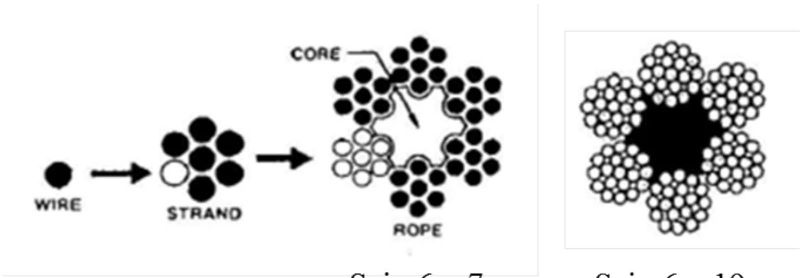
6.3 Types of hoisting equipment

6.3.1 Wire Ropes

Wire ropes are classified according to their size, construction, quality, structure and type of core.

(a) Wire rope structure

Figure 6.1 shows the main components of a wire rope, while Figure 6.2 describes the structure of a wire rope.



Saiz 6 x 7 Saiz 6 x 19

Figure 6.1 Forms and classes of wire ropes
(www.liftingoeregulations.blogspot.com.es)

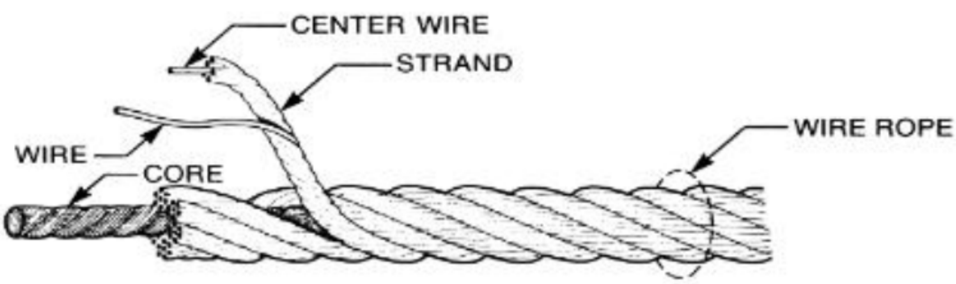


Figure 6.2 Structure of a wire rope (www.edwardswirerope.com)

Figure 6.3 Actual photo of a wire rope (www.liftsafegroupofcompanies-wordpress.com)

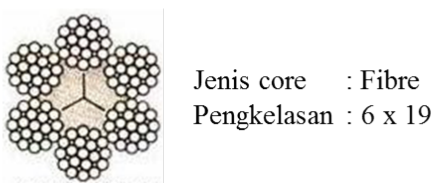
As can be seen in Figure 6.3, a wire is in the middle and six other wires are twisted around it, making it a total of 7 wires. This group of wires is called a strand. Six strands surround a core and are twisted into the required arrangement to form a flexible steel wire rope (FSWR). The size of the FSWR is stated as 6 x 7; meaning six strands and seven fine wires. To the right of Figure 5.1 is a wire rope with a different size, i.e. 6 x 19, meaning 6 strands with 19 fine wires forming each strand.

(b) Types of cores

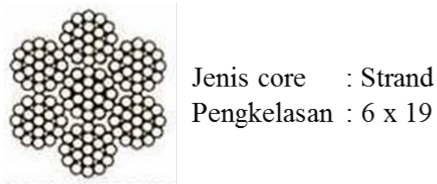
There are two types of cores:

i. Steel cores
 - Their strength is 7.5% more than that of fibre cores
 - They weigh 11% more than fibre cores.

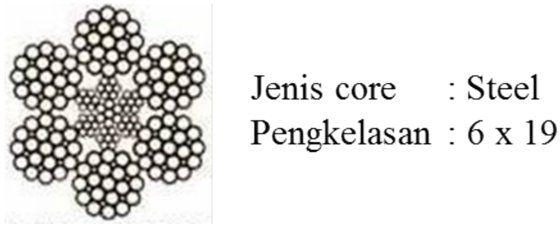
ii. Fibre cores



(a)



(b)



(c)

Figure 6.4 Wire ropes with different cores: (a) fibre core, (b) strand core, (c) steel core (Lee Stinnett, 1986)

- Fibre cores (Figure 6.4 (a)) are usually used for hoisting loads that are not heavy.
- In a wire strand core (Figure 6.4 (b), a group of fine wires, known as a strand, is used as the core to form an FSWR. Wire ropes with this type of core have a high tensile strength and form a larger FSWR.
- Meanwhile, in Figure 6.4 (c), a steel wire rope has been made into the core and six FSWRs have been made into a strand, thereby forming a large-sized FSWR. This type of FSWR will have a very high tensile strength and will give a high flexibility to the load if it is on a small drum or pulley. It is usually used for requirements on the ground and in high temperature conditions. Cranes that lift or lower loads that are extremely heavy will use this type of FSWR.

(c) Size of the wire rope

The size of a wire rope is measured at its diameter using Vernier callipers. Figure 6.5 shows the correct way to measure the diameter of a wire rope. The use of the wire rope varies according to its size.

- The minimum diameter for use as a sling is 8 mm.
- The minimum diameter for use as a hoisting cable is 11 mm.

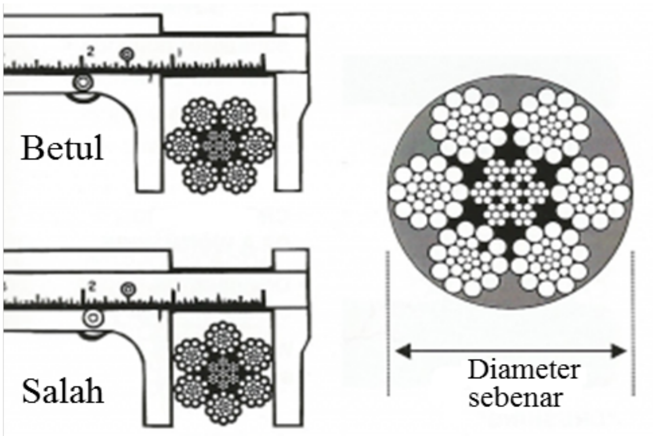


Figure 6.5 Correct way to measure the diameter of a wire rope (www.portcityindustrial.com)

(d) Quality and tensile strength of iron

Based on the production of iron wires from Australia, the international specifications for the classification of the strength of iron are as shown in Table 6.1.

Table 6.1 Classification of the strength of iron (Iron wires from Australia)

Type	*Minimum Tensile*	*Abbreviated Description*
Black 8Bright, non-galvanised) wire	1770 Mpa	1770 grade
Galvanised wire	1570 MPa	G1570 grade

G 1770 (Galvanised 1770 MPa) is the standard iron recommended for making FSWRs. The FSWRs are produced with sizes of 6 x 7, 6 x 19, 6 x 24 and 6 x 37, based on the construction of the FSWR.

(e) Wire rope arrangement

The arrangement of the FSWR depends of the wires that form the strands and the strand in the wire rope. The strands of wires will be twisted, and every twist is controlled by the type of arrangement required by the manufacturer (Table 6.2). Among the arrangements are:

(i) Right-hand ordinary lay (RHOL)

- Wires arranged in a clockwise direction from the right.
- The fine wires are horizontal.
- Suitable for lifting loads.
- Easily worn-out

(ii) Left-hand ordinary lay (LHOL)

- Left arrangement

(iii) Right hand Lang lay

- Coarser wires compared to RHOL/LHOL
- Not suitable for lifting loads because of stiffness

Table 6.2 Types of lays forming wire ropes (www.cableworksusa.com)

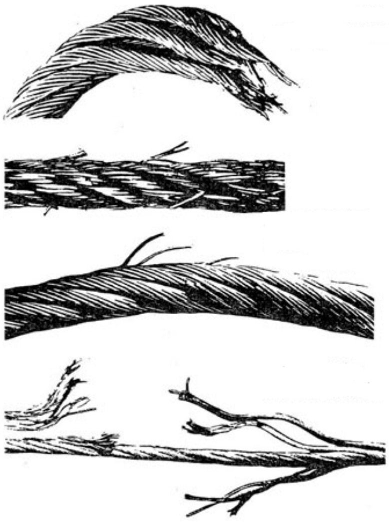
Lay types	Definition	Features
	This is a common lay, where the wire is twisted in one direction while the strand is twisted in the opposite direction. The diagram shows a right-hand lay.	• Not easy to knot and disentangle. • Easy to use • Not easily broken compared to a Lang lay

Right Lay 	Wires are twisted from the right in a clockwise direction. The diagram shows a regular lay	Commonly used on construction sites.
Left Lay 	Wires are arranged from the left in an anti-clockwise direction. The diagram shows a regular lay.	Generally, it is not used with equipment in the construction sector
Lang Lay 	The wires that form the strands as well as the strands are twisted in the same direction. The diagram shows a right-hand lay.	• Higher resistance to abrasion • More flexible and greater resistance to fatigue compared to a regular lay • Can be knotted and disentangled
Alternate Lay 	Combination of strands with regular right-hand lay and right-hand Lang lay.	Combines the best features of a regular lay and a Lang lay for boom hoists and winch lines.

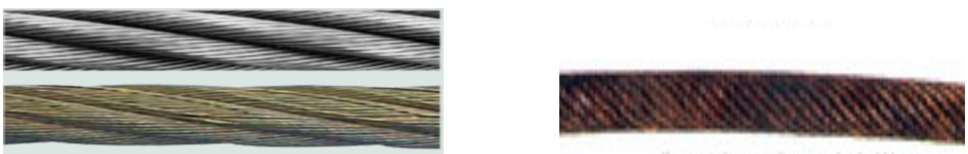
(f) Maintenance and inspection of wire ropes

- Avoid lifting loads with sudden jerks as this may damage the rope
- Avoid exposing the rope to temperatures above 95˚C
- Use suitable covers to protect the rope from sharp edges
- When hoisting, use ropes with a diameter of more than 11 or 12 mm.
- Do not use a Lang's lay rope (rope that is twisted in the same direction) unless the ends of the rope are tightened to prevent the rope from splitting.
- Do not allow the rope to become knotted or to split.
- Store in a clean and dry place.
- Ensure the rope is not exposed to any corrosive substance while in storage.
- Figure 6.6 shows several examples of the damage or destruction that can occur to wire ropes, making them unsafe for use.

(a) Knotted (www.work.alberta.ca)



(b) Strained (www.nasdonline.org)



(c) Eroded and rusted (www.maintworld.com, www.wisc-online.com)

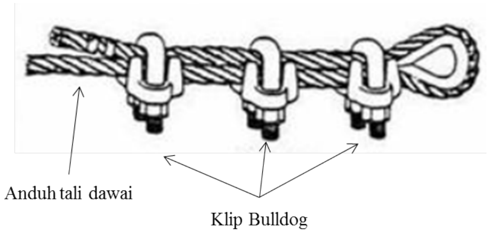
(d) Bird caging (unravelled) (www.work.alberta.ca)

Figure 6.6 Examples of damage to wire ropes

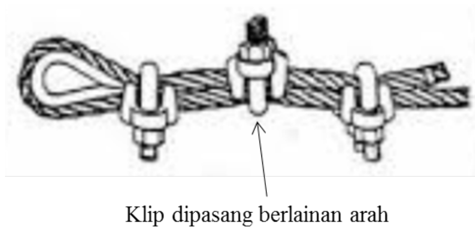
- Use of bulldog clips
  – It is necessary to ensure that the number of clips is sufficient for the size of the wire sling being used, as shown in Table 6.3 and Figure 6.7.

Table 6.3 Number of bulldog clips for use with different sizes of sling ropes

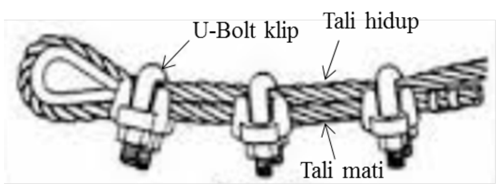
Saiz tali (Diameter, mm)	Bilangan klip minimum
8 - 20 mm	3
21 - 32 mm	4
Melebihi 32 mm	5



(a) Correct way



(b) Wrong way, where the clips are fixed in different directions



(c) Wrong way – U-bolt clips by the side of a live wire rope

Figure 6.7 Correct use of bulldog clips on a rope (Hoisting and Rigging Fundamentals for Riggers and Operators, 2002)

6.3.2 Synthetic slings

Figure 6.8 shows a few synthetic fabric slings that are used for hoisting works. There are several types of such slings, as shown in Figure 6.9. The materials and colour codes that are normally used for these slings are as follows:

- Nylon slings are marked with a green code
- Polyester slings are marked with a blue code
- Polypropylene slings are marked with a red/brown code

The minimum diameter for this type of slings is 12 mm

Figure 6.8 Picture of a synthetic fabric sling (www.craneinstitute.com)

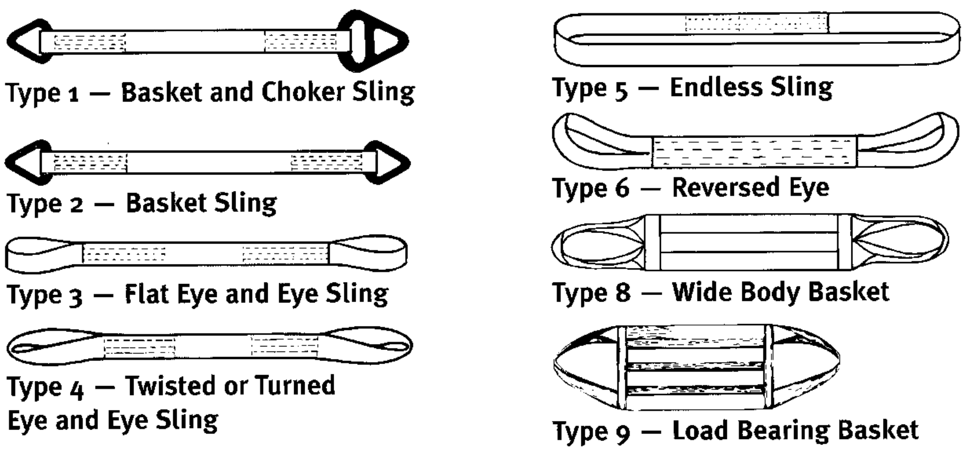


Figure 6.9 Some types of synthetic fabric slings (www.totaltool.com)

(a) Maintenance and inspection

- Loads that are suitable for use with synthetic fabric slings
  - Iron/plastic/polyvinyl chloride (PVC) pipes
  - Electric motors
  - Engines
  - Materials that are non-abrasive.
  - Circular materials that are non-abrasive.

- The sling must be inspected before use to ensure
  - It has the SWL/WLL mark (see Figure 5.14)
  - It is stored in a place where the temperature is not more than 9°F, and it is not exposed to chemicals.
  - There are no burn marks on the sling.
  - The damage that usually occurs with slings includes;
    - Being cut
    - Decay
    - Knotted
    - Entangled
    - Wear

(b) Damage to synthetic fabric slings

Figures 6.10 shows several examples of damage or defects that commonly occur. A sling cannot be used if the following defects are identified.

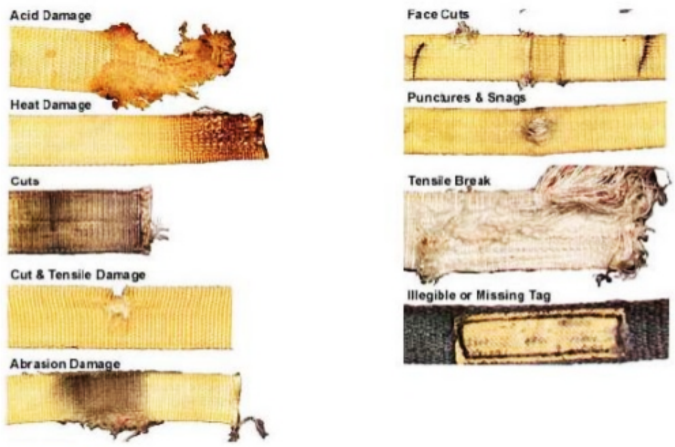


Figure 6.10 Damage to a synthetic fabric sling (www.stren-flex.com)

6.3.3 Chain slings

A grade T 800 Herc-Alloy chain is normally used, with its specifications being according to the Australia 2321-1979 standard. The short-link chain that is used as a sling has the following features:

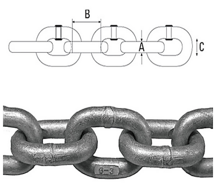
- Minimum tension of 800 MPa to the destruction of strength for a breaking load
- Minimum tension of 400 MPa for a load test approval
- Total minimum elongation limit of 17%

Meanwhile, the working load limit (WLL) according to the same standard is as follows:

- Tension of 200 MPa at the working load limit
- Safety factor: 4.0

(a) Types of chains (Table 6.4)

Table 6.4 Types of chains and their uses

Type of Chain	Use
Short Link  (Sumber: qdacsco-rigging.com)	Lifting Loads
Long link  (Sumber: suncorstainless.com)	Hitching Loads
Stad Link  (Sumber: zszhongnan.com)	For marine use
Calibrated  (Sumber: seagoyachting.com)	For chain blocks
Bush Roller  (Sumber: tsubaki.eu)	For motorcycles that involve gears or sprockets

Short link chains are used to hoist loads, and can be categorised according to their grade. Table 6.5 shows the grades of short link chains and their labels.

Table 6.5 Grades and labels for short link chains

Gred rantai pendek	Label
30	L
40	M
50	P
60	S
80	T

Examples of chain labels are shown in Figure 6.11.

Figure 6.11 Chain labels (www.tresterhoist.com, www.blog.cmworks.com, www.auslift.com.au, www.brindleychains sproket.co.uk)

Figure 6.11 shows the tag/label that is usually attached or affixed to one of the chains. The tag/label provides information on the grade of the chain and the SWL/WLL to show the strength of the chain as a sling.

(b) Use of chains

- The use of a single-leg short link chain is shown in Figure 5.16.

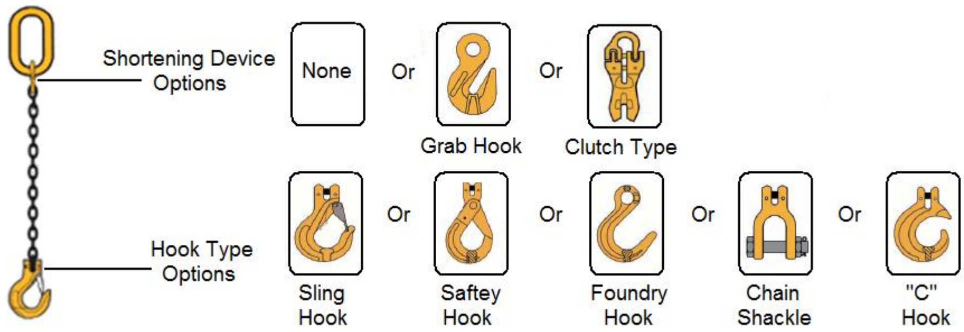


Figure 6.12 Single-leg short link chain with a master link and hook (www.liftsolution.co.uk)

- The use of a four-leg short link chain is shown in Figure 5.17.

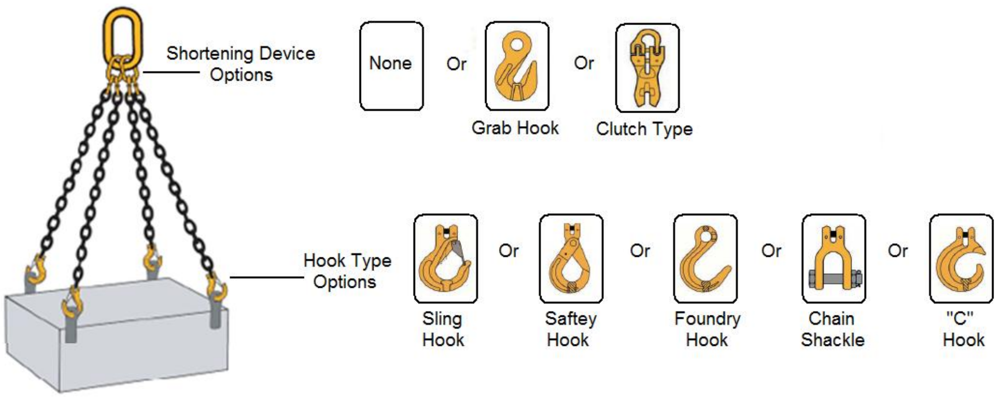


Figure 6.13 Four-leg short link chain with master link and hook (www.liftsolution.co.uk)

(c) Maintenance and inspection of chains

- The diameter of the chain link can be measured using Vernier callipers (Figure 6.14).
  - A minimum diameter of 6 mm is required for use as a sling.

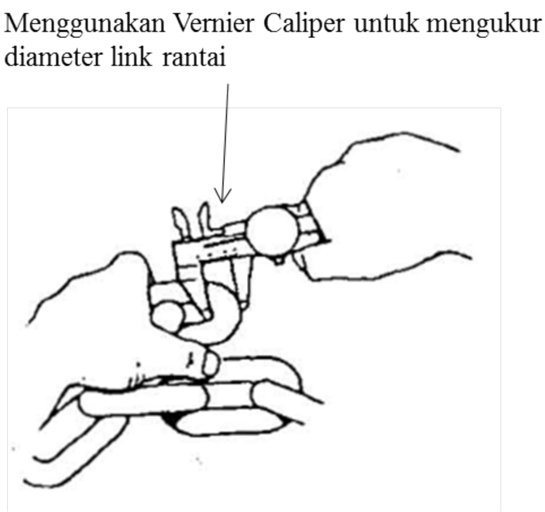


Figure 6.14 Method for inspecting chains

- **The following must be complied with to ensure the safe use of chains:**
  - Do not lift loads that exceed the weight limit.
  - Do not lift loads with sudden jerks
  - Do not allow the chain to become knotted.
  - Do not expose the chain to chemical substances
  - Store the chain at a temperature below 2°F
  - Every chain that is used must have the SWL/WLL label.

- **Use of clutch hooks**

  A clutch hook is used to shorten a chain. Figure 6.15 shows the correct way to fasten a clutch hook. By using this method, the capacity/strength of the sling will not be reduced even though it is shortened.

Attention:

Be careful to ensure the chain is pulled straight after it has been inserted into the clutch hook (refer to Figure 6.16.

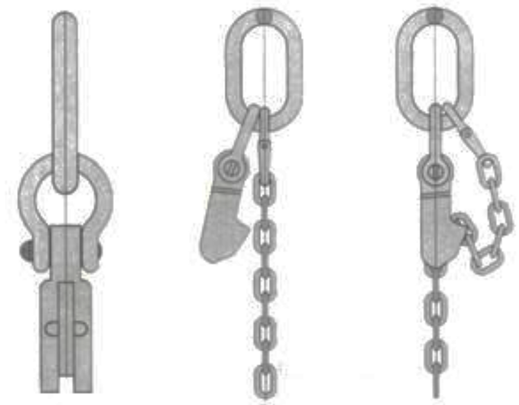


Figure 6.15 Use of clutch hook (www.ecvv.com)

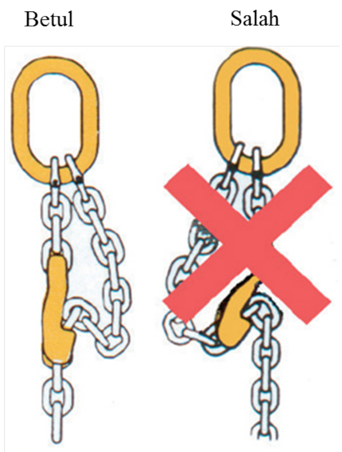


Figure 6.16 Correct and wrong use of clutch hook (www.nobles.com.au)

- Damage to chains

  Chains must be checked before use. A chain that is damaged or defective cannot be used because it can cause accidents. Figure 6.17 below shows several examples of damaged chains.

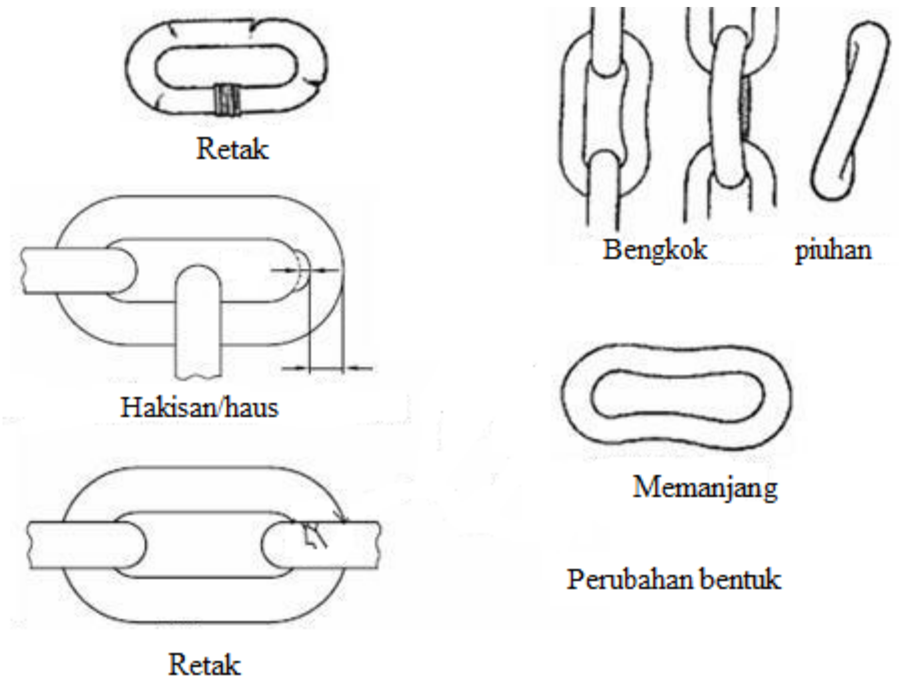


Figure 6.17 Damage to chains (www.Suggest-keywords.com)

- Things to avoid when using chains

  Figure 6.18 below shows several examples of the wrong use of chains and things that should be avoided to prevent accidents and damage to the chains.

Figure 6.18 Wrong ways of using chains (www.practicalmaintenance.net)

6.3.4 Fibre ropes

Fibre ropes are made from waste materials, and equipment can be damaged or destroyed if they are exposed to high temperatures, fire and chemical substances. Therefore, such equipment needs to be inspected frequently. Fibre ropes are used as taglines to control or stabilise loads that are being hoisted to prevent them from swinging (Figure 6.19). They are suitable as taglines because they are flexible and are non-conductors.

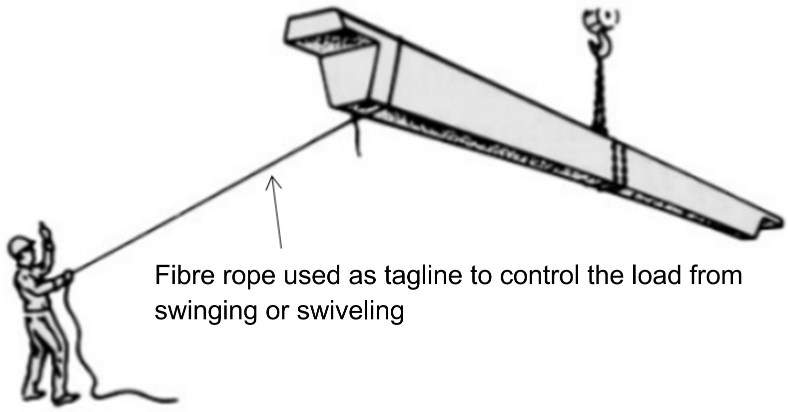


Figure 6.19 Use of fibre rope to control loads (www.lift-it.com)

Maintenance and inspection of fibre ropes

- Fibre ropes must be stored in a dry and clean place, and be protected from:
  - Falling objects
  - Fire, sparks and heat
  - Acids and corrosive chemicals
  - Dust
  - Pests such as rats

- Fibre ropes must be inspected before use for:
  - Any change in colour due to burn marks, exposure to sunlight
  - Change in colour due to corrosion
  - Narrowing or elongation of the rope due to overloading
  - Decay to the rope

- Safety measures when handling fibre ropes
  - Ensure the rope is not entangled around the foot during operations
  - Do not coil the rope around the hand during operations

– It is better to use a long rope rather than a short one

Tagline

The ends of tagline such as fibers are types that are easy to decompose. Therefore, each end of this type of straps should be tied to avoid breaking down and may affect safety during the lifting operation. Figure 6.20 shows one of the common bonding methods used to tie the ends of the tagline. Figure 6.21 - 6.23 shows the method of bonding sailmaker, crown knot and side eye splice that are also used to tie the ends of the fiber rope so as not to break down.

Tagline bonding method is also important to unsure its not easily pulled out when pulled. Figure 6.24 - 6.27 shows examples of rigging methods on loads during lifting operations such as clove hitch, bowline, rolling hitch, and timber hitch.

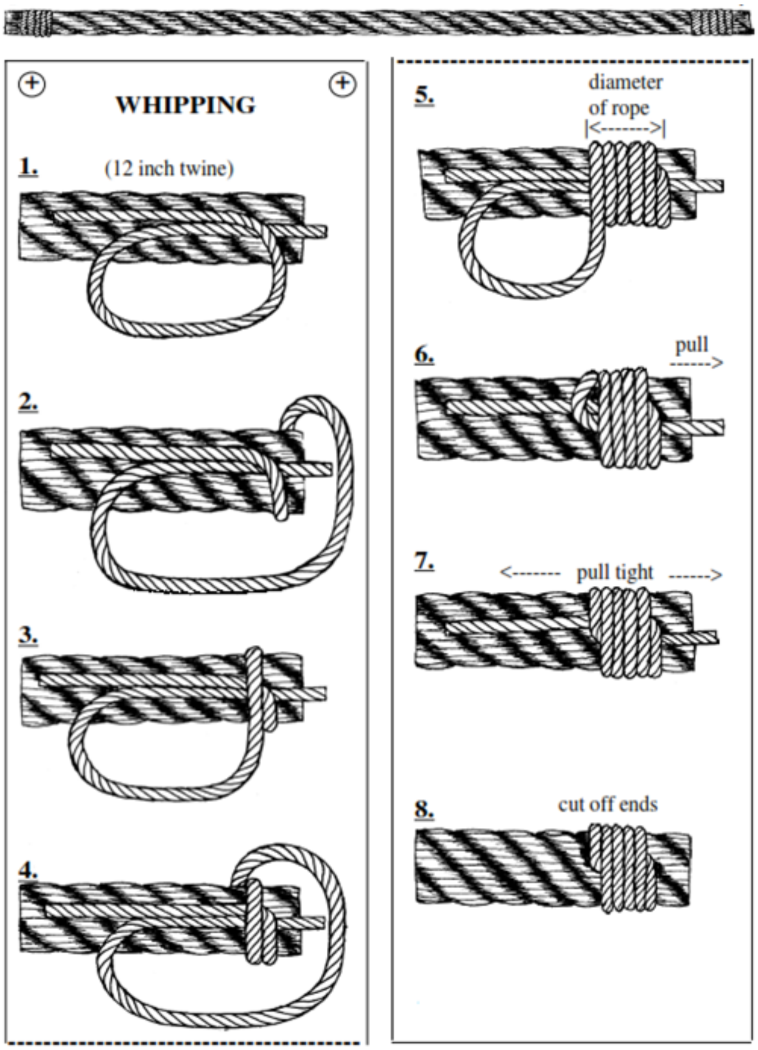


Figure 6.20 Tagline bonding method –whipping (Gerald L. Findley, 1999)

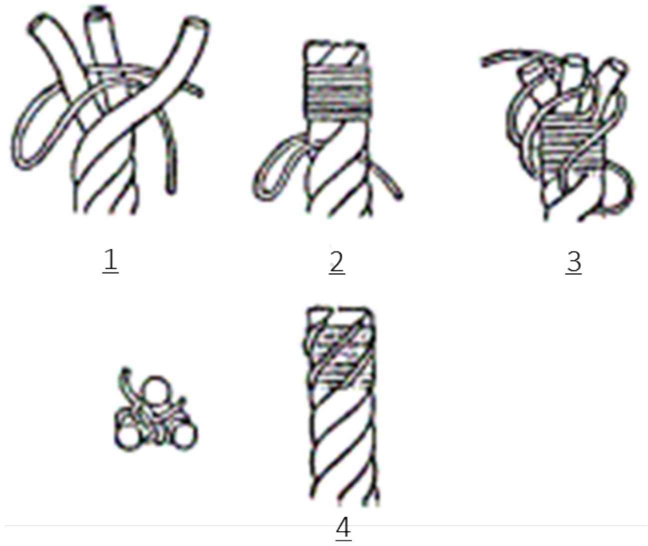
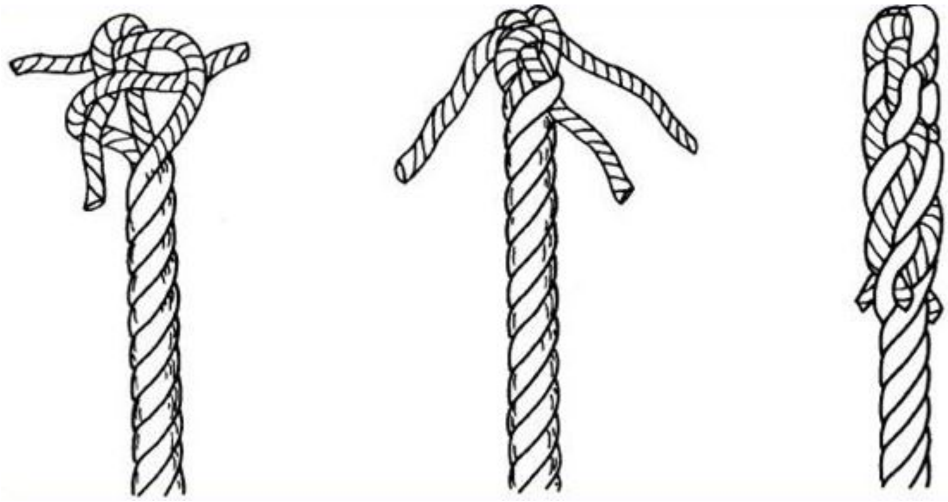
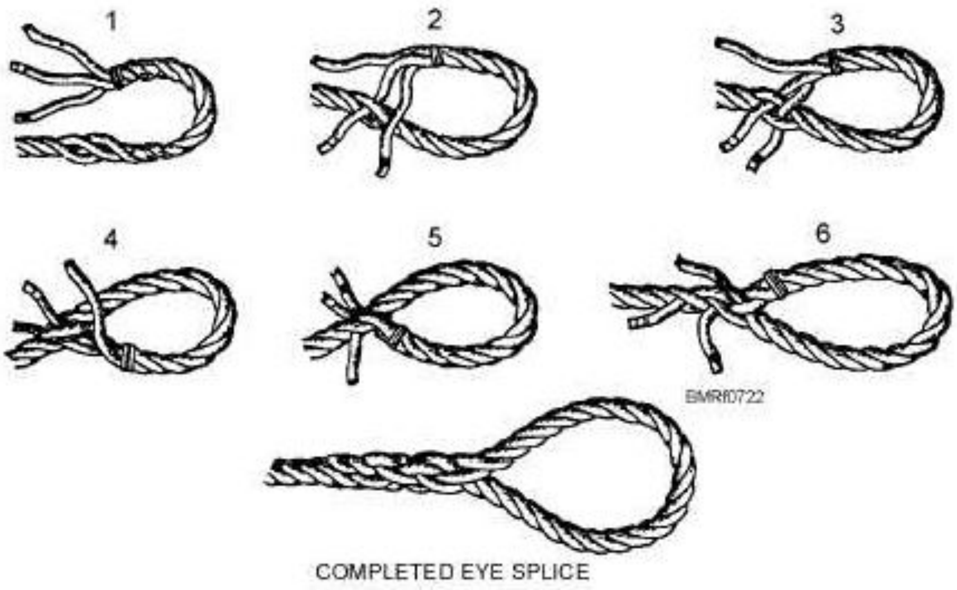


Figure 6.21 Tagline bonding method- *sailmaker* (sailmakerswhip.gif)



Rajah 6.22 Tagline bonding method- *crown knot* (walawi.com)



Rajah 6.23 Tagline bonding method- side eye splice (antisanry.blogspot.com)

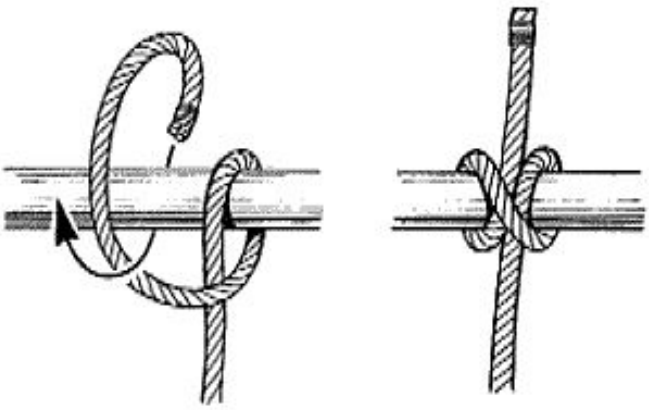


Figure 6.24 Tagline bonding method- *clove hitch* (educatedclimber.com)

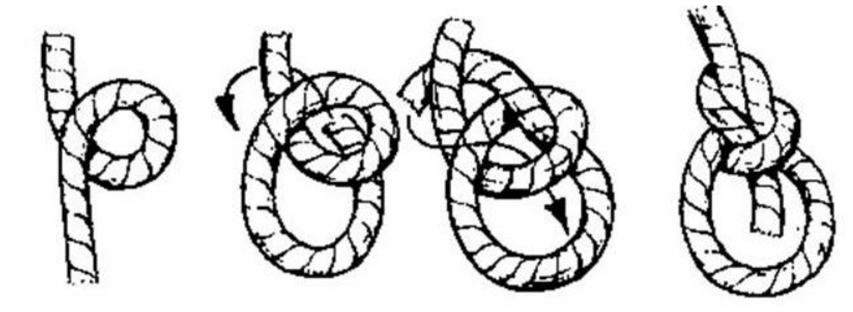


Figure 6.25 Tagline bonding method- *bowline* (pioneeringmadeeasy.co.uk)

1 2 3

Figure 6.26 Tagline bonding method- *rolling hitch* (skippertips.com)

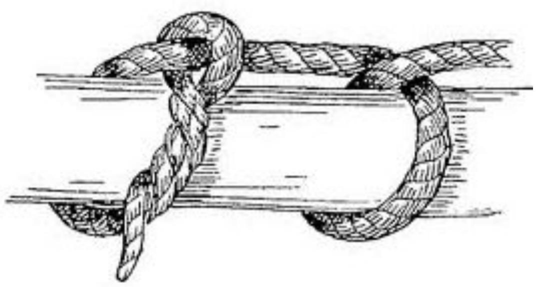


Figure 6.27 Tagline bonding method- *timber hitch* (knowknots.com)

6.4 Procedure for Selecting the Right Sling

- Determine the weight of the load that is to be hoisted beforehand.
- Determine the hoisting method that is to be used, whether it is to be by a single sling, double sling or the use of a sling together with other tools (spreader beam, etc.)
- Determine the required size of the sling based on the safe working load (SWL), whether from a table or by calculations.
- Determine the length of the sling and take into account the sling angle if the hitch is to be at an angle according to the hoisting method.
- Ensure the distance between the sling and the load is measured accurately according to the required angle.

- Select the type of sling that is appropriate for the material to be hoisted.
- Follow all the instructions for the sling with regard to its SWL/WLL and the suitability of its use.

6.5 Storage of Slings

- Before or after a sling is used, it must be cleaned with high-pressure air.
- Do not keep slings in a store with acids, alkalis, chemicals and other liquids that can damage the slings.
- Do not mix slings that can be used with slings that are already damaged and cannot be used (store them separately).
- Before storing after cleaning, rub some grease or oil on FSWR slings.

6.6 Safety Practices When Using Slings

The strength of a sling during hoisting work depends on:

- The weight and shape of the object to be hoisted
- The type of equipment used
- The method of rigging a load

Therefore, to ensure safety when a sling is being used to lift a load, the following criteria should be complied with:

- The sling must be inspected before it is used
- A sling cannot be knotted or damaged
- A sling cannot be shortened by knotting it or by tying it between other lifting gear components
- Clear away all obstacles when hoisting loads
- The sling must be hitched safely and correctly to the load
- The legs of the sling cannot be twisted
- The sling cannot be used to lift loads that exceed the SWL/WLL
- The sling must be shielded from sharp objects
- Loads with a basket hitch must be balanced
- Do not allow loads to be dragged.

- Do not pull on a sling that is caught beneath a load
- It is prohibited to lift persons using a sling
- All lifting equipment must be inspected before and after hoisting a load, and a report must be made of any damage
- All lifting equipment must have the SWL/WLL mark
- Do not use a hard object to tighten the hitch on a sling
- The load should be covered, especially if it has sharp edges, to avoid damaging the sling
- Ensure that all the sling legs are in place and that the master link is inserted in the latched hook
- Check each sling hitch to ensure that it is correct.

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CHAPTER 7

LIFTING ACCESORIES

7.1 Introduction

Lifting gear is one of the important components used in hoisting works involving tower cranes. Each lifting gear has its own features and specifications to ensure that it is not used wrongly or with excessive loads. The tool concerned must also be checked each time it is to be used, and proper care and maintenance should be provided to ensure that it will be safe for use as well as to prolong the life of the tool.

Below are some examples of lifting gear:

- Shackles
- Eye bolts
- Hook blocks
- Pulleys
- Turnbuckles
- Spreader beams
- Plate clamps

7.2 Selection of Lifting accesories

- The tool concerned must be suitable, strong and stable enough for a particular use, and it should be marked with the safe working load.
- Every lifting aid and its components should be identified by its working load limit (WLL) and safe working load (SWL).
- The position of the tool and the type of tool to be installed can reduce any risk of injury/accident.
- To ensure the safe use of lifting gear, the work must be planned, organised and implemented by competent persons.

- A lifting gear tool that does not display/bear the WLL/SWL mark should not be used.

7.3 Inspection

- Employers can appoint someone in their service or an outsider with expertise in the structure, use and inspection of lifting equipment to carry out inspections.
- The inspector must be able to detect faults and defects, and estimate their impact on occupational safety.
- The instructions of the manufacturer must be taken into consideration in the inspection.
- The inspections usually involve visual assessments to determine the effects on the safe operation due to wear, change of shape or damage. If necessary, the inspection can include non-destructive inspection methods
- Inspection marks must be made on every tool to avoid the use of equipment that has not been checked and to facilitate the carrying out of the inspection.
- An effective way of preventing accidents from occurring due to the use of lifting gear that failed inspections and cannot be repaired is to dispose of them completely. After overloading or damage, a thorough inspection of the lifting gear must be conducted before they can be used once again.
- Before a new lifting tool is used, it must be checked to confirm that it complies with all aspects of the operating requirements and is suitable for use.
- Users need to check all lifting gear tools that are used daily on a continuous basis. Tools that are used less frequently must be checked each time the equipment is taken for use.

7.4 Maintenance

- The safe and correct care and storage of lifting tools can protect them from damage and extend their service life.

- Overloading is strictly prohibited. Check the WLL to verify the work load.
- Lifting gear must be well-maintained in reference to the manufacturer's manual.
- The weight of the load to be lifted must be accurate. This weight must include every part that is involved including the hook block, ropes, beams, shackles, slings and so on.
- Ensure that every lifting operation is controlled and free from unplanned movements, and that the centre of gravity is known.

7.5 Repair and Disposal

If there is a lifting tool that shows signs of damage, defects or any uncertainty as to the integrity of the tool, it should not be used, and should be marked with the "**Not Usable**" tag.

The tool concerned must be referred to the hoisting supervisor, who will conduct a lifting assessment, and has the authority to decide whether the damaged tool is to be repaired or disposed of. Any lifting gear that is cracked, broken or bent cannot be repaired and must be replaced.

Repairs

a) All repairs must be conducted by the supplier or an experienced person by referring to the original manufacturer's specifications and any applicable standards.

b) All slings and lifting gear that undergo repairs must be marked according to the relevant standard and then tested to fulfil the following criteria:
   - the tool that is repaired complies with the original strength requirements;
   - the tool has been marked to identify who carried out the repairs; and
   - all tools with cracked, broken or bent parts are replaced and not repaired.

c) If the identification tag and marking have been separated or cannot be read, the lifting tool can be returned after an assessment by a qualified inspector. If the tool is found to be in good condition, it must undergo tests to verify the WLL or SWL, and it will be marked once again after the process is completed.

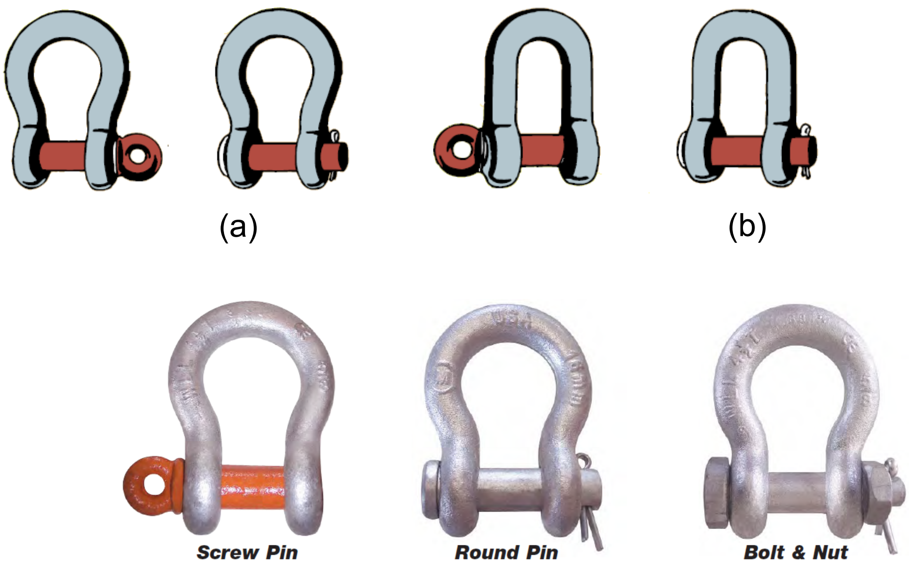
Disposal

All lifting gear tools that are damaged or defective must be assigned the "**Not Usable**" status before they are disposed. If a sling shows signs of defects, it cannot be used and must be disposed of immediately. The registration of lifting gear must be coordinated.

7.6 Lifting accesories

7.6.1 Shackles

A shackle is a hitching component that is comprised of a U-shaped steel piece with a pin through the open end. Shackles are used together with other hitching components such as wire ropes or chain slings for fixed lugs or fittings. There are two types of shackles, i.e. D shackles and bow shackles, as shown in Figure 7.1. Both types of shackles come with a screw pin or a round pin.



(a) (b)

(c)

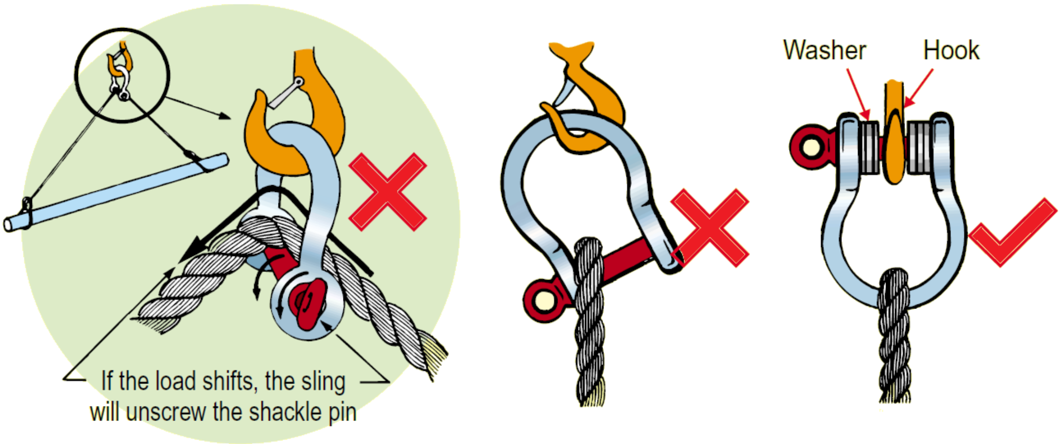
Figure 7.1 Types of shackles: (a) bow shackle, (b) D shackle (Safe Lifting 2002), (c) types of pins on shackles (www.cmindustrial.com)

- A shackle is a kind of loose lifting aid. It should be marked with the WLL or SWL and other usage restrictions as specified in the handling instructions given during delivery.
- Shackles should be tightened before the lifting operation is carried out.
- The surface of each shackle should be marked by the manufacturer to indicate the following information:
  a) name or trademark of the manufacturer
  b) loading rate (WLL or SWL)
  c) size
  Note: This information should not be missing and must be legible.
- Always place the load at the centre of the shackle pin (Figure 7.2) to avoid the angle pull at the end of the shackle.
- The selected shackle must correspond with the load that is to be hoisted. When shackles are used on pad eyes (Figure 7.2 (c)), only shackles that match the WLL of the pad eyes should be used.
- Only shackles with double locks (namely, nuts and wedge pins or screws with wedge pins) are used to lift loads. Other types and designs of shackles can be used for static loads.
- Fixed connections that cannot be monitored continuously must be installed with wedges to prevent the pins from opening.
- The load on the shackle should be perpendicular to the pin (see Figure 7.2(b)).

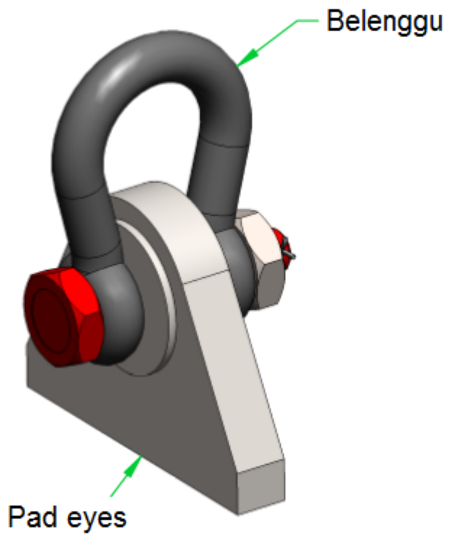
Things to note:

- Never replace a shackle with a bolt.
- Ensure the pin is fully locked.
- Do not use a screw pin shackle if the pin is loose and cannot be screwed on.
- When lifting a load, the shackle should not be leaning to one side.
- Pin shackles should always be fastened to the hook when a load is being lifted.
- A bush can be used at the centre of the shackle.
- The angle limit for bow shackles is from 0^{o} to 90^{o} (Table 7.1)

- Bow shackles are suitable for use with more than one sling.
- D shackles are used to lift loads vertically and are only suitable for use with a single sling.
- The maximum sling angle for shackles is 120º (Figure 7.3).
- Shackles will exhibit extreme deformation before failure.



(a) (b)



(c)

Figure 7.2 Methods for attaching slings to shackles: (a) wrong way, (b) correct way (load perpendicular to pin) (Safe Lifting 2002), (c) connection to pad eye (www.technikdesign.co.uk)

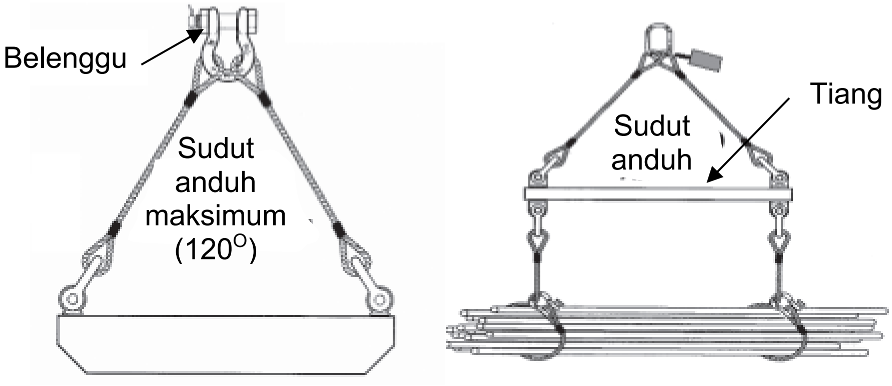
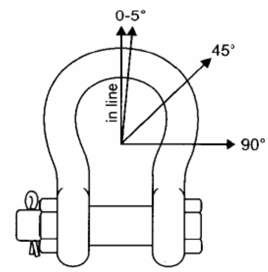


Figure 7.3 Shackles or pole links must be used when the angle is more than 90° but less than 120° (Technical Advisory for Safe Operation of Lifting Equipment, 2009)

Table 7.1 Load angle specifications for screw and bolt shackles

Side Loading Reduction Factors Screw Pin and Bolt Type Shackles		
	Angle of Side Load from Vertical In-Line of Shackle	Percent Rated Load Reduction
	0° - 5°	0%
	5°- 45°	30%
	46°-90°	50%
	Over 90°	Avoid

Source: Basic Rigging Workbook, 2008

Inspection

- Check visually to ensure that the pin grooves are intact and the shackles are free of fractures or deformations.
- Check shackles before and after they are used.
- Check for wear and the pin alignment at the shackle opening, and for wear on parts of the shackle (Figure 7.4).
- Ensure that the WLL mark can be clearly seen and it has been permanently marked on the body and the pin, and refer to the specifications of the manufacturer/maker of the tool concerned (Figure 7.5).

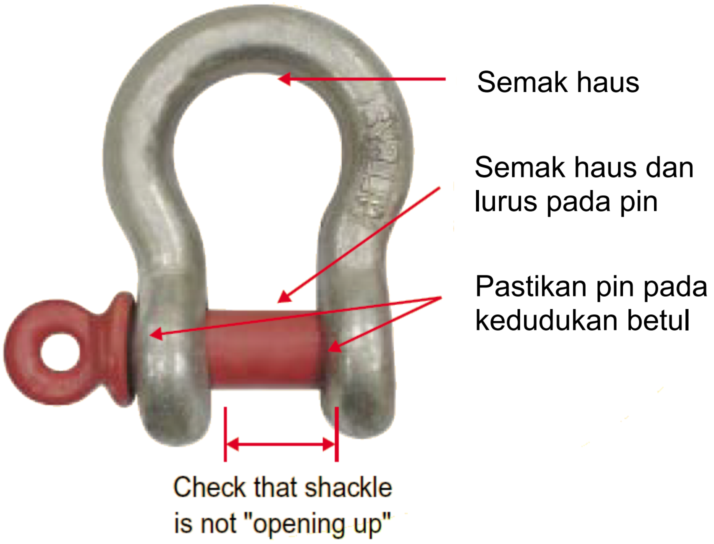
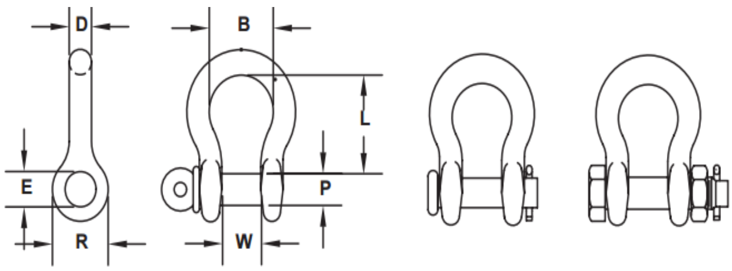
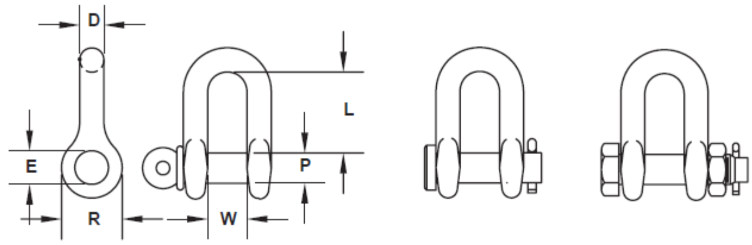


Figure 7.4 Parts of the shackle that must be checked before use (Safe Lifting 2002)



Size D	Working Load Limit	Product Code (Screw Pin)	Product Code (Round Pin)	Product Code (Bolt & Nut)	P	E	W	R	L	B min	Weight
in.	Ton				in.	in.	in.	in.	in.	in.	lb.
3/16	1/2	M645	M345	-	0.250	0.307	0.375	0.625	0.875	0.562	0.06
1/4	3/4	M646	M346	M846	0.312	0.401	0.469	0.875	1.125	0.750	0.12
5/16	1	M647	M347	M847	0.375	0.463	0.531	1.000	1.250	0.812	0.20
3/8	1-1/2	M648	M348	M848	0.438	0.531	0.656	1.125	1.437	0.937	0.30
7/16	2	M649	M349	M849	0.500	0.593	0.750	1.250	1.689	1.062	0.50
1/2	3	M650	M350	M850	0.625	0.718	0.813	1.375	1.875	1.187	0.75
5/8	4-1/2	M651	M351	M851	0.750	0.843	1.063	1.875	2.375	1.500	1.30
3/4	6-1/2	M652	M352	M852	0.875	0.968	1.250	2.125	2.813	1.750	2.30
7/8	8-1/2	M653	M353	M853	1.000	1.109	1.438	2.375	3.312	2.000	3.50
1	10	M654	M354	M854	1.125	1.234	1.688	2.625	3.750	2.312	5.00
1-1/8	12	M655	M355	M855	1.250	1.375	1.812	2.875	4.250	2.625	7.00
1-1/4	14	M656	M356	M856	1.375	1.531	2.031	3.250	4.688	2.875	9.50
1-3/8	17	M666	M366	M866	1.500	1.656	2.250	3.500	5.250	3.250	12.50
1-1/2	20	M657	M357	M857	1.625	1.781	2.375	3.750	5.750	3.375	15.28
1-5/8	24	M685	M385	M885	1.750	1.906	2.625	4.125	6.250	4.000	23.50
1-3/4	30	M677	M377	M877	2.000	2.156	2.875	4.500	7.000	4.500	27.70
2	35	M658	M358	M858	2.250	2.406	3.250	5.250	7.750	5.250	39.00

(a)



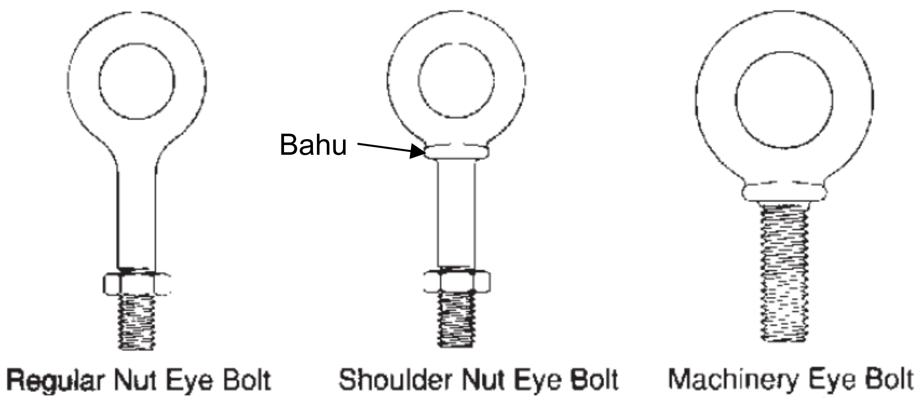
Size D	Working Load Limit	Product Code (Screw Pin)	Product Code (Round Pin)	Product Code (Bolt & Nut)	P	E	W	R	L	Weight
in.	Ton				in.	in.	in.	in.	in.	lb.
1/4	3/4	M746	M546	M946	0.312	0.401	0.469	0.875	0.875	0.12
5/16	1	M747	M547	M947	0.375	0.463	0.531	1.000	1.031	0.20
3/8	1-1/2	M748	M548	M948	0.438	0.531	0.656	1.125	1.250	0.30
7/16	2	M749	M549	M949	0.500	0.593	0.750	1.250	1.437	0.50
1/2	3	M750	M550	M950	0.625	0.718	0.813	1.375	1.625	0.75
5/8	4-1/2	M751	M551	M951	0.750	0.843	1.063	1.875	2.000	1.30
3/4	6-1/2	M752	M552	M952	0.875	0.968	1.250	2.125	2.375	2.30
7/8	8-1/2	M753	M553	M953	1.000	1.109	1.438	2.375	2.812	3.50
1	10	M754	M554	M954	1.125	1.234	1.688	2.625	3.188	5.00
1-1/8	12	M755	M555	M955	1.250	1.375	1.812	2.875	3.562	7.00
1-1/4	14	M756	M556	M956	1.375	1.531	2.031	3.250	3.938	9.50
1-3/8	17	M766	M566	M966	1.500	1.656	2.250	3.500	4.438	12.50
1-1/2	20	M757	M557	M957	1.625	1.781	2.375	3.750	4.875	17.20
1-5/8	24	M785	M585	M985	1.750	1.906	2.625	4.125	5.250	23.50
1-3/4	30	M777	M577	M977	2.000	2.156	2.875	4.500	5.750	27.70
2	35	M758	M558	M958	2.250	2.406	3.250	5.250	6.750	39.00

(b)

Figure 7.5 Specifications for (a) bow shackles, and (b) D shackles of various sizes and WLLs (CM Complete Lifting Systems, 2009)

7.6.2 Eye bolts

Eye bolts can be classified into two types, namely those with a collar and those without a collar (normal type), as shown in Figure 7.6. It is recommended that only eye bolts with a collar be used for hoisting works.



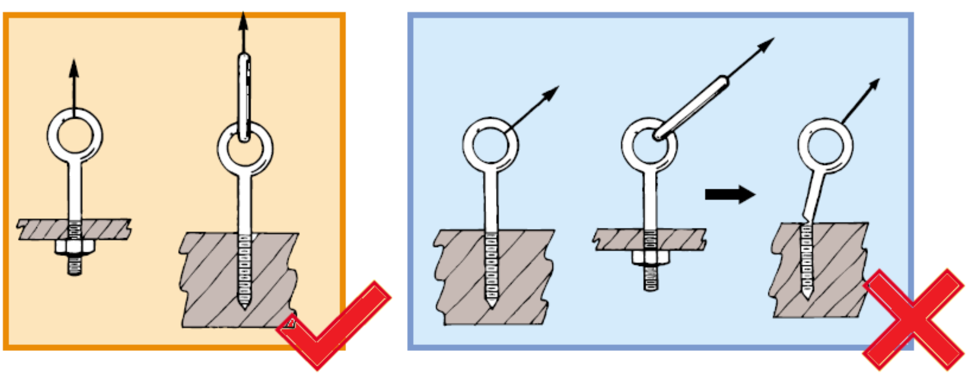
(a) (b)

Figure 7.6 Types of eye bolts: (a) without a collar, (b) with a collar (Bechtel Equipment Operations Rigging, 2002)

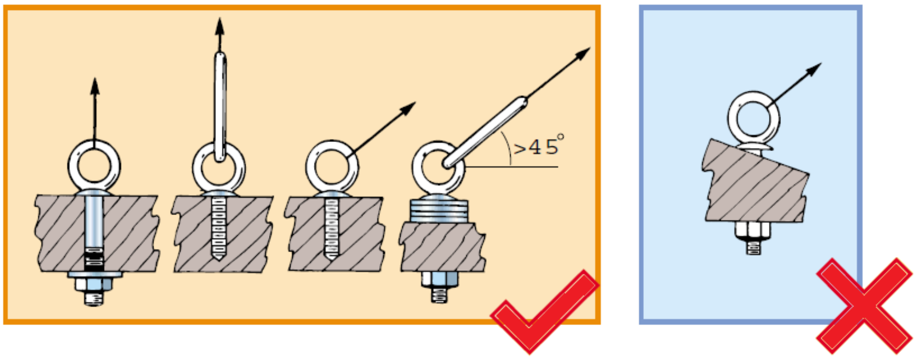
Eye bolts with collars are used for vertical and angled hoisting where, for the latter, the SWL of the tool concerned must be noted. An angle of less than 45° is prohibited (see Figure 7.7). Collared eye bolts must be level with the surface and the screw. Eye bolts without collars are used only for vertical hoisting as angled hoisting will bend the shaft of the eye bolt.

Things to note:

- The length of the bolt must be 1-1.5 times the diameter of the bolt. The bolt must be drilled into the load and must fit into the bolt hole.
- When using a single eye bolt, safety measures must be taken to prevent the eye bolt from coming loose. If possible, use at least two or more eye bolts.
- Eye bolts must be marked with the WLL code or their capacity, and possible restrictions as to their use must be specified in the handling instructions on delivery.
- Loads can be placed on eye bolts at a vertical angle (90°) or at a maximum angle of 45° (Figure 6.7 (b)).
- When using eye bolts and eye nuts, appropriate consideration should be given to the weight of the load to be hoisted and the number of eye bolts/eye nuts required.
- Eye bolts must be screwed down tightly so that the collar is fully in contact with the surface.
- A bush can be used to prevent the load from leaning on the eye bolt (Figure 7.8)
- A sling cannot be used through one eye bolt alone.



(a)



(b)

Figure 7.7 Correct and wrong way of hitching: (a) an eye bolt without a collar, (b) an eye bolt with a collar (Safe Lifting, 2002)

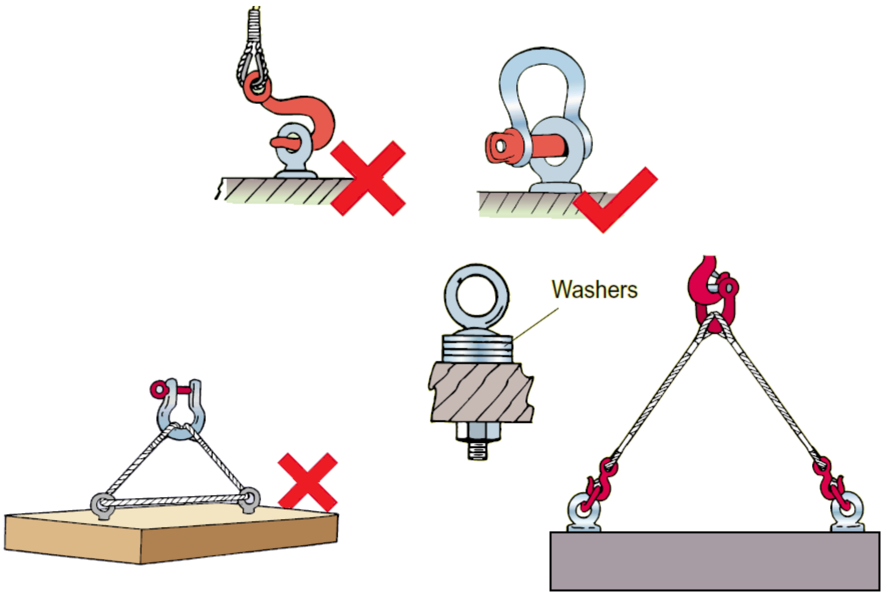


Figure 7.8 Correct and wrong way of hitching and slinging using eye bolts (Safe Lifting, 2002)

Inspection checklist before using eye bolts:

- All eye bolts must be forged, moulded or stamped permanently with the name or trademark of the manufacturer, its size or capacity, and grade (alloyed eye bolts only). This information must not be missing and should be legible.
- Eye bolts must be checked before use, and must be frequently checked during use.

- The grooves of the eye bolts must be visually inspected, and the eye bolts must be tightened completely and be free of deformations.

Avoid use in the following circumstances:

- The eye bolt has nicks/cuts, gouges or a bent pin.
- Severe wear (reduction of 10% in the original dimensions).
- There is wear, rust and/or distortions on the grooves of the bolt.
- There are signs of damage from heat, sparks or knocks due to welding.
- Any modifications or improvements to eye bolts such as grinding, machining, welding, and any changes to their shape by knocking, pressure and so on are not permitted.
- Drilled holes should be cleaned, and the grooves should be checked for any wear and deterioration.

7.6.3 Hook Blocks

A hook is connected to a hook block assembly, and it is also installed with sheaves and pulleys carrying ropes. Hook blocks are designed in different shapes and sizes to fulfil various hoisting requirements. They can be classified as oval or diamond-shaped, or as snatch blocks, which are also known as gate blocks (Figure 7.9).

These blocks are more flexible, and can easily lift loads. The main function of the block is to freely rotate and position the load. This block is provided with a single or paired fixed or rotating hook and also with a fixed or rotating shackle. The advantage of a retractable block is that it allows the rope to be reeved to the pulley when the ends of the rope are not free. The block or any other pulley assembly should come with guards to prevent the rope from escaping from the pulley groove. The simplest form of a guard is a pin or bolt placed at the edge of the pulley flange.

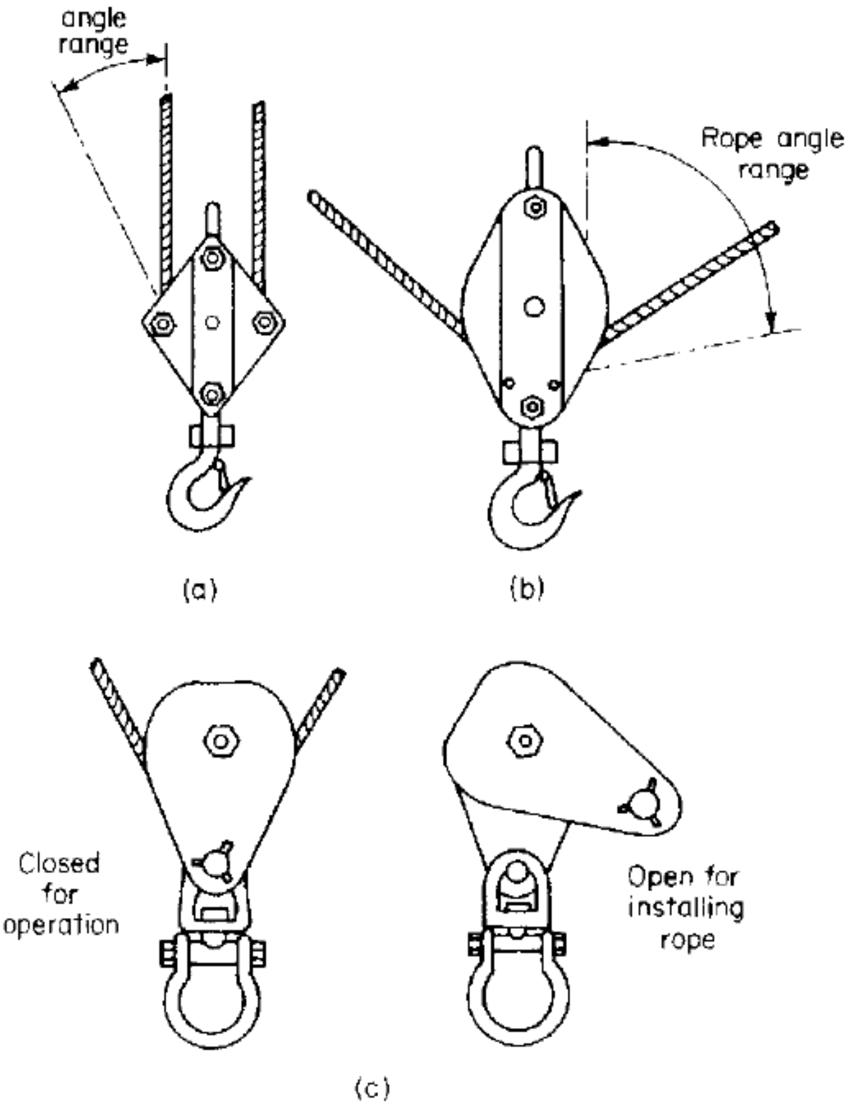


Figure 7.9 Types of blocks: (a) rhombic shape, (b) oval shape,
(c) retractable block (Lawrence K. Shapiro and Jay P. Shapiro, 2011; Cranes and Derrick, 2011)

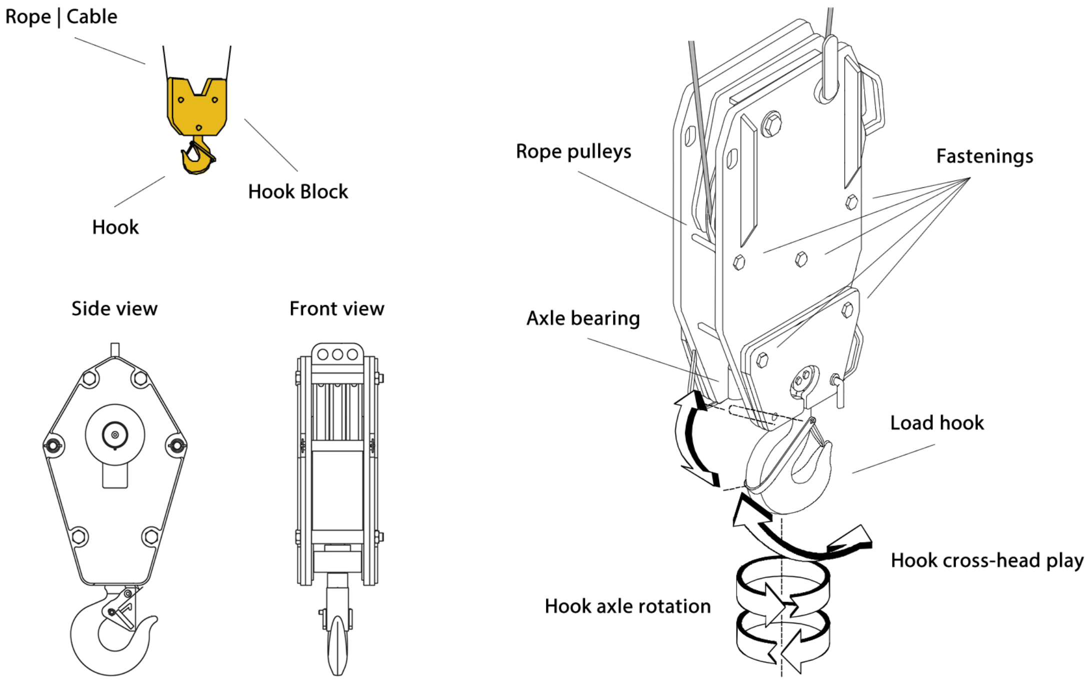


Figure 7.10 Design of complete hook block
(www.morrow.com/crane101)

Inspection

- The use, maintenance, storage, registration, inspection and examination of hook blocks must be according to the recommendations of the manufacturer.
- When mounting a hook block to a support structure, the operator must ensure that the safety lock and pin are in place.
- The operator must ensure that the support structure is strong enough to support the load and that the block is aligned with the rope, especially to prevent the rope from rubbing against the wall of the block/pulley.
- Before using a single hook block, consideration should be given to the combined force acting on the support structure, where a frictional pull of between 4% and 8% of the weight of the load being hoisted will be exerted on the load, depending on the use of a bearing or bush in the pulley.
- The ends of the wire rope are terminated through the use of wedge sockets (Figure 7.11(e)).
- The hook used should be fitted with a safety latch.
- The hook can be fitted with a swivel to enable the load to rotate (Figure 7.11(c)).

- Check the hook for wear, deformations, cracks and signs of opening (Figure 7.11(a)).

Each lifting gear or machine plate that is connected must be marked with the following information:

- Details of the manufacturer.
- Information about the raw materials, if required, for the purpose of compatibility.
- Must bear the WLL or SWL mark.
- Standard operating conditions.
- Instructions on its use, installation and maintenance.
- Restrictions on its use.

Things to note when selecting hooks:

- Select the correct hook size.
- Do not tie or remove the safety latch (Figure 7.11(d)).
- Keep the hook in an upright position. If a load is being carried on the end of the hook, the SWL will decrease (see Figure 7.8).
- The load should be vertically attached to the hook or at a maximum angle of 90^{o} (Figure 7.12).

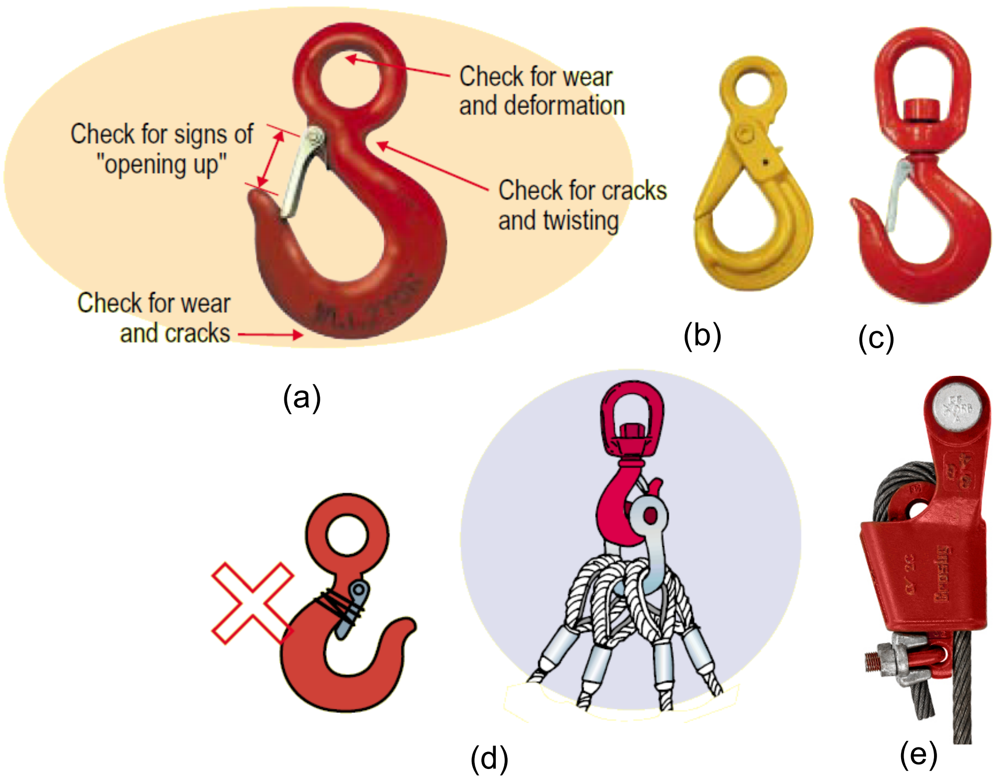


Figure 7.11 Types of hooks and ways of handling (a) inspection of hooks, (b) fixed hook, (c) swivel hook, and (d) wrong and correct way of connecting, (e) wedge socket (Occupational Safety & Health Council, Hong Kong, 2002)

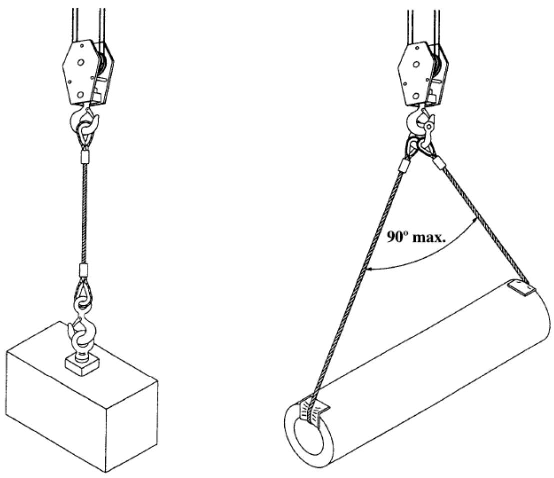


Figure 7.12 Methods of hoisting with a hook block (a) vertical/straight hoist, and (b) angled hoist with a sling (Code of Practice, Occupational Safety and Health Branch, 2011)

Inspection checklist before use

Check the hook each time before use and frequently during use. Avoid using the hook in the following conditions (Safety Standard for Lifting Devices and Equipment, National Aeronautics and Space Administration, 1991):

- The information about the manufacturer is missing or illegible.
- There are cracks, dents, nicks or gouges.
- Damage due to heat.
- Damaged bearing or bush.
- Unauthorized repairs.
- Incorrect operations and self-locking hooks.
- Any rotation from an inflexible hook.
- Opening of the hook throat exceeds 15% (or as recommended by the manufacturer).
- Wear of more than 10% of the original opening (or as recommended by the manufacturer).

For added safety, the hook should be equipped with a latch. The latch is not meant to support the load.

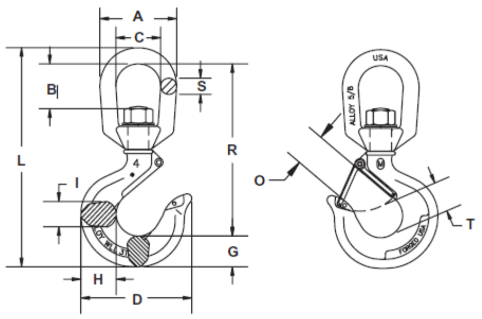
Maintenance

- Defective hooks should be removed from service, replaced or repaired. The replacement hook should comply with the original specifications (Figure 7.13).
- The repairs must be approved by qualified or recognised parties.
- The grinding of minor cracks is not regarded as a repair procedure that requires approval.
- The hook must be removed from the installed crane before welding. Hooks that are repaired by welding must be checked once again to show the difference made by the metal used for this process.
- Cracks, scratches and gouges must be repaired using longitudinal grinding according to the contours of the hook and provided that there is not more than a 10% reduction in the original dimensions (or as recommended by the manufacturer).

- Once a hook is repaired, it must undergo a proof loading test using a lifting device or equipment to provide a proof load value.
- Maintenance and repairs to a hook must be recorded.

Swivel Rigging Hook

- Design factor 5:1
- Pre-drilled for latches
- Hook and latch assemblies furnished separately
- Powder coated orange
- Carbon swivel hooks are technically advanced Micro-alloy which requires no secondary heat treat
- Alloy swivel hooks are heat treated quenched and tempered



Alloy			Carbon			Dimensions												
WLL	Product Code w/o latch	Product Code w/ latch	WLL	Product Code w/o latch	Product Code w/ latch	A	B	C	D	G	H	I	L	R	S	T	O	Weight
ton			ton			in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	lb.
1	M3402A	M3502A	3/4	M3402C	M3502C	2.00	1.11	1.25	3.06	0.87	1.05	0.63	5.83	4.63	0.38	0.87	0.93	1.05
1-1/2	M3403A	M3503A	1	M3403C	M3503C	2.50	1.38	1.50	3.33	0.94	1.11	0.71	6.83	5.44	0.50	0.97	0.97	1.56
2	M3404A	M3504A	1-1/2	M3404C	M3504C	3.00	1.65	1.75	3.67	1.06	1.21	0.88	7.76	6.25	0.63	1.03	1.06	2.50
3	M3405A	M3505A	2	M3405C	M3505C	3.00	1.65	1.75	4.20	1.27	1.43	0.94	8.40	6.49	0.063	1.16	1.16	3.20
5	M3407A	M3507A	3	M3407C	M3507C	3.50	1.77	2.00	5.11	1.44	1.63	1.31	9.76	7.53	0.75	1.53	1.41	5.36
7	M3409A	M3509A	5	M3409C	M3509C	4.75	2.39	2.75	6.24	1.82	2.01	1.68	12.42	9.67	1.00	1.94	1.69	10.56
11	M3411A	M3511A	7-1/2	M3411C	M3511C	5.50	2.55	3.25	7.69	2.25	2.63	1.88	14.89	12.06	1.13	2.46	2.22	19.00
15	M3415A	M3515A	10	M3415C	M3515C	6.00	2.47	3.50	8.37	2.59	2.94	2.19	15.79	11.95	1.25	2.62	2.23	26.75
22	M3422A	M3522A	15	M3422C	M3522C	7.75	3.82	4.75	10.19	3.00	3.50	2.69	21.18	16.68	1.50	2.74	3.05	51.80

Figure 7.13 Hook specifications with various WLLs and sizes (CM Complete Lifting Systems 2009)

7.6.4 Pulleys

There are two pulley configurations (Figure 7.14) as follows:

a) Fixed pulleys, known as change of direction (COD) pulleys, that allow for a change in the pull direction.

b) Movable pulleys that are rigged to the load and move when the load is pulled, dragged or raised.

Tower cranes use fixed and movable pulleys to hoist loads.

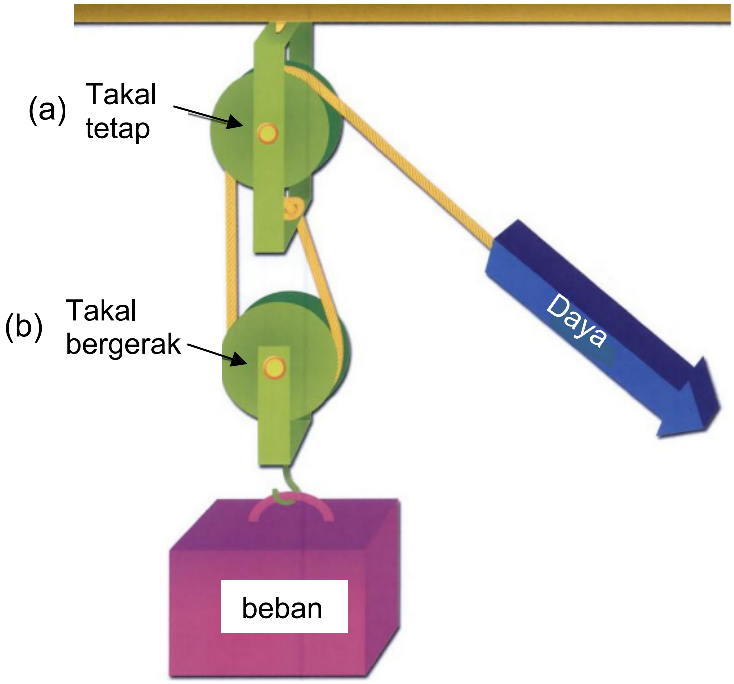


Figure 7.14 Use of pulleys for hoisting (*Anne Welsbacher*, *2001*)

Pulley applications in relation to loads:

- hoisting
- pulling
- moving
- changing direction
- reducing friction

Inspection of pulleys

Most rope assemblies have one or more pulleys, where attention is given to minimum rope movement. Every pulley should be checked periodically for the following:

- the depth, width and contour of the groove
- the smoothness of the groove
- pulley flanges that are broken or chipped
- a cracked hub, radius and so on
- marks of contact between the rope and the pulley guard
- pulley bearing and shaft
- rough turning of the pulley

- alignment with other pulleys
- the physical condition of the pulley and the smoothness of its turning

Things to note:

- Ensure that a new rope is of the correct size for the pulley and hoisting system.
- All pulleys should be checked to ensure that they are not used with old ropes and are not too small for new ropes.
- Avoid using cracked pulleys and those with dents/depressions, and with evidence of wear on the guard and other parts.

7.6.5 Turnbuckles

Turnbuckles are used to eliminate slack in pendent ropes. They come with hooks, rings or shackles (Figure 7.15).

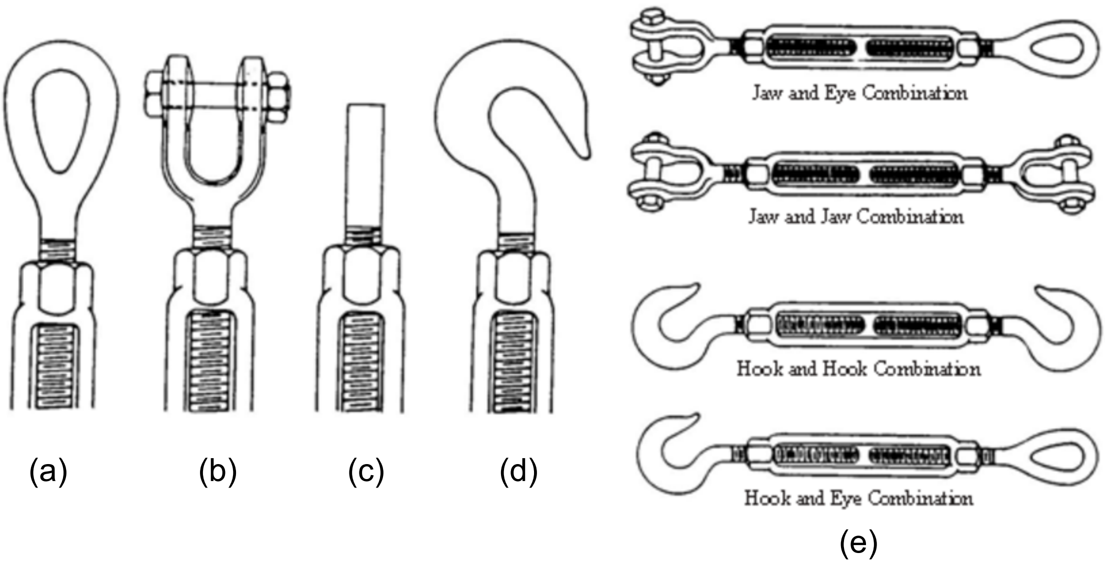


Figure 7.15 Types of turnbuckles (a) eye, (b) jaw, (c) stub, (d) hook (reduced capacity), and (e) combinations of turnbuckles (Hoisting and Rigging Fundamentals for Riggers and Operators, 2002)

- Identification tags on turnbuckles must be identified first before they are used for hoisting operations.

- Turnbuckles have grooves inside the body to ensure that the load is distributed correctly along the grooves.
- When turnbuckles are left in a loaded condition for a long time, they should be checked visually to ensure they are still safe for use.
- Do not use worn-out turnbuckles.
- Turnbuckles that are used for hoisting and hitching operations must be made of wrought iron steel.
- If turnbuckles are used for applications involving vibrations, end fittings should be fixed to the frame with wires to prevent them from twisting and coming loose (Figure 7.16 (a)).
- Locking nuts cannot be used because they can increase pressure on the grooves.
- Turnbuckles must be used for straight pulls only.

(**NOTE: Turnbuckles that are not involved in hoisting operations need not fulfil the criteria for the relevant load tests)**

The following certificates/documents must be provided:

- Manufacturer's certificate and application certificate for turnbuckles.
- The use, maintenance, storage, registration, inspection, and evaluation of turnbuckles must be in accordance with the manufacturer's instructions.

Inspection

Turnbuckles must be checked for defects before being used. The inspection of turnbuckles includes the following (Rajah 7.16 (b)):

- Cracks, kinks and deformations on the body of the turnbuckle.
- Damaged grooves and bent rods.
- Turnbuckles with damaged grooves or a bent body cannot be used.

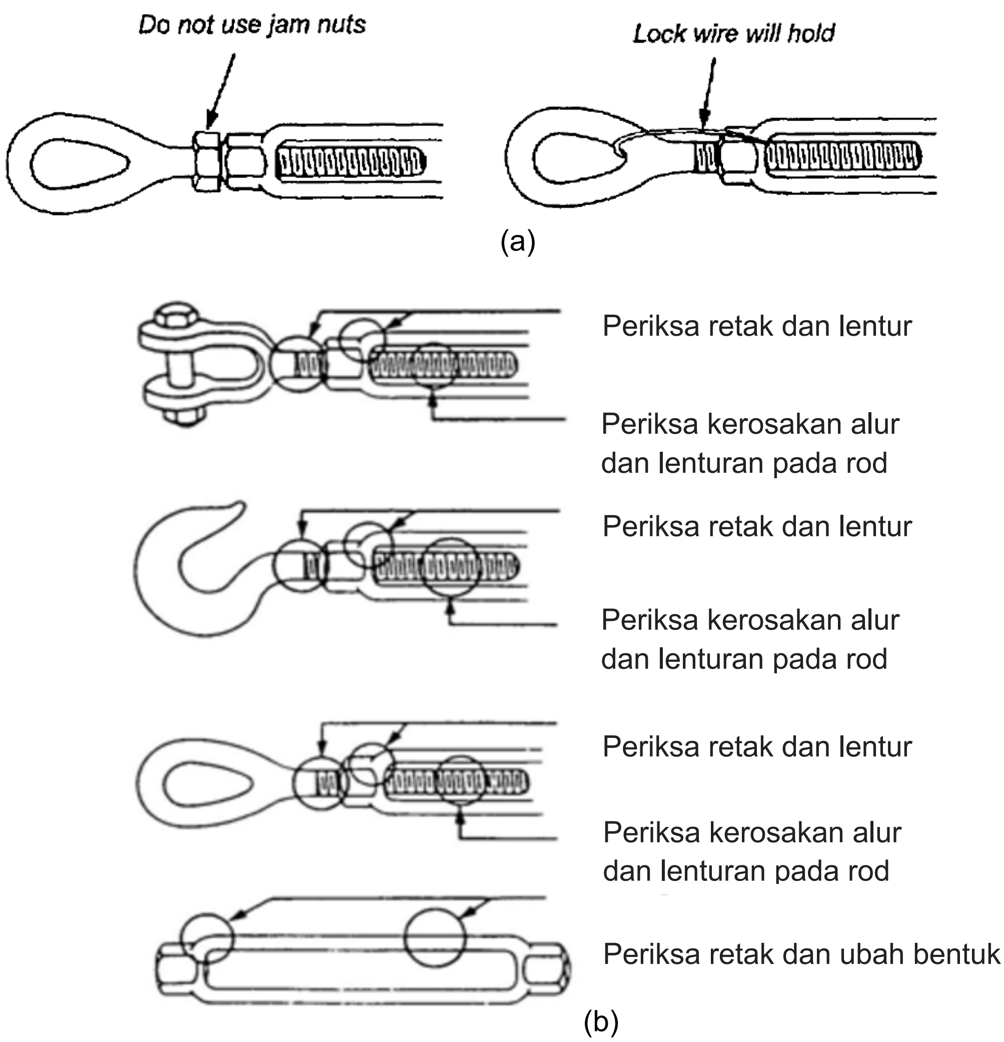


Figure 7.16 (a) Method of locking a turnbuckle, (b) turnbuckle part requiring inspection (Hoisting and Rigging Fundamentals for Riggers and Operators, 2002)

7.6.6 Spreader beams

Spreader beams come in various capacities and are either the fixed or adjustable type. They can also be designed with configurations for hooks or special shackles (Figure 7.17).

Spreader beams are usually used to hoist long loads. The weight of the spreader beam is included as part of the load to be hoisted.

Designers and manufacturers of spreader beams must possess expertise in the design and production of hoisting beams, including knowledge of material strength and structural requirements.

Every spreader beam should have the following markings:

- WLL, for different loading situations,
- Weight of the beam, to enable the overall weight to be determined,
- Year of manufacture/serial number and name of the manufacturer.

The following instructions must be complied with when delivering spreader beams:

- Operating instructions, including possible restrictions on their use.
- Instructions on their maintenance and inspection, and assembly drawings.

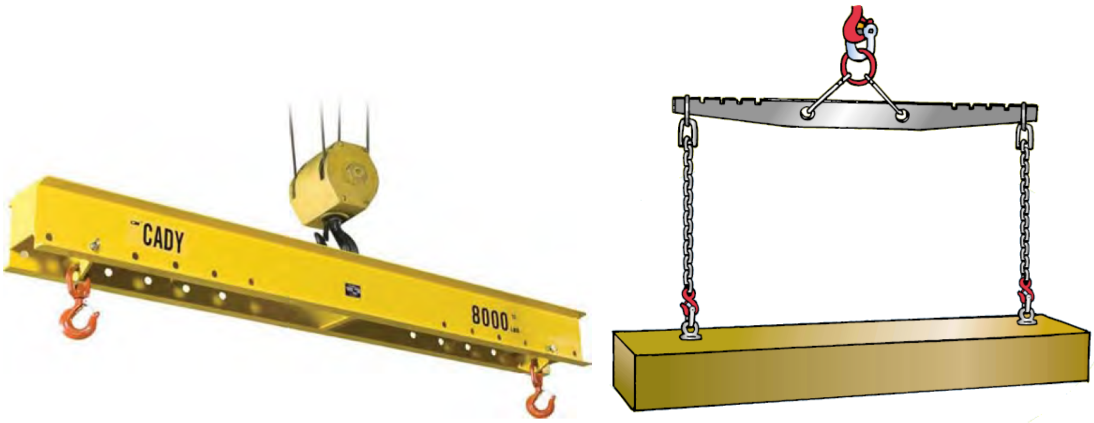


Figure 7.17 Spreader beam design (CM Complete Lifting Systems, 2009; Lifting Accessories, 2007)

Frequency of pre-use inspections

Spreader beams must be inspected at the start of every shift for the following:

- Structural changes, cracks, excessive wear on any part of the hoist.
- Name plate of the manufacturer, weight of the beam and the WLL.

- All the operating mechanisms are functioning, and the lifting and automatic release mechanisms have not been wrongly adjusted as this can interfere with the operation

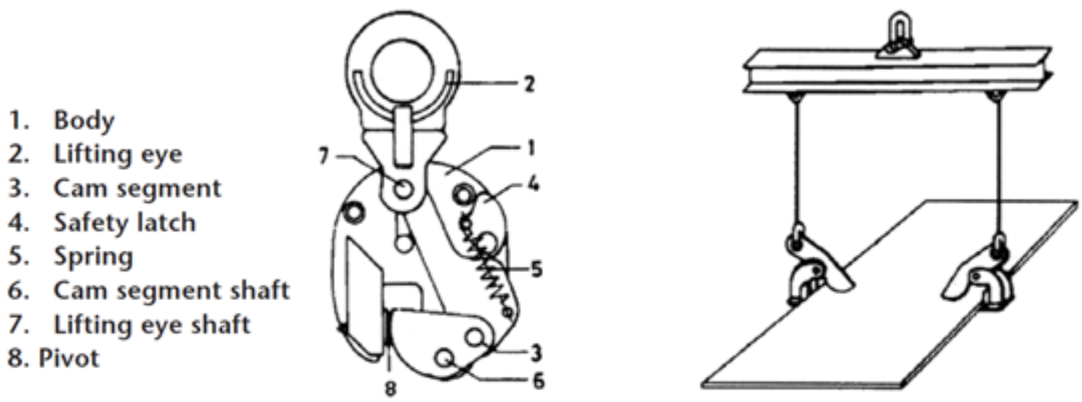
.

7.6.7 Plate clamps

- Hoisting operations using plate clamps cannot be carried out on critical and high-pressure equipment.
- The use of plate clamps to secure loads must be according to the instructions manual, and they cannot be used to fasten inappropriate loads (Figure 7.18).
- Plate clamps cannot be used to lift more than one plate at a time for vertical hoists (Figure 7.19).
- The use, maintenance, storage, registration and inspection of plate clamps must be according to the manufacturer's instructions.

Before using plate clamps ensure that:

- The surface of the plate is free of grease, oil, dirt or other pollutants that can hamper the contact between the teeth and the plate.
- The load is inside the clamp before locking or using the clamp.



(a) (b)

Figure 7.18 (a) Design of plate clamps for hoisting, and (b) a horizontal hoist (Lifting Equipment Operation, 1997)

Plate clamps should display the following markings:

- WLL marking
- Minimum and maximum thickness or width
- Year of manufacture/serial number
- Name of manufacturer/supplier

(a) (b) (c)

Figure 7.19 Method of clamping (a) vertical hoist, (b) angled hoist, (c) horizontal hoist (Technical Advisory for Safe Operation of Lifting Equipment, 2009)

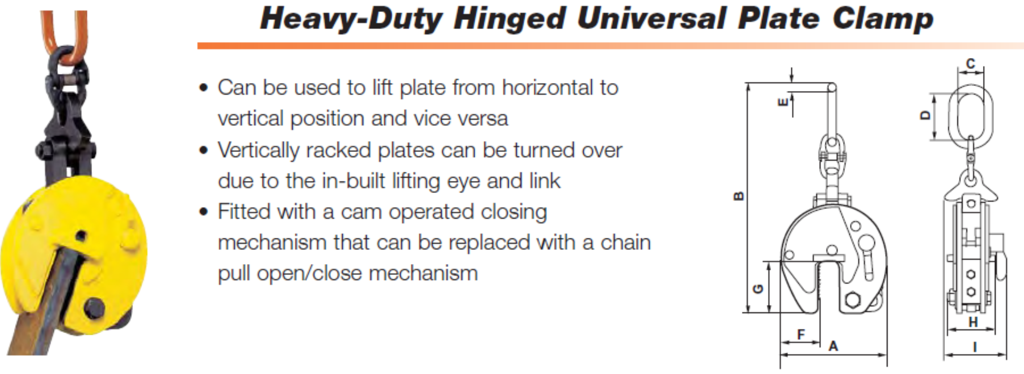
NOTE: As an alternative to plate clamps, holes can be drilled into the plate at appropriate places to enable the use of suitable shackles.

When using plate clamps:

- Make sure the appropriate clamps are used, and that the surface hardness of the item does not exceed the maximum surface hardness of the clamps.
- The clamps must fit the lifting hook and, if necessary, a chain sling with large links must be used.
- Do not exceed the working load limit.
- Make sure the contact surface is free of scratches, dirt, ice, grease or other materials that can weaken the grip.
- Always comply with the specified loading instructions. The clamps must be positioned in the direction of the sling hoist.
- The pendulous movement of a rigged item must be avoided as this can damage the clamp teeth.

- When lifting plates or long sheets, two or more plate clamps should be used.
- Only one plate or sheet is permitted for a vertical hoist.
- At least two pairs of horizontal clamps can be used and they must not exceed the maximum sling angle stated by the manufacturer.
- When turning or moving, make sure the ends of the plate/sheet or the load being lifted is opposite the crane operator. Hoisting at will is strictly forbidden.
- Wear on the contact surface of the clamp and jaw should be monitored and checked, if necessary.
- If the clamp has undergone repairs, the hoisting operation must be tested before the clamp is used.

Examples of the designs and specifications of plate clamps are shown in Figure 7.20.



Model	Working Load Limit Min	Working Load Limit Max	Jaw Capacity	A	B	C	D	E	F	G	H	I	Weight
	lb.	lb.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	lb.
CX3	1,000	6,600	0 to 1-1/4	7.756	20.276	2.638	5.433	0.748	2.677	3.661	3.189	4.331	26.5
CX6	2,650	13,200	0 to 2	11.496	29.016	3.740	6.929	1.102	3.740	5.630	5.394	7.402	83.8
CX6/L*	2,650	13,200	2 to 4	14.449	30.906	3.858	7.087	1.102	4.528	5.630	5.315	7.402	105.8
CX8*	3,550	17,600	0 to 2	11.496	29.016	3.858	6.929	1.102	3.740	5.630	5.354	8.268	86.0
CX8/L*	3,550	17,600	2 to 4	14.449	30.906	3.858	7.087	1.102	4.528	5.630	5.354	8.268	112.4
CX10*	4,400	22,000	0 to 2	14.173	35.551	4.331	7.677	1.299	4.921	6.378	6.693	8.780	134.5
CX10/L*	4,400	22,000	2 to 4	17.559	36.260	4.409	7.677	1.299	6.614	6.378	6.693	8.780	167.5

Figure 7.20 Examples of specifications for plate clamps with various WLLs and capacities
(CM Complete Lifting Systems, 2009)

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CHAPTER 8

PERSONAL PROTECTIVE EQUIPMENT

8.1 Introduction

Personal protective equipment (PPE) means all equipment intended for use or to be held by persons at the workplace, and that protects them against risks to their health and safety. PPE is also related to any additional gear or accessories designed to meet those objectives. PPE must be worn when carrying out work at construction sites.

8.2 Types of Personal Protective Equipment

(a) Safety helmet

A safety helmet is one of the most commonly used PPE (Figure 8.1). The safety helmet serves to protect the head of the user against:

(a) The impact from a falling object by rebounding and deflecting the force

(b) Impact from the side and behind

(c) Fire, splashes from molten metal, high temperatures and electric shock (depending on the standard of the hard helmet chosen. However, standard hard helmets cannot function to protect the wearer against electric shock). A complete safety helmet must come with a shell, harness and headband.

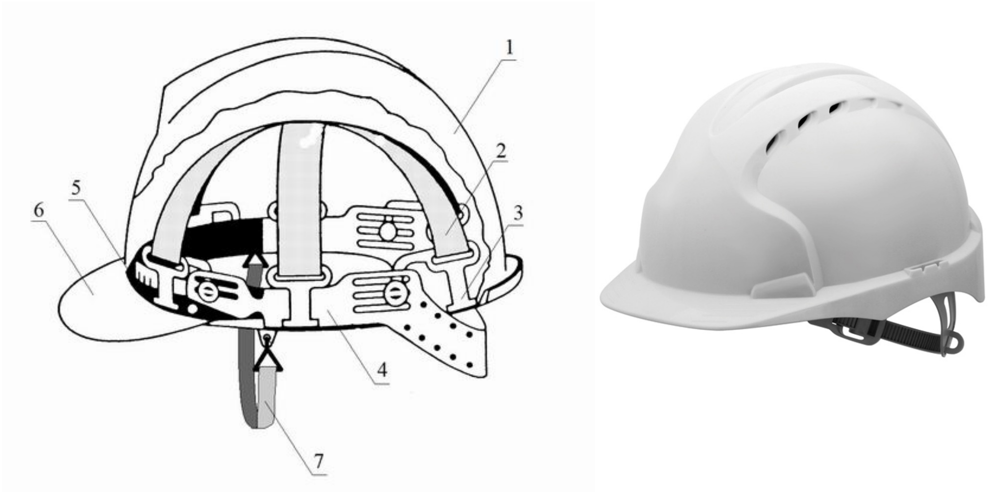

Figure 8.1 Safety helmet for the construction industry; 1 – shell, 2 – harness, 3 – harness adjuster, 4 – headband, 5 – sweatband, 6 – peak, 7 – chin strap

(b) Safety shoes

Safety shoes are designed to protect the feet against various injuries (Figure 8.2). Knocks, compression and piercings are the most common types of hazards that can cause foot injuries. The toecap protects the wearer from falling or rolling objects, as well as compression that can affect the feet in the workplace. Steel toecaps are the most popular and reliable form. Non-metallic toecaps are also commonly used because they do not conduct electricity, and are resistant to heat and cold temperatures, making them more comfortable for the wearer. To prevent injuries to the foot caused by the penetration of sharp or pointed objects, shoes that come with soles to withstand penetration should be selected.

The selection of suitable footwear should begin by identifying the risk factors that may occur in the workplace. The risk factors that should be identified are:

1) Based on the characteristics of the workplace
    (a) heavy items that can fall onto or injure the feet,
    (b) type, concentration and physical properties of chemicals (acids, alkalis, solvents, etc.),

(c) ambient temperature and humidity.

2) Based on the condition of the worker:
   (a) working in a standing position
   (b) activities involving constant movement
   (c) climbing up ladders
   (d) moving on smooth surfaces
   (e) awkward working posture
   (f) working in an open space
   (g) working in a confined space (depending on the temperature)

Figure 8.2 Safety shoes

(c) Gloves

According to the hierarchy of control, the priority is to eliminate risks, followed by engineering aspects, and then the use of PPE such as the wearing of gloves (Figure 8.3). Gloves must be worn together with other PPE. Protective gloves are less effective as a control compared to other PPE. The selection of protective gloves should be based on the type of work, the wearer and the workplace environment. The following factors must be taken into consideration in the selection of gloves:

(a) The material being handled
(b) The risk of danger to the hands
(c) The type and period of contact

(d) The size of the hand and the comfort of the wearer

(e) The type of task

Figure 8.3 Safety gloves

(d) Reflective vests

The purpose of reflective vests (Figure 8.4) is to enable the wearer to be clearly seen in an environment that is compatible to the situation at the workplace. To ensure that the vests can be easily seen during the day, they must be in fluorescent colours (yellow, orange-red or red). The vests should be maintained according to the rules and instructions of the manufacturer. The proper selection and use of reflective vests are as follows:

(a) Reflective vests should be worn in dim workplaces so that the wearer can be easily seen

(b) The colour of the vest must be in contrast to the work environment so that the personnel will be clearly visible

(c) The selection of the appropriate vest should be determined through discussions with the employer.

(d) The vests should carry a valid label by the manufacturer, and be recognized by the authorities.

Figure 8.4 Reflective vest

(e) Safety glasses

Safety glasses (Figure 8.5), face shields, and welding helmets are used to protect the eyes and face. This type of protection needs to be worn when power tools are being used or to prevent liquid from splashing onto the eyes or face. Glasses are the most widely used eye protection equipment.

Figure 8.5 Safety glasses

Figure 8.6 shows three types of eye protection devices, namely, a face shield, safety glasses, and goggles. The face shield provides the best protection against droplets and splashes of hazardous substances.

Figure 8.6 Glasses with a direct and indirect ventilation system

(f) Ear protection devices

Earplugs and ear muffs are ear protection devices (Figure 8.7) that are used to protect the hearing of the wearer. Ear muffs are more comfortable and effective in reducing noise, while earplugs are more effective in terms of their use, although some workers find them uncomfortable.

Figure 8.7 Ear protection devices

(g) Safety harness

A safety harness (Figure 8.8) is a protective equipment that is designed to protect a person who is performing a climbing activity or is coming down from a height. The harness connects a moving object to a stationary object, and it is usually designed with a rope and cable, together with a lock that can be easily opened (Figure 8.9). Figure 8.10 shows the correct way to use a harness when climbing a tower crane.

Figure 8.8 Safety harness

Figure 8.9 Safety rope

Figure 8.10 Correct method of use and climbing
(https://www.123rf.com/photo_13536201_worker-builder-at-facade-construction-works.html)

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Worker's Safety Handbook for Rigger and Signalman

CHAPTER 9

GENERAL SAFETY

9.1 Identification and Assessment of Hazards at Construction Sites

Hazard identification is the process of examining every work and task area for the purpose of identifying all the hazards that “exist on the job”. The work area includes the machine workshops, laboratories, and agricultural, industrial or construction equipment. This process is about finding what can pose a hazard in a task or area.

Hazard identification, risk assessment and risk control

When planning work methods, an appropriate and adequate assessment should be carried out and recorded. Methods, materials and equipment should be selected to eliminate or reduce the risk at work.

- **Employers are responsible for conducting a risk assessment.** A flowchart for the Hazard Identification, Risk Assessment and Risk Control (HIRARC) process is shown in Figure 9.1.

- The risk assessment principles below should be complied with when determining the method and sequence of work:
  a) identify the hazards involved in the proposed works;
  b) risk assessment (possibility and severity) of any hazards that may arise;
  c) elimination of the risks, perhaps by changing the proposed method or process;
  d) control of remaining risks;
  e) review, and where appropriate, updating of the information.

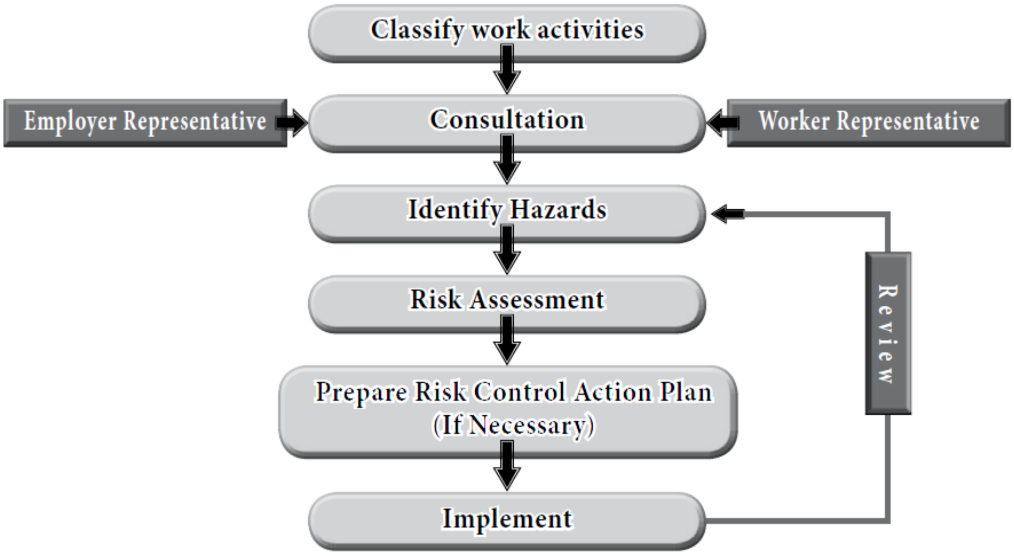

Figure 9.1 Flowchart for HIRARC process (Guidelines for Hazard Identification, Risk Assessment and Risk Control (HIRARC), 2008)

- Accidents can be categorized as low risk or high risk, as shown in Figure 9.2. However, such circumstances can lead to major accidents, and the incidental risks should be identified and managed proactively.

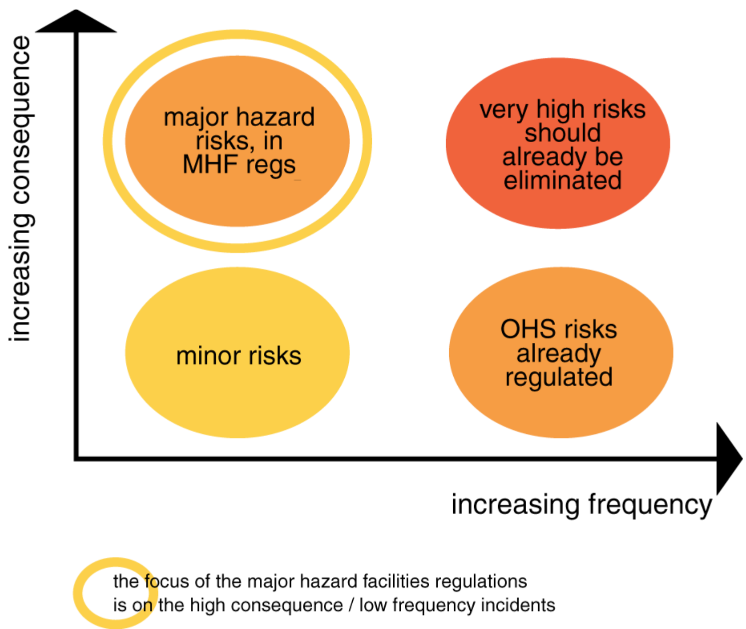

Figure 9.2 Hazard identification focusing on incidents that rarely occur (Hazard Identification, Risk Assessment and Control Measures for Major Hazard Facilities, Booklet 4)

- Twelve (12) types of potential hazards have been identified at construction sites, namely:
  a) scaffolding,
  b) power access equipment,
  c) ladders,
  d) work on roofs,
  e) manual operations,
  f) plants and machinery,
  g) excavation,
  h) fires and emergencies,
  i) hazardous materials,
  j) noise,
  k) vehicular traffic.

9.2 Main Hazards/Risks in the Construction Industry

The hazards/risks that occur most frequently in the construction industry can be divided into two main categories:

i. hazards/risks that can cause work accidents, sometimes leading to death immediately or not long after it occurs;
ii. hazards/risks that can cause sickness at the workplace, sometimes also leading to death in the medium or long term (from several hours to several years later).

(a) The main hazards/risks of accidents in the construction industry in most countries are:

- falls from a height (from floors without guardrails, platforms, scaffolding, roofs, etc.);
- trapped (in or between damaged machinery, building materials, etc.);
- confined (due to damaged shoring system, missing during excavation, etc.);

- electric shock (by touching a power line, power tool, etc.); and
- hit by an object (falling object, etc.).

(b) The hazards/risks of disease in the construction industry in most countries are:

- back injuries (carrying heavy loads, working in an inappropriate position, etc.);
- respiratory diseases (inhalation of dust, toxic fumes, etc.);
- musculoskeletal disorders (due to muscle tension and strain, injuries to the hands and wrists, shoulders, neck and upper back, knees, etc.);
- hearing loss (prolonged exposure to noise); and
- skin diseases (handling of toxic substances, exposure to ultraviolet rays).

(c) Safety and health inspections should be monitored and assessed through regular reports: monthly, quarterly and annually (Figure 9.3).

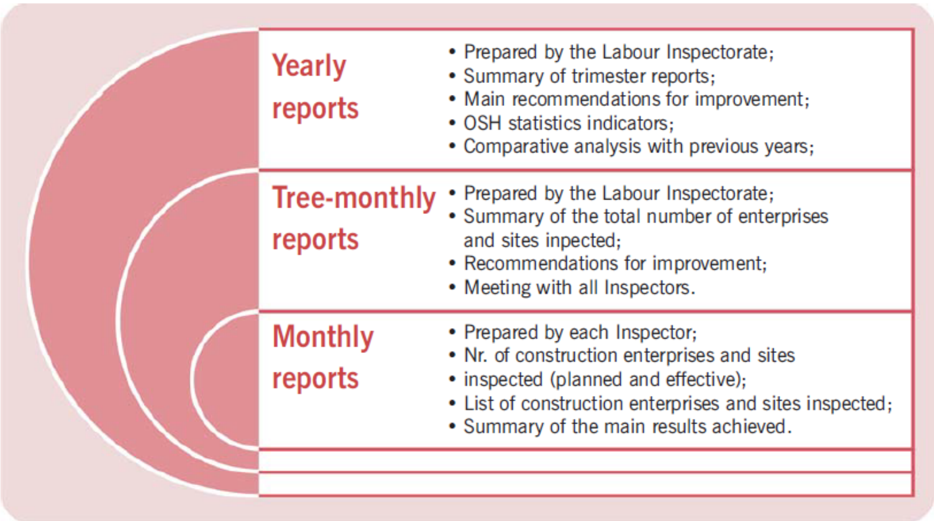

Figure 9.3 Control and assessment of safety and health inspections (Luis Alves Dias, Inspecting Occupational Safety and Health in the Construction Industry, International Training Centre of the International Labour Organization, 2009)

(d) **There are nine general principles for the prevention of the hazards/risks of accidents, namely:**

- avoid risks;
- assess those risks that are unavoidable;
- combat a risk at its source;
- adapt the work to the individual, especially with regard to the design of the workplace, the choice of working tools, and the selection of the work methods and production, with the aim of reducing work boredom;
- adapt to technical progress;
- replace hazardous materials with non-hazardous or less hazardous ones;
- develop an overall prevention policy that covers technology, work organisation, working conditions, social relationships and the influence of factors that are relevant to the work environment;
- give priority to collective protective measures rather than individual protective measures;
- give appropriate instructions to employees.

(e) **Electrical power and working close to overhead power lines**

Table 9.1 shows the voltage range and the safe working distance for positioning machinery from overhead power lines for construction works, as recommended by several countries.

Table 9.1 Total voltage and safe distance from overhead power lines

Voltage (V)	**Recommended distance from overhead power lines (m)**		
	Australia	Hong Kong	Ireland
0 – 33,000	3.0	3.0	3.0
33,000 – 132,000	3.0	6.0	4.5
132,000 – 330,000	6.0	7.0 (275 kV)	6.0
Above 330,000	8.0	7.0 (400 kV)	8.0
Source	Work Near Overhead Power Lines, Code of Practice, Australia, 2006	Avoiding danger from overhead power lines Guidance Note GS6 (Fourth edition), Hong Kong, 2013	Code of Practice for Networks Avoiding Danger from Overhead Electricity Lines, Health and Safety Authority, Ireland, 2008

(f) Emergency procedure during contact with overhead power lines

If a person or object comes in contact with overhead power lines, the following should be carried out:

a) never touch the power line concerned;
b) assume that the power line is live, even if it does not emit sparks or appears to be dead;
c) it should be remembered that even though the power line is dead, it can come to live again either automatically after several seconds or after several minutes or hours if the owner of the line is not aware that the line has been damaged:
d) if possible, call emergency services/TNB;
e) if you happen to touch/are close to a damaged wire, move and distance yourself as quickly as possible until the line is confirmed to be safe;

f) it must be remembered that if the live wire touches the surrounding area (ground) it may be live. Ensure that you are at a safe distance from the wire or anything that can come in contact with it.

9.3 Working at High Altitudes

Working at high places/altitudes is a hazardous situation if safety measures and protection from falls are not taken into account (see Figure 9.4). The guidelines on the prevention of falls from high places are explained in the *Guidelines for the Prevention of Falls at Workplaces* by DOSH.

While at the construction site, the employer is responsible for preventing falls by maintaining a safe work environment through education, the use of fall protection equipment and adequate training.

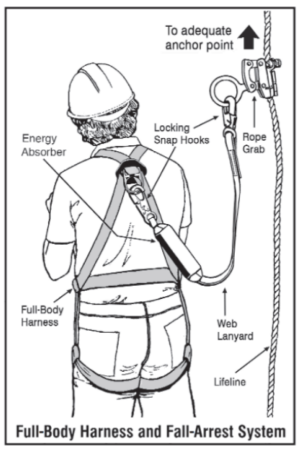

Figure 9.4 Safety equipment for protection against falls (www.simplifiedsafety.com; www.ihsa.ca)

Before working at a high altitude, the individual involved should go through the following steps:

- If working at a high place, ensure the fall protection equipment is worn correctly,
- Wear fall protection equipment that is suitable, stable and strong enough for the work, and that has been maintained and checked regularly;
- Ensure that the weight of the fall protection equipment does not exceed the load limit for the equipment concerned,
- Always be cautious when working on or close to a fragile surface,
- Wear the appropriate personal protection equipment,
- Follow the emergency procedures in the event of a fall.

Access and fixed platforms

Access and permanently-fixed platforms such as stairs or ramped steps must comply with the Acts/regulations and requirements of the Local Authority. The requirements and standards for access and platforms vary, depending on the usage, and the place where they are to be installed, for example:

- Access ways and stairs must maintain a safe distance between the head and the structure above it, i.e. a minimum distance of 2.1 metres vertically from the stairs.
- Doors in/out should not be in front of the stairs or facing the road.
- Barriers should be installed in areas exposed to the risk of falls.

Examples of access and fixed platforms are shown in Figure 9.5.

	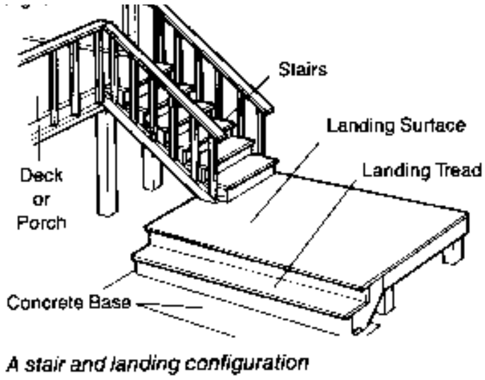
Handrails, guardrails and toeboards (http://www.nzmachinery.com/news_nc1_7)	*Stairway and ramp landings (http://fieldshomecenter.com)*
	
Stairways (http://www.howtospecialist.com)	*Fixed rung ladders (http://speeddemon2.com)*

Figure 9.5 Several types of access and fixed platforms at the workplace

Access and non-fixed platforms

All types of stairs (ladders, trestles, stairwells and so on) and working platforms must comply with the relevant Malaysian Standard or international standard. Equipment or platforms that do not have a standards mark can be used for light work and are not suitable for use on a construction site. Access and non-fixed platforms that are used at the workplace are shown in Figure 9.6.

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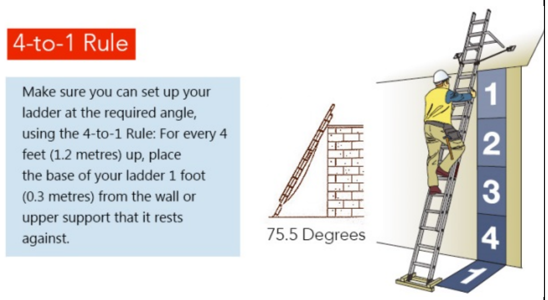
<td>
</td>
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<tr>
<td>Perimeter perlindungan (https://www.peri-usa.com)</td>
<td>Single and extension ladders (http://chainsawjournal.wpengine.netdna-cdn.com)</td>
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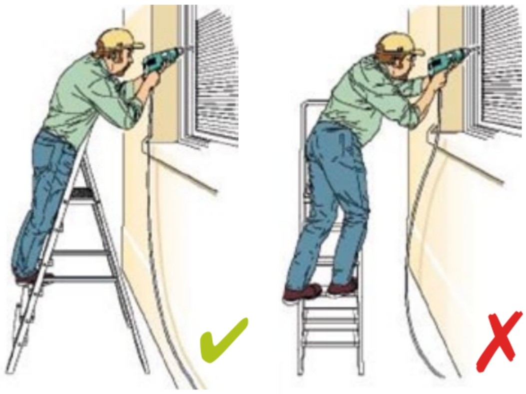
<td></td>
</tr>
<tr>
<td>Cantilevered temporary work platforms (http://www.superiorscaffold.com/blog/page/7/)</td>
<td>Foldable/portable step ladders (Best practice guidelines for working at height in New Zealand, 2012)</td>
</tr>
</table>

Figure 9.6 Access, stairs and non-fixed platforms that are frequently used at the workplace

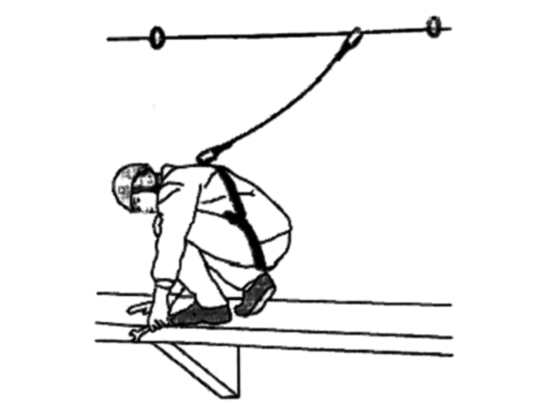
Safety ropes, belts and harnesses

In the construction industry, the selection, checking and use of all safety equipment such as belts, harnesses, safety ropes and fall prevention devices must comply with the relevant standards. The main matters that should be given attention are:

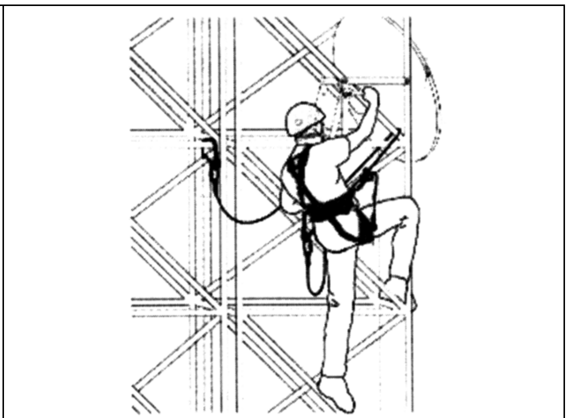
- An evaluation of work methods should be carried out in order to select the appropriate work method and fall protection equipment.
- All equipment should be constantly checked and tested to ensure it complies with MS Standards or international standards.

- Equipment must be inspected visually by a competent person before use.
- Ensure that the equipment that is being used is in conformity with the manufacturer's instructions.
- Individuals using the equipment concerned must be trained or supervised to ensure that the belts or harnesses are fitted correctly to the anchor ropes.
- Ensure that the safety rope can move across the work area and not get entangled around obstructions. If it gets entangled, the rope may jam and become unbalanced.
- Precautionary measures should be taken when working in places that are exposed to gas cuffing, grit blasting, or the use of sharp cutting tools. This is important to prevent wear and damage to the equipment.

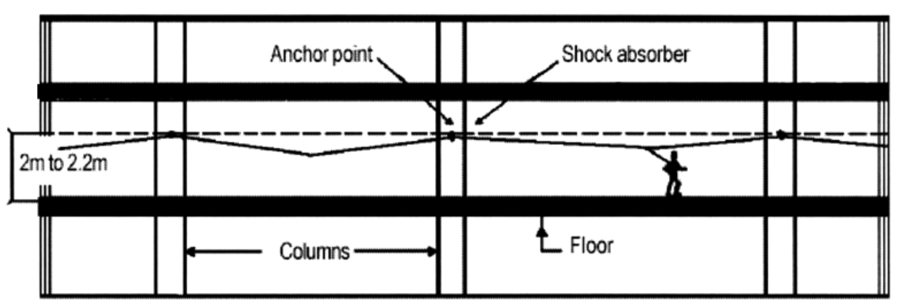
Figure 9.7 shows some of the safety ropes, belts and harnesses as well as the methods used when working in high places.

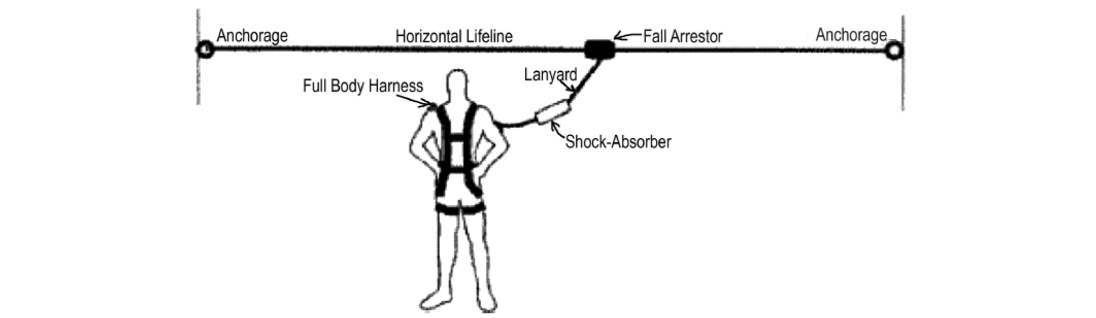


(a) Travel-restriction systems

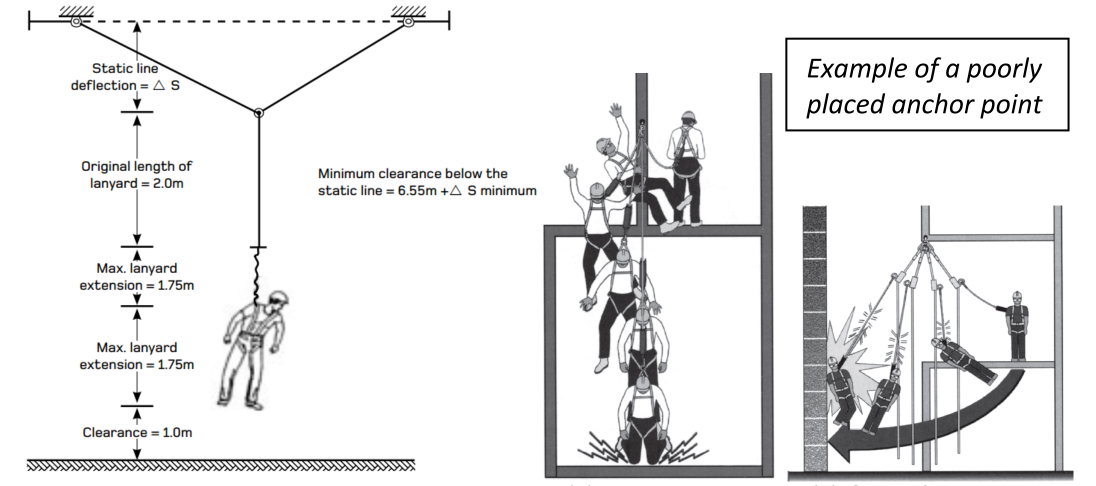


(b) Work-positioning systems





(c) Static line and anchorage techniques



(a) *Bottoming out* (b) *Swing fall orpendulum effect*

(d) Fall-arrest systems

Figure 9.7 Ways to use safety ropes, belts and harnesses as well as the existing risks (Guidelines for the Prevention of Falls at Workplaces, 2007; https://www.ihsa.ca)

9.4 Case studies of accident in Malaysia (lessons that can be taken)

Case 1:

The incident occurred on 15 April 2016 at a construction site at Lot 422, Jalan Bangsar, Section 96, Kuala Lumpur. At approximately 11:50 a.m., a crane at a construction site adjacent to Dataran Maybank toppled over, where the tip of the crane fell on the road near Dataran Maybank (Figure 9.8). No fatalities were reported. The details of the accident were as follows:

- luffing Favelle Favco crane built in 1994
- used at the site on November 2015, according to the logbook

- operator had a valid certificated (refer to the site manager)
- the crane was lifting an iron elbow weighing 1.5 tonnes with the jib being hoisted to an angle of 82 degrees (based on the meter reading) when the jib toppled over in the opposite direction and the tip of the jib extended into the adjacent road, causing damage to a lorry
- the cause of the accident was the failure of the luffing limiter.

Figure 9.8 Accident involving a luffing tower crane in Bangsar

Case 2:

An incident occurred in Johor Bahru, Johor on 24 July 2016. While lowering sand, the crane started to sway haphazardly, and its front boom broke, sending the counter jib of the crane falling to the ground. The tower crane toppled over and got caught at the 13th floor, as shown in Figure 9.9. The details of the accident were as follows:

- the tower crane was carrying sand using a bucket with a capacity of approximately 1 m^3 from ground level to the 10th floor
- when the load was at a height equivalent to the 5th floor and the trolley was positioned in the middle of the jib, the crane suddenly experienced failure
- this failure caused the jib to twist backwards and the counter weight to fall to the ground

- initial investigations based on circumstantial evidence indicated that the accident probably occurred because the bucket got caught in the scaffolding
- the source of the incident was the hoisting rope, which got entangled in the scaffolding.

Figure 9.9 Condition of the tower crane after the incident

Case 3:

This incident occurred in Bukit Bintang, Kuala Lumpur on 25 August 2016 (Figure 9.10). The crane that was involved was a Luffing Model STL230, made in China.

The details of the accident were as follows:

- a crane hook, weighing 300 kg, fell from the roof of a building (height of more than 100 metres) and crashed onto a car
- a 24-year old woman was killed on the spot
- members of the public claimed that the iron hook from the crane was lifting a load when it broke before falling and crashing onto the victim’s car.
- the position of the crane was also in violation of the safety laws because it was operating outside the radius of the fenced construction site.

- the crane operator and signalman could not be traced.
- The accident was probably due to the bypass at the lifting limiter that lowers/raises the hook, causing the hook to be raised until it tugged at the tip of the boom, and the wire rope snapped.

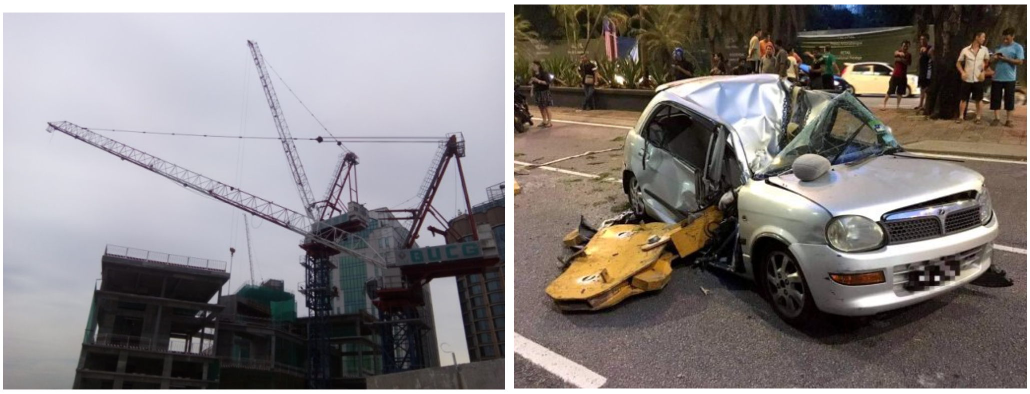
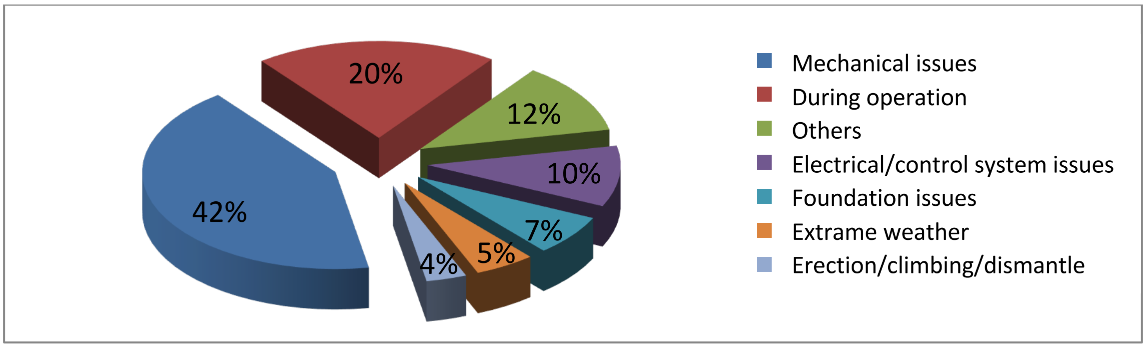


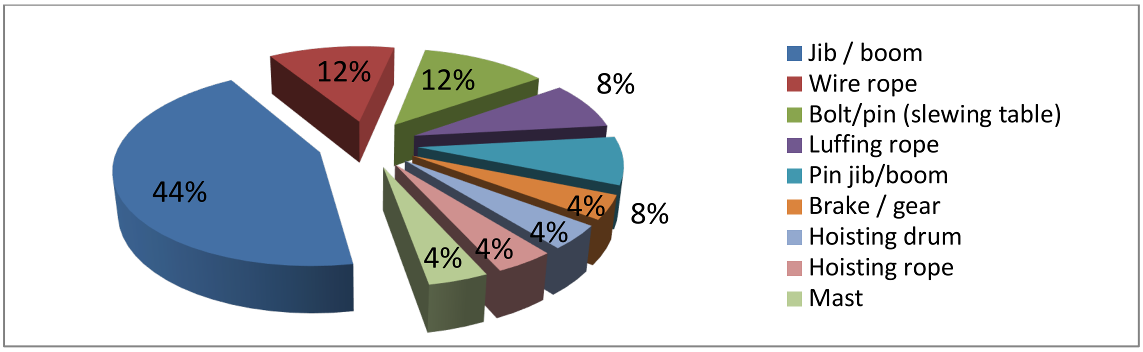
Figure 9.10 (a) Luffing crane model STL230, (b) Iron hook of the crane that crashed onto the vehicle

Causes of accidents

Accidents involving tower cranes are mostly due to mechanical or electrical problems, the crane structure, and negligence on the part of the operator/rigger/signalman, etc. Figure 9.11 shows the percentages of the factors that cause tower crane accidents in Malaysia.



(a)



(b)

Figure 9.11 (a) Percentages of factors that cause tower crane accidents, and (b) percentages of factors due to mechanical/structural issues (Abdullah & Wern, 2010; DOSH investigation files; http://www.dosh.gov.my)

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CHAPTER 10

PRACTICAL TRAINING

10.1 Introduction

The role of rigger is very important to ensure the load is always securely tied by sling during lifting works using cranes including tower cranes. Safe slings depend on the type of loads, types of straps used and the proper types of rigging methods that have been practised. Therefore, the skill of the rigger in the selection of the sling and also the rigging method used is very important to avoid accidents during lifting operations.

10.2 Practical training

10.2.1 Training on ringing and slinging methods

Operators must also undergo practical training for the following before they can become competent persons because they must know the main tasks of a rigger:

a) Direct calculation of the weight of various types and shapes of loads
b) The way to hitch loads using each of the lifting equipment below:
   - Wire rope
   - Chain
   - Synthetic fabric
   - Fibre rope
c) Method for determining the sling angle
d) Selecting the correct sling according to the type of load
e) Method of finding the centre of gravity for a load that is to be hoisted
f) Use of taglines
   - Way to rig a load with taglines.
   - Control of loads using taglines during hoisting operations.

10.2.2 Training for inspections on hoisting equipment

Operators must also undergo the following practical training before they can become competent persons as they also need to know the main tasks of a rigger. Riggers are responsible for conducting inspections of all the lifting equipment to ensure that they are safe for use. The correct method of inspection is important to ensure that damaged equipment can be identified before they are put to use. The training on inspections for the following should be carried out before a person can be a competent rigger:

a) Wire ropes

Inspections for each type of damage that can occur to wire ropes, such as:

- Knotting
- Stretching
- Corrosion and rust
- Bird caging (unravelling)

b) Chains

Inspections should be carried out for each type of damage that can occur to chains as follows:

- Cracks
- Corrosion or wear
- Kinks and distortions
- Elongation

c) Synthetic Fabric

The types of damage that usually occur to such slings are as follows:

- Getting cut
- Rot
- Knots
- Getting hooked
- Wear

d) Fibre ropes

Fibre ropes must be checked for the following before use:

- Any change in colour due to burn marks, exposure to sunlight
- Change in colour due to corrosion
- Shortening or lengthening of the rope due to overloading
- Decaying rope

10.2.3 Determine the appropriate and safe position for rigger

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