TRAINING MODULE FOR PROJECT MANAGERS

(TOWER CRANE)

Prepared for:

Jabatan Keselamatan dan Kesihatan Pekerjaan
Kementerian Sumber Manusia

Prepared by:

UKM
PAKARUNDING

TRAINING MODULE FOR PROJECT MANAGERS (TOWER CRANE)

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(1) MODULE: Training Module for Project Managers (Tower Crane)

(2) OBJECTIVE: To provide better practical guidance to project managers who are directly involved with tower cranes at construction sites

(3) LEARNING PERIODS : 1 day

(4) PRE-REQUISITE: None

(5) SYNOPSIS:

The training module for project managers was developed to provide knowledge and understanding to project managers regarding the code of practice for the correct and safe operation of cranes on construction sites. This training module was also required to familiarise all project managers with an introduction on cranes, while emphasising the responsibility of project managers in ensuring that hoisting activities are managed by a competent lifting team. The responsibilities of the project manager are subject to the Chief Inspector's Special Order to Project Managers Regarding the Management and Safe Operation of Tower Cranes 2017. By having a tower crane system that has a good level of structural integrity during operations and project managers who are efficient and ethical, the number of accidents involving cranes in Malaysia can be reduced.

(6) LIST OF TOPICS

Chapter 1 Legislations (1 hour)
Chapter 2 Introduction to Cranes (1 hour)
Chapter 3 Lifting Equipment and Introduction to Lifting Works (2 hours)
Chapter 4 Load Charts (1 hour)
Chapter 5 Roles and Responsibilities of Personnel (1 hour)
Chapter 6 Accident Statistics and Causes of Crane Accidents (1 hour)
Chapter 7 Safe Operation of Tower Cranes (0.5 hour)
Chapter 8 Inspection and Maintenance of Cranes (0.5 hour)

TOTAL LECTURE : 8 hours

(7) REFERENCES (selected):

Akta Keselamatan dan Kesihatan Pekerjaan dan Peraturan-Peraturan. Published Printers Sdn. Bhd. (Act. 514).

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Guidelines for Creating Lifting Plan for Lifting Operations in Workplaces, WSH Council, 2014.

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CHAPTER 1

LEGISLATIONS

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 1.1. 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.

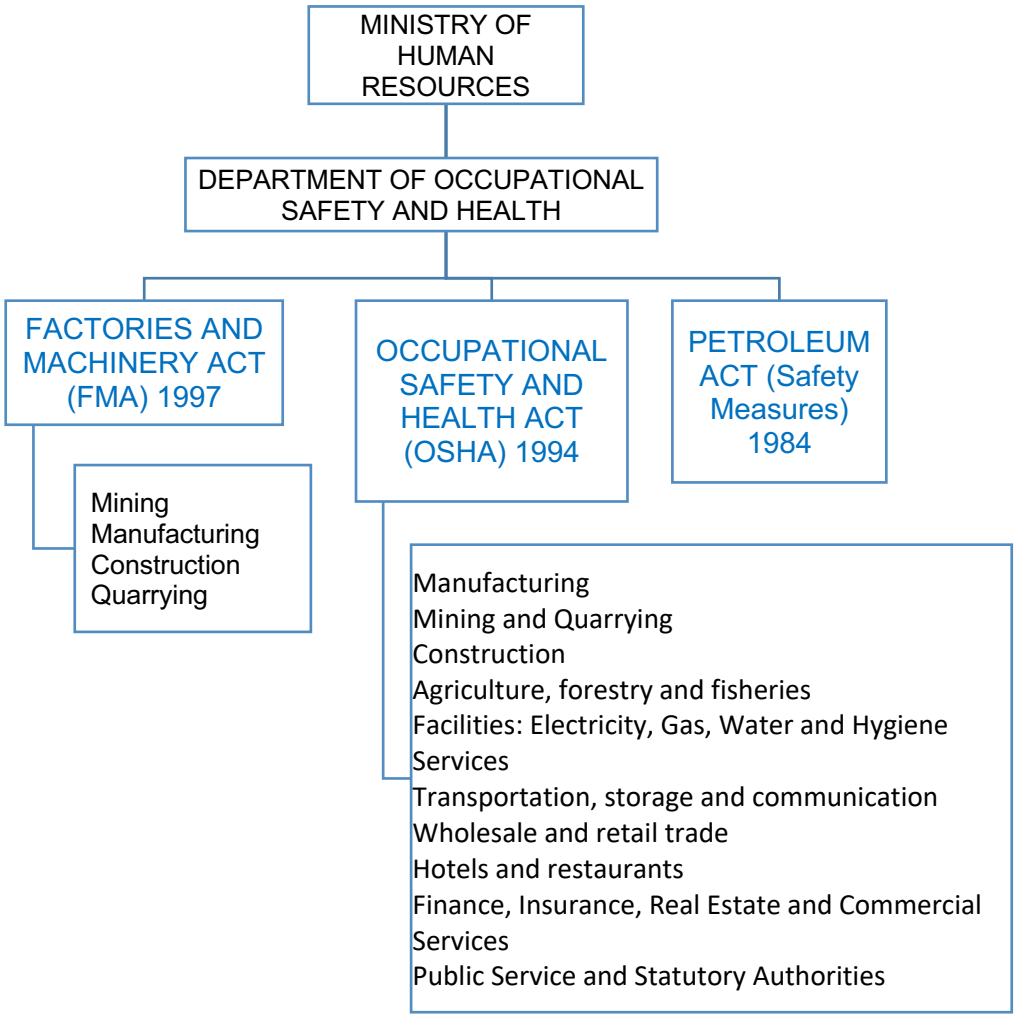

Figure 1.1 Acts that apply in Malaysia

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).

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, erect, 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, erect, 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).

8. MS 2203:2008: *Cranes-Training of Operators-Part 3: Tower Cranes (ISO 9926-3:2005, MOD)*

1.5 Construction Industry Development Board (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.

To enjoy the benefits of protection through the Takaful scheme

1.6 Other Regulations and Code of Practice in relation to Tower Cranes

(a) Occupational Safety And Health (Control Of Industrial Major Accident Hazards) Regulations 1996

PART I - PRELIMINARY

Regulation 1. Citation and commencement

These regulations may be cited as the Occupational Safety and Health (Control of Industrial Major Accident Hazards) Regulations 1996 and shall come into force on 1 February 1996.

Regulation 5. Obligations of manufacturer and employee

(1) Every manufacturer who undertakes an industrial activity shall-

(a) comply with the requirements of these Regulations;

(b) as soon as he becomes aware of an imminent danger which may affect the safety of persons or the environment, take immediate action to rectify the situation; and

(c) establish and maintain a good management system for controlling any major accident as described in the report made under subregulation 14(1) and regulation 16.

(2) Every employee shall-

(a) co-operate with the manufacturer in complying with the requirements of these Regulations;

(b) act in such manner so as not to endanger himself or to cause or be likely to cause bodily injury to himself or to other persons, or damage to life and property; and

(c) notify the manufacturer as soon as he becomes aware of any potential hazard he considers is capable of generating a major accident, and shall have the right to notify an officer of the potential hazard.

PART III - DEMONSTRATION OF SAFE OPERATION FOR NON-MAJOR HAZARD INSTALLATION

Regulation 9. Application.

This Part shall apply to-

(a) an industrial activity in which there is involved or likely to be involved-

(i) for a hazardous substance listed in Part 1 of Schedule 2, a quantity of the hazardous substance which is less than the threshold quantity specified therein; or

(ii) for substances and preparations falling within a category or categories specified in Part 2 of Schedule 2, a total quantity of the substances and preparations in the category or categories which is less than the threshold quantity specified therein and which is not determined as a major hazard installation under paragraph 7(2)(a); and

(b) an installation which is determined as a non-major hazard installation by the Director General under paragraph 7(2)(b).

PART V - NOTIFICATION OF MAJOR ACCIDENT

Regulation 23. Notification of major accident.

Where a major accident occurs on a site a manufacturer shall notify the nearest occupational safety and health office of the accident by the quickest means available and the manufacturer who makes the notification shall provide-

(a) the following information relating to the accident as soon as it becomes available:

(i) the circumstances of the accident;

(ii) the hazardous substances involved;

(iii) the date available for assessing the effects of the accident on persons and the environment; and

(iv) the emergency measures taken; and

(b) a statement of the steps envisaged to alleviate medium or long term effects of the accidents, if any, and prevent the recurrence of such an accident.

PART VI - PENALTY

Regulation 24. Penalty.

(1) A manufacturer who commits an offence against any of the provisions of these Regulations for which not corresponding penalty is provided by the Act shall, on conviction, be liable to a fine not exceeding fifty thousand ringgit or to a term of imprisonment not exceeding two years or to both.

(2) An employee who commits an offence against any of the provisions of these Regulations for which no corresponding penalty is provided by the Act shall, on conviction, be liable to a fine not exceeding one thousand ringgit or to a term of imprisonment not exceeding three months or to both.

(b) Laws of Local Authorities (LA)

Local Authorities have their own duties that drive them to enforce the regulations entrusted to them.

The three main legislations that are enforced by Local Authorities are:

(a) The Local Government Act, 1976 (Act 171);

(b) The Street, Drainage and Building Act, 1974 (Act 133);

(c) The Urban and Rural Planning Act, 1976 (Act 172).

Generally, the three (3) Acts have the following roles:

(a) Through the Local Government Act 1976 (Act 171), the Local Authority is given the role to ensure the local community lives in a conducive environment.

(b) Through the Urban and Rural Planning Act 1976 (Act 172), the Local Authority, as the local planning authority, is given the role of planning and controlling its area in accordance with local conditions.

(c) The Street, Drainage and Building Act 1974 (Act 133) gives the Local Authority the role of controlling and ensuring that the buildings, streets and drains that are constructed are in good condition.

(c) Civil Aviation Act 1969 (Act 3)

PART Ia

Section 2B: Duties and functions of the Director General

(a) to exercise regulatory functions in respect of civil aviation and airport and aviation services, including the establishment of standards and their enforcement;

(b) to represent the Government in respect of civil aviation matters and to do all things necessary for this purpose;

(c) to ensure the safe and orderly growth of civil aviation throughout Malaysia;

(d) to encourage the development of airways, airports and air navigation facilities for civil aviation;

(e) to encourage the provision of efficient airport and aviation services by the licensed company; and

(f) to promote the interests of users of airport and aviation services in Malaysia in respect of the prices charged for, and the quality and variety of, services provided by the licensed company.

(d) Electricity Supply Act 1990 (Act 447)

PART IV:

Section 11: Power to enter on land for purposes of construction

(1) Subject to as hereinafter provided, when it is necessary so to do for the purpose of installing any system of distribution of electricity under this Act, a licensee may lay, place or carry on, under or over any land, other than State land, such posts and other equipment as may be necessary or proper for the purposes of the licensed installation as the case may be, and may take such other action as may be necessary to render the installation safe and efficient, paying full compensation in accordance with section 16 to all persons interested for any disturbance, damage or disability that may be caused thereby, and such compensation may include an annual payment for land used for the purpose of the posts or other equipment.

(2) Before entering on any land for the purpose specified in subsection (1), the licensee shall give a notice stating as fully and as accurately as possible the nature and extent of the acts intended to be done. The notice shall be substantially in the form set out in the First Schedule, and the District Land Administrator shall specify a date upon which the State Authority shall inquire into any objection that may have been made as hereinafter provided.

(e) Land Public Transport Commission Act 2010 (Act 714)

PART III:

Section 16: Powers of the Commission

(1) The Commission shall have the power to do all things necessary or expedient for, or in connection with, the performance of its functions under the land public transport laws.

(2) Without prejudice to the generality of subsection (1), the powers of the Commission shall include the power

(a) to utilise all the property of the Commission, movable and immovable, in such manner as the Commission thinks expedient, including the raising of loads by mortgaging such property;

(b) to impose fees or charges for services rendered by the Commission;

(c) to appoint such agents, experts or consultants as it deems fit to assist the Commission in the performance of its functions;

(d) to grant loans and scholarships to employees of the Commission for such purposes as may be approved by the Minister;

(e) to formulate and implement programs for the proper and effective performance of the Commission's functions, including programs for human resource development, funding and co-operation;

(f) to co-operate with Government Entities or any other body corporate for the purpose of performing the Commission's functions; and

(g) to do anything incidental to any of its functions.

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Lembaga Pembangunan Industri Pembinaan Malaysia, Akta 520.

CHAPTER 2

INTRODUCTION TO CRANES

2.1 Main Functions of Cranes

Cranes are included in the load lifting equipment category. A crane is a mechanical tool that is used for raising or lowering a load and to move the load horizontally to the required location. Its use is also aimed at facilitating and speeding up the construction of tall, huge and wide structures such as buildings and bridges. There are also several types of cranes, namely mobile cranes, crawler cranes, derrick cranes and tower cranes. The selection and use of a crane depend on its suitability for the work requirements at a construction site.

(a) Mobile Cranes

A mobile crane is a type of crane on wheels that is be powered by its own engine and can be driven on the road. It is used to raise and lower loads from a moderately high place and is easy to handle for work in a confined space (Figure 2.1).

Figure 2.1 Example of a mobile crane (Occupational Health and Safety Code 2009, Alberta Canada; www.cccme.org.cn)

(b) Crawler Cranes

A crawler crane is a type of crane for climbing. It moves by means of tyres or on crawler tracks, and it can be manually driven. However, its movements are restricted to the appropriate roads only. Crawler cranes are suitable for use on all types of land and earth surfaces. This type of crane also has the power to raise and lower loads from a height (Figure 2.2).

Figure 2.2 Example of a crawler crane (OSHAcademy Occupational Safety and Health Training, US; www.directindustry.com)

(c) Derrick Cranes

A derrick crane is a type of crane that is used on high-rise buildings, where it is placed in a static position on the building structure and cannot be moved (Figure 2.3). This type of crane is usually used to lower a tower crane structure that is to be dismantled after having completed works to raise or lower loads.

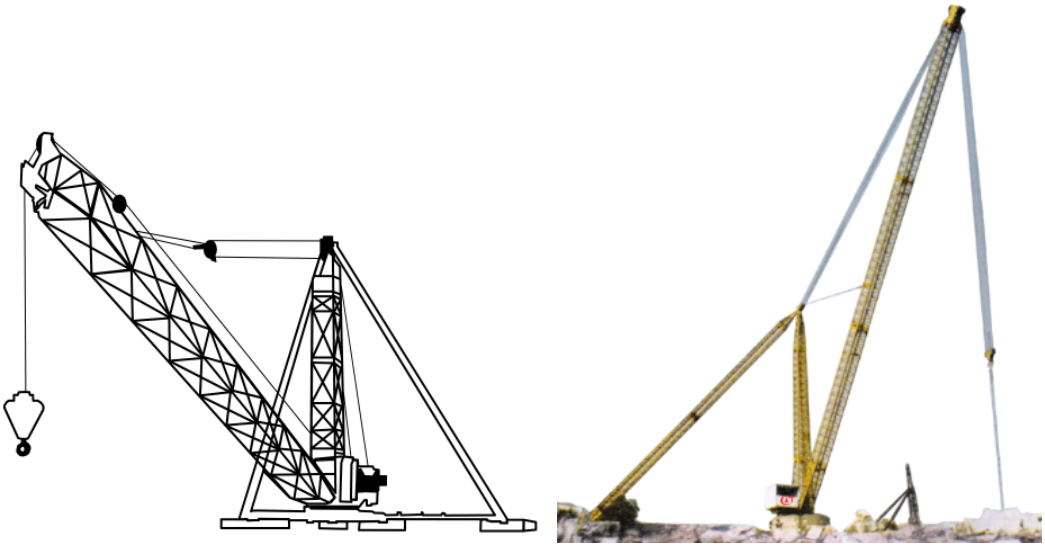


Figure 2.3 Example of a derrick crane (OSHAcademy Occupational Safety and Health Training, US; http://jaipur.all.biz)

(d) Tower Cranes

Tower cranes are designed using high-strength iron shaped into a tower. They are used for industrial works and for the construction of high-rise buildings. Tower cranes can raise and lower heavy loads, and are better than other cranes. They are installed in a static position or move along rails (Figure 2.4).

Almost the entire tower crane structure is made of solid iron, and it is divided into several parts. These parts can be separated and joined back again. This technique of joining and separating the crane section by section is used to facilitate the process of installing and dismantling the tower crane. It is also meant to facilitate the transportation of the crane from one construction site to another.

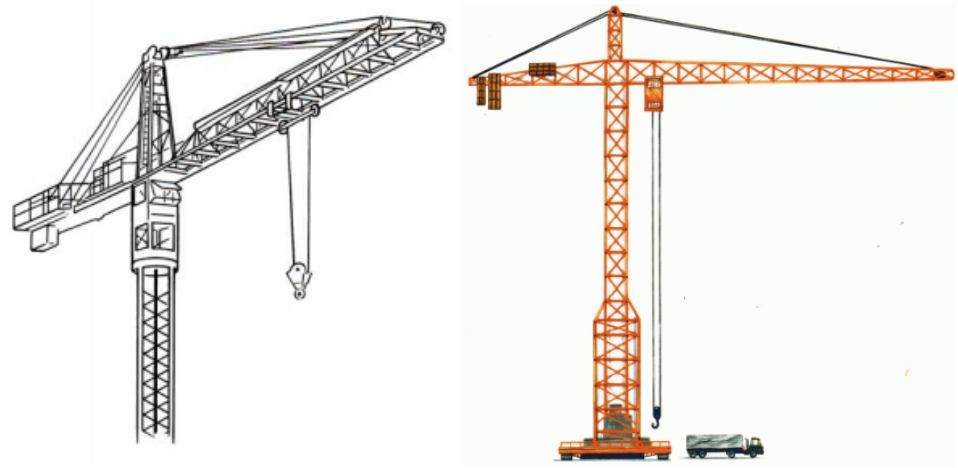


Figure 2.4 Example of a tower crane (Occupational Health and Safety Code 2009, Alberta Canada; www.ictinpractice.com)

2.2 Types of Tower Cranes

Tower cranes are one of several types of cranes in the heavy machinery category that are commonly used to raise and move any heavy and massive load from one place to another. A tower crane is a rectangular tower fitted with several important components such as bolts, nuts, and pins, and its base is made of cast concrete supported by beams or mounted on rails. The slewing platform, hoist, mast and boom are mounted on the base of the tower.

Before a tower crane is installed, safety inspections should be carried out first, and these must be carefully planned according to the established procedures. The installation of the boom and counterweight is a hazardous job, and if it is not carefully planned or studied, it can result in the failed installation of the tower crane. Generally, there are many types of tower cranes, but among the popular types used in Malaysia are the hammerhead (saddle top) , hammerhead (topless) and luffing cranes (Refer to Figure 2.5-2.7 respectively). These cranes can be divided into several categories depending on their size and manufacturer.

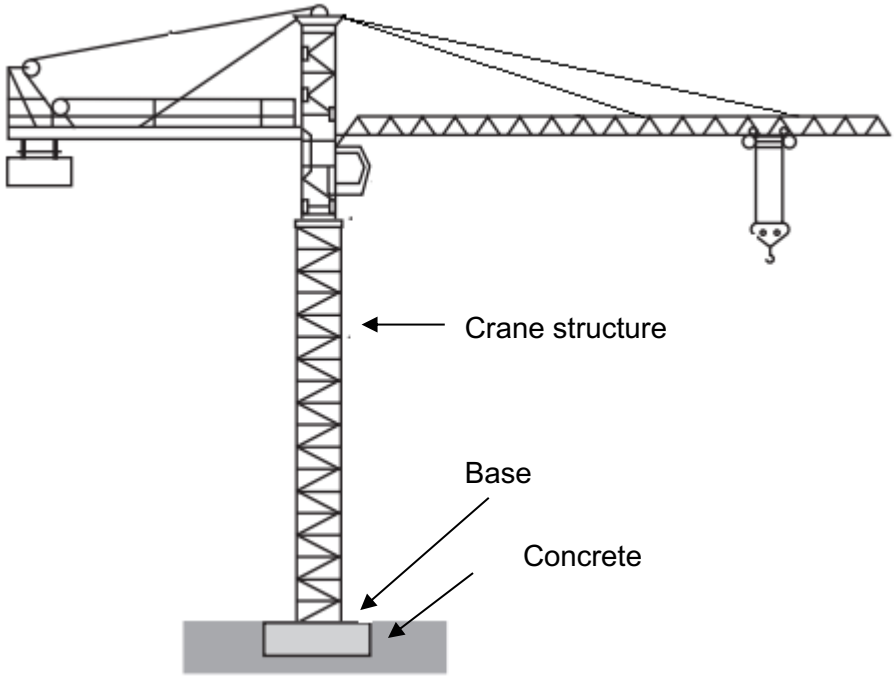


Figure 2.5 Saddle top hammerhead tower crane (Occupational Safety and Health Program, A Guide to Cranes and Derricks, US)

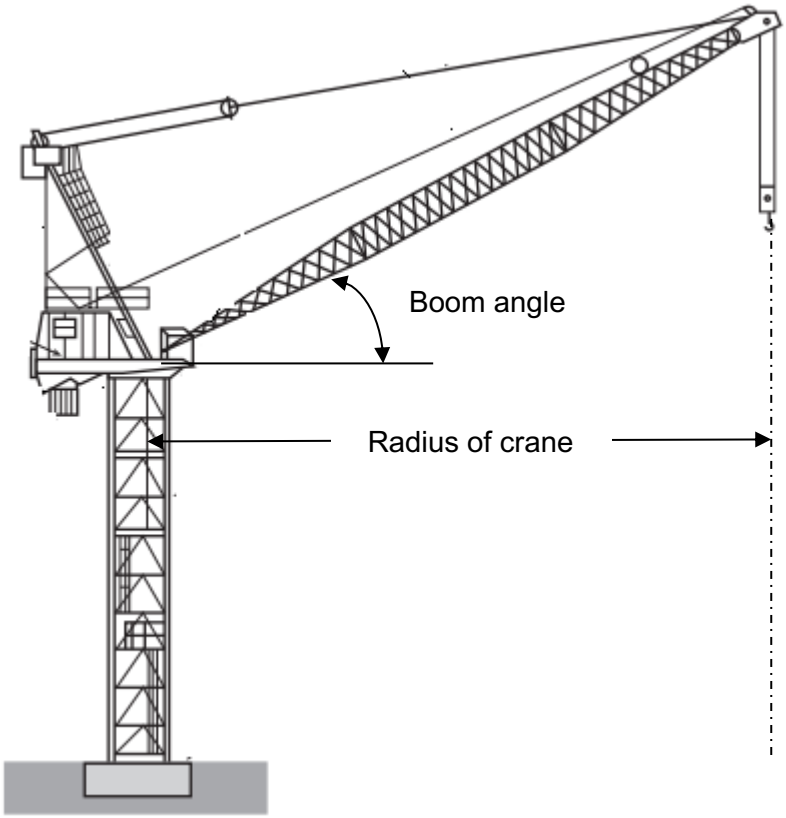


Figure 2.6 Luffing tower crane (Occupational Safety and Health Program, A Guide to Cranes and Derricks, US)

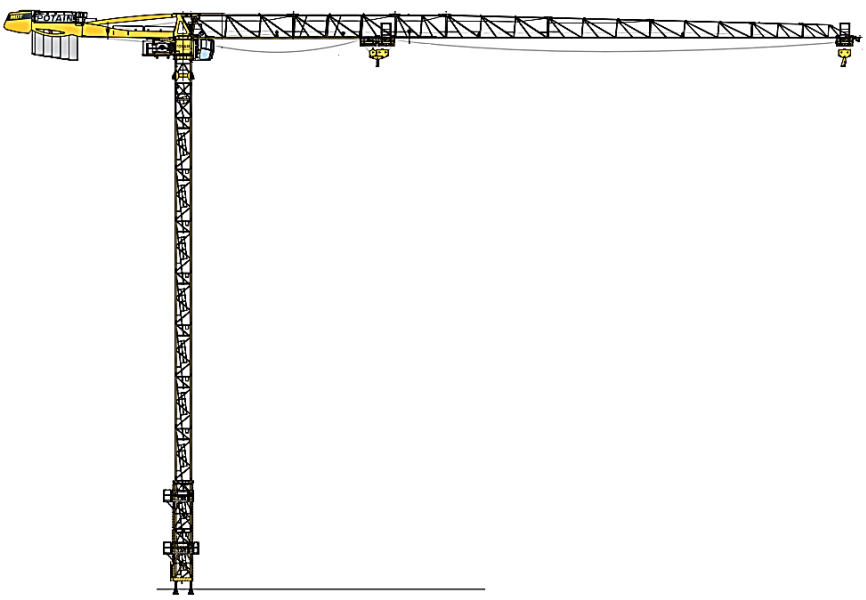


Figure 2.7 Topless hammerhead tower crane *(www.nftcrane.com)*

In general, tower cranes can also be categorized according to their base installation. There are three main types of base installations for tower cranes, namely: -

(a) Static Base

This type of crane is generally popular and is the tallest among all the other types of cranes. It is suitable for installation in open sites, and is usually placed at the front or in any place where there is enough space for the boom to move/rotate (Figure 2.8).

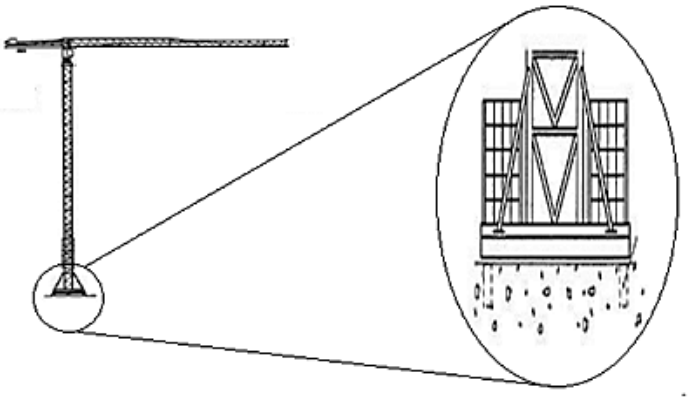


Figure 2.8 Example of a tower crane with a static base installation (Environmental, Health and Safety (EHS) Departments, US)

For the static base category, there are two methods of installation for the tower crane base, namely:

(i) In-situ cast base

This type of base requires a special anchor (known as an expandable anchor) to be embedded in a concrete block (Figure 2.9).

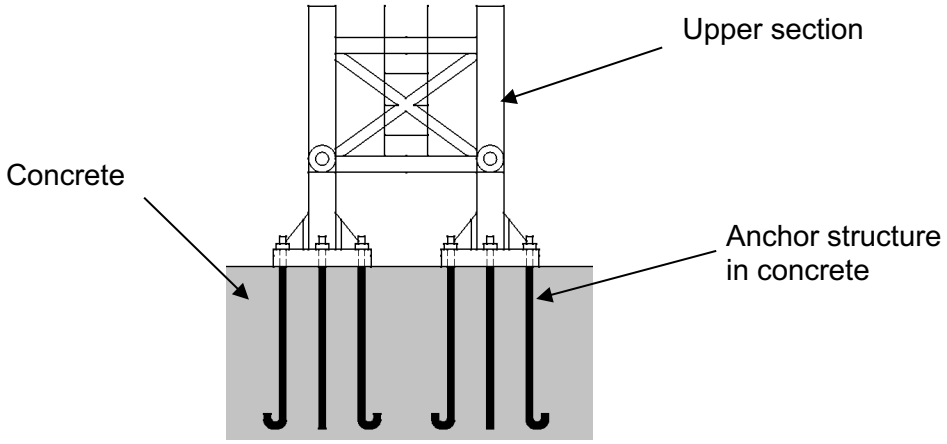


Figure 2.9 In-situ cast base

(ii) Own base

The base of the crane is constructed by placing ballast at the crane base with the chassis as the weight (Figure 2.10).

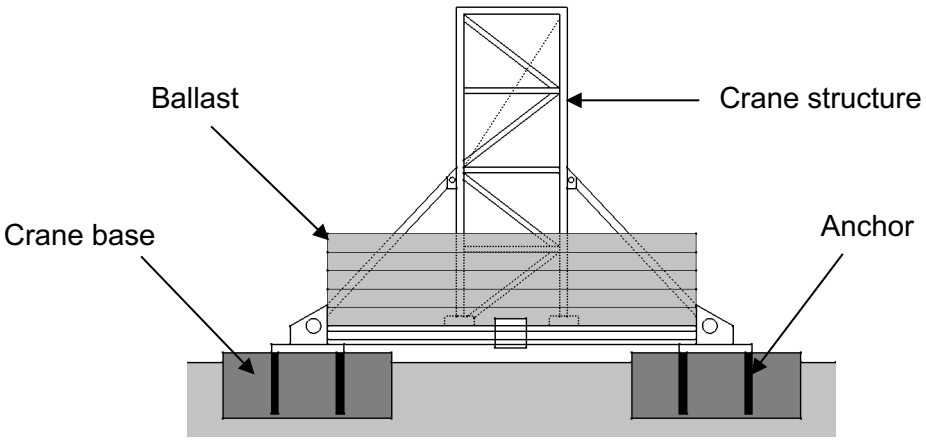


Figure 2.10 Static base (own base type)

(b) Climbing base

Tower cranes with this type of installation are usually used for the construction of high-rise buildings. The installation process involves

installing the base starting from one level to a higher level. There are two methods for the installation of a climbing base, namely: -

(i) Externally supported static crane

The base is supported by a construction/building structure joined by a climbing frame. The height of the crane can be extended, depending on the height of the building structure, and it should be aligned with the climbing frame (Figure 2.11).

Figure 2.11 Installation of crane with external climbing base (www.dcm.milgromandassociates.com)

(ii) Internal climbing crane

This type of tower crane installation is usually designed for tall buildings, and it is placed in a location where it can be supported by structures within the building that is under construction (Figure 2.12). The crane can be adjusted from one level of the building under construction to a higher level.

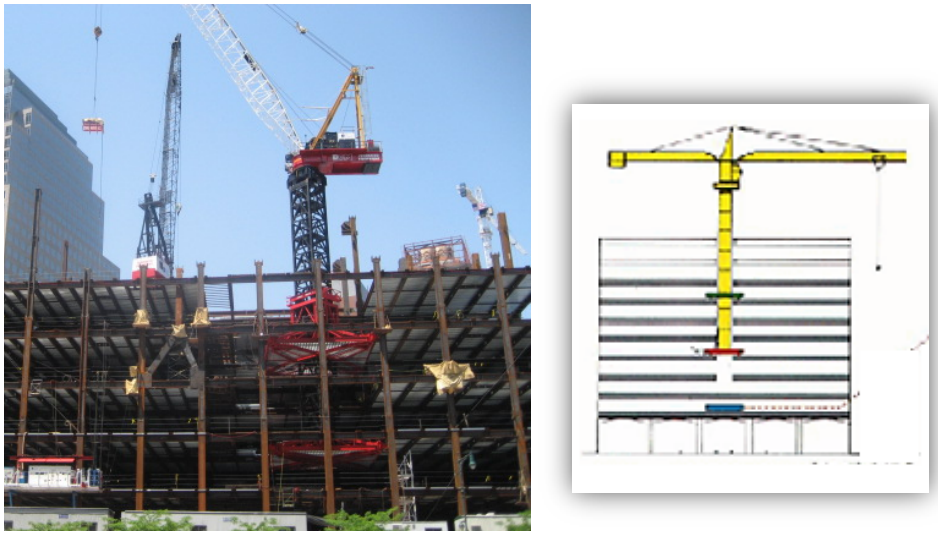


Figure 2.12 Installation of a crane with an internal climbing base (www.dcm.milgromandassociates.com)

(a) Travelling rails

This type of tower crane moves on heavy-wheeled bogies placed on rails. The bogies have no fixed grade but change according to the height of the mast mounted on the tower crane (Rajah 2.13-14).

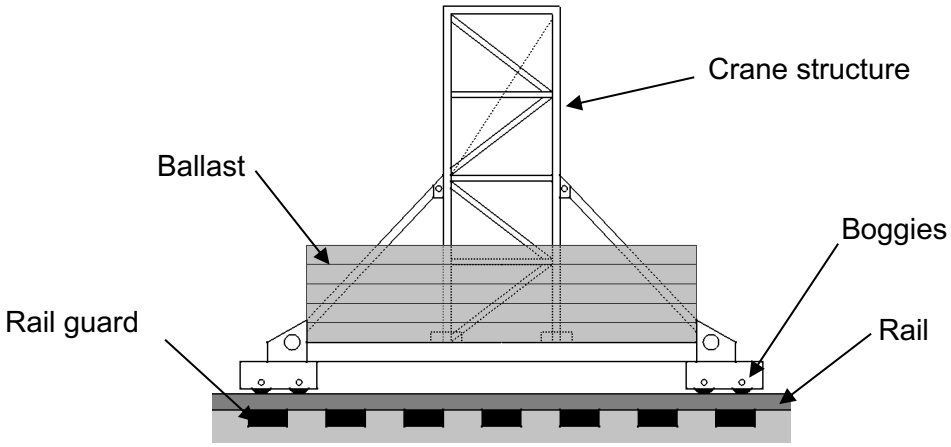


Figure 2.13 Travelling base (type of platform)

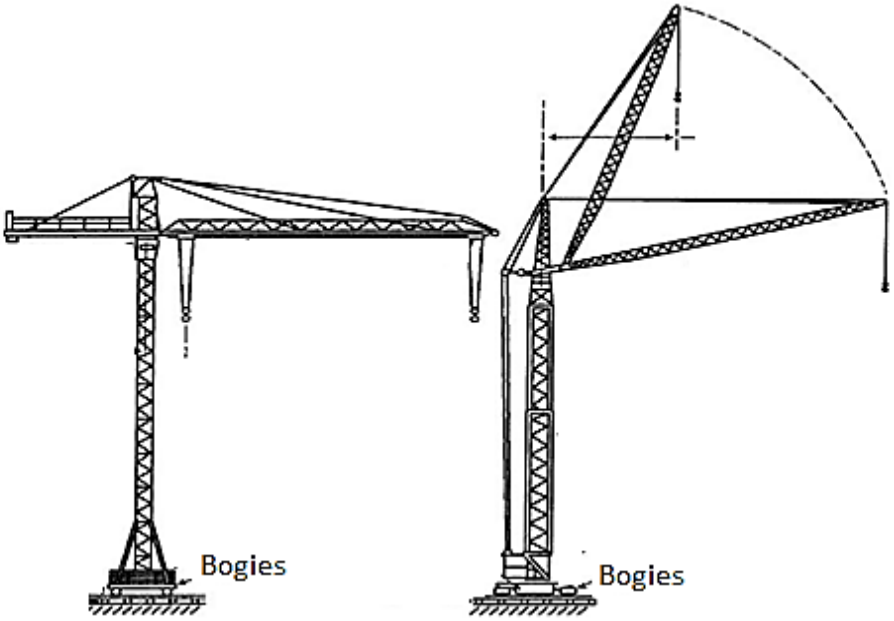
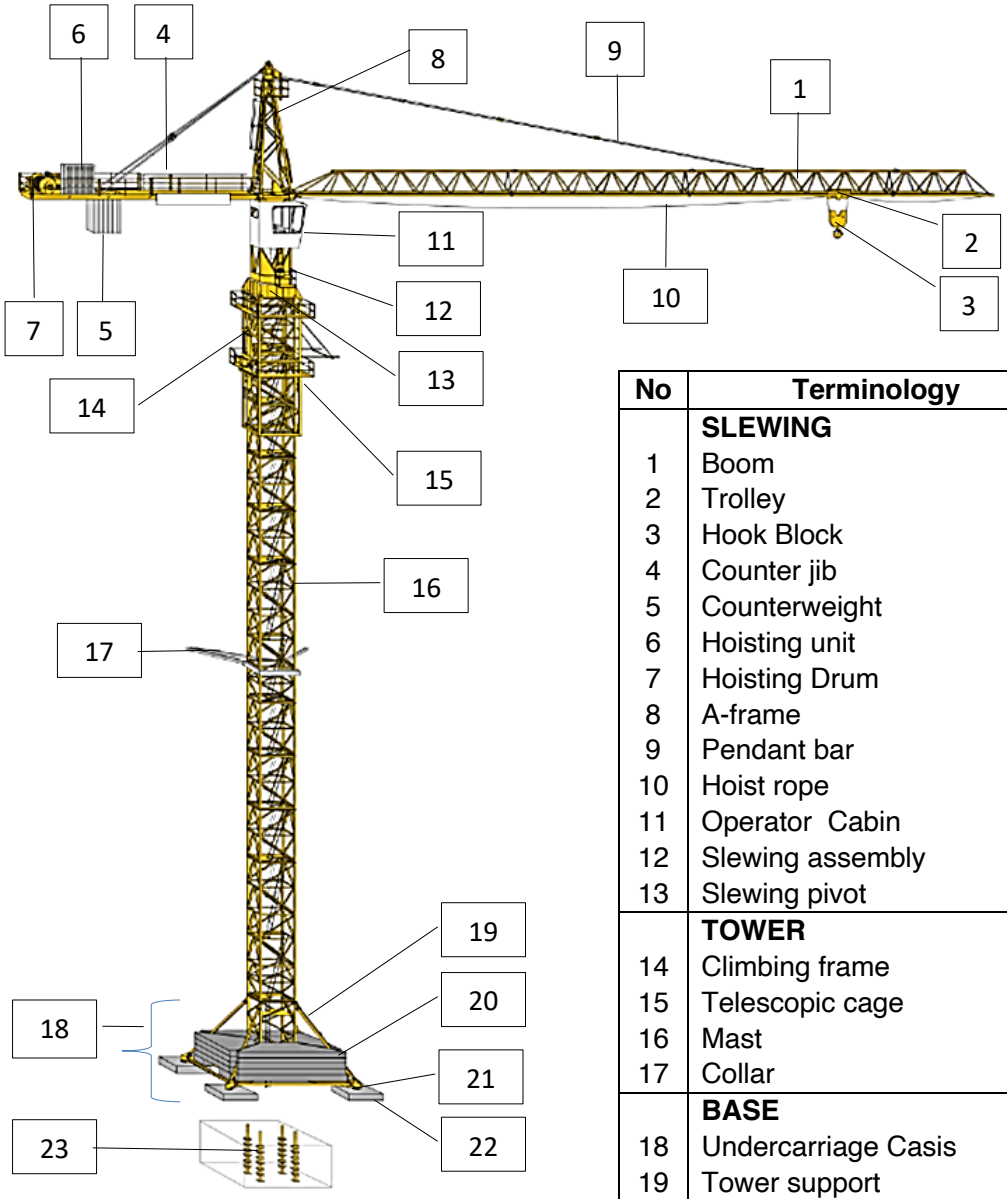


Figure 2.14 Crane with travelling rails base (Environmental, Health and Safety (EHS) Departments, US)

2.3 Tower Crane Terminology and Structures

(a) Saddle top hammerhead tower crane

This type of tower crane is adapted for industrial projects that have certain criteria, such as a wide load area, and it is driven by electrical power. If the area or site meets the specified criteria, then the hammerhead tower crane would be suitable for use (Figure 2.15).

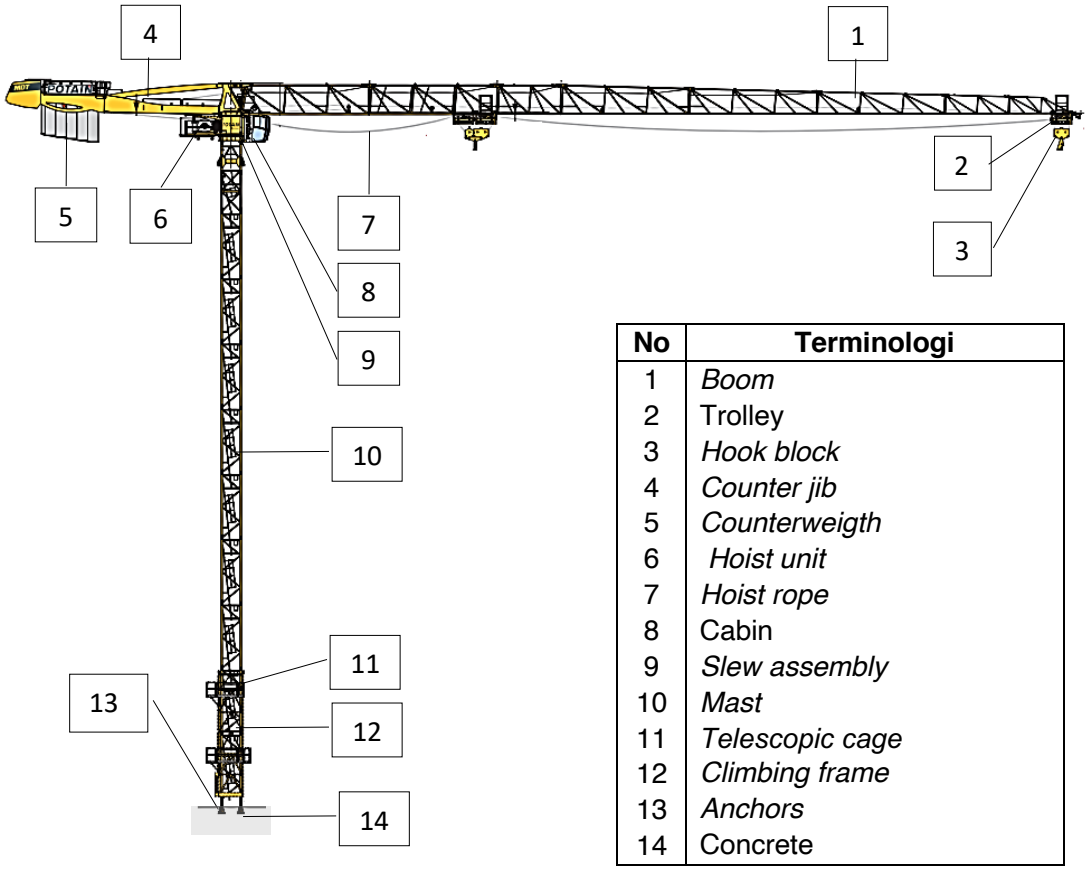


No	Terminology
	SLEWING
1	Boom
2	Trolley
3	Hook Block
4	Counter jib
5	Counterweight
6	Hoisting unit
7	Hoisting Drum
8	A-frame
9	Pendant bar
10	Hoist rope
11	Operator Cabin
12	Slewing assembly
13	Slewing pivot
	TOWER
14	Climbing frame
15	Telescopic cage
16	Mast
17	Collar
	BASE
18	Undercarriage Casis
19	Tower support
20	Center Ballast
21	Cross frame
22	Base plate
23	Anchors

Figure 2.15 Design of a hammerhead tower crane (saddle top) (http://www.morrow.com/crane101)

(b) Luffing tower crane

This type of tower crane, which is able to lift heavy loads and is powered by electricity, can be adapted for industrial projects with criteria such as limited load or rotation span. If the area or site meets the specified criteria, then the luffing tower crane is suitable for use (Figure 2.16).



No	Terminologi
1	*Boom*
2	Trolley
3	*Hook block*
4	*Counter jib*
5	*Counterweigth*
6	*Hoist unit*
7	*Hoist rope*
8	Cabin
9	*Slew assembly*
10	*Mast*
11	*Telescopic cage*
12	*Climbing frame*
13	*Anchors*
14	Concrete

Figure 2.16 Design of luffing tower crane
(http://www.morrow.com/crane101)

2.4 Conditions for the Selection of Tower Cranes

Each tower crane design is reasonably based on the requirements of its use. The explanation for the suitability of two main types of tower cranes is as follows:

(a) Hammerhead tower crane

This type of tower crane is suitable for industrial projects that have the following criteria:

- wide load area or reach
- limited strength of load to be lifted
- this type of tower crane is driven by electric power

If the area or site meets the above criteria, then the type of tower crane that is suitable for use is the hammerhead.

(b) Luffing tower crane

This type of tower crane is adapted for industrial projects that have the following criteria:

- limited load area or span
- a high load strength to be lifted
- most of these cranes use engine power

If the area or site meets the above criteria, then the luffing tower crane should be used. Table 2.1 gives a clearer picture of the differences in the suitability of these tower cranes.

Table 2.1 Differences between the requirements of hammerhead and luffing tower cranes

HAMMERHEAD	LUFFING
• Wide span of radius or rotation. • Load strength that can be hoisted is limited. • Uses electric power	• Limited span of radius or rotation. • Load strength that can be hoisted is higher. • Most tower cranes use electric power

2.5 Selection of Power Supply

Project managers must ensure that power supply is available for every crane used on the construction site. This is to avoid a situation where there is no power to operate the tower crane once it has been installed. When the crane is to be used in an area where there are electric cables, before commencing work advice should be sought from the electric utility company, such as Tenaga Nasional Berhad (TNB), to determine the safe operating distance from electrical conductors for live power lines. The management should hold

discussions as early as possible with those controlling the power lines to identify whether the source of the electricity supply is:

- An electric utility company such as Tenaga Nasional Berhad (TNB), or
- Genset.

The main contractor, project manager or person appointed to ensure the safety of the workers and people in the vicinity should ensure that the workers/workplace are at a safe distance from nearby electric cables. Given below is the recommended voltage range and safe distance when doing work near an electric current:

(a) 0-11,000 volts (distance of 5.79 m)

(b) 11,000-66,000 volts (distance of 6.10 m)

(c) 66,000-132,000 volts (distance of 6.70 m)

(d) 132,000-275,000 volts (distance of 7.00 m)

(e) Exceeding 275,000 volts (distance of 7.30 m)

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CHAPTER 3

LIFTING EQUIPMENT AND INTRODUCTION TO LIFTING WORKS

3.1 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.

This chapter describes the equipment that connects the load to the mechanical equipment.

3.2 Principles Regarding the Handling of 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.

3.3 Uses of Lifting Equipment

3.3.1 Wire Ropes

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

(a) Wire rope structure

Figure 3.1 shows the main components of a wire rope, while Figure 3.2 describes the structure of a wire rope.

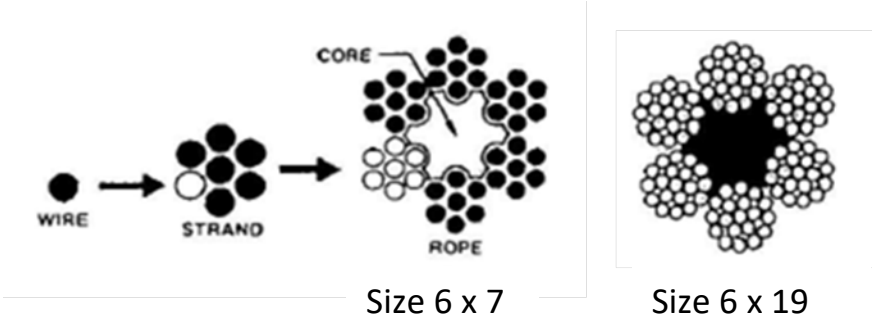


Figure 3.1 Forms and classes of wire ropes (www.liftingoeregulations.blogspot.com.es)

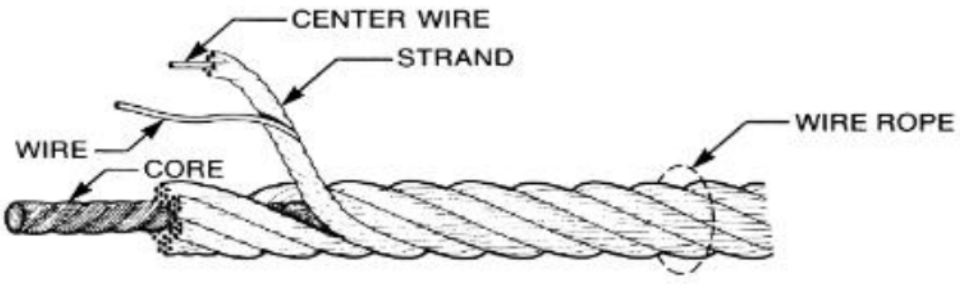


Figure 3.2 Structure of a wire rope (www.edwardswirerope.com)

Figure 3.3 Actual photo of a wire rope (www.liftsafegroupofcompanies-wordpress.com)

As can be seen in Figure 3.3, 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 3.1 is a wire rope with a different size, i.e. 6 x 19, meaning 6 strands with 19 fine wires forming each strand (Figure 3.4).

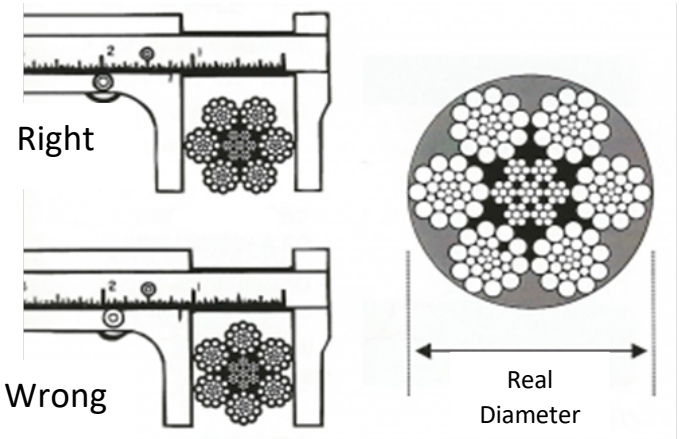


Figure 3.4 The correct way to measure the diameter of a wire rope (www.portcityindustrial.com)

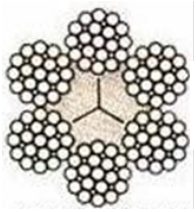
(b) Types of cores

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



Core type : Fibre
Classification : 6 x 19

(a)

Core type : Strand
Classification : 6 x 19

(b)

Core type : Steel
Classification : 6 x 19

(c)

Figure 3.5 Wire ropes with different cores: (a) fibre core, (b) strand core, (c) steel core (Lee Stinnett, 1986)

- Fibre cores (Figure 3.5 (a)) are usually used for hoisting loads that are not heavy.
- In a wire strand core (Figure 3.5 (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 3.5 (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 3.4 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.

(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 3.1.

Table 3.1 Classification of the strength of iron (Iron wires from Australia)

Type	*Minimum Tensile*	*Abbreviated Description*
Black 8Bright, non-galvanished) wire	1770 MPa	1770 grade
Galvanished 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) Maintenance and inspection of wire ropes

- Figure 3.6 shows the correct way to coil a rope from reel-to-drum/from reel-to-reel. The must be coiled in a clockwise direction. The drum must be suspended in a special place without touching the ground to avoid friction and to prevent the wires from unravelling.

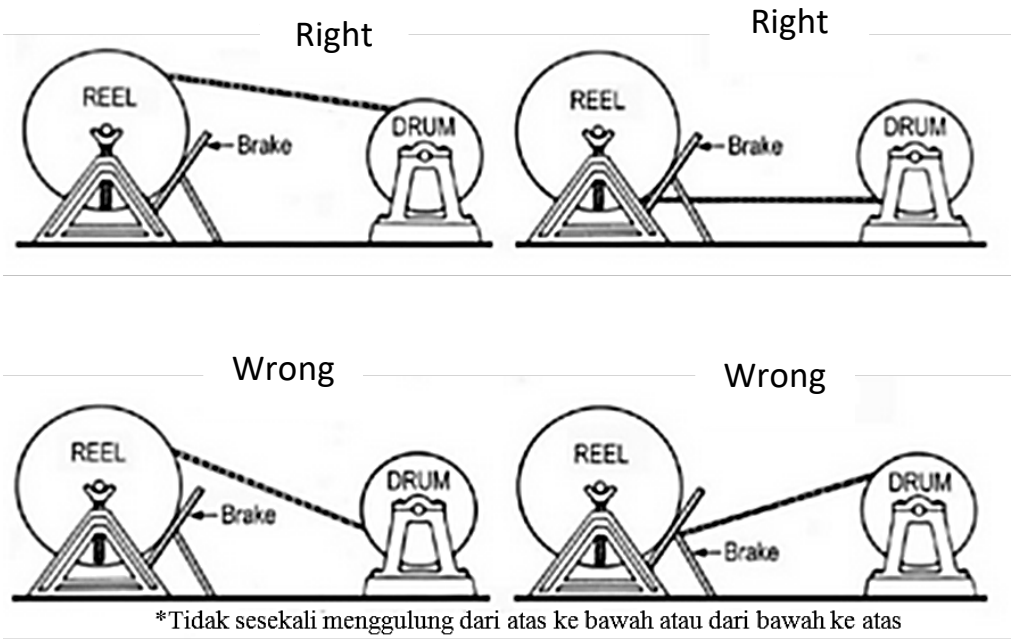


Figure 3.6 Correct and wrong way to coil a rope (www.slideshare.net)

- Figures 3.7 and 3.8 show the way to coil a wire rope round a drum according to the type of rope lay. The drum has grooves, and the distance between the topmost surface of the rope and the edge of the drum frame should be more than 50 mm.

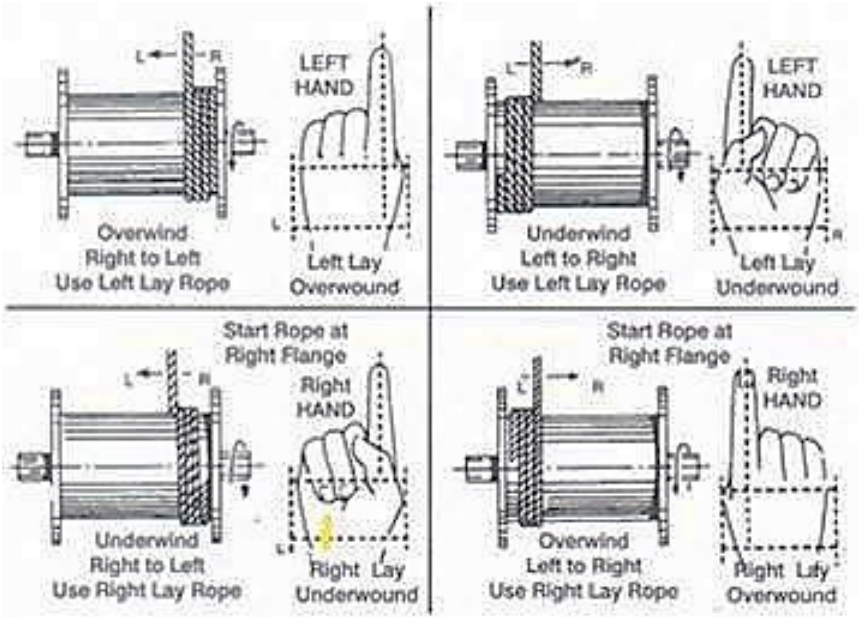


Figure 3.7 Drum grooves and distance between rope and edge of the frame (Lee Stinnett, 1986)

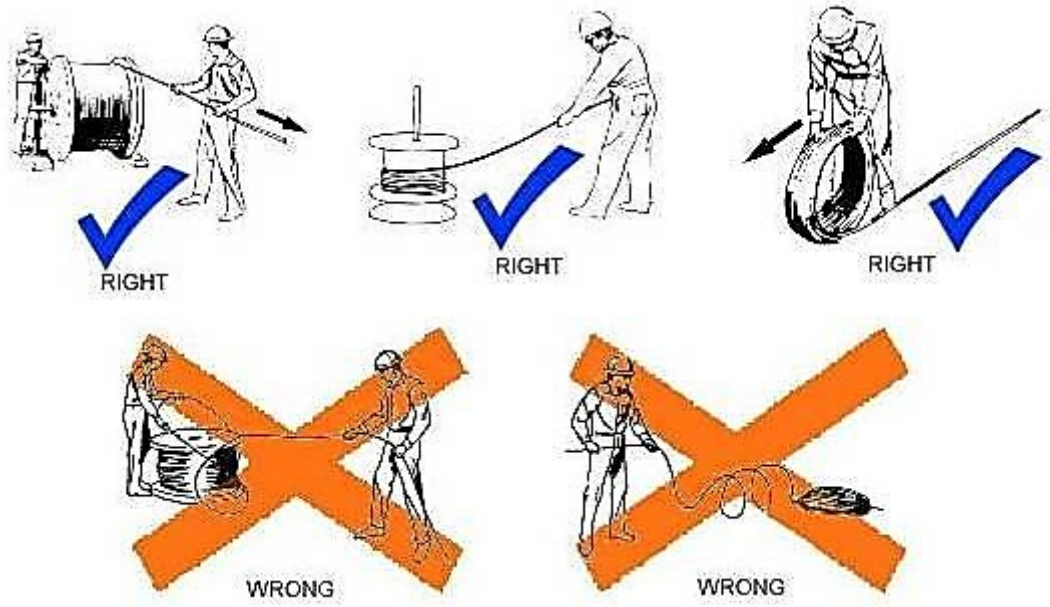


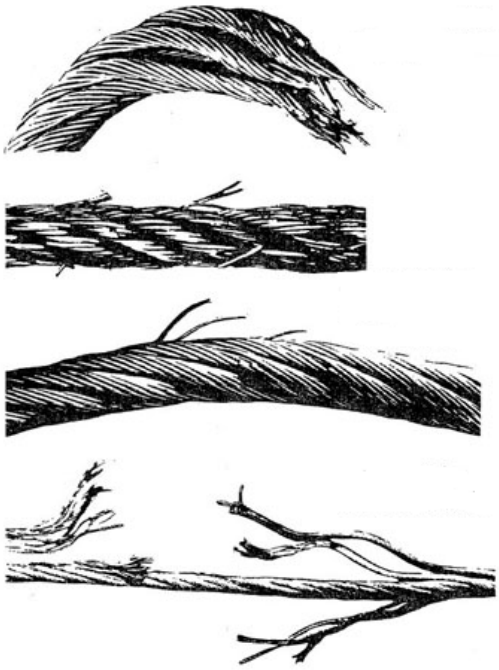
Figure 3.8 Correct and wrong way of handling wire ropes (www.practicalmaintenance.net)

- Avoid coiling the rope in reverse.
- 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.

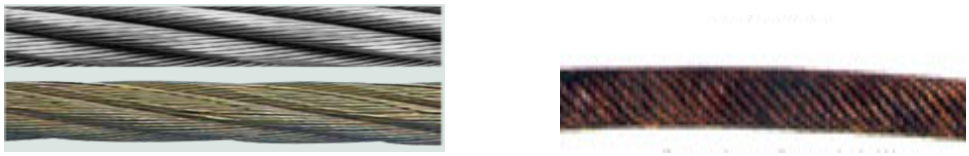
- Do not allow the rope to become knotted or to split.
- Store in a clean and dry place.
- Ensure the rope is not exposed to any corrosive substance while in storage.

Figure 3.9 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)

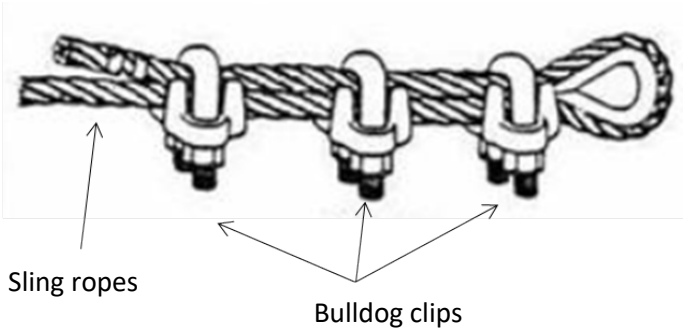
(d) Bird caging (unravelled) (www.work.alberta.ca)

Figure 3.9 Examples of damage to wire ropes

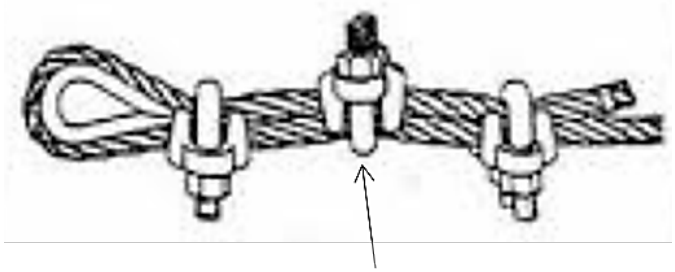
- Use of bulldog clips
  - It is necessary to ensure that the number of clips is sufficient for the size of the wire sling being used, as shown in Table 3.2 and Figure 3.10.

Table 3.2 Number of bulldog clips for use with different sizes of sling ropes

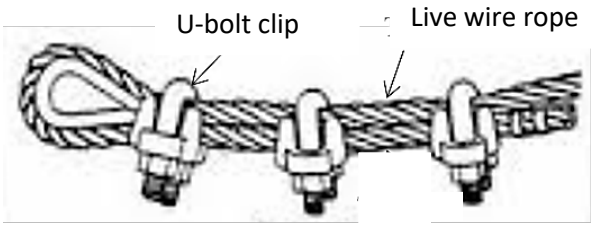
sizes of sling ropes (Diameter, mm)	Number of bulldog clips
8 - 20 mm	3
21 - 32 mm	4
33 mm and above	5



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

3.3.2 Synthetic fabric slings

Figure 3.11 shows a few synthetic fabric slings that are used for hoisting works. There are several types of such slings, as shown in Figure 3.12. 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 3.11 Picture of a synthetic fabric sling (www.craneinstitute.com)

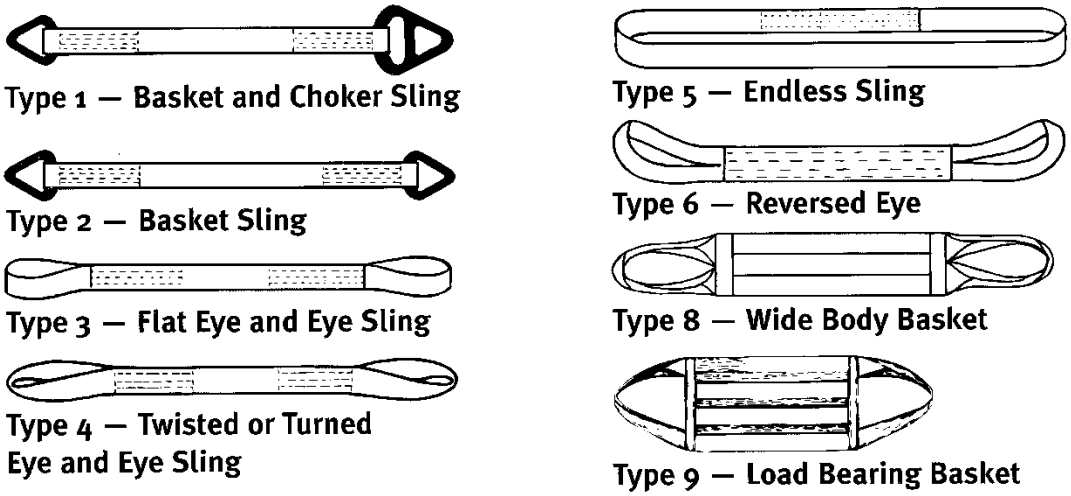


Figure 3.12 Some types of synthetic fabric slings (www.totaltool.com)

(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

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

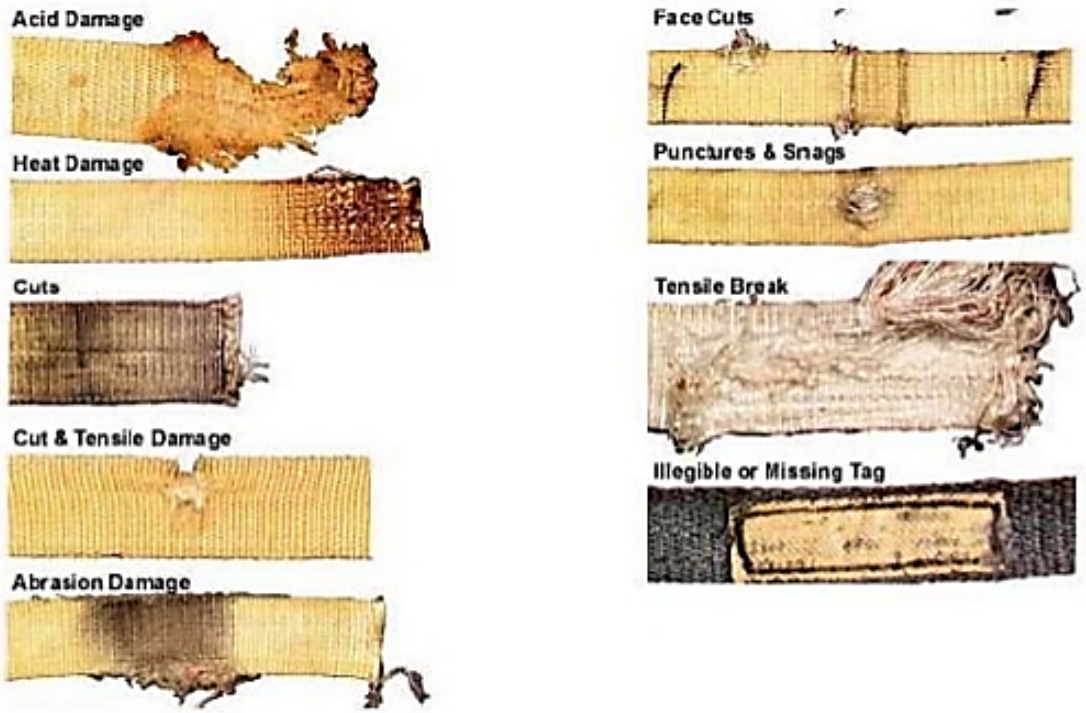


Figure 3.13 WLL mark on a synthetic fabric sling (www.redspearsafety.com.au)

3.3.3 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:

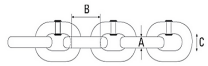
- Minimum tension of 800 MPa to the destruction of strength for a breaking load
- Minimum tension of 400 MPa for a load test approval
- Total minimum elongation limit of 17%

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 3.3)

Table 3.3 Types of chains and their uses

Type of Chain	Use
Short Link  (Source: www.qdacsco-rigging.com)	Lifting Loads
Long link  (Source: www.suncorstainless.com)	Hitching Loads
Stad Link  (Source: www.zszhongnan.com)	For marine use
Calibrated   (Source: www.seagoyachting.com)	For chain blocks
Bush Roller  (Source: www.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 3.4 shows the grades of short link chains and their labels.

Table 3.4 Grades and labels for short link chains

Grades for short link chains	Label
30	L
40	M
50	P
60	S
80	T

Examples of chain labels are shown in Figure 3.14.

Figure 3.14 Chain labels (www.tresterhoist.com, www.blog.cmworks.com, www.auslift.com.au, www.brindleychains sproket.co.uk)

Figure 3.14 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 3.15.

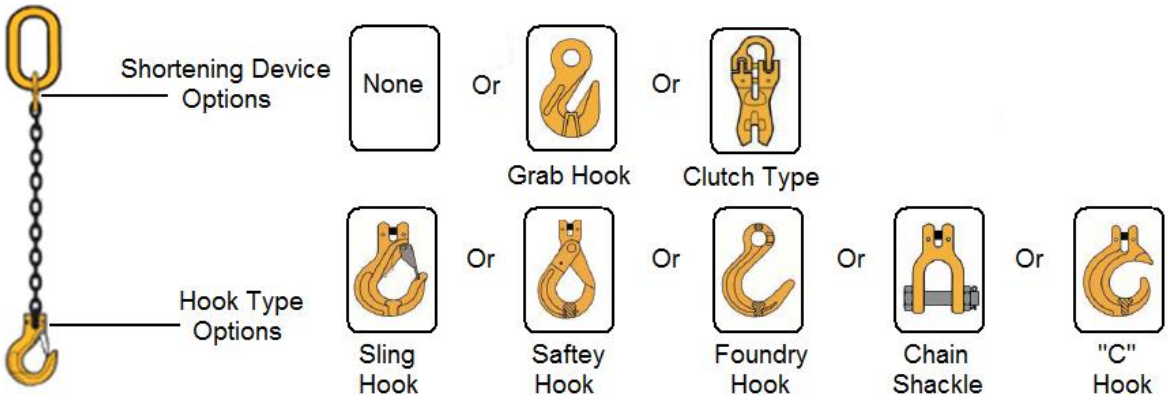


Figure 3.15 Single-leg short link chain with a master link and hook (www.liftsolution.co.uk)

- The use of a four-leg short link chain is shown in Figure 3.16.

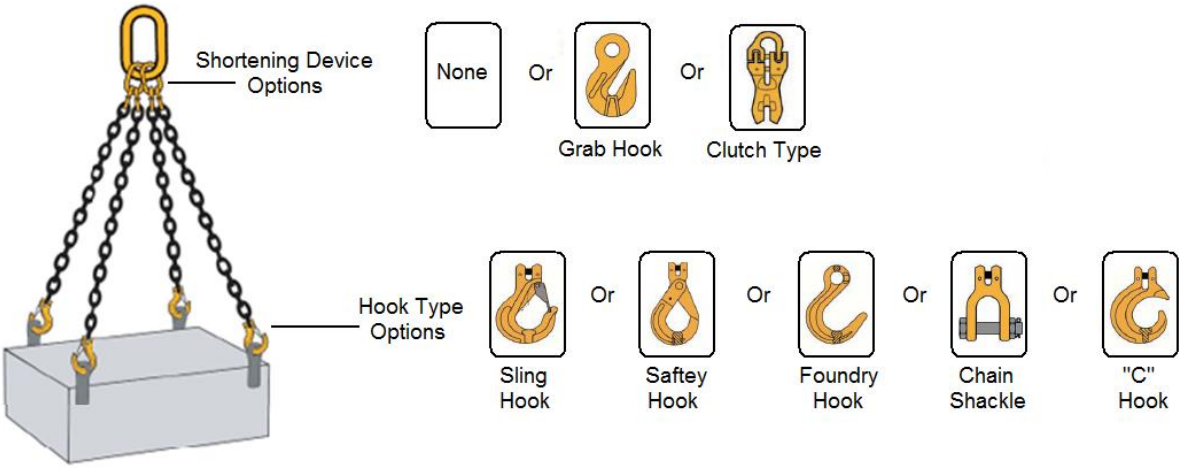


Figure 3.16 Four-leg short link chain with master link and hook (www.liftsolution.co.uk)

(c) Maintenance and inspection of chains

- The diameter of the chain link can be measured using Vernier callipers (Figure 3.17).
  - A minimum diameter of 6 mm is required for use as a sling.

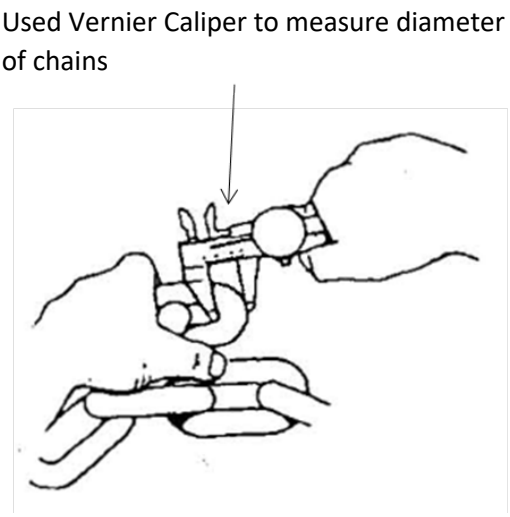


Figure 3.17 Method for inspecting chains

- **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 3.18 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 3.19).

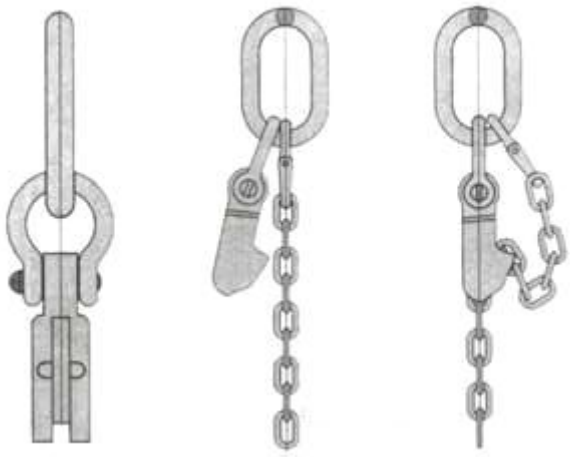


Figure 3.18 Use of clutch hook (www.ecvv.com)

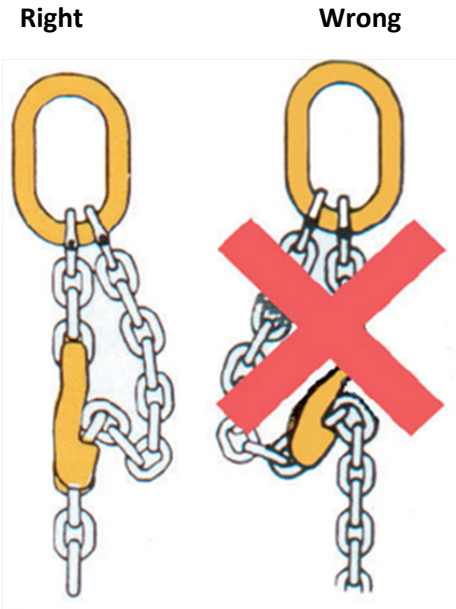


Figure 3.19 Correct and wrong use of clutch hook (www.nobles.com.au)

- 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 3.20 below shows several examples of damaged chains.

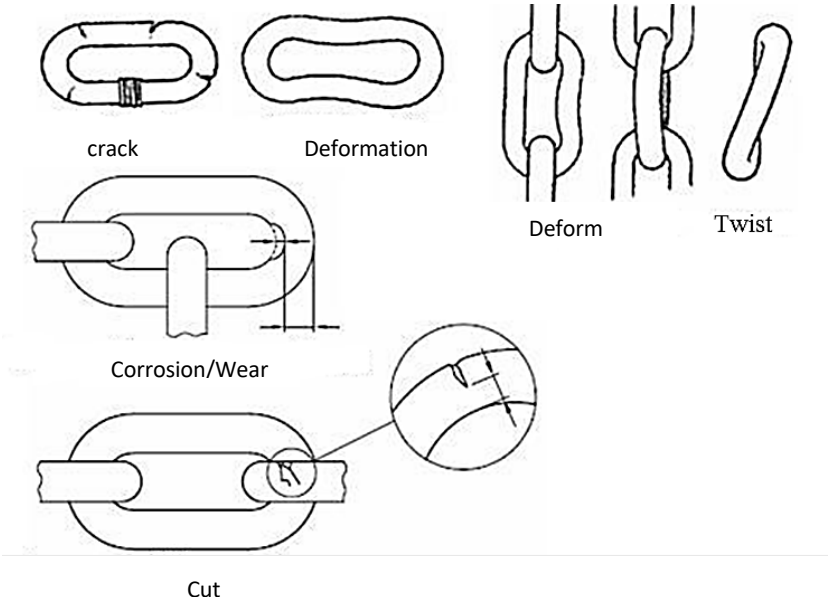


Figure 3.20 Damage to chains (www.Suggest-keywords.com)

- Things to avoid when using chains

  Figure 3.21 below shows several examples of the wrong use of chains and things that should be avoided to prevent accidents and damage to the chains.

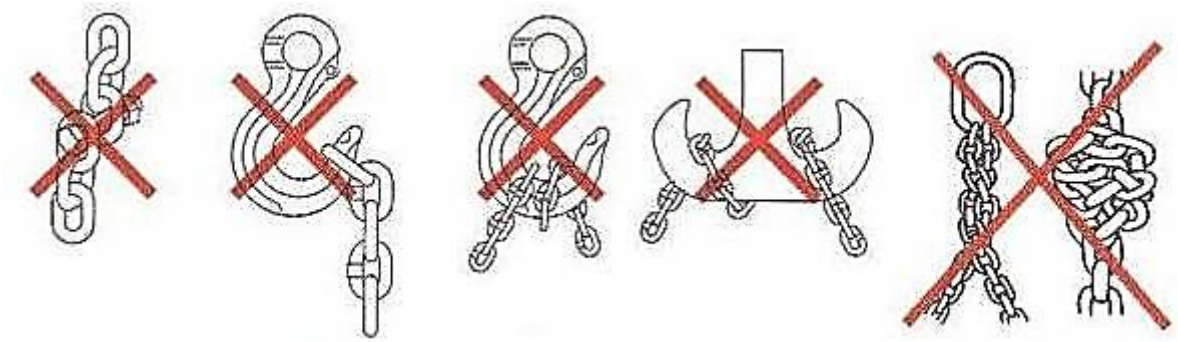


Figure 3.21 Wrong ways of using chains (www.practicalmaintenance.net)

3.3.4 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.

3.3.5 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.

3.3.6 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.

3.4 Uses of Additional Lifting Equipment

To ensure safety during hoisting works, the appropriate additional lifting equipments must be selected such as taglines and push-pull pole.

3.4.1 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 3.22 and 3.23). They are suitable as taglines because they are flexible and are non-conductors.

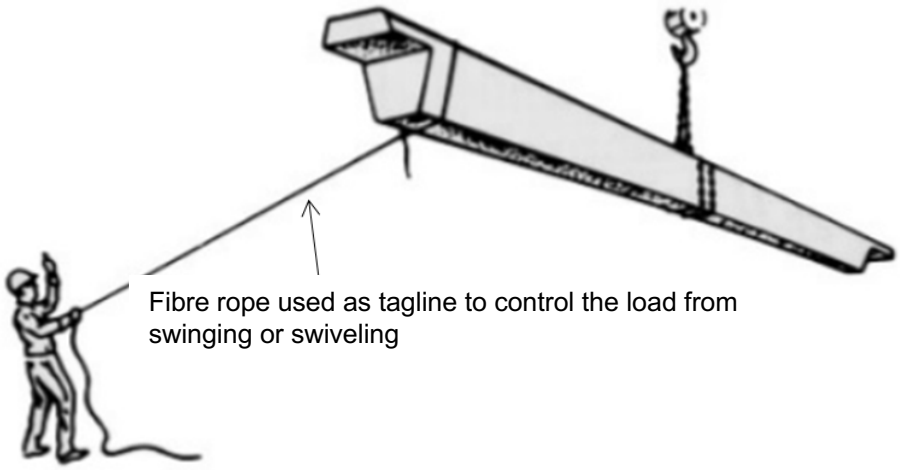


Figure 3.22 Use of fibre rope to control loads (www.lift-it.com)

Rajah 3.23 Use more than one of fibre ropes to contro loads (www.cranetech.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

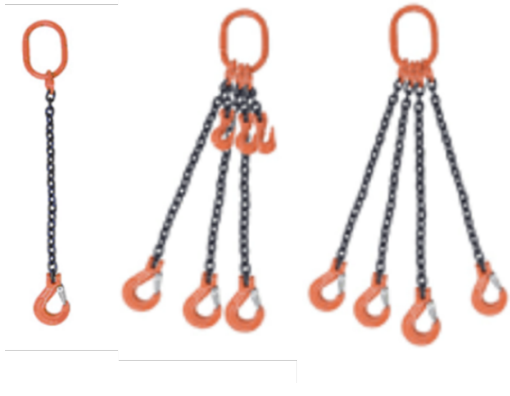
3.4.2 Push-Pull Pole

The push-pull pole is a long rod that is used to aid in the process of descending / lifting loads. The push-pull pole works to ensure that the loads are not directly touched by the relevant workers at the site during lifting operations.

3.5 Load Slinging

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 3.24 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 3.24 Types of slings that are usually used at construction sites (www.uscargocontrol.com/Lifting-Slings)

3.6 Sling Terminology

3.6.1 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.

3.6.2 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.

3.6.3 Breaking strength

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

3.6.4 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.

3.6.5 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 3.5 shows the SF values for several types of lifting equipment.

Table 3.5 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:

$$BS \div SF = WLL \quad (4.1)$$

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.

3.7 Basic Calculations for Determining the Weights of Materials of Various Shapes

There are several ways of determining the weights of building materials, such as:
a) The weight of the material may be marked on the material itself,
b) Ask the supervisor or any person who knows,
c) If the material comes with a catalogue, the weight of the material can probably be obtained from the catalogue,

d) Through business records or instruction manuals that may provide clearer information,

e) Through the engineers' manual,

f) Calculation

Table 3.6 Weight various materials (PN120 Tower Crane-Code of Practice, Australia, 2017)

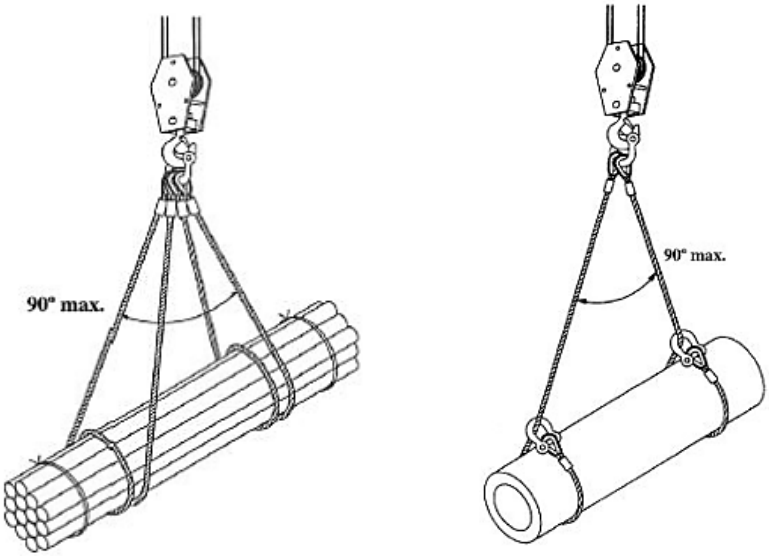
Materials	**Weight**
Aluminium	2.7 tonne/m^3
Bricks, clay	1.6 tonne /m^3
Cast iron	7.2 tonne /m^3
Cement	50 kg/bag
Concrete, wet or set	2.4 tonne /m^3
Concrete panel (Steel reinforced)	3.0 tonne /m^3
Petrol	0.7 tonne /m^3
Diesel	0.8 tonne /m^3
Earth	1.8 tonne m^3
Glass	2.6 tonne /m^3
Hardwood	1.1 till 1.4 tonne /m^3
Lead	11.3 tonne /m^3
Road metal, Crushed rock	1.9 tonne /m^3
Dry sand	1.7 tonne /m^3
Wet sand	1.9 tonne /m^3
Softwood	0.6 tonne /m^3
Steel	8.0 tonne m^3
Mild steel	7.84 tonne /m^3
Water	1.0 tonne /m3 (1000 litre/m3)
Scaffold fittings (4.9 mm thick) (Frame)	0.5 kg/m; *AST Rigging Handbook*, 1.5 kg/m *(for Australia Scaffold)*
Scaffold tubes (tubes turbular type) (Steel)	4.41 kg/m
Scaffold planks	7 kg/m
H" (Steel H-beam)	45 kg/m
Steel pipe (20 mm thick)	2.4 tonne /m3

3.8 Classification of Lifting Works

Lifting works can be classified as routine and non-routine lifting works. Both types of lifting works should have a carefully prepared lifting plan to identify the existing risks and the required level of control. The lifting plan can be planned on a daily, weekly or monthly basis.

3.8.1 Routine lifting works

Routine lifting works can be carried out under a basic lifting plan. This lifting plan must clearly define the load limit, the lifting method and the area of operation. For every load to be lifted, the lifting supervisor should conduct a risk assessment, which must be evaluated by the site safety supervisor and approved by the project manager before the lifting works can commence. Non-routine lifting works can also be carried out using the same documents, but they require more detailed information. The lifting plan has to be reviewed before the lifting works begin. Some examples of routine lifting works are shown in Figure 3.25.



(a) (b)

Figure 3.25 Examples of routine lifting works: (a) lifting of several metal rods, (b) lifting of cylinders (Hoisting and Rigging Safety Manual, 2012)

Among the factors involved in routine lifting works are:

(a) lifting within the normal operating range of the crane,
(b) lifting loads in an area that is not inconvenient/normal
(c) construction site is in suitable surroundings,
(d) shape, weight and centre of gravity of the load have been identified,
(e) repetitive lifting works using the same lifting equipment or lifting gear,
(f) an equally competent crane operator,
(g) the weight of the load to be lifted is below 75% of the load weight limit in the load chart,
(h) the lifting equipment is specially assembled by a skilled rigger,
(i) an appropriate lifting point is used,
(j) a suitable lifting height,
(k) standard hitching method.

Note: In the case of repetitive or routine lifting works, the lifting work plan is only required at the beginning with regular observations.

3.8.2 Non-routine lifting works

Non-routine lifting works require more detailed lifting plans and factors compared to routine lifting works. These lifting plans, and any other requirements identified from those plans, must be approved by the project manager before the lifting works can be carried out. Figures 3.26 and 3.27 illustrate the flowchart for the identification, planning and implementation of lifting works based on the *Guidebook for Lifting Supervisors* (2011).

Among the factors involving non-routine lifting works are:

(a) the use or two or more lifting equipment,
(b) lifting of loads in a sensitive, difficult or confined area,
(c) lifting works are resumed by different individuals,
(d) lifting a machine without a lifting point,
(e) in an environment that may influence the performance of the equipment,
(f) difficult to estimate the weight of the loads and/or the centre of gravity,
(g) hitching method that is not according to the standard,

(h) load is lowered or raised from a confined space,

(i) weight of the load is more than 75% of the load weight limit in the load chart.

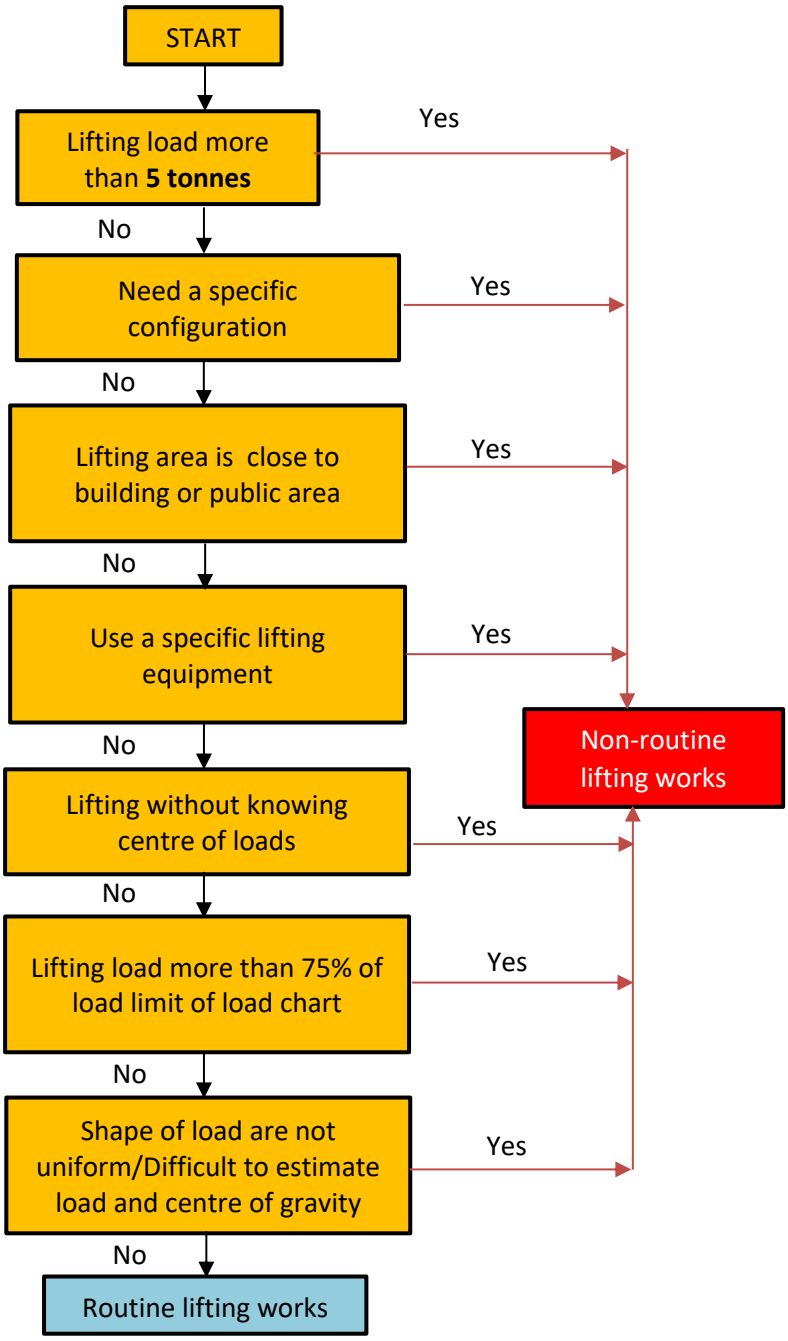


Figure 3.26 Identification of routine or non-routine lifting works

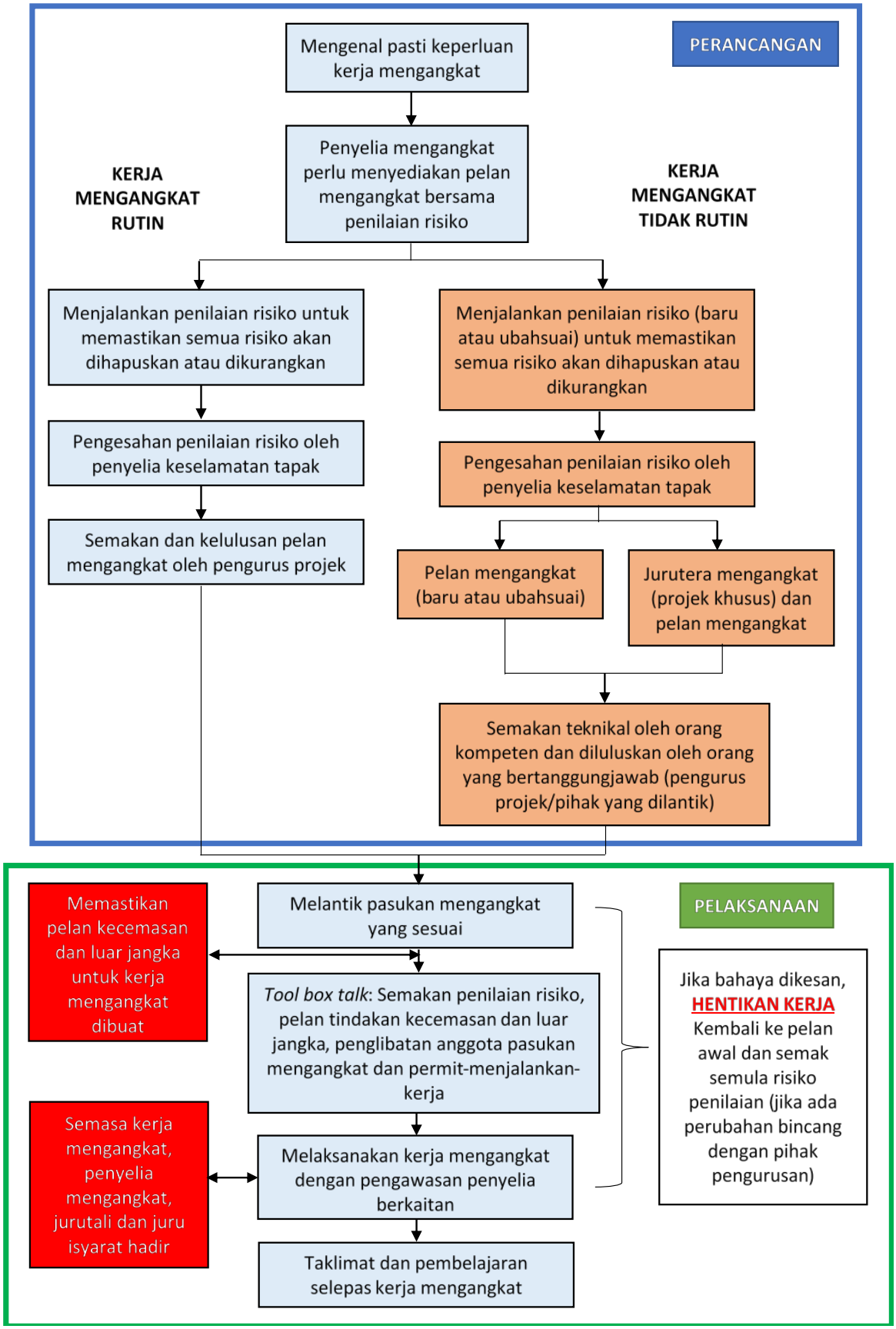


Figure 3.27 Flowchart on planning and implementation of lifting works

3.9 Permit-to-Work

A permit-to-work system is a system for managing and controlling several types of hazardous works, including lifting operations. The lifting supervisor, who is coordinating the lifting operations, has to apply to the project manager to conduct the lifting operations. The scope and conditions for the lifting operation that is to be carried out must be stated in the permit-to-work (PTW) application. The project manager is responsible for conducting an inspection to confirm that appropriate control measures have been taken to reduce any risk of expected hazards. Once it is confirmed that the safety measures have been taken, the application will be approved by the project manager. The contents that must be in the PTW (guide to contents in PTW issued by DOSH, as shown in Figure 3.28) are as follows:

(a) Identification of hazards,

(b) Risk assessment,

(c) Required control measures for the eradication of hazards and the level of risk,

(d) Determining the persons who are at risk, and they being not limited to:

  (i) the lifting supervisor

  (ii) signalman

  (iii) rigger

  (iv) crane operator

  (v) persons who inspect, install, climb, test, maintain and dismantle the tower crane

  (vi) construction workers

  (vii) members of the public

(e) Prepare a PTW in writing to include the following:

  (i) level of competence, skills and expertise in all lifting operations

  (ii) list of segregation/precautionary measures before lifting works are carried out

  (iii) list of prohibited activities

  (iv) list of lifting equipment and machines to be used

  (v) list of personal protection equipment to be used

(vi) list of the planned work sequence on identifying the hazards/control measures for eradicating the hazards

(vii) emergency action plan

(viii) list of the personnel and the relevant authorised personnel involved in the application, assessment, issuing, monitoring and cancellation of the PTW

(f) Hold a briefing for members of the lifting team regarding the hazards and control measures that should be taken,

(g) Ensure the individuals in the lifting team understand and comply with the PTW,

(h) The PTW must be displayed at the workplace for the reference of the workers who are involved, and a copy must be kept for the reference of DOSH,

(i) Ensure the work area is clean and safe,

(j) Ensure all the safety devices on the crane are functioning properly.

Figure 3.28 Guide to contents and works that require a permit-to-work

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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 Figures 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) 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.

(c) 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

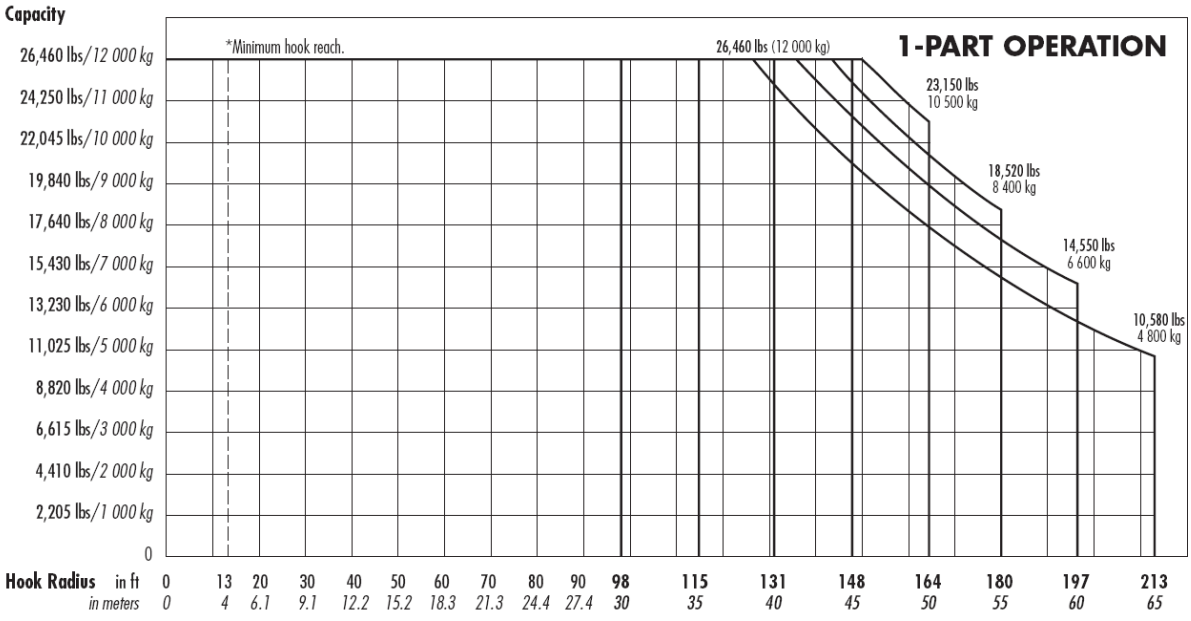


Figure 4.1 Load chart for a luffing crane (single-wire rope reeve) (Lift Director-Tower Cranes Load Chart Manual, 2013)

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

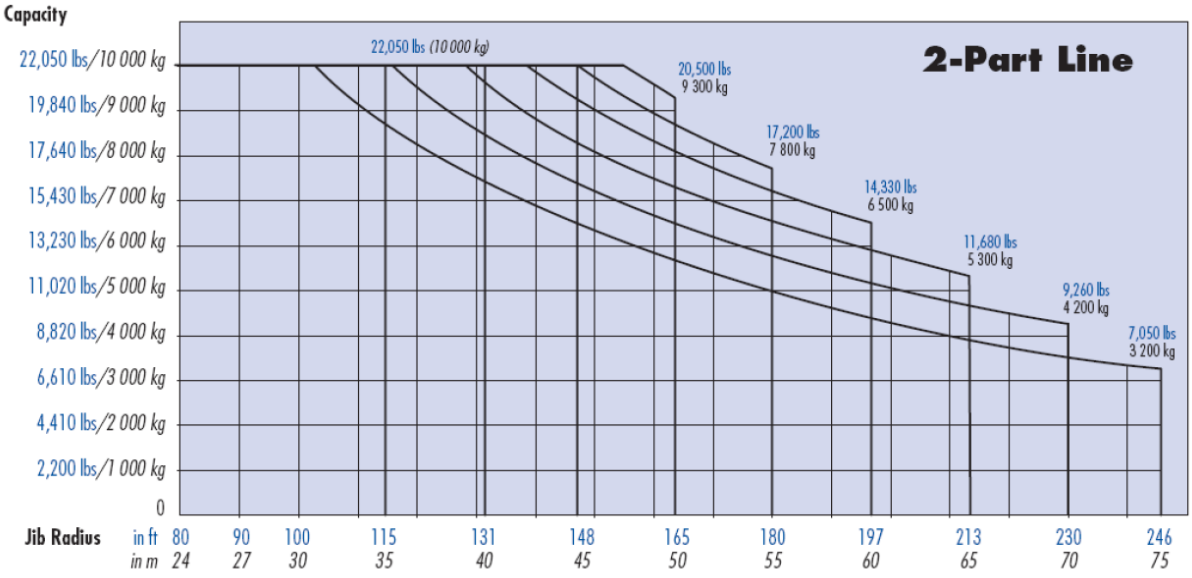


Figure 4.2 Load chart for a hammerhead crane (double-wire rope reeve) (Lift Director - Tower Cranes Load Chart Manual, 2013)

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.

Examples of boom configurations and specifications for tower crane operations of hammerhead model Kroll K180 are shown in Figures 4.3-4.4.

- Kroll K180 hammerhead tower crane model

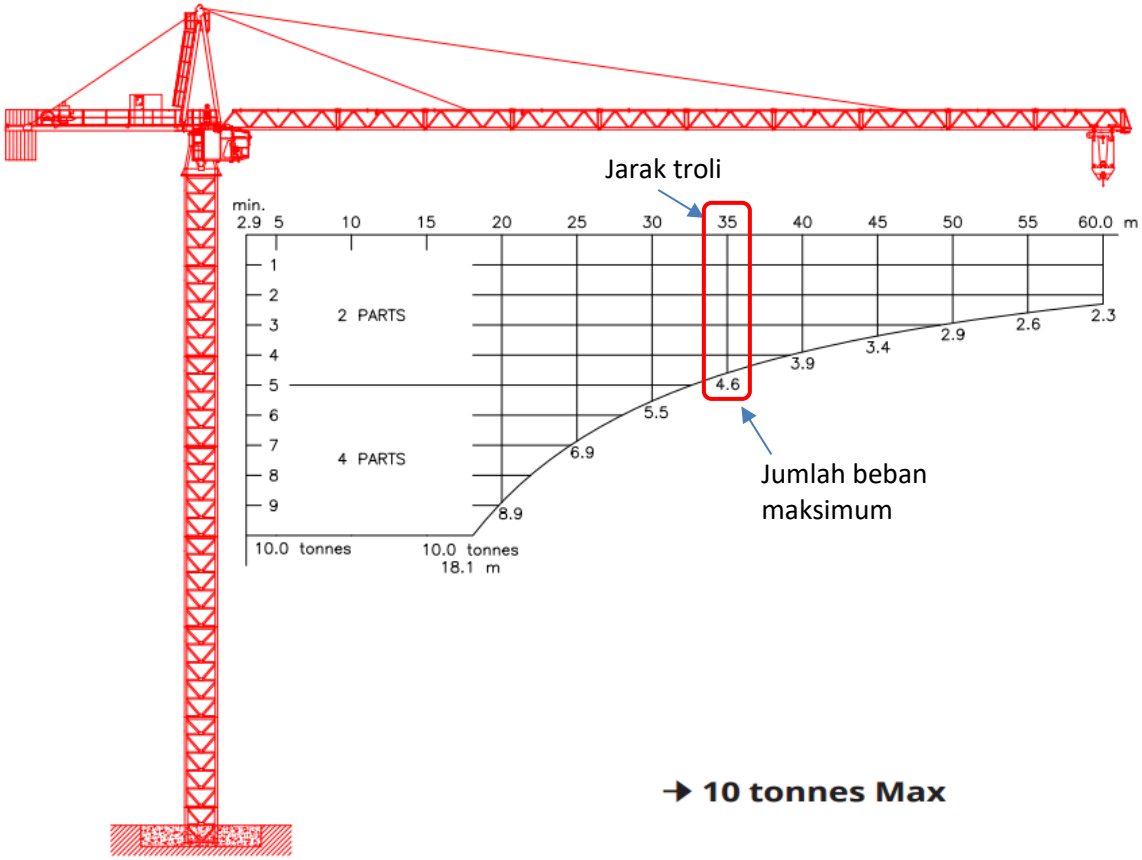


Figure 4.3 Boom configuration and maximum load for hammerhead tower crane (www.krollcranes.dk)

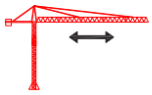
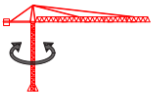
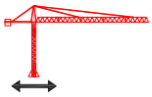
TROLLEY SPEEDS			TROLLEY WIRE	
	0 - 10 t	0 - 70 m/min	Diameter	10 mm
			Safety Factor	5
			MBL	87 kN
	SLEW DRIVE Motor 2 x 7 kW			POWER SUPPLY 400 - 480 V, 50/60 Hz
SLEW SPEEDS			Consumption	50 kVA
	0 - 10 t	0 - 0.7 rpm	Main Fuse	80 A
			Recommended Genererator Size	125 kVA
	UNDERCARRIAGE Motor 2 x 5.5kW			SUPPLY CABLE
TRAVEL SPEEDS			Cable Length	Cable Type
	0 - 10 t	0 - 20 m/min	0 - 175 m	4 x 16 mm²
			175 - 250 m	4 x 25 mm²

Figure 4.4 Specifications for the operation of hammerhead tower cranes (www.krollcranes.dk)

Examples of the boom configurations, design specifications and load charts for luffing tower cranes are shown in Figures 4.5-4.7.

- Potain MR605 luffing tower crane model

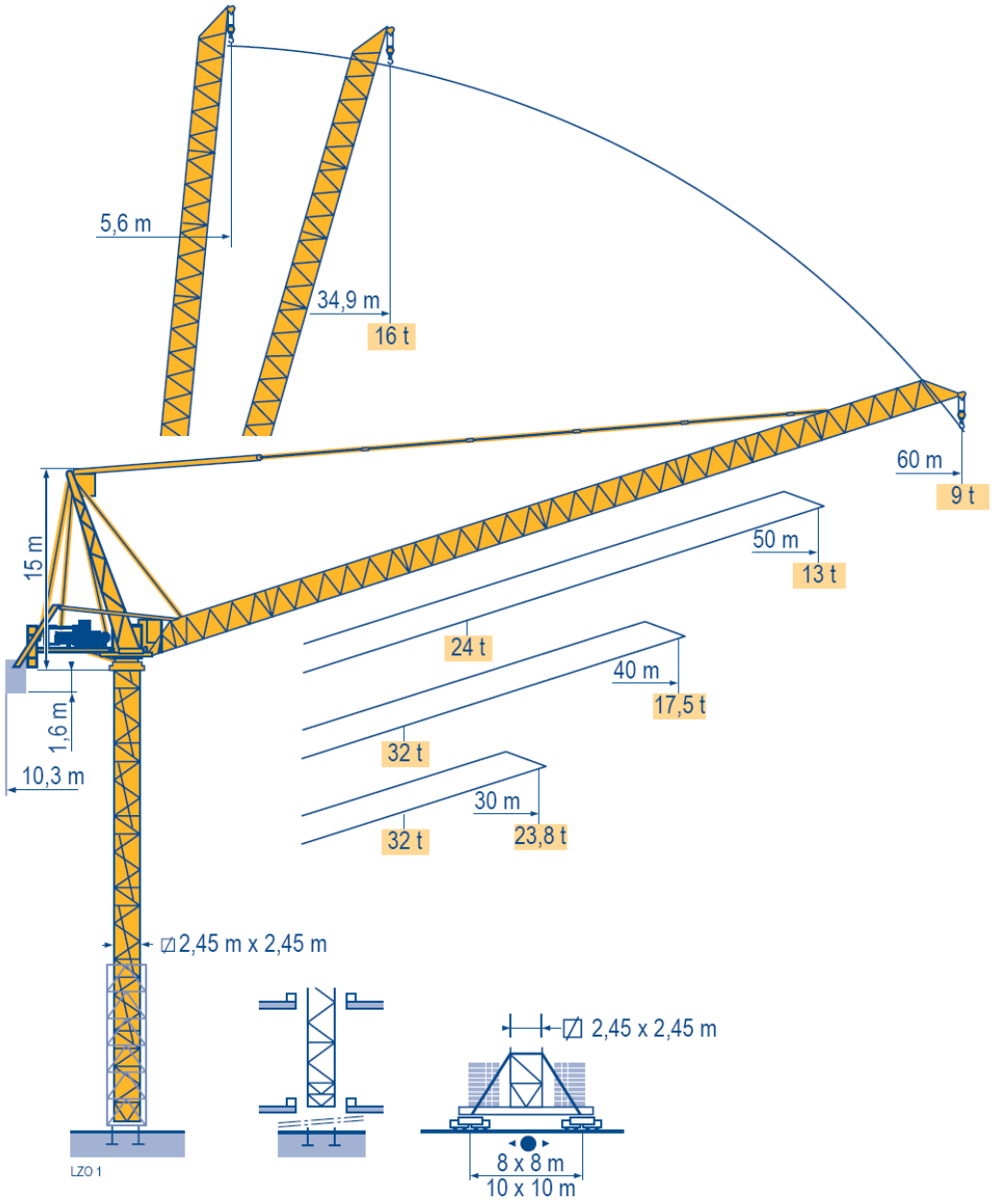


Figure 4.5 Configurations for boom distance and safe load weight for luffing tower cranes
(www.bigge.com)

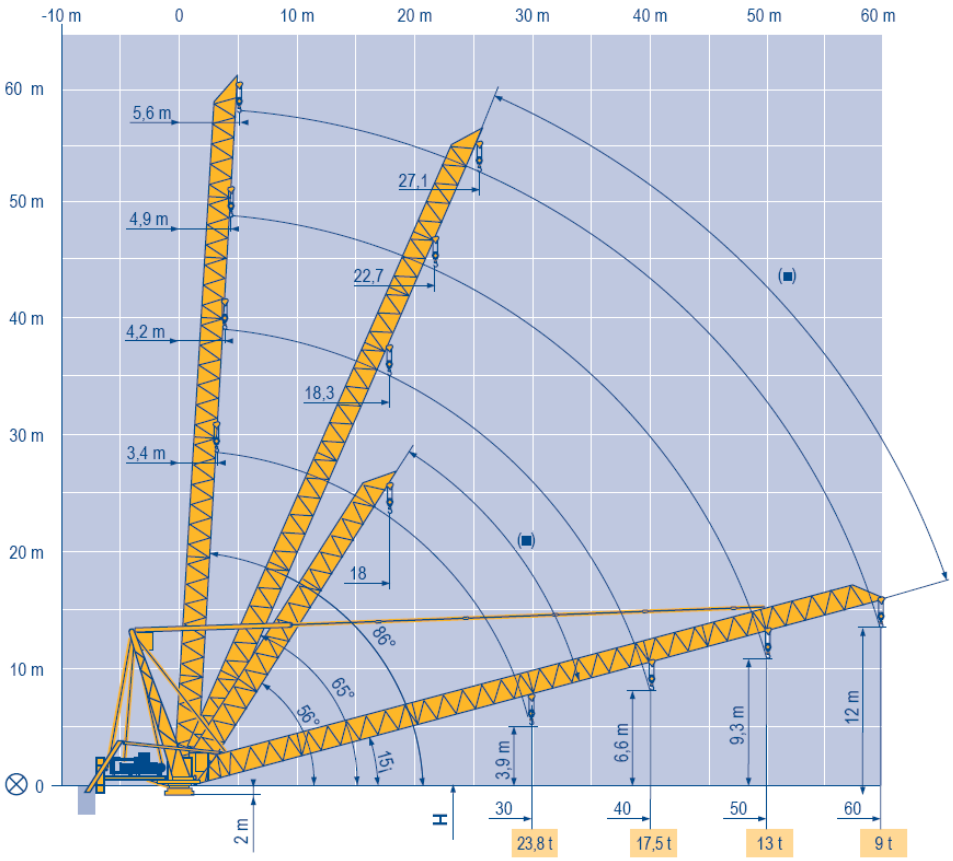


Figure 4.6 Configuration for boom of luffing crane (www.bigge.com)

MR 605 B H32 50 Hz											ch - PS hp	kW	
180 LBR 80 L 1090		m/min	3,8/38	6/60	9,5/95	15,2/152	1,9/19	3/30	4,75/47,5	7,6/76	180	132	1090 m
		t	16	10,1	5,9	3,25	32	20,2	11,8	6,5			
90 VBR			3 min 17 s								90	66	
R - 13,2		tr/min U/min rpm	0 → 0,67								3 x 6	3 x 4,4	
Y 800 A J 850 A		m/min											

CEI 38	IEC 38	kVA
400 V (+6% -10%) 50 Hz		270 kVA

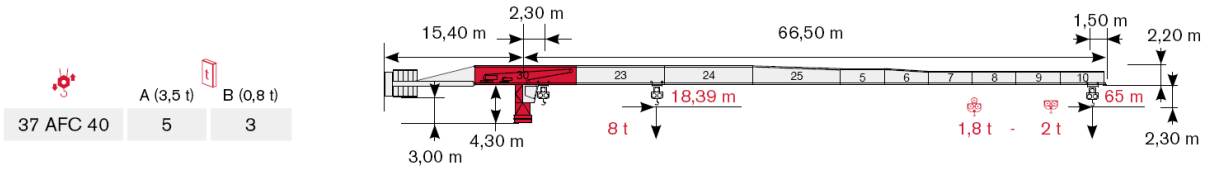
MR 605 B H32 60 Hz											ch - PS hp	kW	
215 LBR 80 L 1090		m/min	4,6/46	7,2/72	11,4/114	18,2/182	2,3/23	3,6/36	5,7/57	9,1/91	215	158	1090 m
		t	16	10,1	5,9	3,25	32	20,2	11,8	6,5			
108 VBR			2 min 44 s								108	79	
R - 15,8		tr/min U/min rpm	0 → 0,8								3 x 7,2	3 x 5,3	
Y 800 A J 850 A		m/min											

CEI 38	IEC 38	kVA
480 V (+6% -10%) 60 Hz		325 kVA

Figure 4.7 Example of specifications for a luffing tower crane (www.bigge.com)

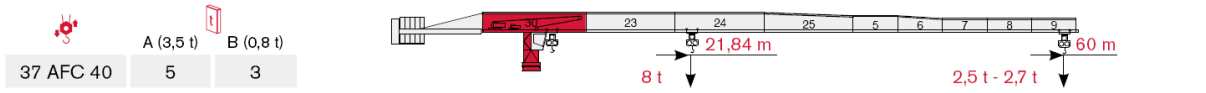
Examples of the load charts and specifications for the speed of hoisting operations for topless hammerhead tower cranes are shown in Figure 4.8-4.9.

- CTT182-8 hammerhead tower crane model (topless hammerhead)



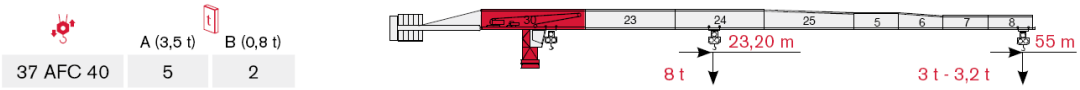
	A (3,5 t)	B (0,8 t)
37 AFC 40	5	3

			15 m	20 m	25 m	30 m	35 m	40 m	45 m	50 m	55 m	60 m	65 m
4 t →	36,21 m	t	4,00	4,00	4,00	4,00	4,00	3,57	3,12	2,75	2,46	2,21	2,00
4 t →	34,23 m	t	4,00	4,00	4,00	4,00	3,90	3,33	2,89	2,53	2,24	2,00	1,80
8 t →	18,39 m	t	8,00	7,31	5,72	4,65	3,90	3,33	2,89	2,53	2,24	2,00	1,80



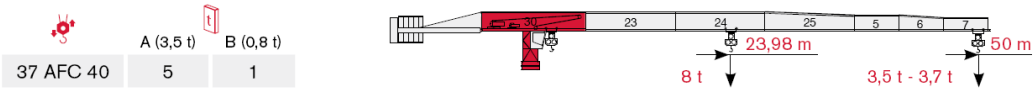
	A (3,5 t)	B (0,8 t)
37 AFC 40	5	3

			15 m	20 m	25 m	30 m	35 m	40 m	45 m	50 m	55 m	60 m
4 t →	42,73 m	t	4,00	4,00	4,00	4,00	4,00	4,00	3,77	3,34	2,99	2,70
4 t →	40,63 m	t	4,00	4,00	4,00	4,00	4,00	4,00	3,55	3,13	2,79	2,50
8 t →	21,84 m	t	8,00	8,00	6,91	5,65	4,75	4,07	3,55	3,13	2,79	2,50



	A (3,5 t)	B (0,8 t)
37 AFC 40	5	2

			15 m	20 m	25 m	30 m	35 m	40 m	45 m	50 m	55 m
4 t →	45,26 m	t	4,00	4,00	4,00	4,00	4,00	4,00	4,00	3,57	3,20
4 t →	43,16 m	t	4,00	4,00	4,00	4,00	4,00	4,00	3,81	3,36	3,00
8 t →	23,20 m	t	8,00	8,00	7,38	6,04	5,08	4,37	3,81	3,36	3,00



	A (3,5 t)	B (0,8 t)
37 AFC 40	5	1

			15 m	20 m	25 m	30 m	35 m	40 m	45 m	50 m
4 t →	46,68 m	t	4,00	4,00	4,00	4,00	4,00	4,00	4,00	3,70
4 t →	44,62 m	t	4,00	4,00	4,00	4,00	4,00	4,00	3,96	3,50
8 t →	23,98 m	t	8,00	8,00	7,65	6,26	5,28	4,54	3,96	3,50

Figure 4.8 Example of load chart for topless hammerhead tower crane (www.bigge.com)

			t	m/min	kW	
	37 AFC 40 (Variant)		4	0 ➔ 44	37	510 m / max 255 m
			3	0 ➔ 57		
			2	0 ➔ 82		
			1,5	0 ➔ 105		
			1	0 ➔ 132		
			8	0 ➔ 22		
			6	0 ➔ 28		
			4	0 ➔ 41		
			3	0 ➔ 52		
			2	0 ➔ 66		

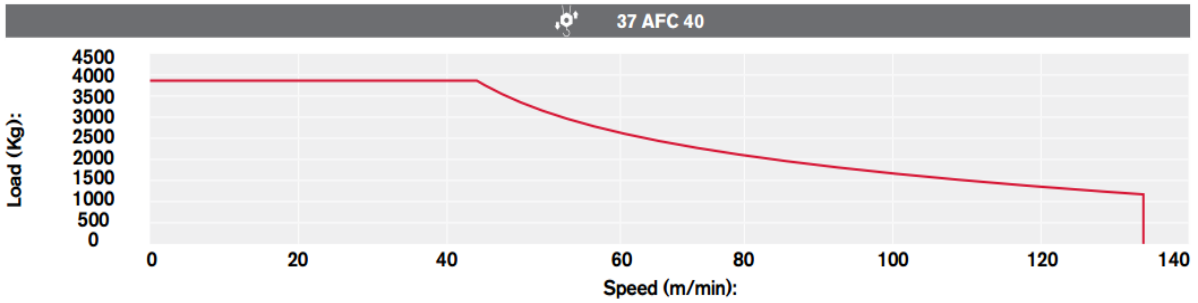
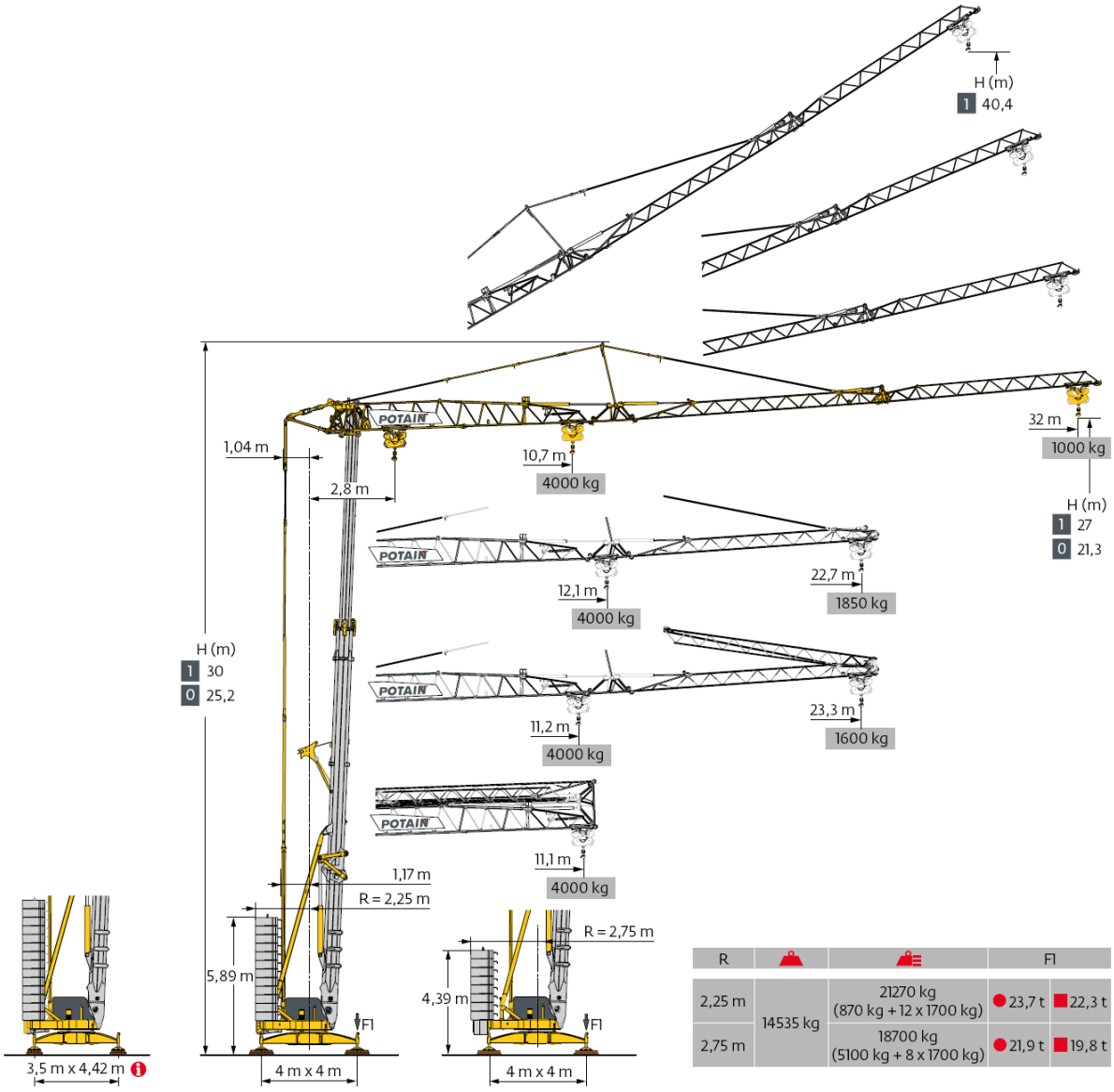
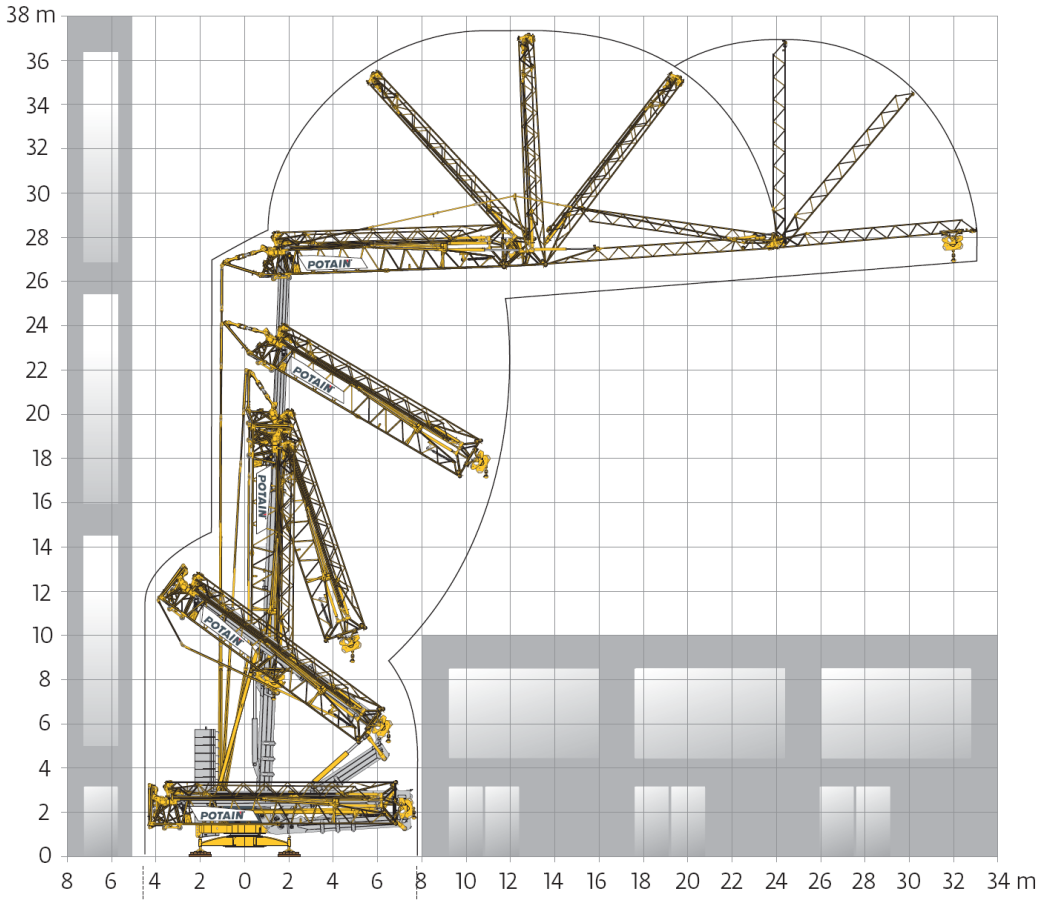


Figure 4.9 Specifications for the speed of hoisting operations (www.bigge.com)

Examples of the load charts installation movement for self-recting tower cranes (model Hup 32-27) are shown in 4.10-4.11.



Rajah 4.10 Examples of load chart for self-erectiong tower cranes (www.manitowoccranes.com)



Rajah 4.11 Installation movement for self-erecting tower cranes (www.manitowoccranes.com)

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CHAPTER 5

ROLES AND RESPONSIBILITIES OF PERSONNEL

5.1 Responsibilities of Personnels

The personnel who are involved are important elements in determining the safe use and operation of the tower crane. They include the project manager, lifting supervisors, tower crane operator, rigger and signalman. In determining the responsibilities of the project managers, reference should be made to the Chief Inspector's Special Order to Project Managers Regarding the Management and Safe Operation of Tower Cranes 2017.

5.2 Project Managers

The responsibilities of the project manager are subject to the Chief Inspector's Special Order to Project Managers Regarding the Management and Safe Operation of Tower Cranes 2017. 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.

5.2.1 Responsibilies of Project Managers for Tower Cranes

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.

5.2.2 Responsibilies of Project Managers during the operation, handling and maintenance

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.

5.2.3 Responsibilies of Project Managers for Any Person Appointed by the Occupier

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, erect, 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, erect, test, maintain and dismantle a tower crane according to the specifications of the manufacturer and good engineering practices; and
d) Perform repairs or modifications 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.

5.3 Responsibilies of Lifting supervisor

Lifting supervisor 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:

(a) Coordinates and executes the lifting work according to plan
(b) Brief all lifting workers (crane operator, signalman and rigger) regarding the lifting plan, risk controlling measures and safe lifting procedures prior to lifting operation
(c) Ensures all crane operators are registered with DOSH, while the signalmen and riggers are adequately trained
(d) Evaluates risk and prepare controlling measure accordingly to avoid risks
(e) Attends all lifting operations
(f) If unsafe condition is reported, suitable steps must be taken to rectify the situation to ensure safe lifting operation

5.4 Responsibilities of Tower Crane Operators

The tower crane operator should be responsible for the safe operation of the crane according to the manufacturer's instructions and the work system set by the tower crane owner or contractor. In particular, the tower crane operator should:

a) have attained the age of 21 years and hold a valid certificate issued by any party recognised by DOSH;
b) be healthy in terms of eyesight, hearing and reflexes;
c) have the physical capacity to handle the hoisting process;
d) at all times only respond to signals from the rigger or signaller during the lifting operation. The rigger or signalman must be identifiable and clearly visible to the tower crane operator;
e) understand the signal code

f) fully understand the radio telecommunication signals between the parties involved;
g) ensure no lifting activities to be carried out without the risk assessment by authorised individual or parties
h) the working period of the tower crane operator in operating the tower crane shall be consistent with the period permitted by the provisions of the Employment Act 1955.

5.5 Responsibilities of the Signalman

The signalman is responsible for giving a clear signal to the operator when the rigger has indicated that the load is ready to be hoisted. The signalman is also responsible for directing the safe movement of the crane. In particular, a signalman should:

a) have attained the age of 18 years and hold a valid certificate issued by any party recognized by DOSH;
b) be fit in terms of eyesight, hearing and reflexes;
c) understand the signal code and is able to relay clear and precise signals;
d) capable of directing the movement of the crane and load in such a manner as to ensure the safety of personnel and others; and
e) fully understand the radio tele-communication signals between the parties involved.
f) wear coloured clothes that can be clearly seen by the tower crane operator.

5.6 Responsibilities of Riggers

The rigger is responsible for attaching and detaching the load to and from the crane, and for the correct use of the lifting equipment in accordance with the planning of the operation. In particular, the rigger should:

a) have attained the age of 18 years and hold a valid certificate issued by any party recognized by DOSH;
b) be fit in terms of eyesight, hearing and reflexes;
c) have the physical capacity to enable him to handle the hoisting process;
d) have been trained in the general principles of slinging and be able to establish weights and estimate distances, heights and clearances;
e) be capable of selecting, handling and hoisting loads by using suitable equipment and methods;
f) understand the signal code and be able to give clear and precise signals;
g) be capable of directing the movement of the crane and load in such a manner as to ensure the safety of personnel and others; and
h) fully understand the radio telecommunication signals between the parties involved.

Planning and preparation prior to lifting activities need to be considered carefully by lifting team. Safe lifting operations using tower cranes not only depend on the operators, but rather on all members of the lifting team. Responsibilities of lifting teams can be shown in a poster published by DOSH (Refer Figure 5.1)

Figure 5.1 Responsibilities of lifting teams and safe lifting operations (www.dosh.gov.my)

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CHAPTER 6

ACCIDENT STATISTICS AND CAUSES OF CRANE ACCIDENTS

6.1 Introduction

With reference to the statistics by DOSH (2017), the states with a high number of tower cranes are Kuala Lumpur, Selangor, Johor and Penang. To date, there are 1434 tower cranes and 1614 registered and active tower crane operators in Malaysia. A large number of these tower cranes (1120) are being used in Kuala Lumpur, Putrajaya, Selangor and Johor.

6.2 Statistics and Factors Giving Rise to Accidents Worldwide

From the year 2000 until now, more than 1125 tower crane accidents have occurred involving 780 deaths worldwide. According to the data from surveys, many accidents go unreported, and these are estimated to be twice as many as the reported cases.

In 2009, there were 188 cases involving 78 deaths, while a total of 154 accidents with 113 deaths were reported in 2010. The statistics on the number and causes of such accidents are shown in Figures 6.1 and 6.2.

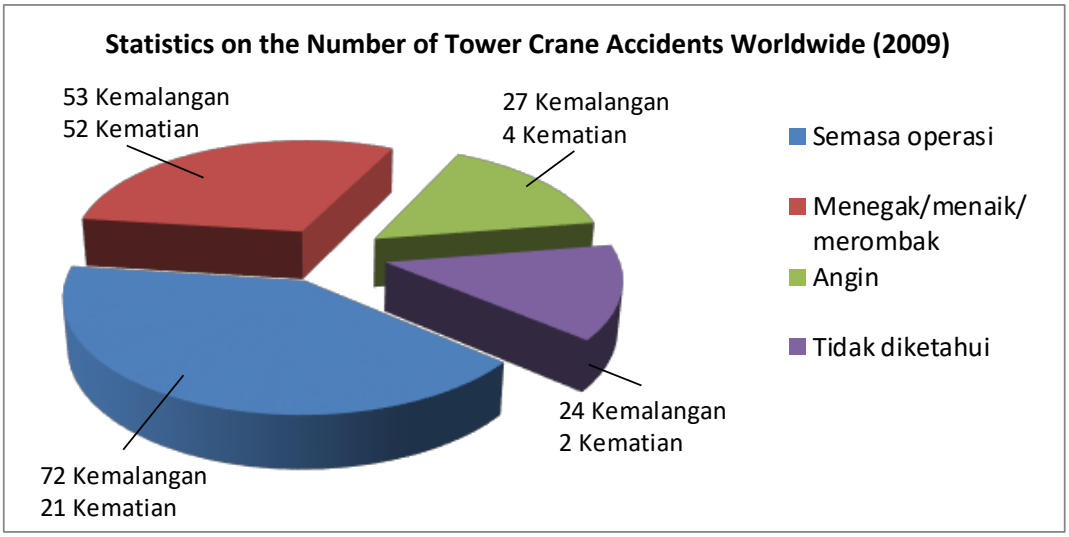

Figure 6.1 Statistics on the number of tower crane accidents worldwide (www.towercranesupport.com)

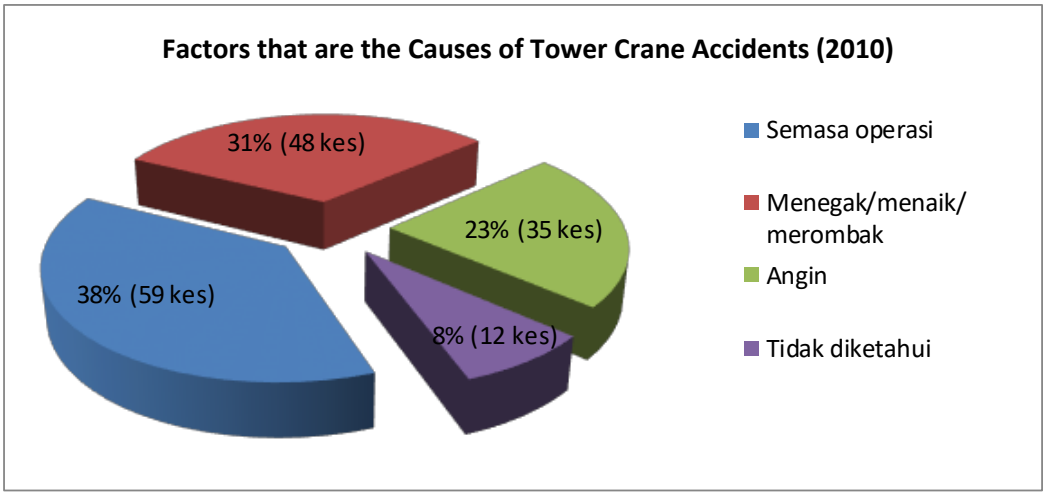

Figure 6.2 Statistics on the percentage of factors that are the causes of tower crane accidents (www.towercranesupport.com)

6.3 Statistics on Tower Crane Accidents

From the aspect of the trend for accidents in Malaysia, 58 accidents were reported from year 2000 until 2016, and are increased every year as shown in Figure 6.3. From the 58 accidents, 26 cases involve luffing tower cranes, 11 cases for hammerhead and 21 cases are unidentified.

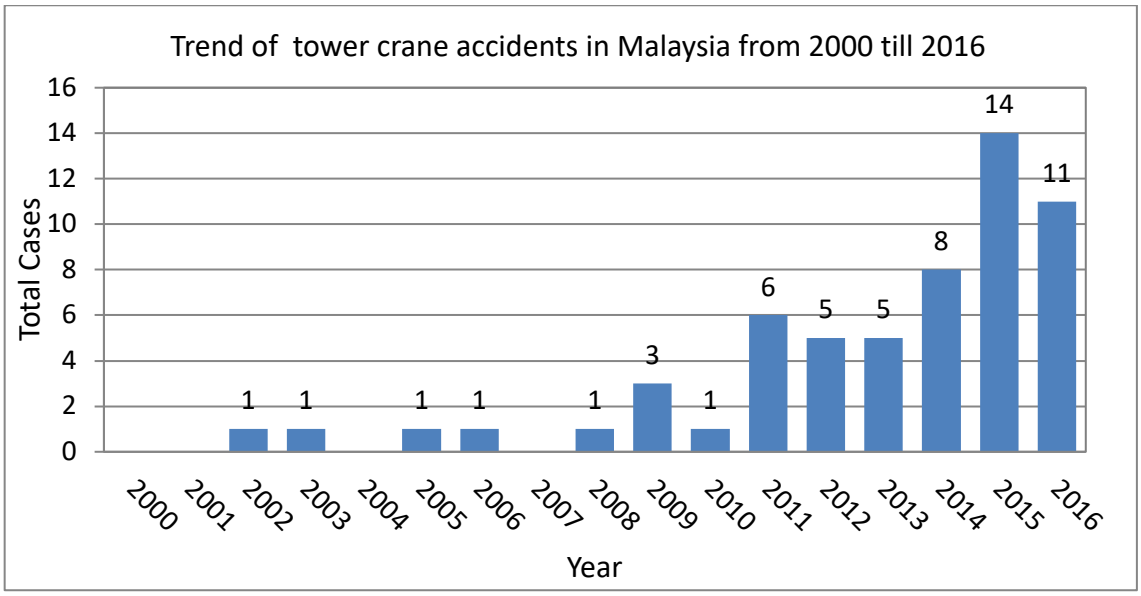

Figure 6.3 Trend of tower crane accidents (Abdullah & Wern, 2010; DOSH investigation files; www.dosh.gov.my)

6.4 Main Factors that Contributed to Accidents

Referring to reports from the Department of Occupational Safety and Health (DOSH) from 2000-2017, among the main factors that contributed to tower crane accidents were mechanical or structural issues, and those that occurred during the operation of the crane, as shown in Figure 6.4.

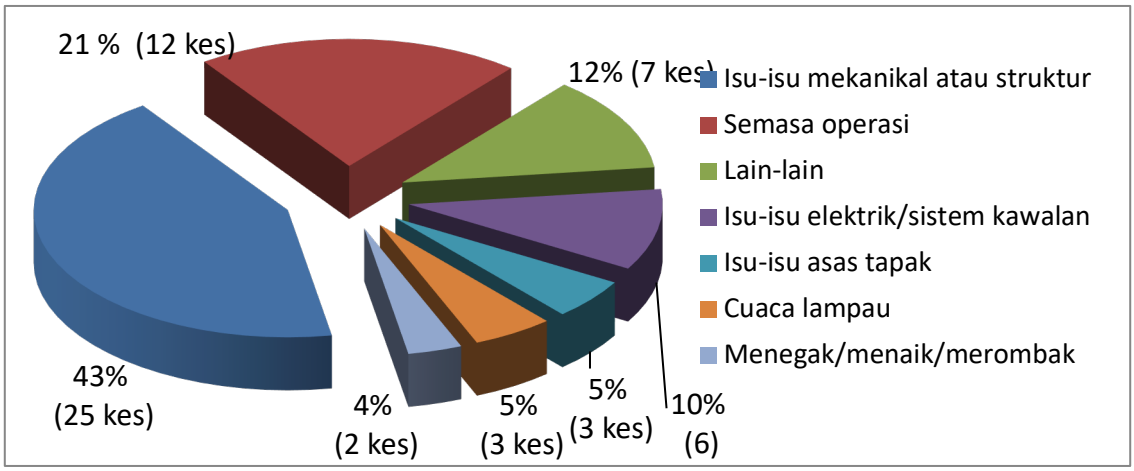

Figure 6.4 Percentage of causes of tower crane accidents (through surveys)

With reference to Figure 6.3, out of 58 accidents that occurred, 43% were due to mechanical or structural issues with the crane, i.e. damage to the crane components, such as:

(a) bent boom,
(b) snapped crane cable,
(c) broken pin/bolt, and slewing table,
(d) snapped luffing wire rope,
(e) broken or cracked boom pin,
(f) gear/brake problems,
(g) hoisting drum problems,
(h) snapped wire rope hoist,
(i) bent or cracked crane mast.

The factors that occurred during the operation of the crane contributed to 21% of the accidents, and these were due to the negligence of crane operators and signalmen, and the failure of the management in ensuring that the hoisting team comprised members who were competent. The other factors were electrical or control system issues, where 10% of the accidents were due to failure in the crane control system, such as:

(a) hoist limit switch,
(b) hoisting system,
(c) failure of the luffing system.

In addition, crane accidents were also caused by the failure of the tower crane base, where 4% were due to the installation/erecting/dismantling of tower cranes, 5% to extreme weather (wind and lightning), and 12% to other factors/unknown causes. Among the factors that affected safety during the installation, erecting or dismantling of tower cranes were:

(a) inadequate knowledge and skills of the installer/dismantler,
(b) incomplete instructions or manuals regarding safe work procedures,
(c) damage to tower crane parts due to improper storage.,
(d) poor supervision at the workplace,
(e) work pressure, space and time constraints.

To control hazards associated with hoisting equipment and operations, the members of the hoisting crew should take note of the following:

(a) the selection of the hoisting equipment,
(b) the position of the hoisting equipment,
(c) the determination and identification of a safe work load for each hoisting equipment,
(d) safe storage of hoisting aids,
(e) maintenance of hoisting equipment,
(f) planning of hoisting operations,
(g) slinging and rigging methods,
(h) adequate training for personnel involved in hoisting.

6.5 Previous Accident Cases

Examples of Cases

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 tower crane at the construction site adjacent to Dataran Maybank toppled over, where the tip of the crane fell onto the road in front of Dataran Maybank (as shown in Figure 6.5). No fatalities were reported. The details of the accident were as follows:

(a) the luffing tower crane was manufactured in 1994;
(b) according to the logbook, it was first used at the construction site in November 2015;
(c) the crane was lifting an iron elbow weighing 1.5 tonnes, where the boom was lifted up to 82 degrees (according to the meter reading, it had exceeded the permissible safe limit). The boom then toppled over in the opposite direction, while the tip of the boom dropped off and fell on the adjacent road, causing damage to a lorry.
(d) The cause of the accident was the failure of the luffing limit switch.

Figure 6.5 Luffing tower crane accident in Bangsar

Case 2:

The incident took place in Johor Bahru, Johor on 24 July 2016. The tower crane became unstable when it was lowering sand, and the front part of the boom broke first, followed by the jib balancer. The boom toppled over and got stuck on the 13th floor, as shown in Figure 6.6. The details of the accident were as follows:

(a) the tower crane was unloading sand using a bucket with a capacity of approximately 1 m^3 from ground level to the 10th floor;

(b) when the load was at a height equivalent to the 5th floor and the trolley was at the mid-point of the boom, the crane suddenly experienced failure;

(c) this failure caused the boom to fall backwards and the buffer weight to fall to the ground;

(d) from the results of the preliminary investigation and based on the surrounding evidence, it was found that the accident probably occurred when the bucket got caught on the scaffolding;

(e) the cause of the accident was the wire rope hoist, which got caught on the scaffolding.

Figure 6.6 Condition of the tower crane after the incident

Case 3:

The incident involving a luffing tower crane occurred in Bukit Bintang, Kuala Lumpur on 25 August 2016, as shown in Figure 6.7. The details of the accident were as follows:

(a) the hook block of the crane, weighing more than 300 kg, fell from a height of more than 100 metres, and crashed onto a car on the road, resulting in the death of a 24-year-old woman.

(b) members of the public claimed that they saw the boom moving across the road beyond the operating boundary of the crane before the hook block fell and crashed onto the victim's car.

(c) the position of the crane also violated the rules of safety because it was operating beyond the site fence for the building project.

(d) the incident could have been caused by the lifting limit switch being diverted when lowering or raising the hook, thereby causing the hook to jerk on the tip of the boom and to cause the wire rope to snap.

Figure 6.7 Luffing tower crane

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Abdullah, D. N. M. A. & Wern, G. C. M. 2010. An Analysis of Accidents Statistics in Malaysian Construction Sector. 2010 International Conference on E-business, Management and Economics, IPEDR vol.3 (2011) © (2011) IACSIT Press, Hong Kong, pg. 1-4.

CHAPTER 7

SAFE OPERATION OF TOWER CRANES

7.1 Safe Operation of Tower Cranes

Planning for the safe operation of tower cranes involves the estimation of load capacity (permissible load range). If the sizes of load are known, the weight of the load can be calculated based on the density data as shown in Table 7.1

Table 7.1 Type and weight of construction materials

Materials	Berat (kg/m^3)
Water	1000
Aluminium	2700
Charcoal	1450
Bricks	2100
Steel and Alloy	7700
Wood	800
Concrete	2400
Soil	1600

To ensure the safe operation of cranes, the parties involved in hoisting, works, such as lifting supervisors, operators, riggers and signalmen, should ensure hoisting works are safely conducted. During hoisting works, the project manager or lifting supervisor must ensure the following matters into consideration such as operators, riggers and signalmen must be competent and lifting equipment and lifting gear are in good condition, and are marked with the working load limit (WLL).

7.2 Safe Working Load

The safe working load (SWL) is the maximum load that can be hitched or lifted by a piece of lifting equipment that has been confirmed to be able to withstand lifting operations. The SWL for crane operations must be stated according to the results of a certified test and inspection, and the load cannot be exceeded during the lifting operation. In most cases, the SWL will be the same as the WLL. Exceptions apply in certain situations that require a reduction in the SWL to a much lower value, for example, in severe environmental conditions, such as very low temperatures, inaccurate weights, and the possibility of sudden jerks to the load.

7.2.1 Reach distance of load

The reach distance will be displaced forward whenever the crane lifts a heavy load from ground level because then, the wire rope hoist will be stretched and will cause the boom and mast to lean forward, as shown in Figure 7.1. Therefore, the operator plays an important role in determining the lifting of a load for a large range of reach distances by taking into account the height of the mast and the length of the crane boom.

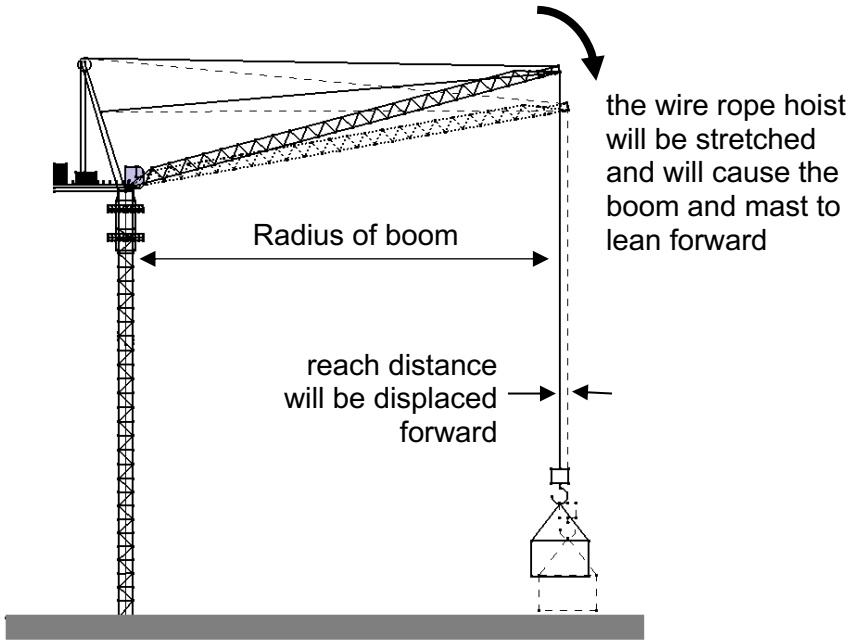


Figure 7.1 Increase in boom range during lifting of load

7.2.2 Luff angle (only for luffing tower cranes)

The luff angle is the angle between the horizontal line of the slew-boom platform pin and the line of tilt of the boom (Figure 7.2). The maximum luff angle for a luffing tower crane is determined by the crane manufacturer. The maximum luff angle of some cranes can be up to 86°. Therefore, every luffing crane should be installed with a luff limiter switch to stop the boom from moving once the maximum luff angle is exceeded. This is to prevent the occurrence of over-luffing. In addition, the crane operator must exercise caution when a large luff angle is used during the lifting of a load because this will expose the load to the risk of collision with the mast. The sudden release of the load at a large luff angle position can also cause the boom to bounce backwards and hit the jib counter.

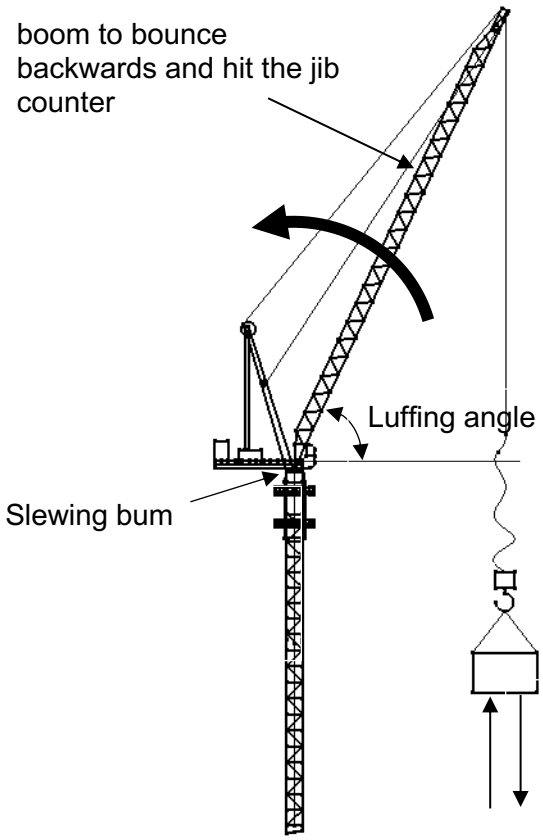


Figure 7.2 Effect of luff angle on the stability of a tower crane

7.3 Handling of loads close to where people are working and public routes

If loads are to be handled close to where people are working, the following precautions should be taken:

- It should be ensured that the place where the load is to be lowered, raised and shifted to is safe,
- The hoisting crew (operator, signalman, rigger, lifting supervisor) will need to plan a safe route for the load to avoid lifting it over or across workers,
- All workers must stay away from the route along which the load is to be lifted,
- Written approval must be obtained from the local authority if any hoisting work or part of the crane is to extend beyond the construction site,
- Avoid lifting loads across highways, railway tracks, rivers or public places that can be accessed by the public.

7.4 Control of tower crane operations

Before commencing a crane operation, the operator must ensure the following:

- He has a clear view of the load and the zone of operation. If not, the crane operator will have to follow the instructions of a signalman who has a clear view,
- Safety devises that warn of danger should be clearly visible to the operator,

- Hand and flag signals by a signalman must be clearly visible,

- The signal codes that are conveyed verbally must be clearly audible, especially when communicating by telephone or two-way radio (walkie-talkie),
- Ensure that hoisting activities do not cause damage to crane components and the material being hoisted,

- Ensure that the operator has a clear view of the load and wire rope hoist, and is not obstructed by any object,

- Ensure that the wire rope hoist is vertical throughout the hoisting work,

- The load must be lifted clearly from the surface of the ground/area,

- The rigging and counterweight of the load must be inspected before the hoisting work,

- The load should not be left suspended unless a site safety officer or lifting supervisor is present during the period when it is suspended,

- Ensure the brake locks for the hoist and boom (luffing crane) can function during an emergency.

7.5 Weather conditions

Generally, cranes are designed to operate in normal wind speed conditions, and they should not be operated during strong winds. An anemometer or tool for measuring wind speed must be installed in a suitable position on the tower crane. During the operation of the tower crane, the maximum wind speed as recommended by the crane manufacturer must be complied with. Besides strong stormy/windy conditions, other weather conditions can also invite the risk of accidents. The crane operator must stop operating the crane during severe weather conditions such as heavy rain, lightning or situations that are

hazardous for the operator (haze, mist, excessive heat and so on) and for the stability of the crane (earthquakes, landslides, floods and so on).

7.6 Safety devices in Tower Cranes

It is necessary to install a terminal device or a limiting switch in the crane so that the crane can be adjusted to the load that is to be lifted based on its design capacity. Every brake and hoisting as well as the movements of all three phases must be limited so that the movements of the crane will be normal and will not be hampered. The limit switches are meant to control and provide safety to the tower crane as well as to the people who are working. Figure 7.3 and 7.4 show the safety devices for hammerhead and luffing tower cranes respectively.

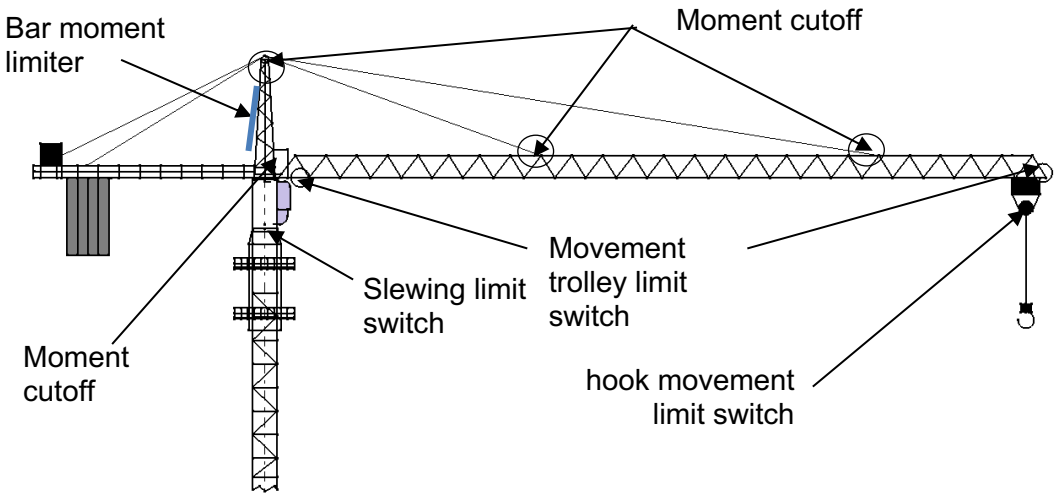
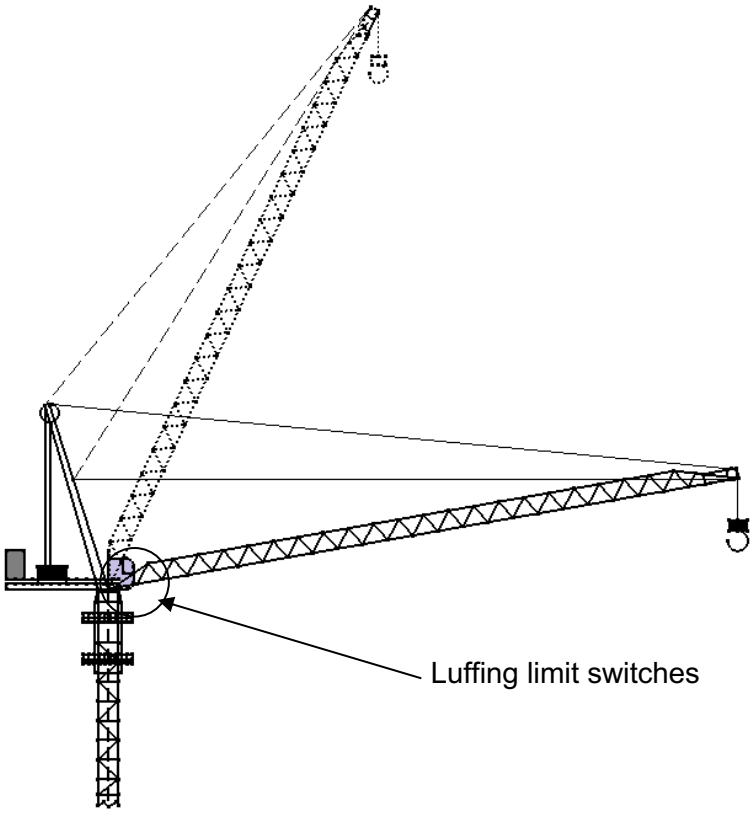


Figure 7.3 The positions of safety devices at *hammerhead* tower cranes



Rajah 7.4 The positions of safety devices at hammerhead tower cranes

To maintain good control over the safety of the tower crane, the limit switches and load limiters will be required to limit the movements of the crane.

CHAPTER 8

INSPECTION AND MAINTENANCE OF CRANES

8.1 Pre-operational inspection

Inspections are conducted for the purpose of ensuring safety during the operation of tower cranes. A visual inspection and functional test of the crane must be carried out by the crane operator before the commencement of each work shift. This should include inspection and testing of the following:

(a) all relevant items indicated in the operations manual

(b) operating and emergency controls

(c) brakes

(d) safety switches and interlocks, including limiting and indicating devices

(e) visual inspection of the structure

(f) wire ropes to ensure they are on the drum and correctly reeved on the sheave

(g) wire ropes for obvious damage.

The results of the inspection must be entered into a logbook and kept with the crane. All personal protective equipment should be inspected to ensure it is functioning correctly. All safety-related problems should be recorded and rectified prior to crane use. If all the components are found to be in good condition after the inspection, then the operator can commence operations. However, if the inspection reveals that there are components that are damaged or whose condition is in doubt, then the operator must report this to the lifting supervisor.

8.2 Routine Inspection and Maintenance

Employers may appoint someone in their service or from outside who is an expert in the structure, use and inspection of lifting equipment to conduct an inspection.Routine inspection and maintenance should include the following:

(a) all functions and their controls for speed, smoothness of operation and limits of motion
(b) all emergency and safety switches and interlocks, including limiting and indicating devices
(c) lubrication of all moving parts and inspection of filter elements and fluid levels
(d) visual inspection and measurements as necessary of structural members and other critical components such as brakes, gears, fasteners, pins, shafts, wire ropes, sheaves, locking devices and electrical contactors
(e) signage, including warning signs and control markings
(f) wear on wheels and rails
(g) additional items nominated in the crane manufacturer's instructions.

All replacement parts and components must be identical or equivalent to the original parts or components. A written report must be provided upon completion of the inspection.

8.3 Annual inspections

An annual inspection by a Competent Person, CS (*Orang Yang Bertanggungjawab, OYB*) is required as part of registration requirements of the crane. An annual inspection should include all items specified by the crane manufacturer for annual inspection, as well as relevant items included in the routine inspection and maintenance programs.

Annual inspections include:
(a) all relevant items in the pre-erection inspection and tests that can be safely completed while the crane is erected
(b) the effective functioning and calibration of all limiting and indicating devices
(c) detailed visual inspection and tolerance checking of all critical structural and wear components
(d) checking of tolerances for wear limit
(e) a detailed visual check for corrosion

(f) a detailed visual examination of critical areas for evidence of cracking.

A written report must be provided upon completion of the inspection.

8.4 10-year major inspection

Tower cranes must undergo a major inspection every 10 years. The parameters of the 10-year major inspection should be considerably more comprehensive than the yearly inspection, due to the amount and severity of operation that a tower crane will be exposed to after 10 years. Even if the crane has not been exposed to regular operation during the 10-year period, the crane may have deteriorated due to the way it has been stored or the environment in which it has operated in (e.g. dirty or corrosive environments). The 10-year major inspection must be certified by an Professional Engineer who has experience in the inspection of tower cranes. The Professional Engineer may use the advice of other competent persons, CS (*Orang Yang Bertanggungjawab, OYB*) when preparing the inspection report.

A 10-year major inspection requires particular attention to be given to the following:

(a) structural, mechanical, electrical, instrumentation, control and operational anomalies
(b) non-destructive testing examination to an appropriate standard
(c) controls and emergency stop
(d) braking systems
(e) manufacturer's safety upgrades
(f) adequacy of safety instructions and manuals

The following items, where appropriate, must be included in a 10-year major inspection for tower cranes:

(a) slew ring
(b) hydraulic motors
(c) hydraulic pumps
(d) valve blocks (bodies)

(e) hoist and luff drums

(f) braking systems

(g) rope sheaves

(h) hydraulic luffing cylinder

(i) gear boxes and drive shafts

(j) boom

(k) mast

(l) A-frame

(m) pins with moving parts (e.g. boom heel pins, ram pins)

(n) static pins

(o) steel wire ropes

(p) electrical systems

(q) control systems

(r) electric motors

(s) hook trolley (non-luffing cranes)

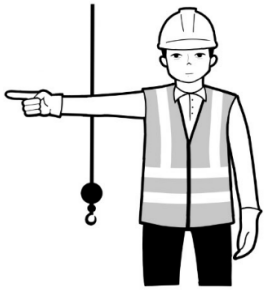
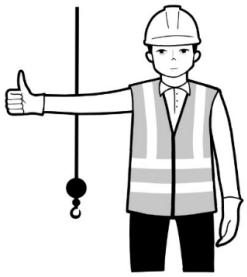
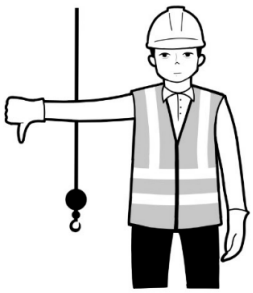
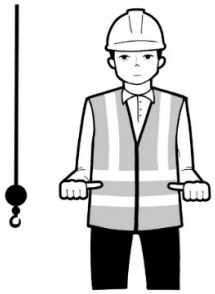
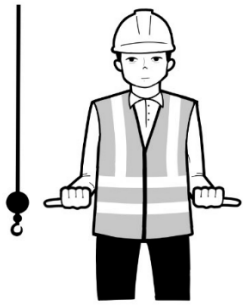
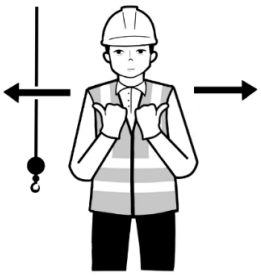
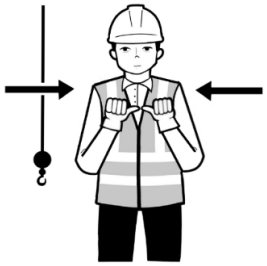
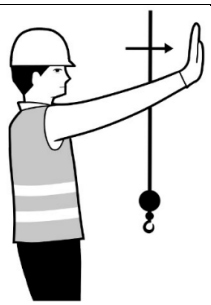
(t) hook assembly.

Some items will require NDT inspection during 10-year major inspection as shown in Table 10.1,

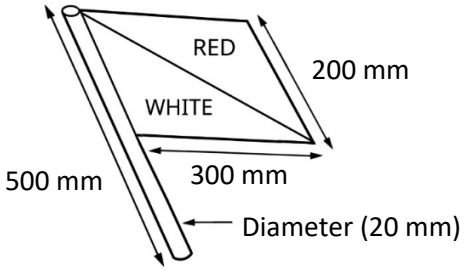
Table 10.1 NDT test for some components of tower crane

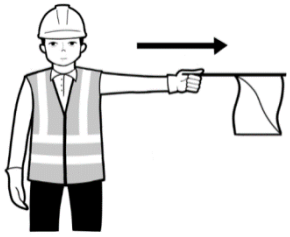
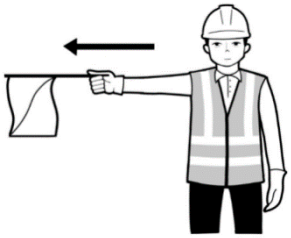
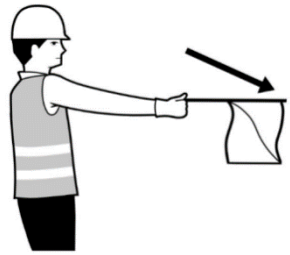
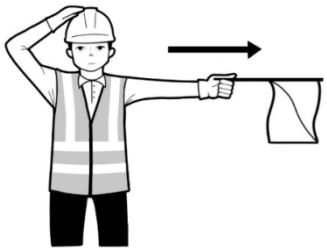
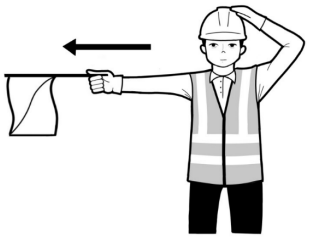
Components	**Details of NDT Test**	**Frequency**
Chord thickness of boom	Material thickness test	10 years
Slew ring	Crack test	9 years
Steel nuts of Hydraulic luffing	Crack test	10 years
Hydraulic luffing cylinder and ram	Crack test	10 years
Welds on the boom connector	Crack test	10 years
A-Frame (all connector welds)	Crack test	10 years
Hook	Crack test	10 years
Welds on hook assembly and trolley	Crack test	10 years

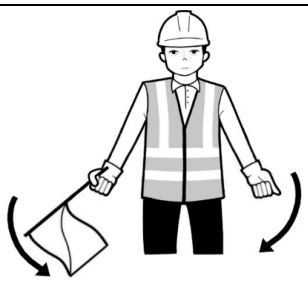
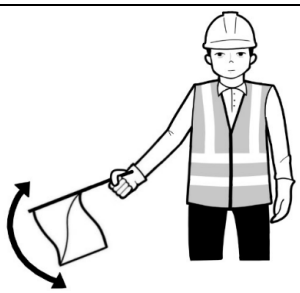
Attachment A (Hand Signal)

			
Turun ke bawah *(Hoist down)*	Angkat ke atas *(Hoist up)*	Memusing *(Swing)*	Angkat ke atas perlahan-lahan *(Hoist up slowly)*
			
Naik bum *(Boom up)*	Turun bum *(Boom down)*	Retract boom	Extend boom
			
Gunakan cangkuk utama *(Apply main hook)*	*Dog everything* (Berhenti seketika apabila berlaku risiko bahaya seperti hujan, angin, dan lain-lain faktor)	Berhenti *(Stop)*	*Use whipline* (Guna alat bantu angkat tambahan)
			
Trolley out	Trolley in	Travel	

Flag Signal



		
Memusing ke kanan *(Slewing right)*	Memusing ke kiri *(Slewing right)*	Menunjuk kedudukan *(Indicationg position)*
		
Luf-mengangkat ke atas *(Luffing-boom up)*	Luf-menurun ke bawah *(Luffing-boom down)*	Berhenti kecemasan *(Emergency stop)*
		
Mengangkat *(Hoisting)*	Berhenti *(Stop)*	Panggilan *(Call)*

		
Bergerak *(Travel)*	Merendah *(Lowering)*	Mengangkat secara perlahan *(Hoist slowly)*
		
Merendah secara perlahan *(Lower slowly)*	Terima kasih *(Thank you)*	