TRAINING MODULE FOR SIGNALMAN (TOWER CRANE)

Prepared for:

Jabatan Keselamatan dan Kesihatan Pekerjaan
Kementerian Sumber Manusia

Prepared by:

UKM PAKARUNDING

Training Module for Signalman (Tower Crane)

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ABBREVIATION

FYK	-	Approved Firm (*Firma Yang Kompeten*)
DOSH	-	Department of Occupational Safety and Health
OYB	-	*Orang Yang Bertanggungjawab*
PTW	-	Permit to work (*permit-menjalankan-kerja*)
SWL	-	Safe working load (*Beban kerja selamat*)
WWL	-	Working load limit (*Had beban kerja*)

(1) MODUL: Training Module for Signalman (Tower Crane)

(2) OBJECTIVE: To produce a competent signalman for a tower crane operation.

(3) LEARNING PERIODS: 3 days (2 days lecture and 1 day practical)

(4) PREREQUISITE: None

(5) SYNOPSIS:

The duty of attending the training is to determine the skill level and also to enable the signalmen to learn the correct and clear signals to the tower crane operator. This training is important for obtaining a valid working certificate issued by DOSH. A signalman is a qualified person to guide the crane operator using a hand signal, flag or communication tool for providing a direction and also to monitor the movement of lifting, suspending, dropping and moving operations. The decision for all crane operations is depending on the signal given to the operator. A signalman should have a relevant qualification and able to communicate using standard hand signal, flags and any communication device tools. It is important to ensure the uniformity of understanding between the signalmen and operators. In hope, the trend of crane accidents in Malaysia can be reduced with the combination of a good tower crane forformance with an efficient and ethical signal communication.

(6) LIST OF TOPICS

Chapter 1	Legislations
Chapter 2	Roles and Responsibilities of Signalmen
Chapter 3	Introduction to Cranes
Chapter 4	Statistics and Causes of Crane Accidents
Chapter 5	Basic Calculation for Weight of a Mass
Chapter 6	Safe Operation of Tower Cranes
Chapter 7	Communication
Chapter 8	Personal Protection Equipment

Chapter 9	General Safety and Response to Accidents and Emergencies
Chapter 10	Practical Training
Chapter 11	Written Assessment

TOTAL LECTURE : 14 hours

TOTAL PRACTICAL : 6 hours

(7) REFERENCES (selected):

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BS 7121-5:2006 Code of practice for safe use of cranes-Part 5: Tower cranes Code of Practice for Safe Use of Tower Cranes, Hong Kong, 2012.

PN12040 Tower Crane-Code of Practice, Autralia, 2017.

CHAPTER 1

ROLES AND RESPONSIBILITIES OF SIGNALMAN

1.1 Introduction to Signalman

Signalman is a person who provides a guide to crane operators by using hand signals, flags or communication tools for direction and supervision of lifting, suspending, dropping and moving operations. The decision for all crane operations depends entirely on the signal guide to the crane operator. The information and instructions provided by the signal engineer must be clear and understandable by the crane operator to avoid any accident. Signalman should have the qualifications in practicing the right way and according to hand signal standards, flags and any communication using device tools during crane operation. This is important to ensure the uniformity of understanding between the instructor which is signal operator and crane operator.

Signalman also need to work with lifting members consisting of lifting supervisors, crane operators and rigger to ensure safe directions can be given to crane operators. Additionally, signalman should carry out work under supervision of lifting supervisors to ensure that workplace safety and working conditions are controlled and monitored.

1.2 Responsibilities of Personnels During Lifting Operation

1.2.1 Lifting Supervisor

Sumber: *Safe lifting* (2002)

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) Possesses the adequate theoretical knowledge, technical and practical training, plus the experience and knowledge in lifting operations
(b) Prepares and plans for the lifting work
(c) Coordinates and executes the lifting work according to plan
(d) Brief all lifting workers (crane operator, signalman and rigger) regarding the lifting plan, risk controlling measures and safe lifting procedures prior to lifting operation
(e) Identifies types and weight of the loads to be lifted
(f) Ensures periodic inspections on the lifting appliances and lifting gear
(g) Ensures safe working load (SWL) markings for all lifting appliances and lifting gear, and with valid test certificates
(h) Ensures all crane operators are registered with DOSH, while the signalman and riggers are adequately trained
(i) Evaluates risk and prepare controlling measure accordingly to avoid risks
(j) Attends all lifting operations
(k) If unsafe condition is reported, suitable steps must be taken to rectify the situation to ensure safe lifting operation
(l) To stop all works if lifting activities lead to unsafe condition

1.2.2 Tower Crane Operator

Sumber: *Safe lifting* (2002)

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

(a) To own a log book
(b) To perform daily inspection on crane system such as handling mechanisms, controlling switches, hydraulic hose, hydraulic oil level and various others
(c) To correctly respond to the signalman and rigger during lifting operation

(d) Only giving lift to allowable loads in accordance to the load chart provided by crane manufacturer, and to ensure loads lifted do not exceed allowable load limits
(e) To ensure no lifting activities to be carried out without the risk assessment by authorised individual or parties
(f) Understand hand signal and verbal communication codes when communicating using hand signal or walkie-talkie respectively
(g) Understand emergency procedure and know how to react in the event of accidents during lifting operation

1.2.3 Rigger

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

Figure 1.1 Safety wear of a rigger (*Worker's Safety Handbook* 2011)

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

1.2.4 Signalman

Signalman is responsible to give clear signals as a mean of communicating with the crane operator after rigging is completed and the load is ready to be lifted. Signalman is also responsible to coordinate safe crane movement with the crane operator. Safety wear of a signalman must be complete and visually distinct (Figure 1.2). A signalman must:

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

(b) Able to give instruction to the crane operator and coordinate movement of crane and load safely

(c) Able to estimate safe distance between the lifted load and the surrounding objects during lifting operation

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

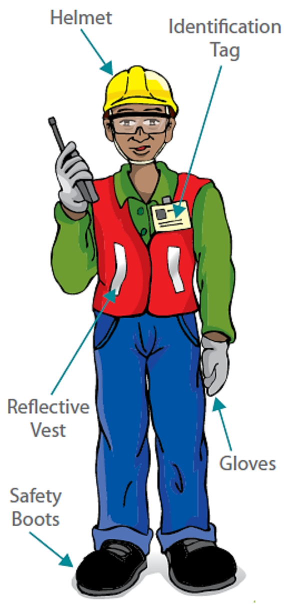

Figure 1.2 Safety wear of a signalman (*Worker's Safety Handbook* 2011)

1.3 Signalman Roles during Crane Operation

The role of a signalman is very critical during crane operation especially under the following conditions:

(a) The crane operator's view on the lifted load is not clear during lifting and bringing the load down

(b) The crane operator's view on load is completely blocked

(c) The crane operator is not able to see the load clearly due to large distance involved

(d) The crane operator is not able to make an informed decision due to the nature of the loads (e.g. abnormally shaped load, etc).

(e) The crane operator is not able to clearly see the load because lifting operation is carried out at night

(f) Lifting activities nearby to public road
(g) Lifting activities nearby to electric cable

1.4 Planning and Preparation by Signalman

Planning and preparation prior to lifting activities need to be considered carefully by lifting team including signalman. The planning and preparation by signalman must include as follows:

(a) Wear personal protective outfit
(b) Ensure location is viewable by crane operator
(c) Ensure communication tools are in good condition
(d) Plan the type of signal to be used with the crane operator, such as using hand signal, flag or other communication devices
(e) Ensure the standard communication signals or codes is understood by both himself and the crane operator
(f) Cooperate with lifting team to ensure orders given to crane operator is well received and accurate
(g) Ensure there is no obstacle or hazard interfering with the lifting operation. Information on such possible interference must be relayed to the crane operator
(h) Inform the crane operator on the decision made by lifting team with regards to the lifting plan

1.5 Criteria as a Signalman

A signalman is responsible to give clear signal to a crane operator after rigging is completed and the load is ready to be lifted. Criteria to become a signalman are as follows:

(a) Must be a person of the age of 18 years old and above, and possess a valid certification by an entity (e.g. a training provider) recognised by DOSH.
(b) Visually, hearing and reflection wise in good health condition
(c) Understand and able to use the various communication codes, such as hand signals, flags, walkie-talkie, etc.

(d) Able to give clear and precise instructions that will ensure safe movement of the crane and loads
(e) Wear outfit with clear distinct colours easily seen by the crane tower operator
(f) Must undergo signalman training at DOSH certified training centre
(g) Must going through a signalman refreshment course every 2 years after obtaining training certificate as signalman

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BS 7121-5:2006 Code of practice for safe use of cranes-Part 5: Tower cranes.

Code of Practice for Safe Use of Tower Cranes, Hong Kong, 2012.

PN12040 Tower Crane-Code of Practice, Autralia, 2017.

SS 559: 2010 Code of practice for safe use of tower cranes.

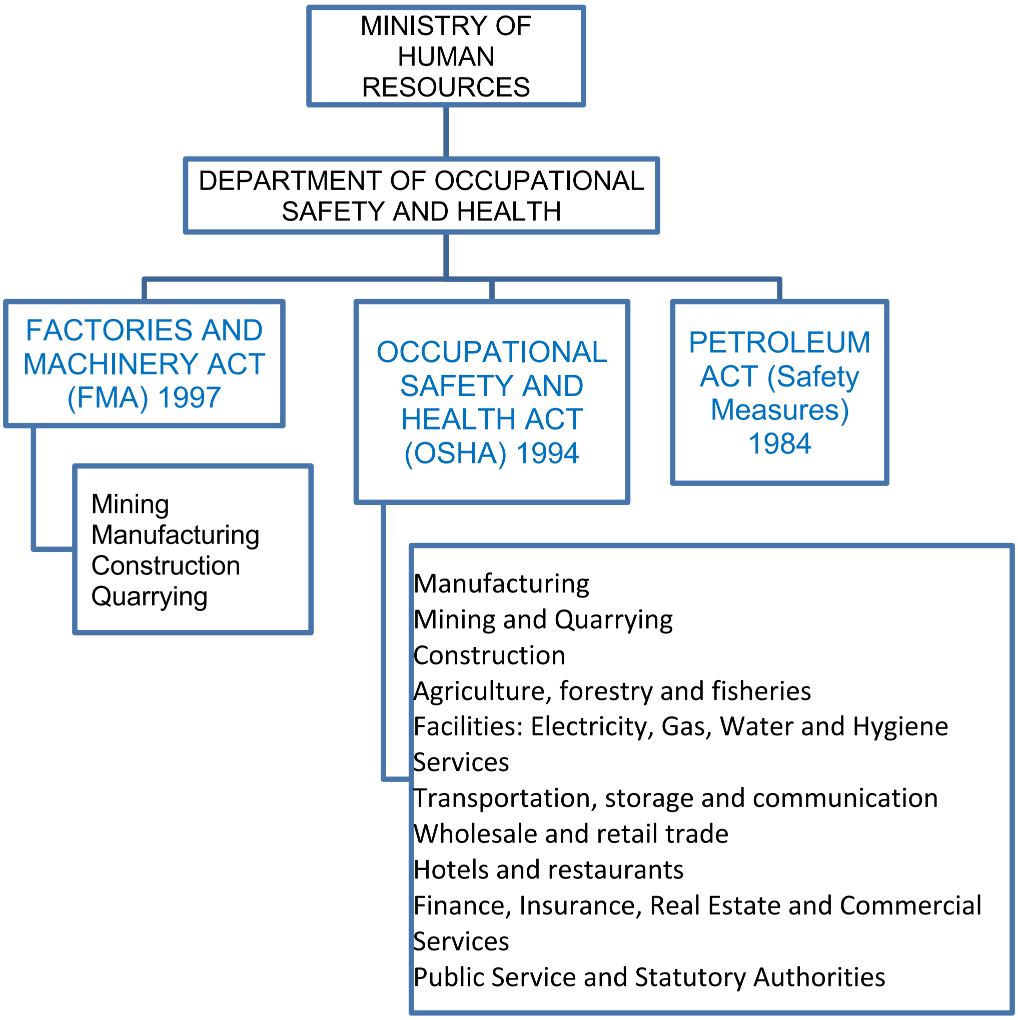
CHAPTER 2

LEGISLATION

2.1 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 2.1. 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 2.1 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.

2.2 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

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

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

1. Factories and Machinery (Exemption of Certificate of Fitness for Hoisting Machine) Order 2015;
2. Factories and Machinery (Building Operations and Works of Engineering Construction) (Safety) Regulations 1986;
3. Factories and Machinery (Notification of Fitness and Inspections) Regulations 1970;
4. Factories and Machinery (Safety, Health and Welfare) Regulations 1970 (Amended - 1983); and
5. Chief Inspector Special Order (To The Project Manager On the Management and Safe Operation of Tower Cranes) 2017.

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

Project managers must ensure that tower cranes:

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

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

The responsibilities of the project manager are as follows:

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

2. The project manager should ensure that during the operation, handling and maintenance of the tower crane:
    (a) The operator who is appointed is registered with the Department of Occupational Safety and Health to operate the crane;
    (b) The appointed lifting supervisor, signalman and rigger have relevant and adequate knowledge, experience and competency;
    (c) A permit-to-work system is implemented;

(d) All the lifting gear is inspected and maintained according to the specifications of the manufacturer and good engineering practices;
(e) All safety devices are maintained to function properly at all times and are not easily disrupted; and
(f) Records relating to the use, inspection, maintenance and permit-to- work are kept at the construction site for checking purposes at any time..

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

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

Penalty:
"Any person who violates this special order shall be guilty of an offence and can be charged under section 8(g) of the Factories and Machinery Act 1967 (Act 139) and, if convicted, shall be liable to a fine not exceeding two hundred thousand ringgit or to imprisonment for a term not exceeding five years or to both".
However, no specific Regulations have been made under either of the two Acts (OSHA 1994 and FMA 1967) regarding the correct use or operation of tower cranes at work sites. This can be found in the following guidelines and standards:

1. Guidelines of Occupational Safety and Health (OSH) in the Construction Industry (Management) 2017;
2. Guidelines for Public Safety and Health at Construction Sites, 2007;
3. Guidelines for the Prevention of Falls at the Workplace, 2007;

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

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

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

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

Objectives of Act 520:

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

Jobs that require skills and certification

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

19) Tiler
20) Carpenter
21) Welder
22) Plasterer
23) Plumber
24) Scaffolder

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

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

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

Occupational Safety and Health (Control of Industrial Major Accident Hazards) Regulations 1996

PART I

Regulation 1: Preliminary

These regulations may be cited as the Occupational Safety and Health (Control of Industrial Major Accident Hazards) Regulations 1996, and take effect 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) take immediate action to rectify the situation as soon as he becomes aware of an imminent danger which may affect the safety of persons or the environment; and
   (c) establish and maintain a good management system for controlling any major accident, as described in the report made under sub-regulations 14 (1) and regulation 16.

(2) Every employee shall:
   (a) cooperate 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 II:

Regulation 9: Demonstration of Safe Operation

A manufacturer who has control of an industrial activity to which this Part applies shall, at any time, at the request of the Director General, provide evidence, including the production of documents, to show that he has:

(a) identified the possible major accident hazards; and

(b) taken adequate steps to -
   (i) prevent any major accident or minimize its consequences to persons and the environment; and
   (ii) provide persons working on the site with the information, training and equipment necessary to ensure their safety; and

(c) prepared and kept up-to-date an adequate on-site emergency plan detailing how major accidents will be dealt with.

PART III:

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 occurs:
   (ii) the circumstances of the accident;
   (iii) the hazardous substances involved;
   (iv) a suitable date for assessing the effects of the accident on persons and the environment; and
   (v) the emergency measures taken; and

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

PART IV:

Regulation 24: Penalty

(a) A manufacturer who commits an offence against any of the provisions of these Regulations shall, on conviction, be liable to a fine not exceeding fifty thousand ringgit (RM 50,000.00) or to a term of imprisonment not exceeding TWO (2) years or to both.

(b) An employee who commits an offence against any of the provisions of these Regulations shall, on conviction, be liable to a fine not exceeding one thousand ringgit (RM 1000) or to a term of imprisonment not exceeding THREE (3) months or to both.

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Lembaga Pembangunan Industri Pembinaan Malaysia, Akta 520.

CHAPTER 3

INTRODUCTION TO CRANES

3.1 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 3.1).

Figure 3.1 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 3.2).

Figure 3.2 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 3.3). 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.

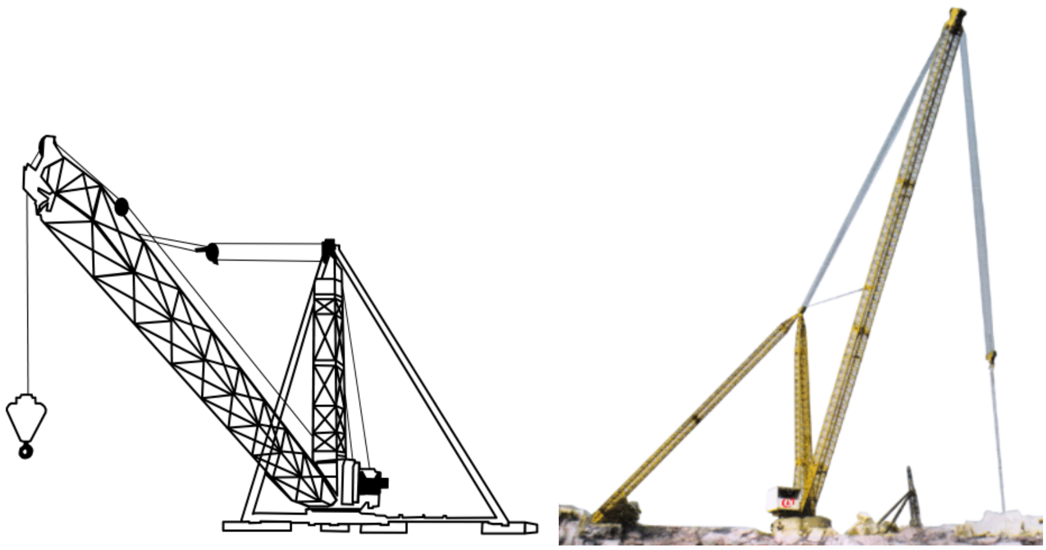


Figure 3.3 Example of a derrick crane (OSHAcademy Occupational Safety and Health Training, US; *http://jaipur.all.biz*)

(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 3.4).

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.

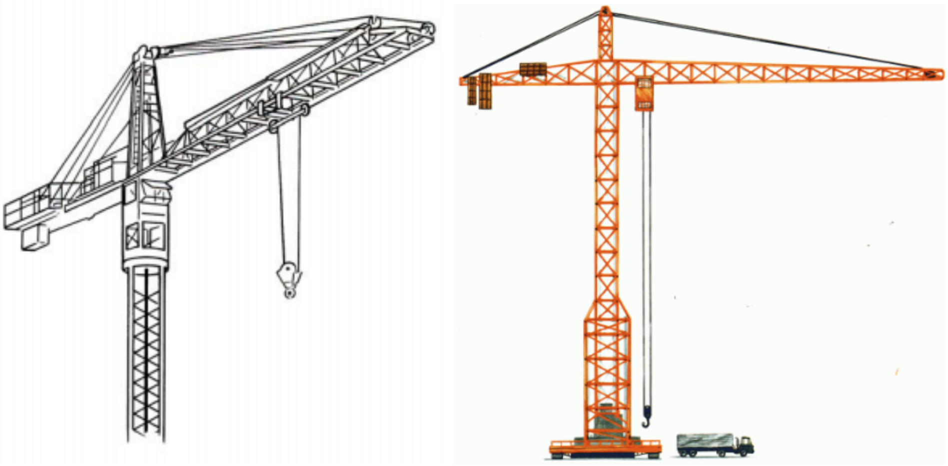


Figure 3.4 Example of a tower crane (Occupational Health and Safety Code 2009, Alberta Canada; www.ictinpractice.com)

3.2 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. These cranes can be divided into several categories depending on their size and manufacturer.

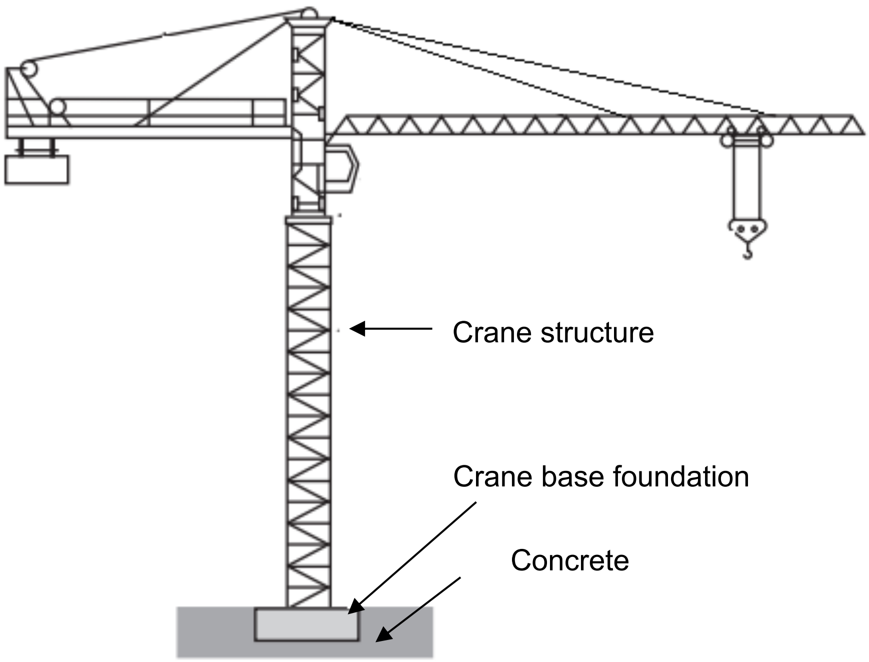


Figure 3.5 Saddle top hammerhead tower crane (Occupational Safety and Health Program, A Guide to Cranes and Derricks, US)

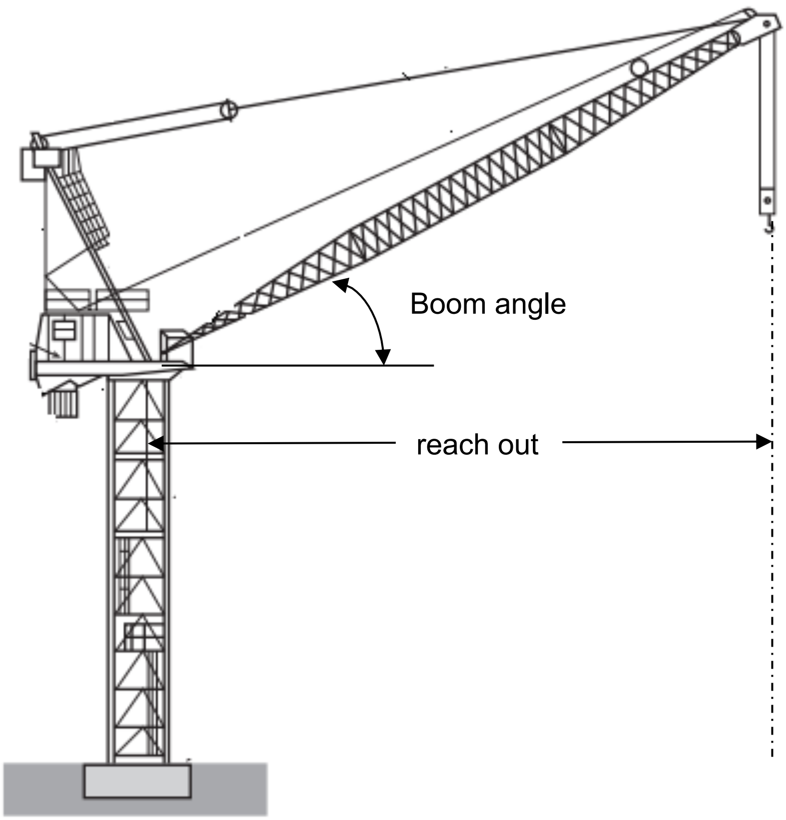


Figure 3.6 Luffing tower crane (Occupational Safety and Health Program, A Guide to Cranes and Derricks, US)

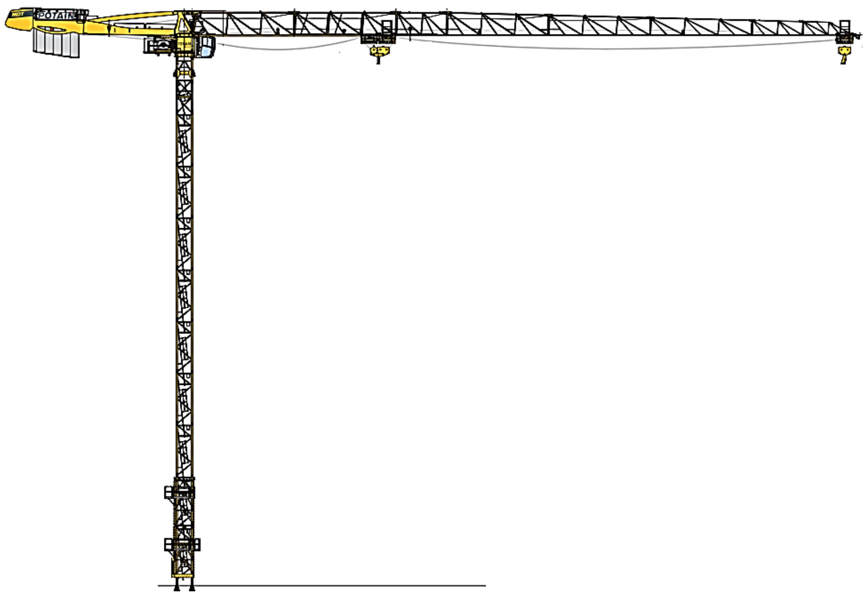


Figure 3.7 Topless hammerhead tower crane *(www.nftcrane.com)*

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 3.8).

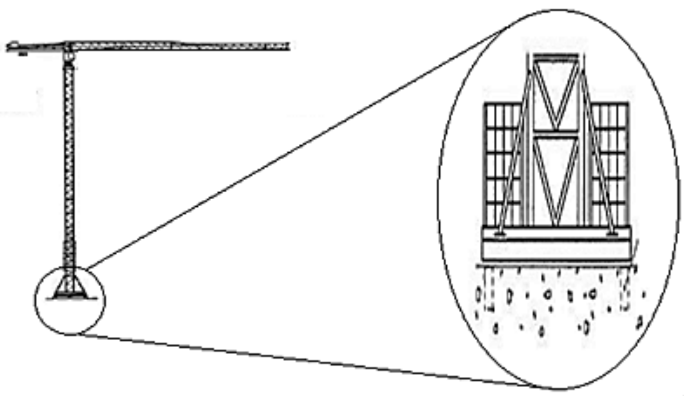


Figure 3.8 Example of a tower crane with a static base installation (Environmental, Health and Safety (EHS) Departments, US)

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 3.9).

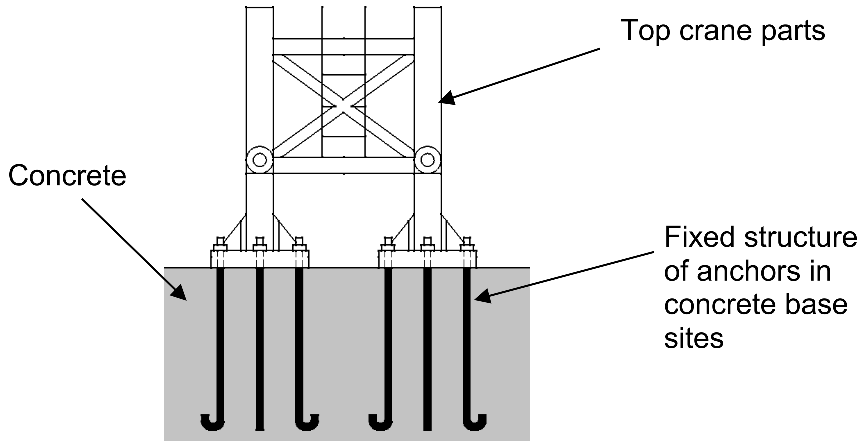


Figure 3.9 In-situ cast base

(i) Own base

The base of the crane is constructed by placing ballast at the crane base with the chassis as the weight (Figure 3.10).

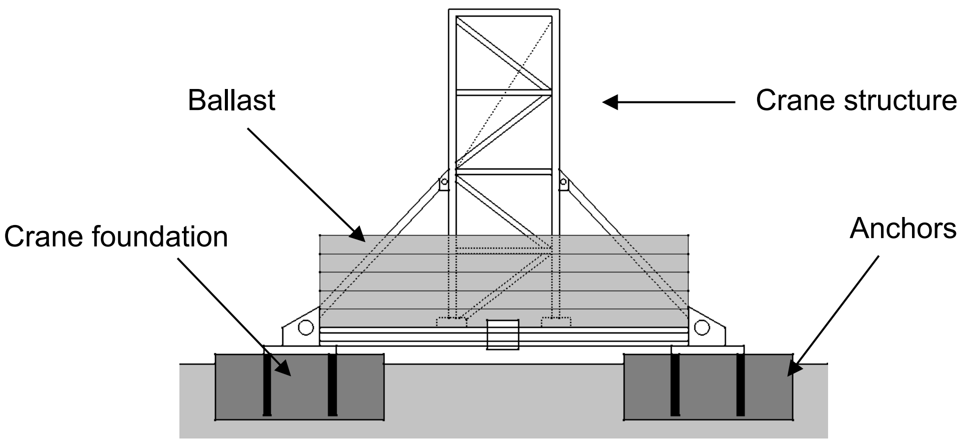


Figure 3.10 Static base (own base type)

(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 3.11).

Figure 3.11 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.

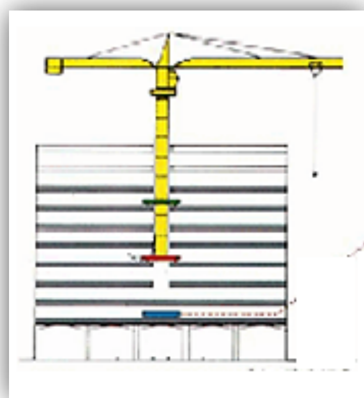


Figure 3.12 Installation of a crane with an internal climbing base (www.dcm.milgromandassociates.com)

(c) 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).

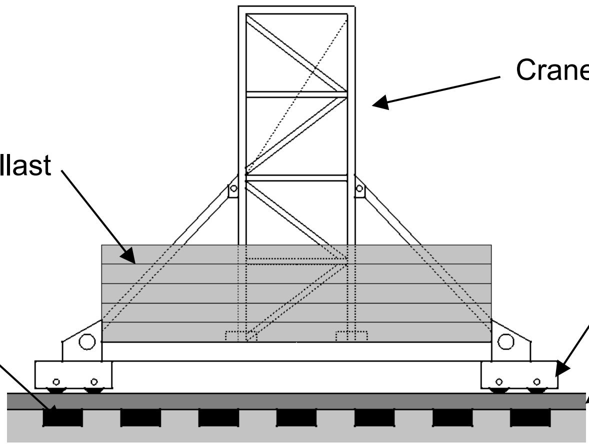
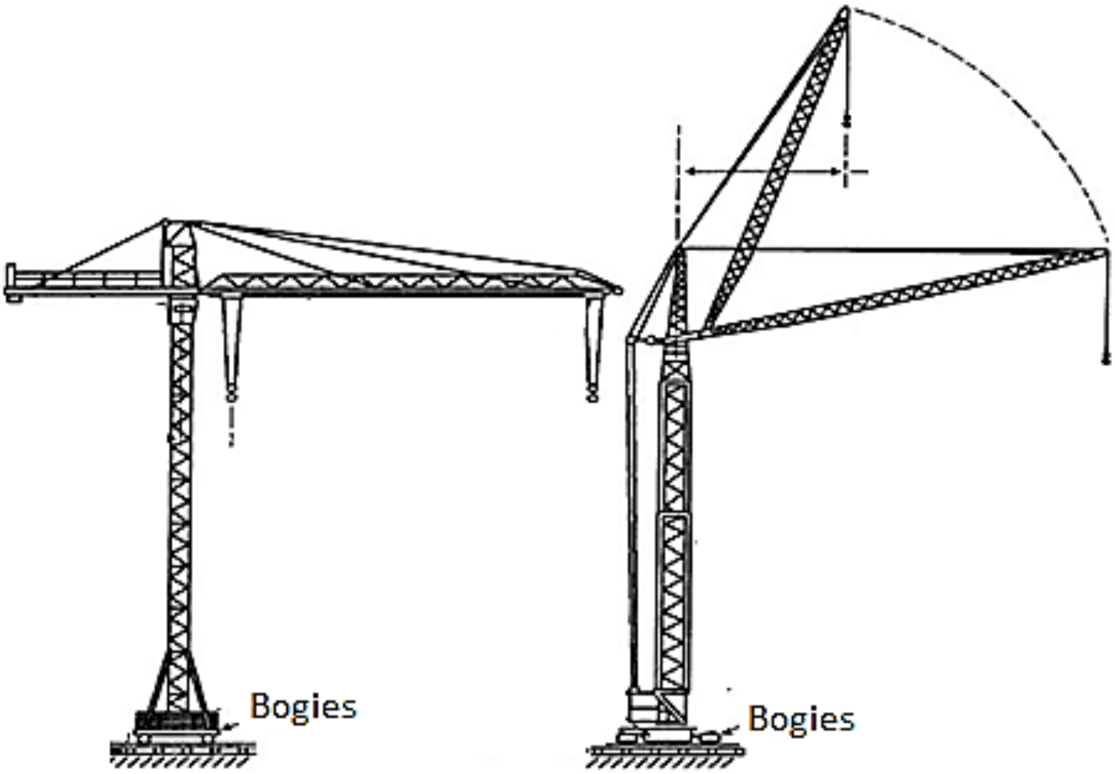


Figure 3.13 Travelling base (type of platform)

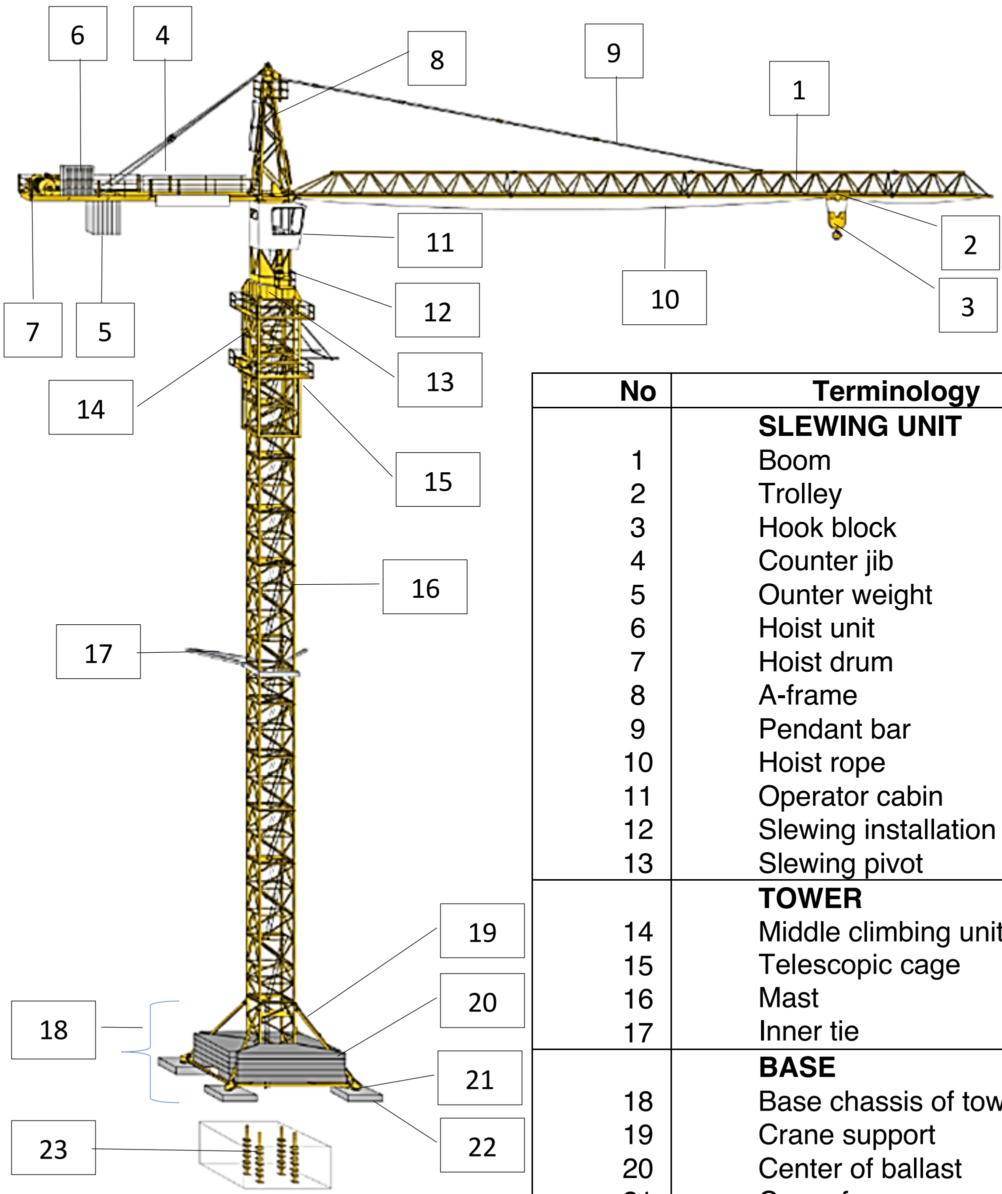


Rajah 3.14 T*ravelling tower crane* (Environmental, Health and Safety (EHS) Departments, US)

3.3 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 3.15).

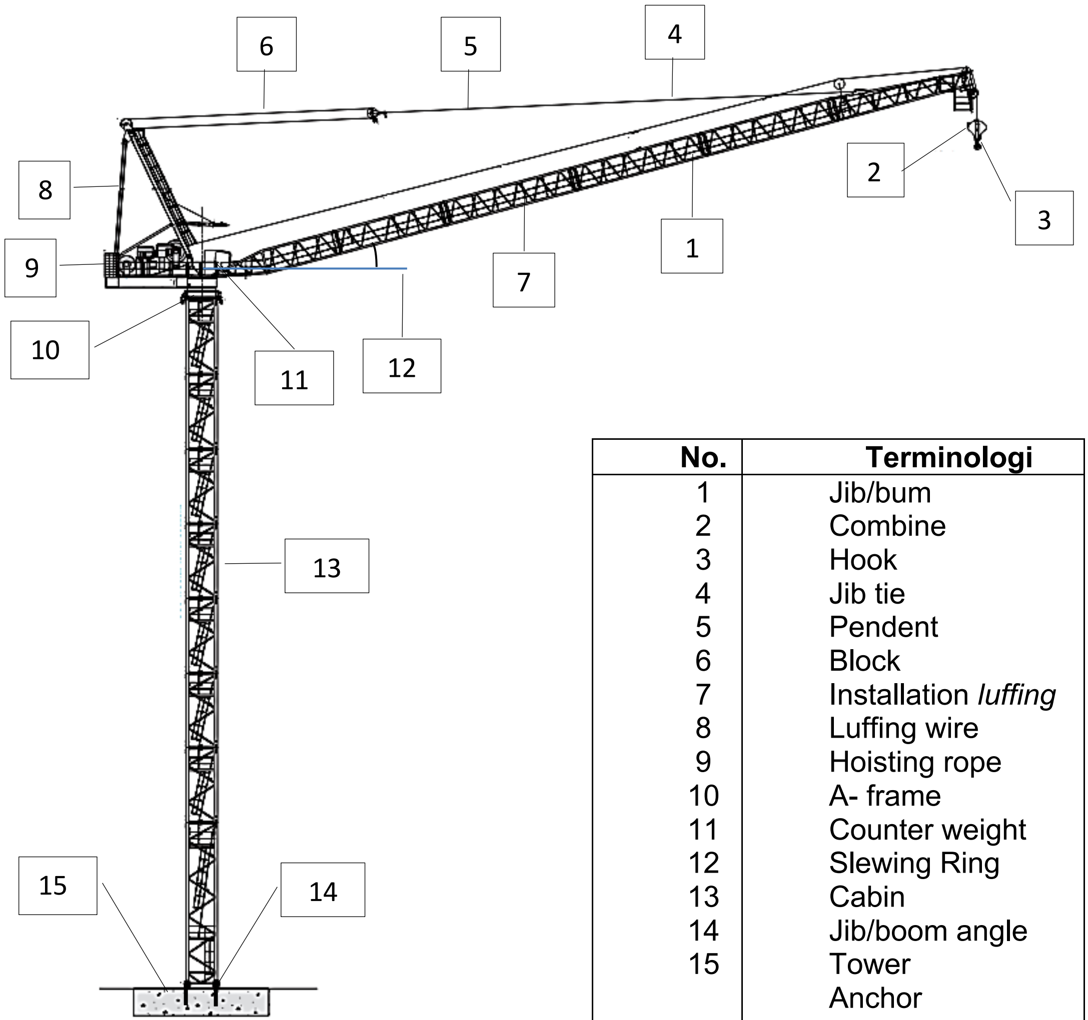


No	Terminology
	SLEWING UNIT
1	Boom
2	Trolley
3	Hook block
4	Counter jib
5	Ounter weight
6	Hoist unit
7	Hoist drum
8	A-frame
9	Pendant bar
10	Hoist rope
11	Operator cabin
12	Slewing installation
13	Slewing pivot
	TOWER
14	Middle climbing unit
15	Telescopic cage
16	Mast
17	Inner tie
	BASE
18	Base chassis of tower
19	Crane support
20	Center of ballast
21	Crose frame
22	Pad
23	Anchors

Figure 3.15 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 3.17).



No.	Terminologi
1	Jib/bum
2	Combine
3	Hook
4	Jib tie
5	Pendent
6	Block
7	Installation *luffing*
8	Luffing wire
9	Hoisting rope
10	A- frame
11	Counter weight
12	Slewing Ring
13	Cabin
14	Jib/boom angle
15	Tower
	Anchor
	Concrete

Figure 3.16 Design of luffing tower crane (http://www.morrow.com/crane101)

3.4 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 3.1 gives a clearer picture of the differences in the suitability of these tower cranes.

Table 3.1 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

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CHAPTER 4

STATISTICS AND CAUSES OF CRANE ACCIDENTS

4.1 Introduction

The construction industry has been identified as one of the largest and most dangerous industry in the world, based on the rate of job-related deaths, workers' compensation, injuries and fatalities. The construction industry also involves the use of cranes, especially tower cranes, to help speed up the construction of buildings. In this industry, consideration to safety and health requirements is widely recognised as a useful approach in managing occupational safety and health as hazards at the workplace can be eliminated or minimised by placing greater emphasis on these factors. With regard to hazards to the safety of workers, high risk activities, including working at heights and hoisting works, have been identified as causes of accidents in the construction sector.

With the increase in the number of tower cranes in Malaysia each year, the accident rate may rise if safety factors and regulations/codes on the standard use of tower cranes are not complied with. According to a study by Chong and Low (2014), during the period 2000 to 2009, as many as 69,126 accidents occurred in the construction industry, of which 653 cases involved tower cranes. 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.

4.2 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 4.1 and 4.2.

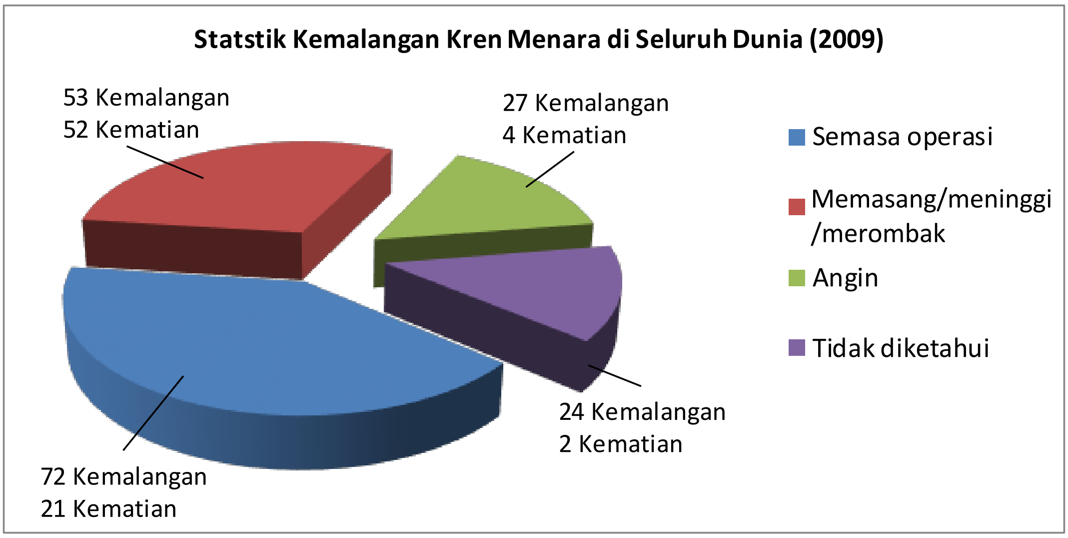

Figure 4.1 Statistics on the number of tower crane accidents worldwide (www.towercranesupport.com)

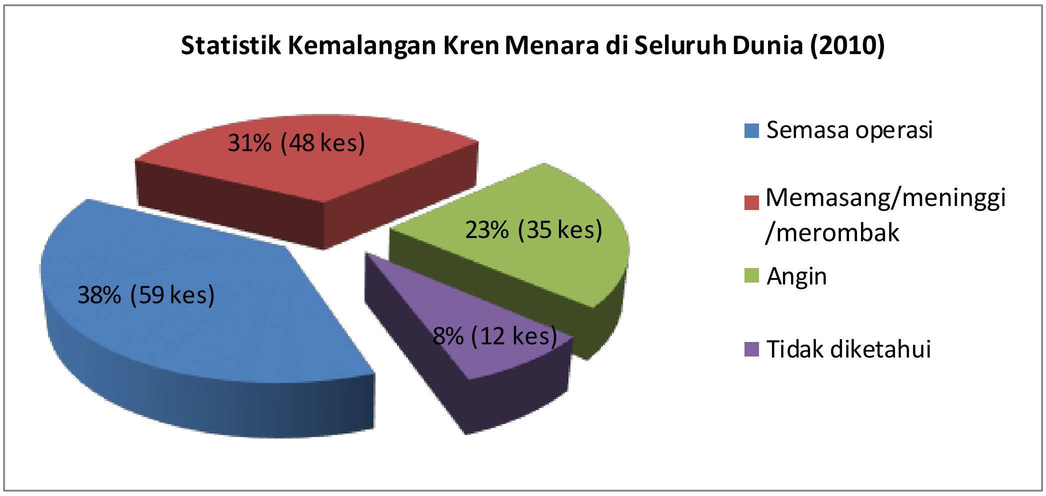

Figure 4.2 Statistics on the percentage of factors that are the causes of tower crane accidents (www.towercranesupport.com)

4.3 Statistics on Tower Crane Accidents

Based on surveys that have been conducted, the accident statistics show that deaths and hazardous incidents at the workplace involving tower cranes and hoisting equipment are increasing every year (see Figure 4.3). Among the causes of the accidents are:

(a) failure of the crane structure or components,

(b) failure of the hoisting equipment (such as the wire rope, pulley, hook block, etc.),

(c) falling objects,

(d) swinging object during the hoisting of a load.

Based on the causes of accidents mentioned, it is necessary for the construction industry to improve its practices for the safe operation of tower cranes. Therefore, the stakeholders in the operation of tower cranes (such as crane manufacturers, crane contractors, engineers and designers, project managers, lifting supervisors, operators, signalman, riggers and construction workers) should play their respective roles and carry out their responsibilities to ensure that the hoisting operations are conducted safely.

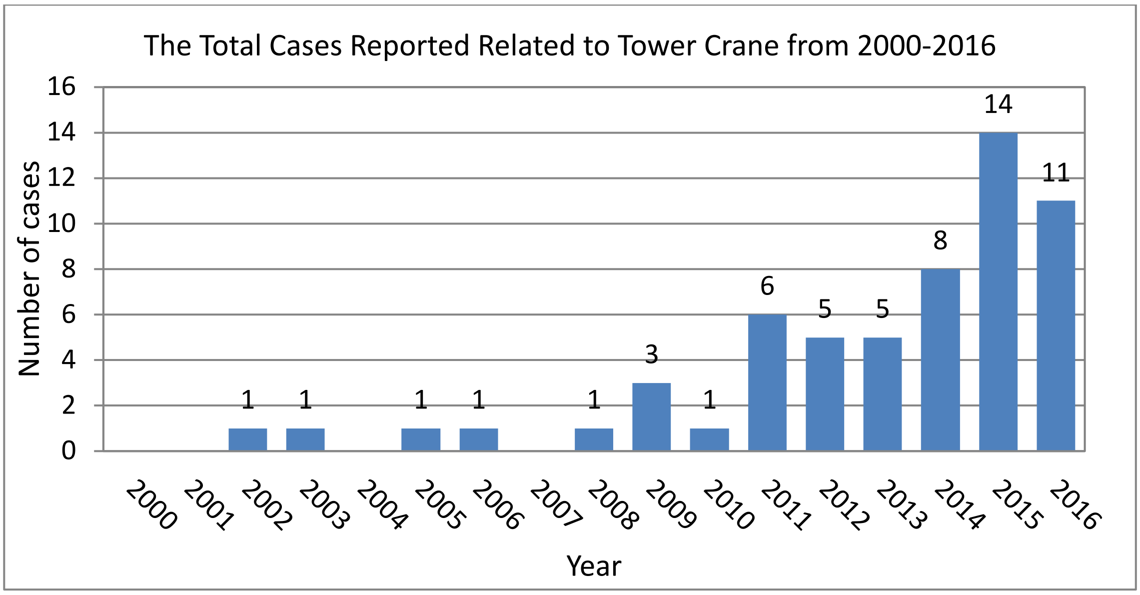

Figure 4.3 Statistics on accidents involving tower cranes

Among the factors identified as being the cause of accidents during hoisting operations are the following:

(a) damage to a single mechanical system (such as the hoisting system, hook block, electronic system and the brake system),

(b) the lackadaisical attitude of the hoisting crew,

(c) unsafe working environment for cranes,

(d) defective lifting equipment or tools,

(e) abnormal load types and shapes, and

(f) improper rigging and slinging methods.

More than 80% of the respondents to a questionnaire agreed that crane accidents were due to the negligence of the crane operator, poor communication, mechanical issues and the lifting of excessive loads, as shown in Figure 4.4. 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 4.5.

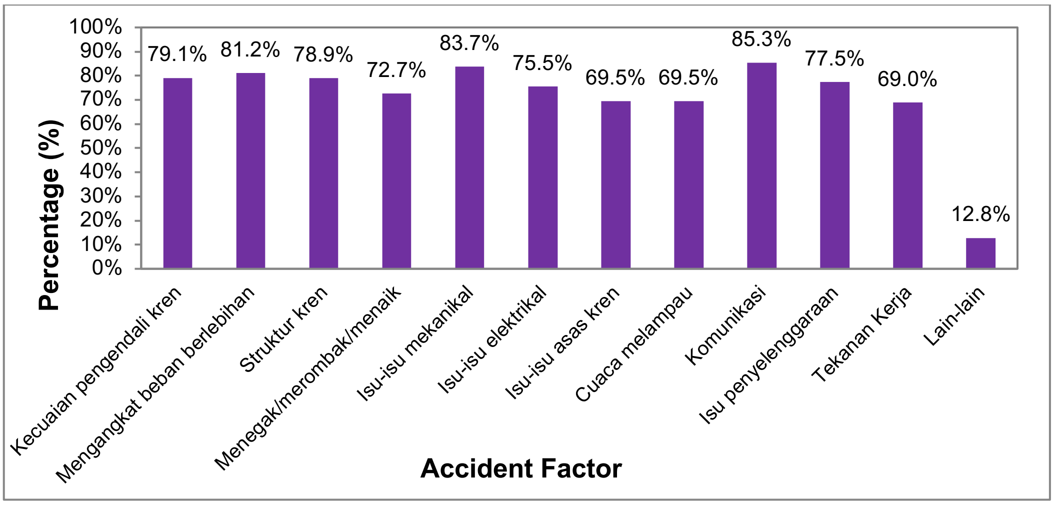

Figure 4.4 Percentage of causes of tower crane accidents (through surveys)

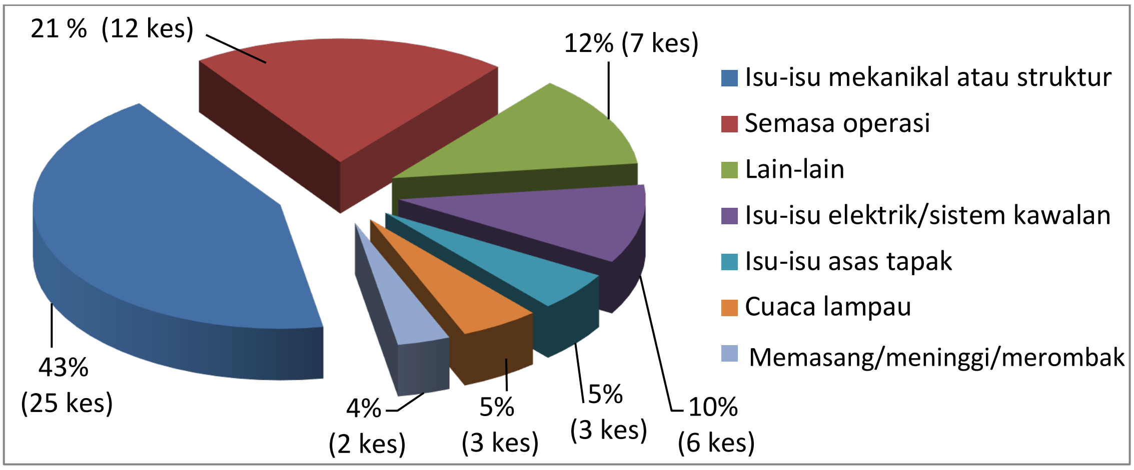

Figure 4.5 Percentage of factors that cause tower crane accidents (Abdullah & Wern, 2010; DOSH investigation files; www.dosh.gov.my)

With reference to Figure 4.5, 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 signalman, 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/mounting/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, mounting 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.

4.4 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 4.6). 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 4.6 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 4.7. 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 4.7 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 4.8. 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.

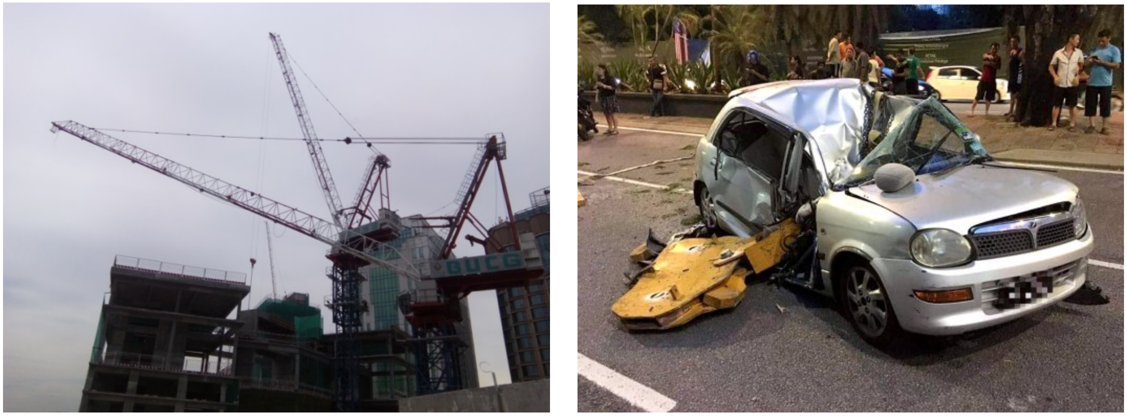

Figure 4.8 (a) Luffing tower crane, and (b) iron hook of crane that fell on the victim's car

4.5 Measures to Prevent Accidents

Preventive measures must be taken by the responsible parties to ensure that such accidents involving tower cranes are not repeated. Among the preventive measures that can be taken are the following:

(a) When encountering difficulties in hoisting a load, the crane operator must avoid using force, and the hoisting work must be stopped immediately. An inspection should be carried out, and the parties concerned should be informed so that further action can be taken,

(b) Ensure the pulley sheave is in good condition, without any defects or damage,

(c) Ensure the luff wire rope that is used is according to the specifications set by the manufacturer,

(d) Conduct inspections from time to time to ensure that the crane is being handled safely by the operator,

(e) Perform regular checks on the luff wire rope, and if it is damaged, defective or a few strands of the wire rope have given way, change the rope immediately,

(f) Carry out checks on safety devices such as the overload limit switch and the hoisting speed limit before use,

(g) Carry out a risk assessment around the area of operation of the crane and take the appropriate steps to reduce such risks,

(h) The crane operator should handle the crane in the correct manner, and comply with the procedures outlined in the operating manual,

(i) The crane operator should identify the inherent risks around the crane when lifting or lowering a load,

(j) Periodic inspections should be carried out on the crane structure,

(k) Regular inspections and maintenance of the pulley and trolley should be performed at frequent intervals,

(l) Owners must ensure that all tower cranes are handled by competent and registered operators,

(m) Crane owners must ensure that the cranes are safe for use,

(n) Crane owners must ensure that cranes are maintained and checked regularly,

(o) Contractors should conduct a risk assessment of every work activity that is carried out using a tower crane,

(p) The brake components should be carefully inspected. Among the brake components requiring attention are:

 (i) brake lining

 (ii) hydraulic oil supply

 (iii) electrical wiring or related component of the brake system, etc.

(q) If the crane stops operating for a short period of time, the crane operator must comply with the procedure concerning ‘leaving a crane unattended’ by ensuring:

 (i) the load has been removed from the hook,

 (ii) the electricity supply has been switched off,

 (iii) the brake lock has been engaged.

(r) The boom should be parked according to the angle outlined in the crane manufacturer’s manual.

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CHAPTER 5

BASIC CALCULATION FOR WEIGHT OF A MASS

5.1 General Formula for Calculation

(I) Basic unit of measurement for a load

Quantity	Unit	Symbol
Mass	kilogram ton	kg tan
Length	millimetres centimetres metre	mm cm m

(II) Measurement unit

a) 1 ton = 1000 kilogrammes

b) 1 metre = 100 centimetres = 1000 millimetres

(III) To convert the unit of measurement

a) Tons to kilogrammes

Example: 2 tons x 1000 = 2000 kg

b) Kilogrammes to tons

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

c) Metres to millimetres

Example: 2 m x 1000 = 2000 mm

d) Millimetres to metres

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

e) Metres to centimetres

Example: 5 m x 100 = 500 cm

f) Centimetres to metres

Example: 300 /100 (divided) = 3 m

Examples of unit conversions for length:

1cm	➔	10mm
10mm	➔	1cm
1m	➔	100cm
100cm	➔	1m
1 km	➔	1000m
1000m	➔	1 km

(IV) Calculations Using a Calculator

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

Example:

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

100.87651 tons is taken as 100.877 tons

100.1111 tons is taken as 100.111 tons

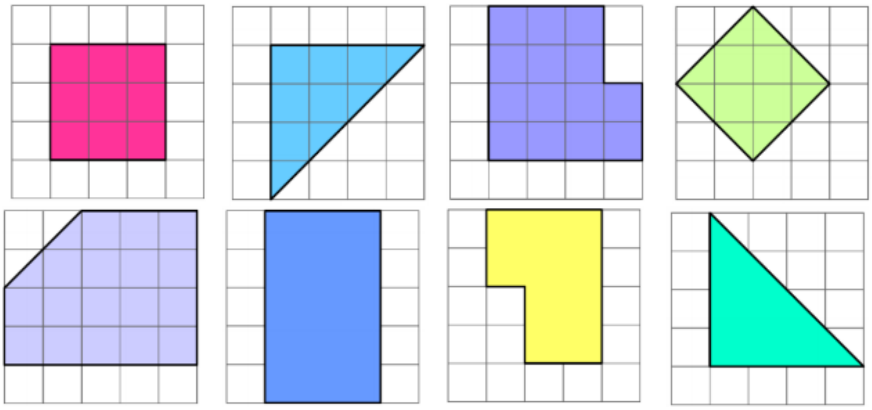
Example: 200.9999 kg is taken as 201.000 kg

Example: 200.1111 kg is taken as 200.111 kg

5.2 Calculation of Area and Volume of Various Shaped Objects

(a) Surface Area

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

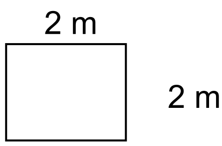


i) Surface area of a square (m^2) = Length x Width

Example:

m^2 = 2 m x 2 m

= 4 m^2 (square metres)

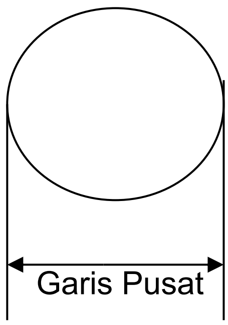


ii) Surface area of a Circle (m^2) = Radius x Radius **x 0.79**

Example:

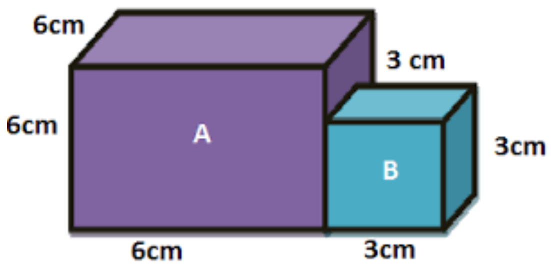
m^2 = 1.2 x 1.2 x **0.79**

= 1.138 m^2 (square metres)

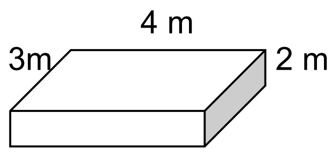


(b) Volume

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



i) Volume of a Rectangular Object (m^3) = Length x Width x Height

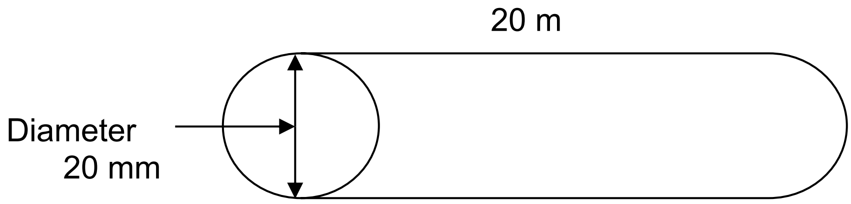


Example:

m^3 = 4m x 3m x 2m

= 24 m^3 (cubic metres)

ii) Volume of a Cylinder (m^3) = Radius x Radius x Length x 0.79



Example:

m^3 = 0.02m x 0.02m x 20m x 0.79
= 0.00632 m (cubic metres)

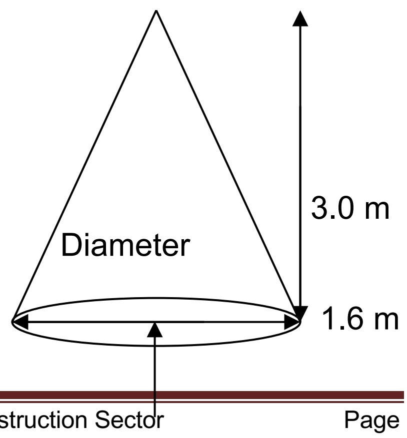
Note: Pi (π) = 3.142 = 3.142/4 = 0.79

iii) Volume of a Cone (m^3) = $\frac{\text{Radius x Radius x Height x 0.79}}{\text{(divided) 3}}$

Example :

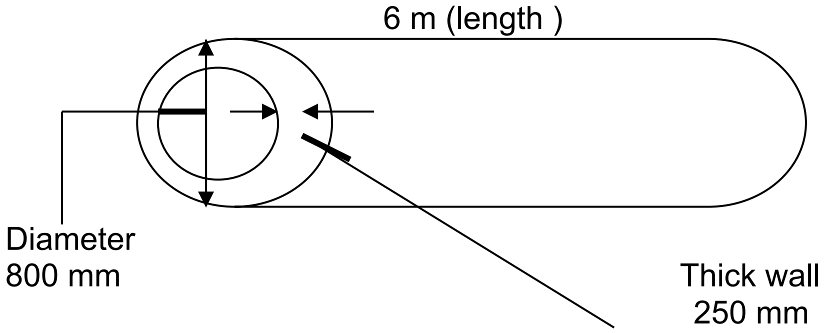
m^3 = $\frac{\text{1.6 m x 1.6 m 3 x 3.142}}{\text{(divide) 3}}$

= 2.022 m^3 (cubic metres)



iv) Volume of a Metal Pipe (m^3) = Radius x Thickness x Length x Pi (π)

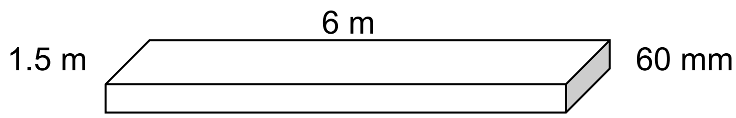
Pi = 22 /7 = 3.142



Example:

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

v) Volume of Iron Board (m^3) = Length x Width x Thickness



Example:
m^3 = 6 m x 1.5 m x 0.06 m

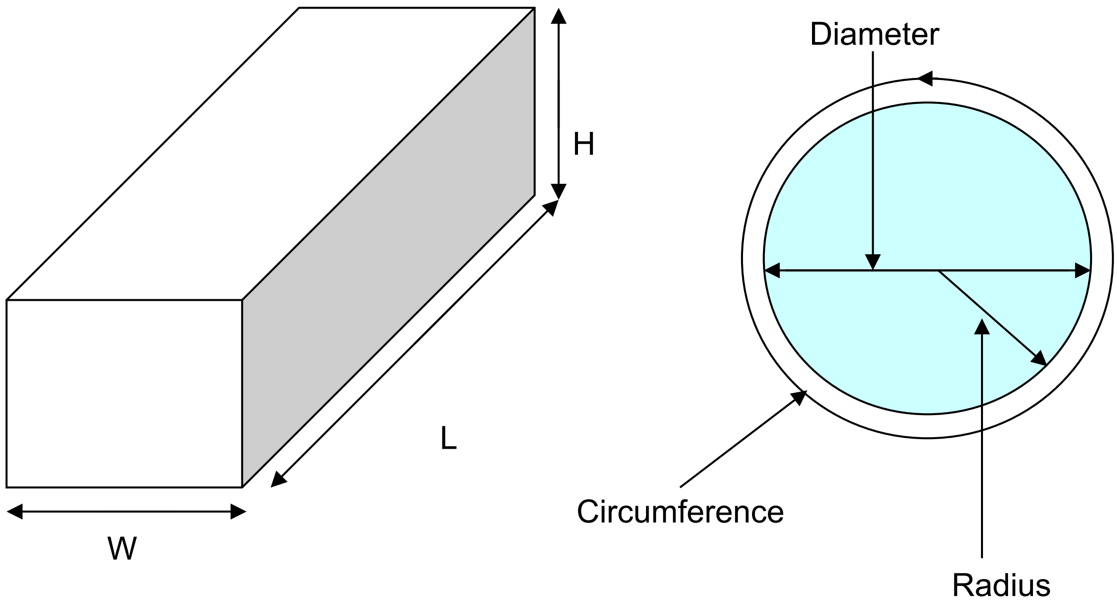
= 0.54 m^3 (cubic metres)

- Summary of Formulas

CODES FOR UNITS OF MEASUREMENT

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

Th	Thickness	**Pi**	3.142



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

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

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

a) The weight may be marked on the item.
b) Ask your supervisor or any person who might know.
c) If the item appears in a catalogue, perhaps the weight of the item can be obtained from the catalogue that comes together with the item.

d) The weights of machines might be obtained more clearly from the business records or Operator's Manuals.
e) Through the Engineer's Manual
f) Calculations

5.3.1 Calculated weights of several materials

MATERIAL	WEIGHT
Aluminium	2.7 tonnes/m^3
Bricks, Clay, Common (2.5t/1000)	1.6 tonnes/m^3
Cast Iron	7.2 tonnes/m^3
Cement (20 bags/T)	1.0 ton (50 kg per bag)
Concrete, wet or set	2.4 tonnes/m^3
Concrete Panel (Steel reinforced)	3.0 tonnes/m^3
Petrol	0.7 tonnes/m^3
Diesel	0.8 tonnes/m^3
Earth, Loose	1.8 tonnes/m^3
Glass	2.6 tonnes/m^3
Hardwood	1.1 to 1.4 tonnes/m^3
Lead	11.3 tonnes/m^3
Road metal (Crushed rock)	1.9 tonnes/m^3
Sand, Dry	1.7 tonnes/m^3
Sand, Wet	1.9 tonnes/m^3
Softwood (average)	0.6 tonnes/m^3
Steel	8.0 tonnes/m^3
Mild Steel	7.84 tonnes/m^3
Water, fresh (1 Kg per litre) (1 m^3)	1.0 tonne/m^3 (1000 litres/m^3)
Scaffold fittings (4.9 mm thick) (Frame)	0.5 kg/m; AST Rigging Handbook, 1.5 kg/m (for Australian scaffolds)
Scaffold Tubes (tubular type) (Steel)	4.41 Kg/m
Karri Scaffold planks	7 Kg/m
Steel H-Beam	45 kg/m
Steel Pipe (20 mm thick)	2.4 tonnes/m^3; From material catalogue

5.3.2 Calculation of weight of load/mass

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

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

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

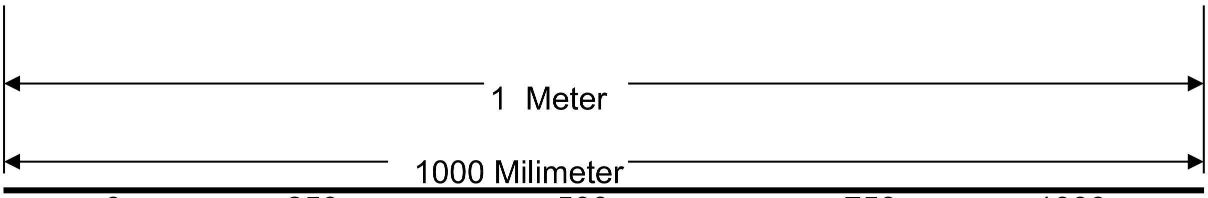
Volume = Surface area x Height = m^3 (cubic metres)

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

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

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

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



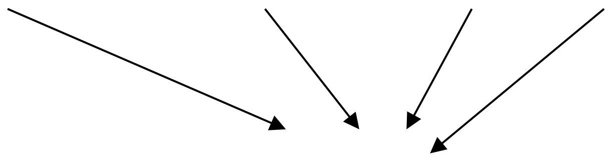
mm.	0	250	500	750	1000
m	0	.25	0.5	0.75	1.0

One metre is equivalent to 1000 mm

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

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

Thousand Hundred Ten One (Unit)



T H T U

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

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

Example:

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

5.3.3 Tonnes to pounds

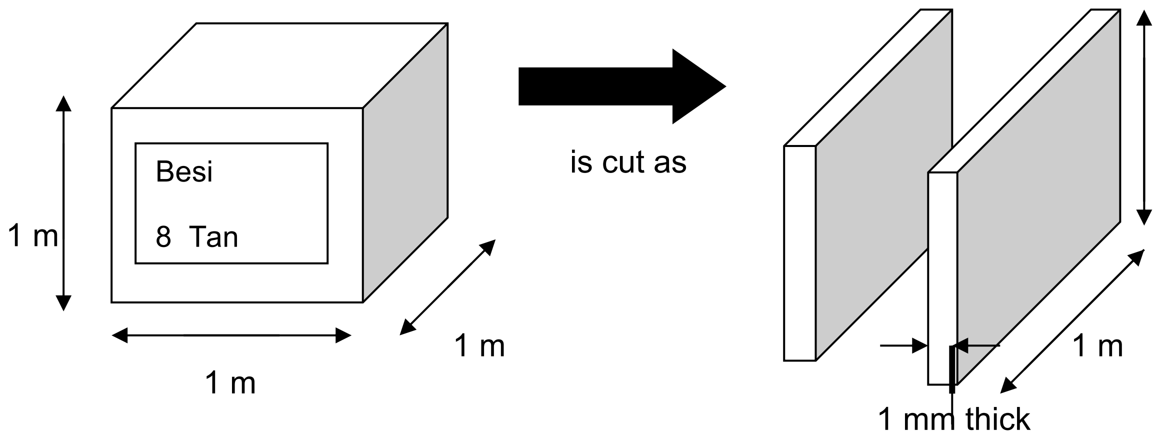
1 US tonne	=	2000 Ibs.
1 (M) tonne	=	2204 Ibs.
1 kg	=	2.2 Ibs
1 metre	=	3.28 feet

(a) Plate Formula

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

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

8000 kg/1000 small pieces = 8 kg/piece



Each small piece of iron weighs 8 kilograms

Below is shown how these facts are used:

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

Each square metre of this piece weighs 40 kilograms.

1 m

3 m

Method for obtaining the weight:

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

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

3 x 40 = 120 kilograms

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

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

Example:

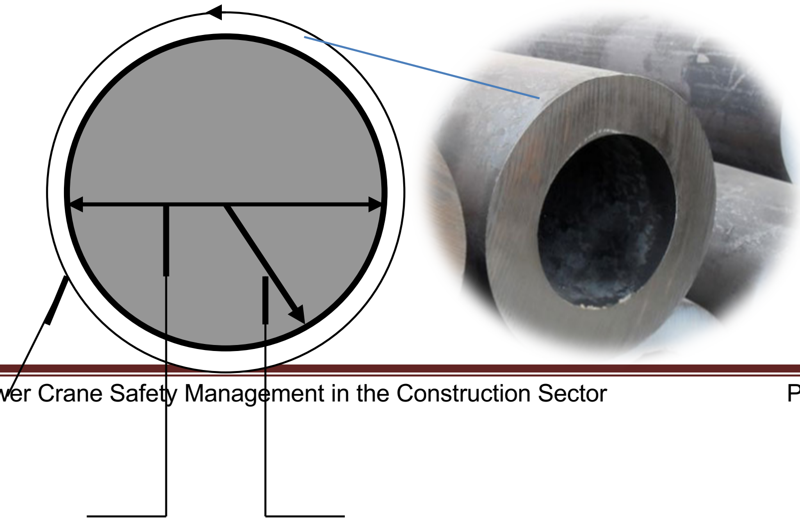
Weight = 3 x 1 x 5 x 8 = 120 kilograms

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

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

5.3.4 Calculation of weight of load/mass for circular objects

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



Circumference

Diameter Radius

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

The diameter is twice the radius.

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

Formula for calculating the area of a circle:

AREA = DIAMETER X DIAMETER X 0.79 = M²

OR

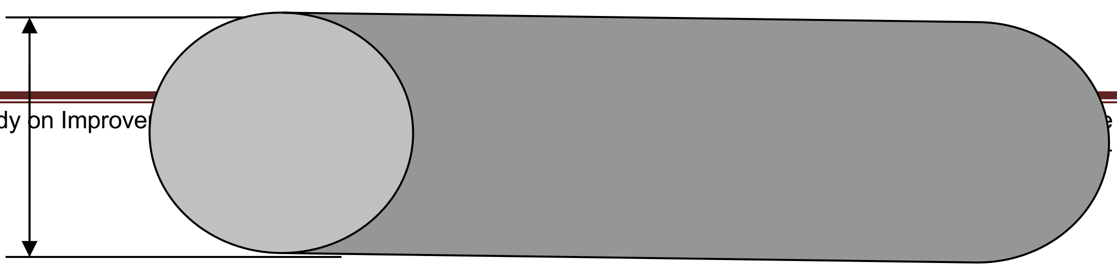
AREA = D X D X 0.79 = M²

Formula for calculating the circumference of a circle:

CIRCUMFERENCE OF A CIRCLE = 3.142 X DIAMETER

(b) Estimated weight of a circle

Figure 5.1 Oil Tank (http://tslack.com)



1.5m

3.5 m

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

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

Total area of circular surface = D x D x 0.79 = M^2 x 2 (both ends) = m^2
= 1.5 x 1.5 x 0.79 = 1.77 x 2 = 3.5 m^2

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

Area = Length x Breadth = m^2

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

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

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

Area of the tank body = 3.142 x Diameter (D) x Length (L) = m^2
(Area of a cylinder)

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

Step 2: Calculation of the weight of steel

WEIGHT = Area x Thickness X Weight of Material = Tonnes

Calculation:

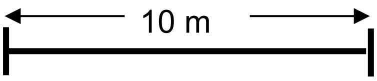
Area = 20 m^2
The thickness of the body of the steel tank at 3 mm must be changed to 0.003 m.

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

Therefore, the Weight of the Tank = 20 x 0.003 x 8 = 0.48 tonnes

EXAMPLES OF CALCULATIONS OF THE WEIGHT OF A LOAD/MASS

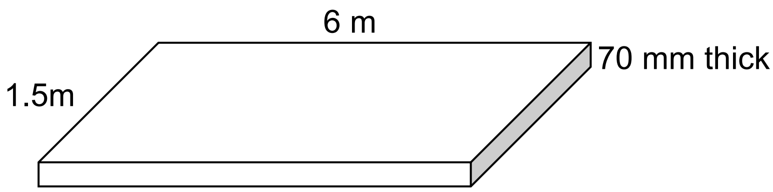
1. Find the weight of 2 iron beams, given that:



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

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

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



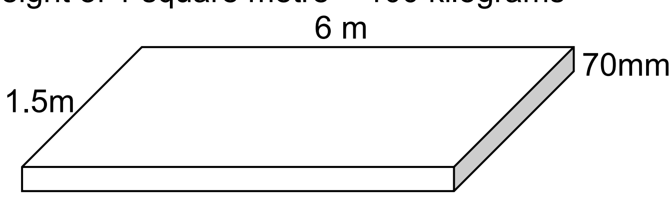
Solution:

Thickness of 70 mm = 0.07 m

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

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

Given:
Weight of 1 square metre = 100 kilograms

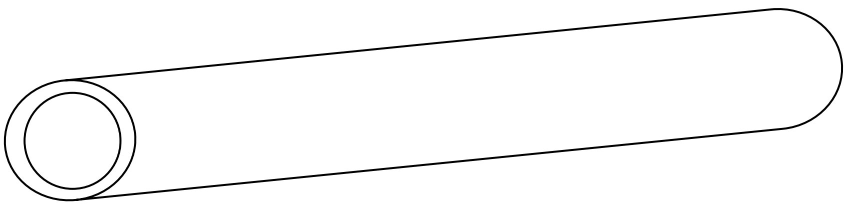


Solution:
Convert the thickness of 70 mm into metres = 0.07 m

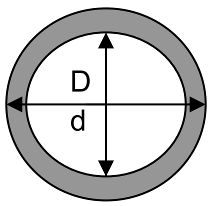
Answer: 6 m x 1.5 m x 100 kg = 900 kg x 2 = 1800 kilograms

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

Given:
Length = 6 m
Diameter = 1.5 m
Thickness = 20 mm



Solution:
Convert the thickness of 20 mm to 0.020 m



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

Volume of pipe = 3.142 x Length x Outer diameter x Thickness = m³

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

or

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

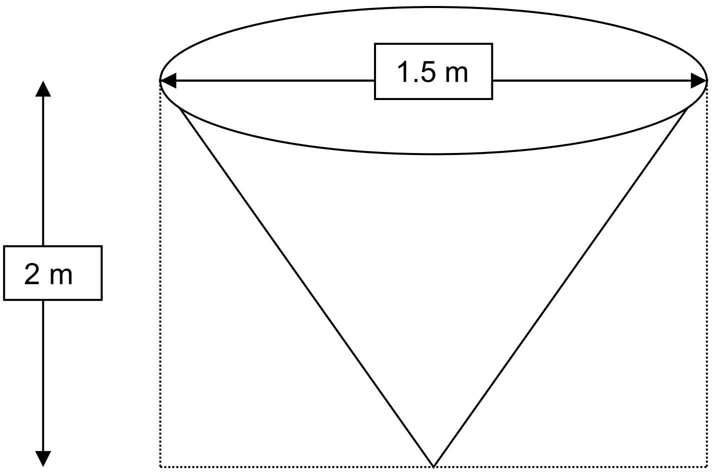
$$\frac{3.142 (1.5 - 1.46^2)^2}{4} \times 6 = 0.558 \text{ m}^3$$

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

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

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

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



Solution:

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

Use the formula for the volume of a cone

$$= \frac{0.79 \times \text{Diameter} \times \text{Diameter} \times \text{Height}}{\text{(divide) } 3}$$

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

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

Note:

R = Radius D = Diameter π = Pi = 3.142

Step 1

Find the volume of the concrete bucket:

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

Step 2

Find the weight of the concrete:

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

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

= 1.185 m^3 x 2.4 tonnes/ m^3

= 2.844 tonnes

Step 3

Find the weight of the concrete bucket filled with concrete:

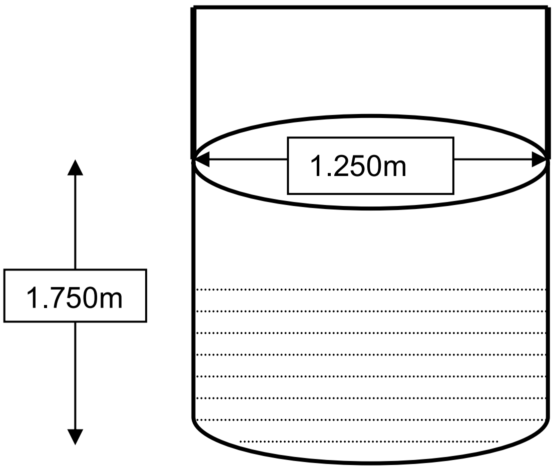
Convert the weight of the empty bucket, given as 300 kg, to 0.3 tonnes

Weight of the concrete bucket filled with concrete = weight of wet concrete in the bucket + Weight of the empty concrete bucket

= 2.844 tonnes + 0.3 tonnes

= 3.144 tonnes

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



Solution:

Step 1

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

Step 2

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

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

Step 3

Find the weight of the water in the bucket:

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

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

= 1.621 tonnes

Step 4

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

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

Total weight = Weight of bucket + weight of water content

= 1.621 tonnes + 0.3 tonnes
= 1.921 tonnes

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CHAPTER 6

SAFE OPERATION OF TOWER CRANES

6.1 Safe Load Control

Project planning should involve two key points: the estimated load capacity to be lifted and the overloaded load or the load reduction area. Information on load weights can be obtained from signs on loads, drawings or project documentation or cranes load charts. If the load size is known, the material weight can be calculated from the density information of the material as in Table 6.1.

Table 6.1 The type and weight of the materials for construction

Materials	**Weight (kg/m^3)**
Water	1000
Aluminum	2700
Charcoal	1450
Brick	2100
Iron and steel	7700
Wood	800
Concrete	2400
Soil	1600
Copper	8800
Lead	8500

Lifiting supervisor, signalman and rigger are responsible for ensuring that light weight materials such as bricks, bricks, tiles, whiteboards or other objects should be lifted in a sturdy and enclosed container with safe equipment (eg plastic). The project manager is responsible for ensuring that lifting work are handled by lifting supervisor, operator, signalman and rigger have received sufficient training in terms of operating lifting principles, load weight and appropriate distance of the materials.

6.2 Work load Allowed

The safe working load (SWL) or lifting load allowed for the tower crane refers to the load specification on hooks with certain range distance, the use of the appropriate wire rope, the length of the boom, and the height of the crane and the location of the load lift site. Each equipment involved in the lifting operation has its own SWL. The load lifted must be lower than SWL crane tower system and also take into account the dynamic effects such as impact caused by the sudden lifting movement. Machinery / equipment specification is suitable to be referred to the crane manufacturer's manual to find out the usage limit or the limit the load allowed for each machine / equipment.

6.2.1 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 6.1. 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.

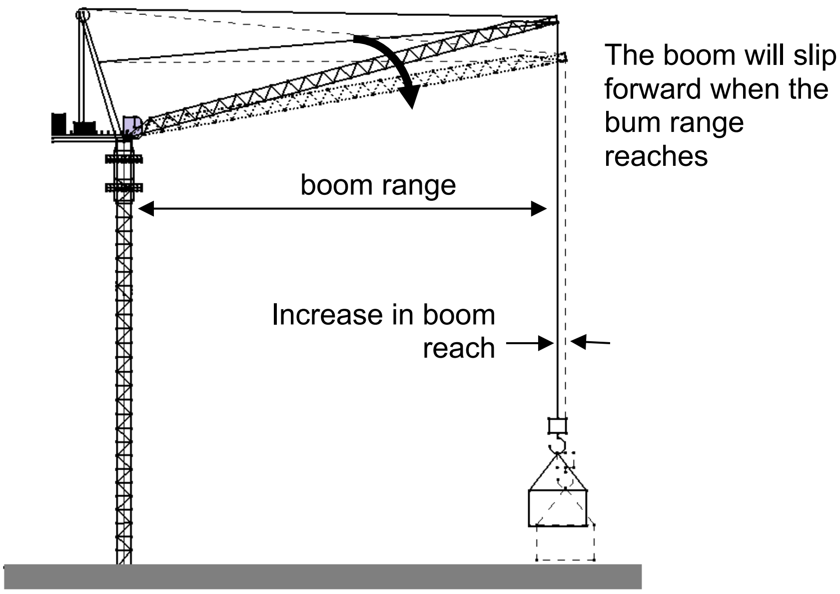

Figure 6.1 Increase in boom range during lifting of load

6.2.2 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 6.2). 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 86o. 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.

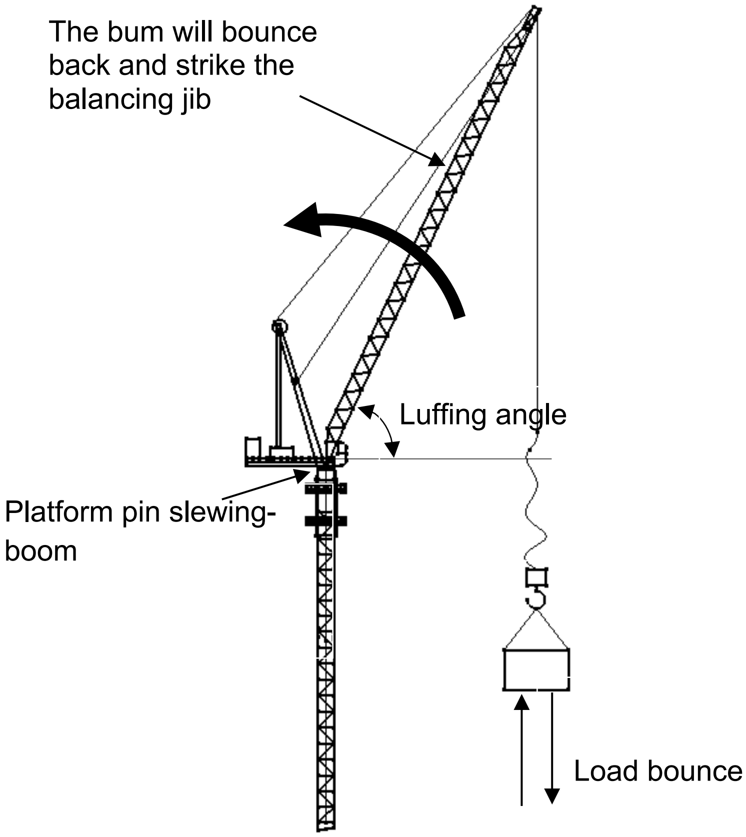

Figure 6.2 Effect of luff angle on the stability of a tower crane

6.3 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:

(a) It should be ensured that the place where the load is to be lowered, raised and shifted to is safe,

(b) 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,

(c) All workers must stay away from the route along which the load is to be lifted,

(d) 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,

(e) In danger zones where hoisting works are being carried out, warning signs (see Figure 10.5) or warning lights should be erected to direct the public or traffic away from the construction site,

(f) Avoid lifting loads across highways, railway tracks, rivers or public places that can be accessed by the public.

6.4 Control of tower crane operations

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

(a) 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,

(b) Safety devises that warn of danger should be clearly visible to the operator,

(c) Hand and flag signals by a signalman must be clearly visible,

(d) The signal codes that are conveyed verbally must be clearly audible, especially when communicating by telephone or two-way radio (walkie-talkie),

(e) Ensure that hoisting activities do not cause damage to crane components and the material being hoisted,

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

(g) Ensure that the wire rope hoist is vertical throughout the hoisting work,

(h) The load must be lifted clearly from the surface of the ground/area,

(i) The rigging and counterweight of the load must be inspected before the hoisting work,

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

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

6.5 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).

6.6 Tower Crane Security Devices

All tower cranes must be equipped with a limit switch and safety device that operate automatically to prevent crane damage; if crane operators make mistakes during operation. Figures 6.3 and 6.4 respectively show the limiting switches and safety devices installed on hammerhead and luffing cranes.

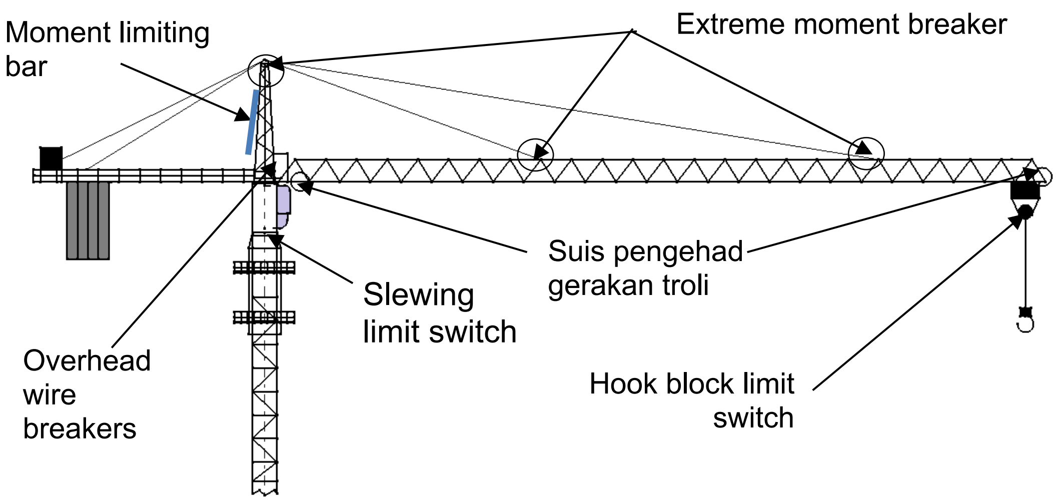

Figure 6.3 Position of the safety device on the hammerhead crane

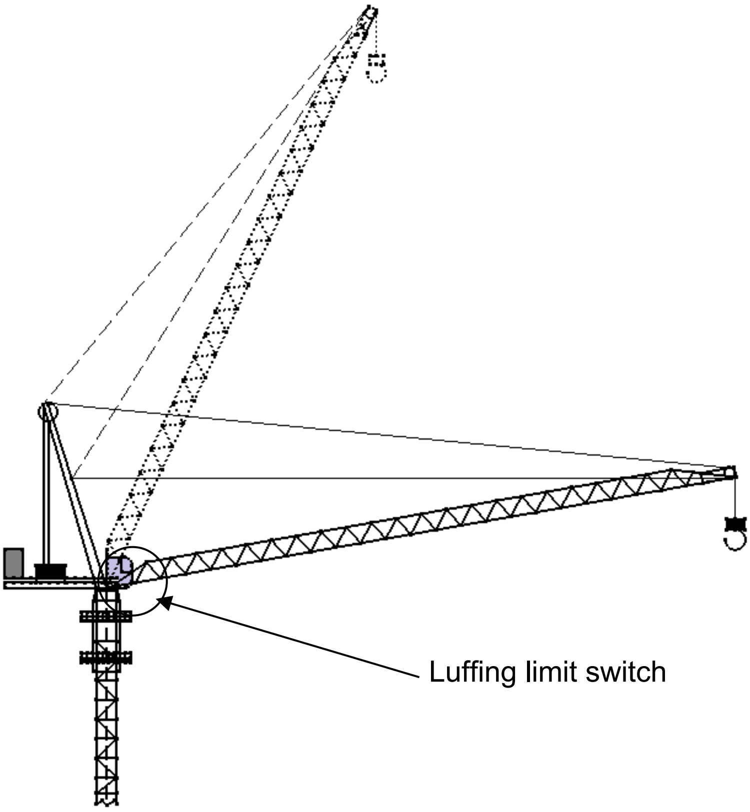

Figure 6.4 Luffing limit switch position

(note: additional limiting switch for luffing cranes)

Crane safety devices such as limiting switches and load indicators need to be installed on the cranes and ensured functioning well during operation. Warning issued by security device is in the form of warning lights and / or sound alerts to crane operators.

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CHAPTER 7

COMMUNICATION

7.1 Communication Signals

Sign language is important for ensuring communication between the signalman and the operator during crane operations. The signalman will give the signal to the operator, who must be familiar with the signals to avoid accidents while the crane is in operation.

Signals that cannot be understood or are misinterpreted will pose a danger to workers, including the operator and the personnel involved in the hoisting operations. Hence, a signalman must be competent in the sign language used for cranes so that the information or signals given to the operator are correct and can be understood.

A signalman must be able to convey standard signals, such as the ISO16715: 2014 *Crane - Hand Signals Used with Cranes*, at all times for the following cases:

(a) A tower crane operating with a long boom. The signalman is required to give signals regarding the movement of the boom or trolley,

(b) The operator is unable to see the hook or the load at all times, and therefore, the assistance of a signalman is required at such moments.,

(c) A tower crane is installed for mobile operations and the operator is unable to see all the parts of the crane and the platform in order to move.

A signalman must be sure of the following when working on construction sites:

(a) The place where the signalman stands must be visible to the operator at all times, and if hand signals are used, the signals must be clearly visible to the operator. Ensure that the place where the signalman is standing poses no danger to him.

(b) The operator must be experienced in the handling of a tower crane and must be able to understand the sign language used by the signalman.

(c) A signalman must be responsible for all the persons working within the range of the tower crane, and he must ensure that all persons are beyond the reach of the boom.

(d) There must be continuous communication with the operator regardless of whether hand signals, flags or two-way radios (walkie-talkies) are used.

(e) The signalman must wear the proper personal protection equipment such as a reflective vest, safety helmet, and brightly-coloured gloves for the hand signals.

There are three types of signal languages that are usually used in tower crane operations, namely:

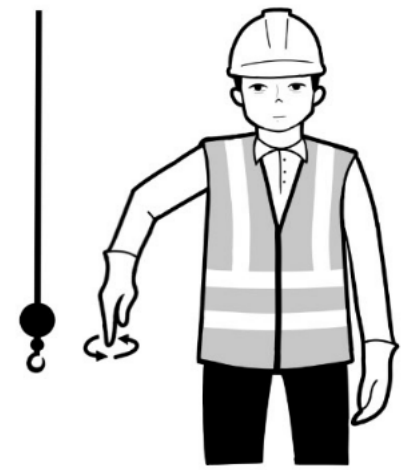
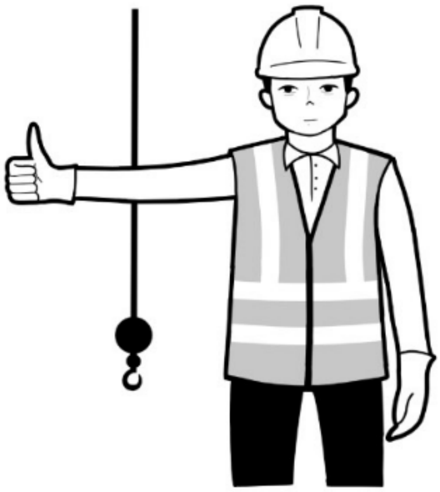
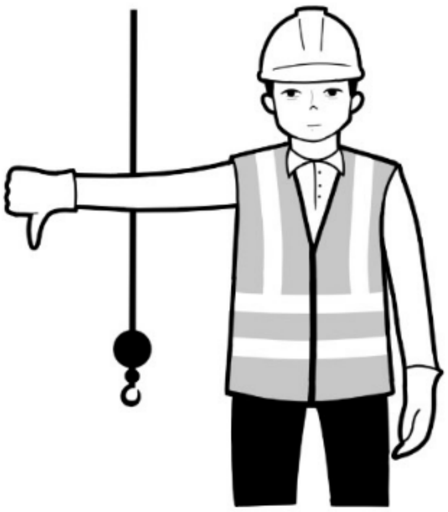
(a) Hand signals

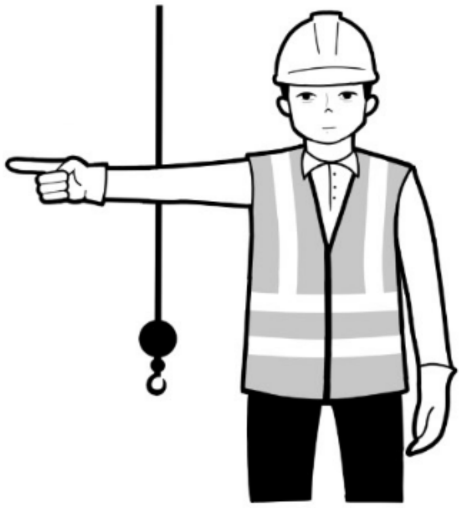
(b) Flag signals

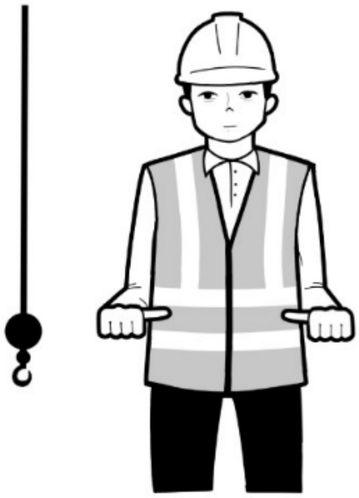
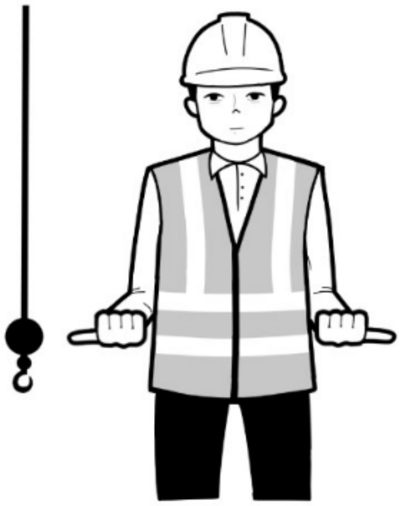
(c) Transmission of information by two-way radio

7.2 Hand Signals

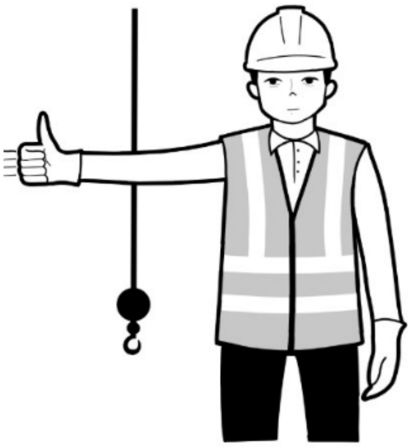
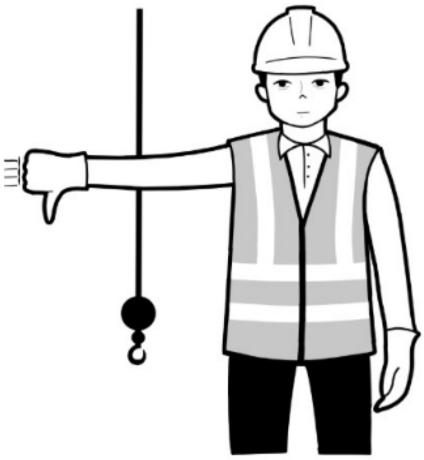
Hand signals are the main form of communication used by signalman to convey information to operators. Figure 7.1 shows the standard hand signals based on MS2203:2008 *Cranes - Training of Operators - Part 3: Tower Cranes* or ISO16715: *2014 Crane-Hand Signals Used with Cranes* that are used in crane operations.

Signal	Signal meaning
	1.Lower
	2.Raise boom
	3.Lower Boom

Signal	Signal meaning
	4.Hoist
	5.Swing
	6.Move slowly

Signal	Signal meaning
	7.Use main hoist
	8.Retract Boom
	9.Extend Boom

Signal	Signal meaning
	10. Dog Everything
	11.Stop
	12.Use Whipline

Signal	Signal meaning
	13. Move
	14. Raise boom lower the load
	15. Lower boom raise the load

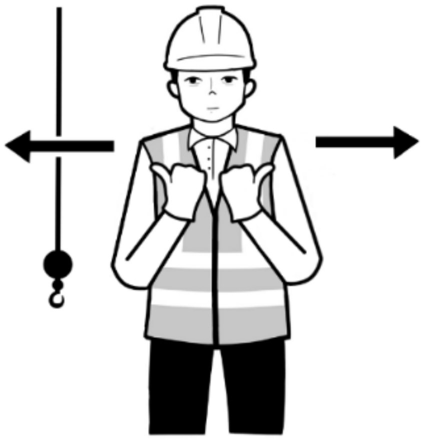
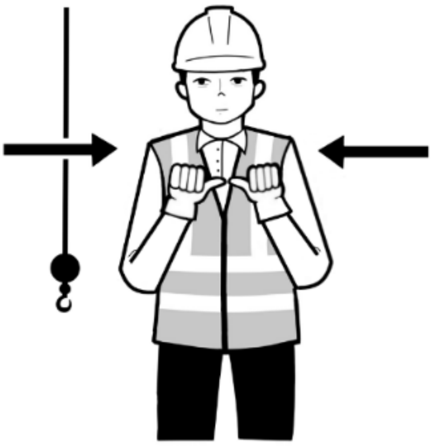
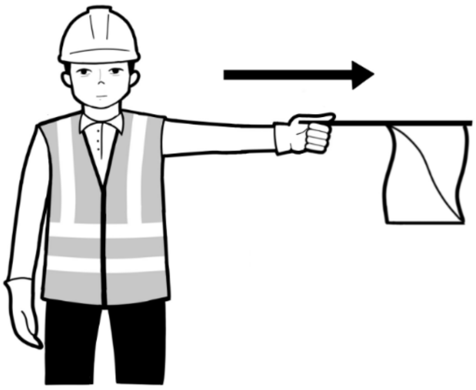
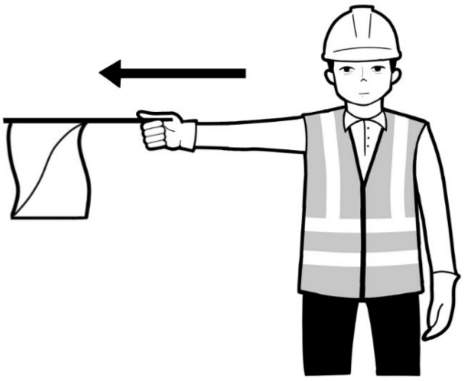
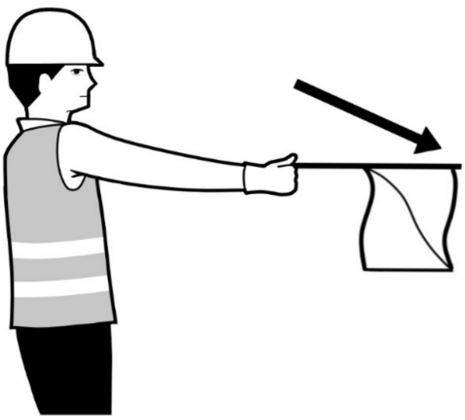
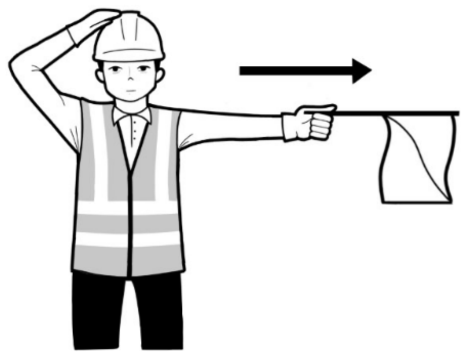
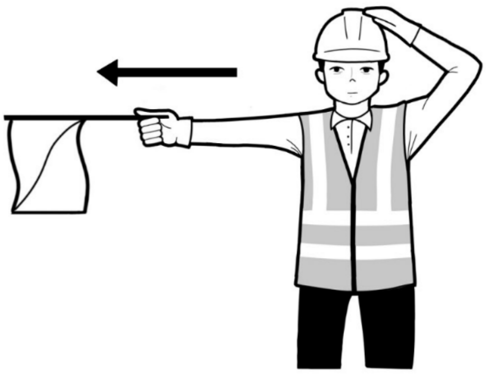
Signal	Signal meaning
	16. Trolley to the out
	17. Trolley to the in

Figure 7.1 Hand Signals

7.3 Flag Signals

When hand signals cannot be clearly seen by the operator, then flag signals should be used instead. The standard flag signals are shown in the diagram in Figure 7.2.

Signal	Signal meaning
	1.Turn to the left
	2. Turn to the right
	3.Show position

	4. Raise lufing boom
	5. Lower lufing boom
	6.Stop emergency

	7.Raise
	8.Stop
	9.Calling

	10.Moving
	11.Lowering
	12.Raise slowly

	13.Lowering slowly
	14.Thank you

Figure 7.2 Flag Signals

7.4 The Use of Two-Way Radios and Other Signals

7.4.1 Sending Information by Two-Way Radio

Two-way radio communication is used during the operation of all types of cranes. It not only provides precise directions for the movement of the crane but also gives the operator more confidence in handling the crane. However, it also has its disadvantages. For example, the battery power can be depleted, there may be interference from waves/frequencies, other waves may be combined simultaneously, and the surroundings may be noisy. Both the operator and the signalman must agree to the form of communication and the public/authorities (Police Station, Fire Department and others) in the vicinity must be informed before they take their respective positions. Communication by two-way radio can be used when handling all types of cranes.

When using a two-way radio, make sure the information is clear, and there must be a specified instruction from the operator for each required term code, for example, whether to lower a boom/trolley by one metre or the reverse; or to turn to the left or right, or other instructions. The information must be precise and clear to avoid any mistakes, such as 5 metres being heard as 25 metres over the two-way radio. Therefore, the pronunciation must be audible and clear at all times.

It is recommended that Malay and an international language, i.e. English, be used as the intermediate language between operators and signalman (see Table 7.1). The use of other native languages for the operation of cranes in Malaysia is not encouraged.

Table 7.1 Example of codes by two-way radio

MOVEMENT	CODE
HOOK/HOIST MOVEMENT	HOIST UP AND HOIST DOWN
BUM MOVEMENT	BUM UP AND BUM DOWN
TROLLEY MOVEMENT	TROLLEY IN AND TROLLEY OUT
SLEWING	SLEW LEFT AND SLEW RIGHT
OK TO RAISE	ALL CLEAR
DO NOT MOVE	STOP

WARNING:

(a) For tower crane operations at night, where the range of vision is limited, communication must be by two-way radio.

(b) The operator must stop operating the tower crane if communication is lost, and resume operations once communication is restored.

(c) If a load is lifted to a high place and another to a low place (for example, during concrete works), two signalman are required, one at the place to which the load is being hoisted, and the other at the low place where the concrete is being loaded into the bucket.

(d) If there are doubts as to the instructions or the language in the delivery of information to the operator, the operator must cease all hoisting operations.

8.4.2 Whistle

When two or more cranes are in use at the same time, there will be confusion in the signal communications. Therefore, an alternative signal, like the blowing of a whistle, can be used.

The key to the symbols and standard whistle-blowing signals are given in Tables 7.2 and 7.3.

Table 7.2 Key to whistle-blowing symbols

★	Short blowing once
−−−−−−−−−−−−−−−−−−−−	Long blowing once

Jadual 7.3 Whistle Blowing Standards

SYMBOL	MOVEMENT
★	*STOP*
★ ★	*HOIST UP*
−−−−−−−−−−−−−−−−−−	*HOIST DOWN*
★ ★ ★	*BUM UP or TROLLEY IN*
★ ★ ★ ★	*BUM DOWN)* or *TROLLEY OUT*
−−−−−−−−−−−−−−− ★	*SLEW LEFT*
−−−−−−−−−−−−−−− ★ ★	*SLEW RIGHT*

The following tools can also be used as a means of communication between operators and signalman:

- Speakers
- Horns
- Torchlights

The use of the above tools must be discussed between the operator and the signalman so that the information conveyed by the signalman can be interpreted by the operator.

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CHAPTER 8

PERSONAL PROTECTION EQUIPMENT

8.1 Introduction

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

8.2 Types of Personal Protective Equipment

(a) Safety helmet

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

(a) The impact from a falling object by rebounding and deflecting the force
(b) Impact from the side and behind

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

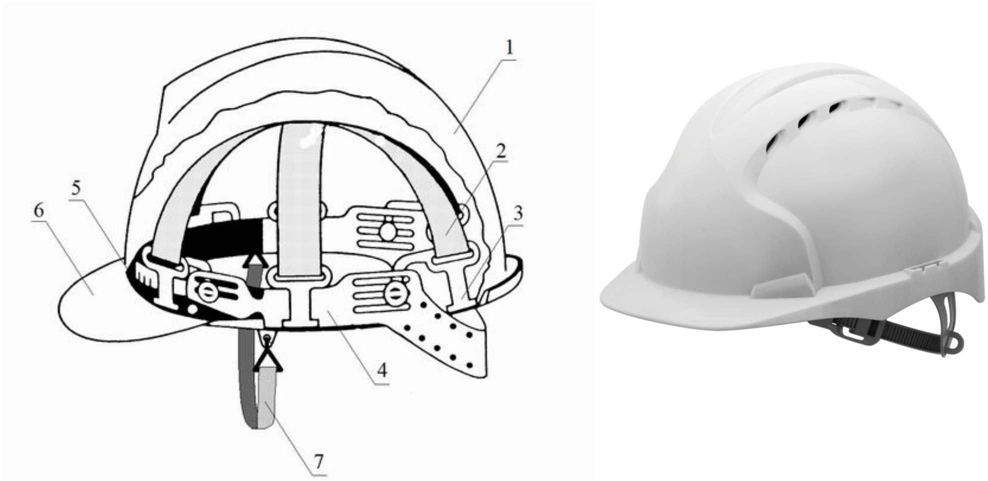

Figure 8.1 Safety helmet for the construction industry; 1 – shell, 2 – harness, 3 – harness adjuster, 4 – headband, 5 – sweatband, 6 – peak, 7 – chin strap

(b) Safety shoes

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

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

1) Based on the characteristics of the workplace
   (a) heavy items that can fall onto or injure the feet,

(b) type, concentration and physical properties of chemicals (acids, alkalis, solvents, etc.),
(c) ambient temperature and humidity.

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

Figure 8.2 Safety shoes

(c) Gloves

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

(a) The material being handled

(b) The risk of danger to the hands

(c) The type and period of contact

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

(e) The type of task

Figure 8.3 Safety gloves

(d) Reflective vests

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

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

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

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

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

Figure 8.4 Reflective vest

(e) Safety glasses

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

Figure 8.5 Safety glasses

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

Figure 8.6 Glasses with a direct and indirect ventilation system

(f) Ear protection devices

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

Figure 8.7 Ear protection devices

(g) Safety harness

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

Figure 8.8 Safety harness

Figure 8.9 Safety harness

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

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Worker's Safety Handbook for Rigger and Signalman

CHAPTER 9

GENERAL SAFETY AND RESPONSE TO ACCIDENTS AND EMERGENCIES

9.1 Identification and Assessment of Hazards at Construction Sites

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

Hazard identification, risk assessment and risk control

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

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

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

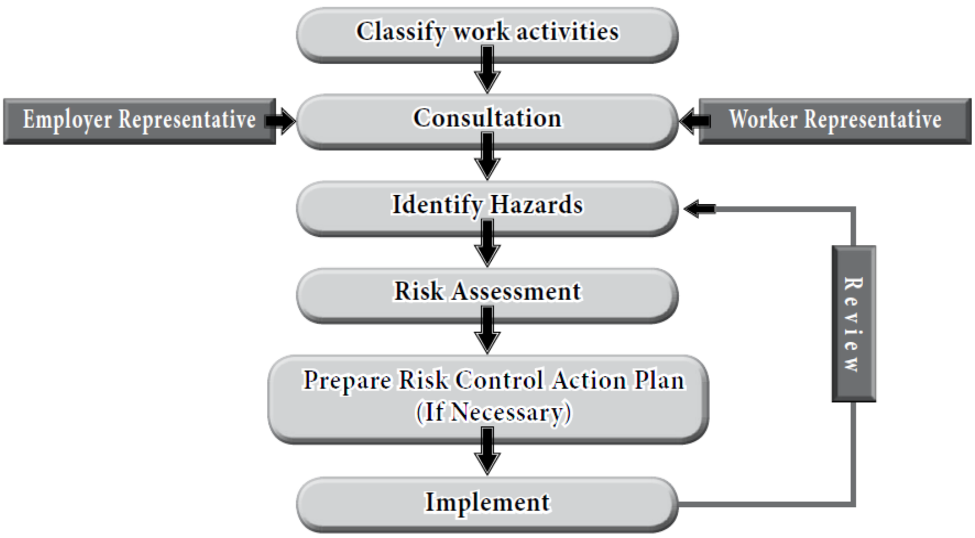


Figure 9.1 Flowchart for HIRARC process (Guidelines for Hazard Identification, Risk Assessment and Risk Control (HIRARC), 2008)

9.2 Main Hazards/Risks in the Construction Industry

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

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

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

(a) falls from a height (from floors without guardrails, platforms, scaffolding, roofs, etc.);
(b) trapped (in or between damaged machinery, building materials, etc.);
(c) confined (due to damaged shoring system, missing during excavation, etc.);
(d) electric shock (by touching a power line, power tool, etc.); and
(e) hit by an object (falling object, etc.).

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

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

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

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

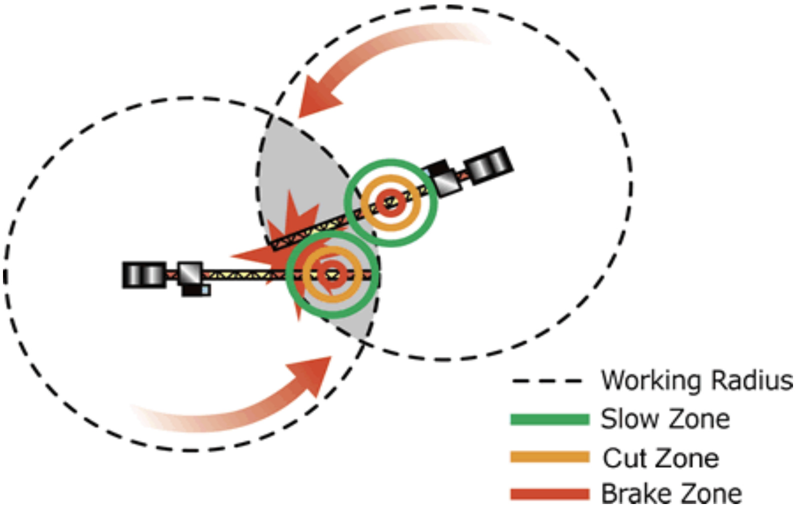
(i) give appropriate instructions to employees.

9.3 Examples of hazards at construction sites

Collisions between cranes, other objects and structures

The placement of the tower crane must take into account hazards (Figure 9.2) such as:

(a) overhead power lines
(b) adjacent structures
(c) other cranes or concrete placement booms (including those at adjacent sites)
(d) surrounding airfields and flight paths.
(e) concrete placement booms functioning within the operating radius of the tower crane.
(f) tower cranes located at adjacent sites that are operating in the same airspace.



(g) Figure 9.2 Collisions and operating radius of tower cranes (http://www.opticrane.com/tac-3000)

Collisions between cranes or with other structures/objects can cause injury to those who are within the vicinity of the crane due to:

(a) Falling loads,
(b) Collapse of the crane,
(c) Failure in a crane component, such as the boom section.

The risk of injury due to collisions between cranes and other structures is greater when the crane crew members are unable to communicate directly.

9.4 Ways to reduce the risk of injury due to collisions between cranes and other structures

- The relevant procedures with regard to the location/space where the tower crane might collide with other structures must be documented. For example, safe work method statements must be established in the early planning stage to ensure that there are proper controls at the site to reduce the risk of injury due to collisions.

- These procedures should identify the persons responsible for the implementation of the safe work method statements. All those involved in the operation of the tower crane and other structures must be trained in the procedures concerned.
- These procedures should handle the following issues:
  - The placement of the crane to give the crane/other machinery the space to operate within the operating radius of the crane.
  - The placement of the crane and other machinery with counterweights so that the counterweights do not collide during slewing operations.
  - The method of communication between the crane crew and other crane operators.
  - Work scheduling to reduce the time for which the crane and other machinery are required to operate in the same area or at the same height.
  - The procedure for climbing a tower crane to ensure it remains at an appropriate distance/height from any other structure or machinery.
  - The frequency of meetings to monitor and review the effectiveness of the control measures and who should attend such meetings.

b) Location of access/entry to area

When placing a tower crane, the following should be taken into consideration:

(a) the normal access to the worksite for workers and other persons.
(b) public access such as pedestrian walks, roads and paths between buildings around the crane.

c) Working close to overhead power lines

(a) Contact with an overhead power line while operating a machine may cause an electric shock (Figures 9.3 and 9.4). It can be very difficult for a crane operator to spot power lines and to estimate the distance from them.
(b) Before erecting a tower crane where there are overhead power lines, there must be consultations between the main contractor and the tower crane operator regarding the work and the related risks.
(c) When a crane and high-range machinery are to be used in an area where there are overhead power lines, the following steps should be taken:
   a) the operations must be properly planned by a competent person
   b) the work should be supervised accordingly by a competent person
   c) the work should be implemented in a safe manner.
(d) There are two options when working close to overhead power lines:
   a) cut the power supply to the power lines, or
   b) remain outside the exclusion zone

- If the power lines are to be switched off, discuss with the person who is controlling the lines as early as possible when planning a job. The process of shutting down the power supply may take some time and may depend on the situation, and this can lead to delays in the work.

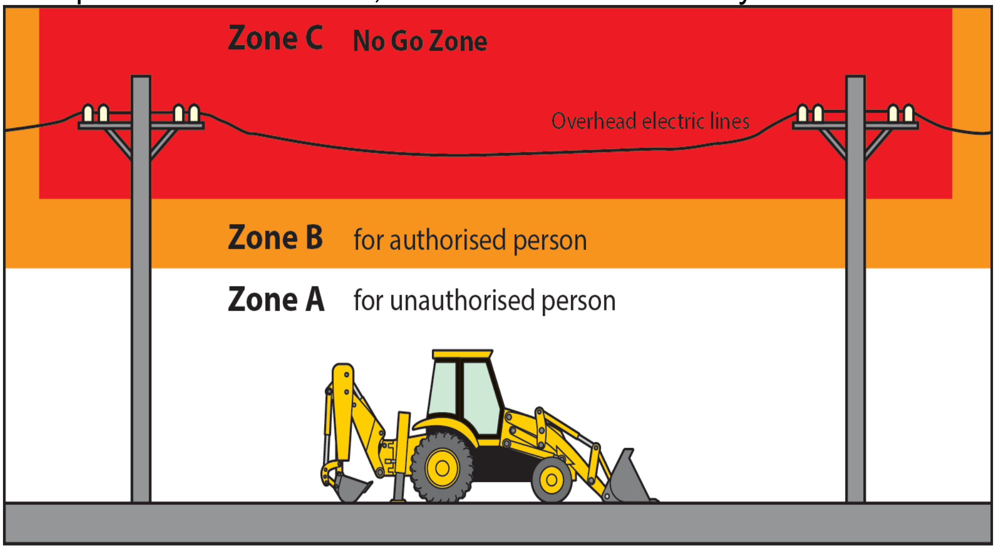


Figure 9.3 Zone for cranes and mobile machinery working close to overhead power lines (Work Near Overhead Power Lines, Code of Practice 2006, Australia)

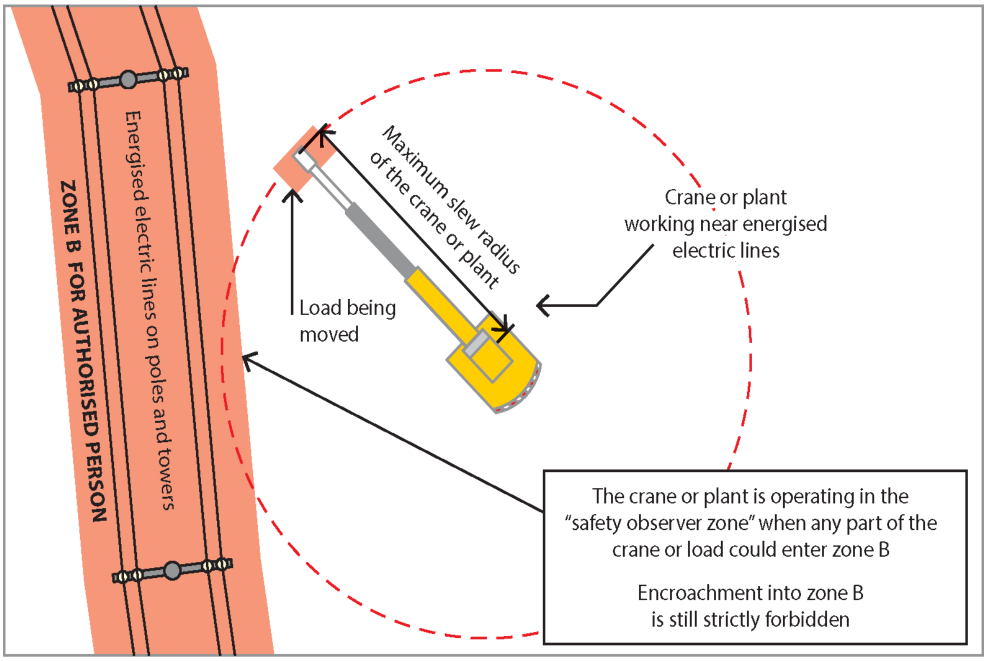


Figure 9.4 Safety observer zone for overhead power lines on pillars and towers (Work near Overhead Power Lines, Code of Practice 2006, Australia)

- If the crane or load touches an aerial conductor, inform the electrical supervisor immediately of the situation, and the competent person (Safety Officer) should remain in his position to warn of the danger of an electric shock (Figure 9.5).

Actions and measures that should be complied with and carried out by the crane operator:

a) Remain in the cabin of the crane until the power line is disconnected.
b) Warn others (signalman) to stay away from the crane and not to touch any part of the crane, rope or load.
c) Without anyone approaching the crane, handle the crane (boom) in any way to break contact.
d) When unable to move the crane or break contact with the aerial conductor, remain in the cabin or with the crane, and wait until the situation is confirmed to be safe.
e) If it is necessary to exit the cabin or crane due to a fire or for other reasons, to avoid electrocution, jump clear of the crane (except for a tower crane), and do not touch the crane and the ground at the same time.
f) When moving from the crane, walk slowly through the affected area to avoid coming into contact with other high-voltage capacity areas (see Figure 9.7). The actions recommended by the competent person should be completed/carried out before the crane is put into operation once again.

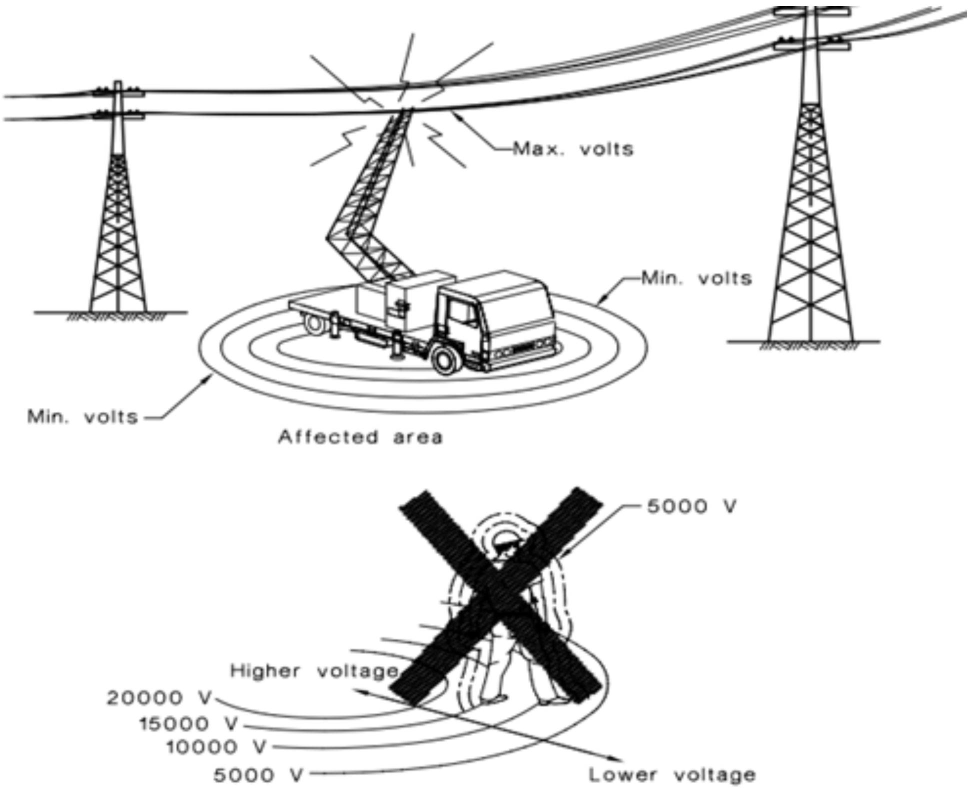


Figure 9.5 Affected area around the crane when in contact with an aerial conductor (AS 2550.1—2011 Australian Standard ® Cranes, hoists and winches-Safe Use Part 1: General requirements, 2011)

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

Table 9.1 Total voltage and safe distance from overhead power lines

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

9.5 Emergency procedure during contact with overhead power lines

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

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

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CHAPTER 10

PRACTICAL TRAINING

10.1 Demonstration of the Tower Crane Control

Cranes must be handled with trainers. The signalman must have a clear communication signal that will be used to the operator. The operator will see how the tower crane moves as taught. The signalman must give signal to the operator about the all appropriate movements formoving items from one location to another.

10.2 Communication Using Hand

The signalam must indicate the appropriate hand signal for the process of moving the load to the operator. The involved operator must handle the crane by relying entirely on the hand signal by signalman.

10.3 Communication Using Flag

In addition to hand gestures, practicality must also be made for flag signers using the flag. Only by using flag signals, signalman give directions to operators for every crane and loading of goods.

10.4 Communication Using Walkie-Talkie

For voice communication using walkie-talkies also monitored by the trainers. Some instructions by the signal interpreter should be provided to the operator using the prescribed standard language. If this communication is clear and capable of assisting each movement properly, the signal engineer may be deemed successful, and is entitled to be awarded a signal certificate.

CHAPTER 11

WRITTEN ASSESSMENT

11.1 Written training

Written training is a form of assessment to assess the level of understanding of candidates who take the course of signalman. Candidates will be assessed for understanding in signaling hands and flags (all should be compulsory) as well as general questions (50% correct enough to pass).

11.2 Communication Using Hand

Signalman must identify hand signal. Examples of questions are as follows:

a) What is this signal? :-

b) What is this signal? :-

11.3 Communication Using Flag

Signalman must identify flag signal. Examples of questions are as follows:

a) What is this signal? :-

b) What is this signal? :-

11.4 General Question for Signalman

General questions of the signalman authority, legal and personal protection tools can be addressed to candidates applying for a signalman certificate. For this question, the candidate must successfully answer 50% correct to be successful.