Guidelines for Creating Lifting Plan for Lifting Operations In Workplaces

WSHCOUNCIL

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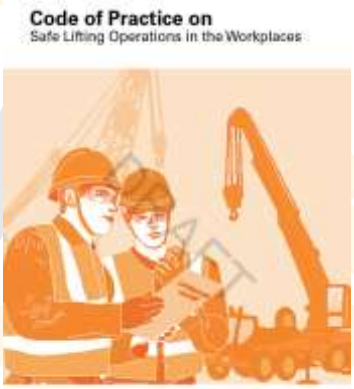
1. Introduction

WSH Council understands that the successful control of lifting operations and safe use of lift equipment requires a high level of management commitment, professional competence and adequate resources. Fundamental to the success of any Lifting Operation is the fact that it must be accepted by managers, those responsible for lifting operations and employees prior to the commencement. These stakeholders must do all that is reasonably practicable to achieve compliance with statutory duties arising from health and safety legislation, Council guidance and advice.

Lifting of objects generally takes place at construction sites, shipyards, factories and other industrial situations such as offloading with a forklift truck, containers at a warehouse or at a commercial area. Good practice and correct lifting methods can move large objects efficiently, safely and reduce manual handling operations. Incorrect lifting methods however, can lead to major accidents and fatalities. The process of carrying out correct and safe lifting operations involves a range of requirements which must be considered during the planning of any lifting operation.

This set of guidelines must be read in conjunction with the Code of Practice (CP) on Safe Lifting Operations in the Workplaces which act as an overarching document regarding lifting operations and the use of lifting equipment.



1.1 Scope

Besides reiterating the key responsibilities of those involved in a lifting operating, these set of guidelines offer further guidance for the organisation, assessment, planning, implementation, management of change and the development of safe systems of work for lifting operations. It is not a definitive document and does not describe in any detail the individual requirements of a particular lifting operation or piece of lifting equipment.

In order to assist stakeholders in the development of a comprehensive lifting plan, the guidelines should be used as a reference, to aide managers, competent personnel responsible for lifting operations, lifting equipment and employees to consider the safety factors when they assess, plan, supervise and carry out lifting activities. Managers who use or hire in lifting equipment must ensure their service specific procedures regarding lifting operations and lifting equipment links to and follows the requirements as outlined in these guidelines.

1.2 Target audience

The guidelines serve to assist key stakeholders, Responsible Persons, Appointed Persons, Competent Persons, Project Managers, Crane Supplier Management, Lifting Supervisors etc., in the process of planning lifting operations and help ensure the transfer of vital safety, health & environmental information required within the development of lift planning.

The provisions of these guidelines should be applied separately for all industry sectors that require a crane or lifting equipment to lift / hoist any objects, regardless of whether above or below ground level. Similarly, the provisions of these guidelines should be applied separately for each differing sites in a multi-site project.

1.3 Objective

Planning is an essential component in every lifting operation at all workplaces. In line with the Workplace Safety and Health Act (WSH Act), reducing risk at source is one of the components to improving workplace and worksite safety. To address risk at source, there is a need to look at whom and what creates the risks, every effort should then be made to eliminate or minimize such risks to the lowest possible levels.

While the WSH Act imposes a duty on the occupiers, employers and principals of a workplace, the risks inherent in the planning of all lifting activities are required to be addressed, with mitigating actions identified and implemented. Additionally, accidents are often as a result of either poor planning or lack of communication between or among stakeholders, this sometimes resulting in loss of vital information that is fundamental to the safety of the operation. The process to ensure transfer and communication of all relevant information and documents is therefore recorded in the Lifting Plan. Essentially, No Plan - No Lift!

Appendix 1 outlines various stakeholders' involvement in planning a safe lifting operation.

1.4 Site Survey

It is essential that a survey be conducted to establish what the load to be lifted is, what all the characteristics are, weight, size, type of lifting lugs etc., what the ground conditions are, where it has to be lifted from and to, what the access route is like, etc. The survey must be completed by a competent person(s).

1.5 Risk Assessment

The site survey is an ideal time to begin a risk assessment of the proposed lifting operations that will be carried out. The aim of the risk assessment is to prevent incidents and/or accidents that arise from hazards* during the lifting operations. With the identified hazards, the risks^ posed by these hazards can be reduced to as low as reasonably practical through the implementation of control measures, using the principle of the hierarchy of controls.

*hazards	A hazard is anything that with a potential to cause harm.
^risks	Risk is the likelihood that an accident can occur due to a hazard and as a result, how badly someone is hurt. This largely depends on the implementation of control measures, the working conditions of the control measures and site conditions. For example, a control measure that is higher up on the hierarchy of control (such as engineering controls) would result in a lower risk.

Other potential hazards that may present a risk to the lifting operation from other activities in

the vicinity should also be considered. This can be easily done during the site survey. Examples of other hazards and associated risks include, narrow access, excavations, pipe-racks, overhead structures, other plant operating in the vicinity of the lifting area etc.

A sample of a risk assessment for lifting operations can be found in **Appendix 2**.

It is essential that the information within the risk assessment is translated into implementation on-site. Checks should be done to ensure that control measures are in place and in good working condition.

As site conditions may change, the following table may be used to check that control measures indicated in the risk assessments are put in place and that they remain applicable to the actual site conditions.

Step No.	Task	Control Measures	Suitable and Implemented?
			(to ✓ if it is a yes answer

2. Classifications of Lifts Types

There are generally two types of lift, Routine and Non-Routine. Categorising the type of lifts before planning the lift and documenting in a lifting plan is critical because it allows for the proper assessment of the amount of risk present in the lifting operation and the level of control required in mitigating the risks involved.

2.1 Routine Lifts

Routine lifting operations may be executed under a basic lift plan. These plans must clearly define the limitations on the loads, lifting methods and areas of operation. A Risk Assessment will be required in each case, and authorized prior to commencement. A Non-Routine may also be completed using similar documents but will require greater detail. Prior to any lifting operation commencing, a review of the lift plan must be conducted.

	
Example: Routine Lifts - Bundle of rebars / I-Beam	Example: Routine Lifts – Receptacle

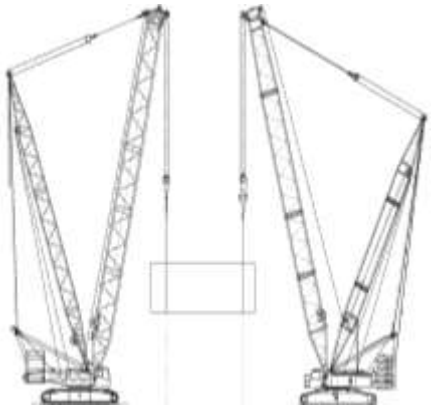
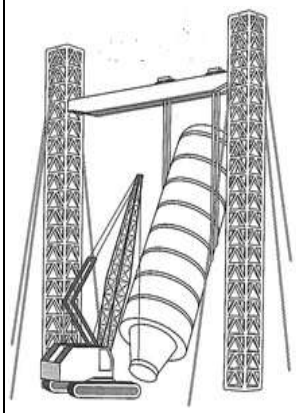
A Routine Lift is a lift which conforms to the following factors:

- Within the normal operating parameters of the crane
- Lifting over non-sensitive areas
- Suitable environmental conditions
- Load has known and evaluated weight, shape and centre of gravity
- Standard rigging arrangements
- Routine repetitive lifting operations using the same equipment
- Load has pre-determined weight, shape and centre of gravity
- Single function or series of functions repeated manually or automatically
- Order of function repeated
- Same equipment
- Same competent Crane Operators
- Load under 75% of rated load of the load chart
- Equipment specifically installed by a competent operator/ installer
- Load has known and evaluated weight
- Centre of gravity below the lifting hook
- Use of a certified lifting point
- Ample headroom
- Not within sensitive, difficult or restricted areas
- Single lifting machine
- Unlikely to be affected by changing environmental conditions
- Standard rigging arrangements
- Suitable lay-down area available

Note: Routine lifting operations require the above factors to be considered but this list is not exhaustive. The risk of each individual lift should be separately considered prior to classifying the lifting operation as a routine one.

2.2 Non-Routine Lifts

Non- Routine lifting operations will require a more detailed Lifting Plan containing all of the elements as described within these guidelines. The plan will have to be approved by a Responsible Person prior to commencement of any Lifting Operation and any deviation requirement identified from the plan, must also get the approval of the Responsible Person prior to commencement of the lifting operation.

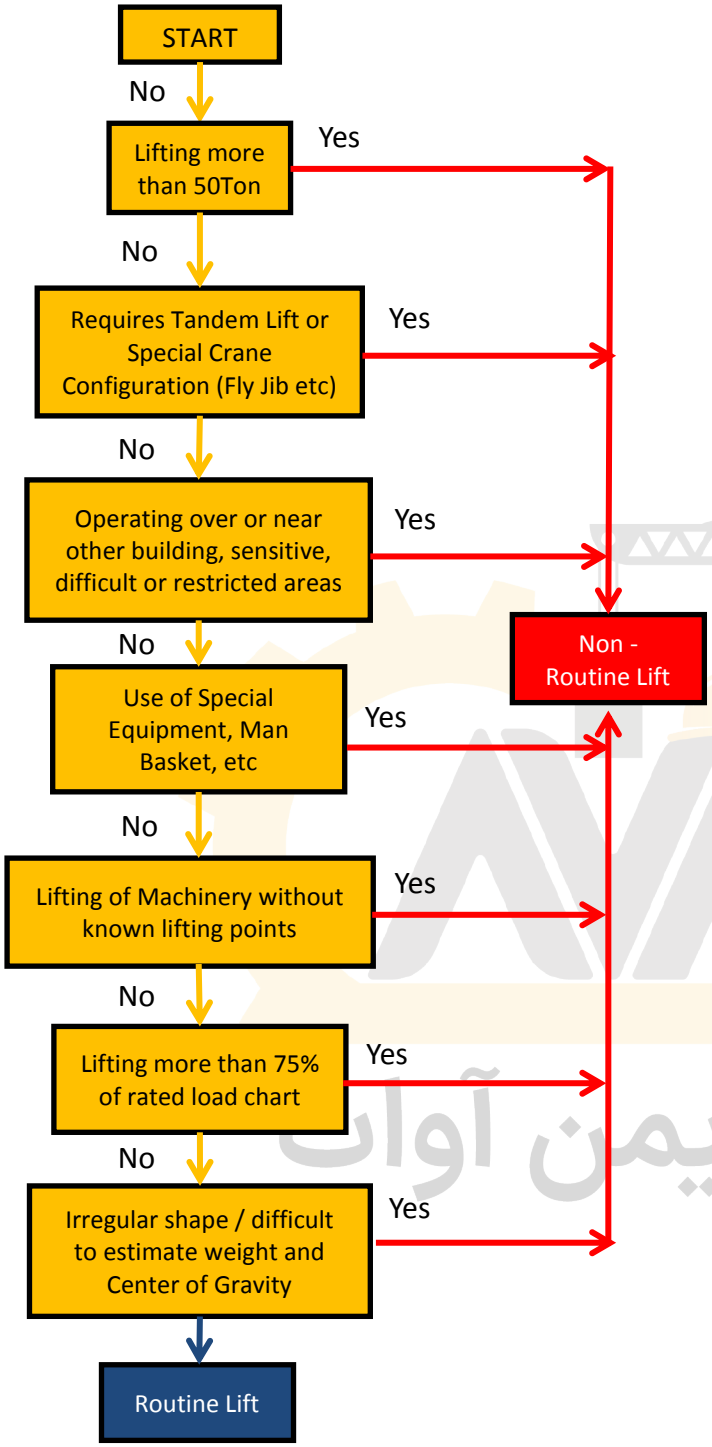
		
Example: Non-Routine Lifts - Heavy Lift	Example: Non-Routine Lift Tandem Lift	Example: Non-Routine Lift - Complex Lift

A Non-Routine Lift is a lift which conforms to the following factors:

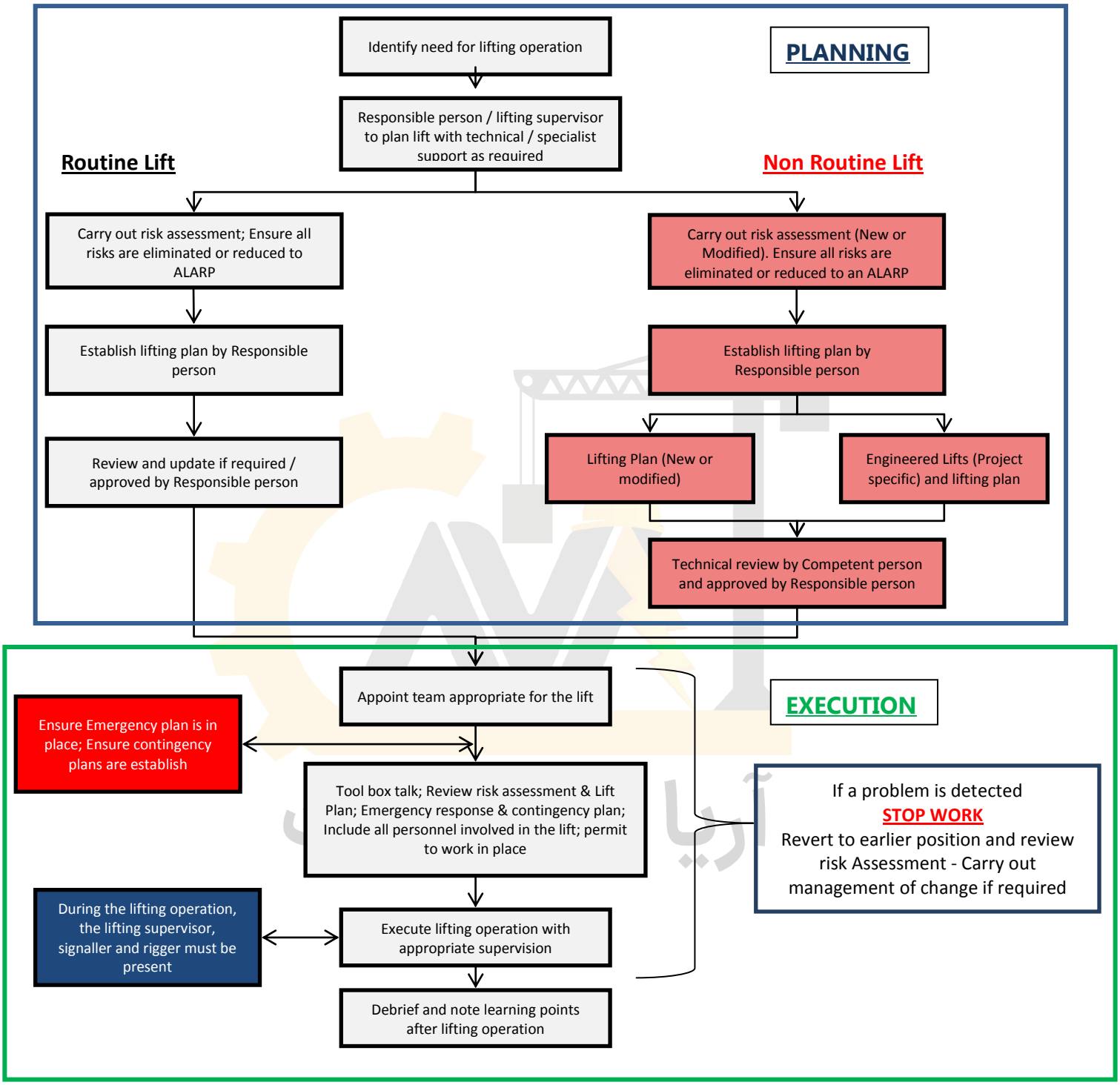
- Use of two or more Lifting Appliances, including tallying pipe using winch and crane (tandem lift)
- With sensitive, difficult or restricted areas
- Lifts from one offshore vessel to another
- Continuation of a lifting operation with different people
- Lifting of machinery without lifting points
- In environmental conditions likely to affect equipment performance
- Load with unknown / difficult to estimate weight and/or centre of gravity
- Non-standard rigging arrangements
- Load lowered into or lifted from a confined space
- Weight of load in excess of 75% rated load of the load chart

Note: Non-Routine lifting operations require the above factors to be considered but this list is not exhaustive

2.3 Flow Chart for Identification of Routine or Non-Routine Lifting Activities



2.4 Planning and Execution of Routine and Non-Routine Lifts



3. Roles & Responsibilities

3.1 Directors, Operation Managers, and Project Managers

These appointment holders must be aware of this guidance and understand their responsibilities with regard to lifting operations, lifting equipment and the links to the relevant health and safety legislation around lifting operations, ensuring that all lifting equipment used for lifting operations is appropriate for the task, used correctly and that employees involved in the organising, planning and use of lifting equipment are suitably trained.

In addition, Operation Managers must ensure in all cases where lifting equipment is being used, that:

- All risks arising from operations involving lifting equipment are suitably and sufficiently assessed by a competent person and appropriate control measures implemented.
- All lifting operations are suitably planned, supervised and carried out in a safe manner.
- Planning of a single lift or series of lifts must address the risks identified by the risk assessment and that appropriate control measures have been implemented (safe systems of work, lifting plans etc.)
- All relevant information, training and instruction are given to users of lifting equipment and they are competent to carry out those tasks.
- All persons using lifting equipment must work within the agreed safe working practices, reference information, instruction and training given.
- Systems exist for the reporting of and removing from use lifting equipment that has developed a fault or defect.

3.2 Competent Person(s)

Persons who have been appointed or been given the responsibility for planning lifting operations should have sufficient technical, practical and theoretical training, knowledge and experience of the work they are likely to safely plan /assess the lift.

They shall:

- Be capable of identifying the hazards and risks associated to lifting operations within their area of work or the environment where the lifting operation will take place.
- Be able to select the correct lifting equipment for the work. Understand the characteristics of the lifting equipment they are selecting and the nature of the work it will be carrying out.
- Carry out and document risk assessments (lifting operation) or site surveys; have the ability to communicate their findings to those involved in and affected by the lifting operations.
- Be able to create method statements or lifting plans and implement safe systems of work for lifting operations.
- Where appropriate seek additional support and expertise including the use of external specialists to assist them with the planning of lifting operations.

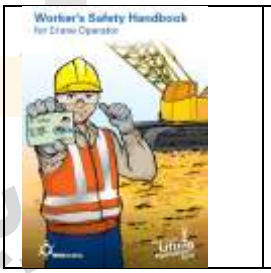
3.3 Supervisors

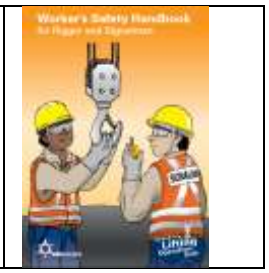
The appropriate supervision of lifting operations should be proportionate to the level of risk and take into account those involved in a particular lifting operation. Levels of supervision will be determined by the nature or complexity of the work and the competence of those involved in using lifting equipment and assisting with the lifting operation.

Persons who have been authorised to supervise lifting operations shall:

- Have sufficient technical, practical and theoretical training, knowledge and experience of the work being carried out.
- Be briefed and instructed on the outcomes of the risk assessment and fully understand the requirements of the safe system of work or lifting plan for the lifting operation to be carried out and an understanding of all those involved in the task.
- Supervise all complex or unusual lifting operations.
- Monitor a sufficient number of lifting operations to ensure correct working practices are being followed.
- Where appropriate direct lifting operations, offering clear instructions to those involved.
- Be able to assess changes in circumstances e.g. ground conditions, and where appropriate stop a lifting operation if the risk is unacceptable or if it is considered unsafe to carry on. Referring the concerns to their manager, competent person or person responsible for planning lifting operations.

3.4 Operators /Riggers /Signalmen





They shall:

- Not attempt any lifting operation or use lifting equipment, without prior training/assessment, guidance and appropriate supervision or which is beyond the level of their competency.
- Ensure that both routine and complex lifting operations are not undertaken without a suitable and sufficient risk assessment being carried out by a competent person.
- Ensure they fully understand the lifting equipment, be familiar with how it operates and the proposed lifting operation(s) they have been authorised to do and that safe systems of work, training, guidance and advice are followed at all times.
- Carry out pre-use checks of lifting equipment prior to use, to ensure there are no obvious visual defects.
- Remove faulty or defective equipment from use, clearly record fault or defect on the appropriate documents and report the issue to their manager or person in charge as soon as is reasonably practicable. This includes reporting concerns they may have regarding a lift operation to their supervisor or manager in the first instance and not continuing with the operation.
- Have an understanding of the emergency procedures relating to lifting equipment in use and take part in training and periodic drills, where appropriate.

4. Description of Load(s) to be Lifted

Sufficient information must be provided to give a clear, but brief, description that will clearly identify the lift(s) to be undertaken. A separate risk assessment form will need to be completed for every time the crane is moved to a new position, unless the risk assessment has taken into account the hazards associated with all positions.

4.1 Details of Load(s) to be Lifted

It is extremely important that as many details as possible are gathered about the load/loads to be lifted. The customer or client requiring the lift must provide the Competent Person with full details of all loads to be lifted. Details of each load to be lifted must be entered on the risk assessment form. The Competent Person must carefully consider all the loads to be lifted and ensure that sufficient information is provided and recorded to enable other persons to see how the lifts are to be performed in a safe manner.

4.2 Load Crucial Information.

No load must be lifted without the following crucial information:

- the load weight
- the overall dimensions (length, width and depth).
- indication of the position of centre of gravity.
- the lifting/slinging points
- the pickup radius
- the final location radius
- the height to which the load has to be lifted.
- the overall weight (load + all lifting accessories)

A.	**Lifting Machine:**	AC-100 (100 TON)
	Counter Weight:	25 Ton
B.	**Lifting Gear :**	1) 4 x 5ton x 8M m WEBBING Sling
		2) 4 x 8.5 ton Shackle

C. **Crane Details:**

Crane	**AC-100 (100 TON)**	
Configuration	Main Boom	
Boom Length	33.7	M
Working Radius:	14	M
Corresponding SWL:	18000	KG

D. **Load Details**

Description	Electical Equipment, Transformer with estimated load of 8500kg
Lifting Points	Transformer have 4 lifting points, using 4 Wire sling and webbing sling connected to hook block
Dimension	L 5.25m x W 3.5m x H2.38m
Center of Gravity	■ Given ■ Calculated ☐ Unknown

E. **Load Calculation:**

OLD Transformer Weight:	8500.00	KG
25% add on	3400.00	KG
Lifting Gear Weight :	100.00	KG
Hook Blocks Weight :	700.00	KG
Total Weight :	12700.0	KG
Safety Factor :		1.42
Crane Capacity Usage (Load/SWL):		70.56%

F. **Routine Lift** ☑ **Non Routine Lift** ☐

Example of description of loads for a Routine Lift

D. **Load Details**

Description	Silo tank at horizontal level to be lifted to Vertical level using two cranes (Tandem lift)
Lifting Points	Transformer have 4 lifting points, using 4 Wire sling and webbing sling connected to hook block
Dimension	L 7.5m x W 2.5 m x H 3.35m
Center of Gravity	☐ Given ■ Calculated ☐ Unknown

Example of description of loads for a Non-Routine Lift

4.3 Load(s) Weight(s) Including Lifting Gear

The most important thing that you require to know is the weight of the load. This information should be given at the earliest point in the planning stage, it is from this information that your crane selection will be made and all the planning around it. The weight of the load must be accurate.

It is also important that the load dimensions are recorded, this will also help in the planning of the lift, particularly to establish boom clearance, calculate required clearances when in restricted and confined areas, it also allows calculation to be completed on wind sail area giving a maximum wind speed that crane can operate in.

The weight of the load must include every piece of lifting gear involved in the lift from the hook block downwards, ropes, beams, shackles, frames, slings etc.

A crane is not designed to be nor is it a weighing machine; weights must be known by other means. However, every load lifted should in the first instance be lifted slowly from the ground, should it start to exceed the given weight it must be placed back on the ground and the Responsible Person / Competent Person must then take whatever actions are required to re-plan the lifting operation.

4.4 Centre of Gravity (CG) of the load

To ensure that every lifting operation is under control and free of unplanned movement, the CG must be known. In simple lifting terms with balanced loads the CG is generally in the middle, this point will always be directly below the centre line of the crane hook block when slung.

5. Crane Selection

Using the previously gathered information in conjunction with crane manufactures duty charts it will allow the selection of a crane that is suitable with sufficient capacity to safely execute the lifting operation.

5.1 Details of the Crane

Details of the preferred crane(s) to be used must be recorded within the Method Statement and must include:

- the make and model;
- capacity
- jib length (plus fly/luffer jib with offset where required);
- outrigger spread;
- outrigger load;
- maximum ground bearing capacity
- counterweight/super-lift counterweight required;
- weight of the crane.

C. **Crane Details:**

Crane	**AC-100 (100TON)**	
Configuration	Main Boom	
Boom Length	33.7	M
Working Radius:	14	M
Corresponding SWL:	18000	KG

Example of Simple description of Lifting Equipment

25 t | 7,10 m x 7,00 m | 360° | AC-100 | ISO

m	m	12,5 t	16,8 t	21,0 t	25,2 t	29,5 t	33,7 t	38,0 t	42,2 t	46,4 t	50,2 t	m
		100,0*	-	-	-	-	-	-	-	-	-	
3		85,5	-	-	-	-	-	-	-	-	-	3
4		73,7	70,8	68,3	53,0	-	-	-	-	-	-	4
5		64,2	62,2	59,8	47,9	41,7	-	-	-	-	-	5
6		56,2	55,3	53,1	43,5	39,5	33,9	-	-	-	-	6
7		49,0	49,1	47,8	39,7	36,6	30,9	27,5	-	-	-	7
8		42,0	42,1	41,6	36,5	34,1	28,4	25,5	21,0	-	-	8
9		36,5	36,6	35,9	33,7	31,9	26,2	23,6	20,5	15,4	13,0	9
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24		-	-	-	-	8,5	8,6	8,7	8,4	8,0	8,1	24
26		-	-	-	-	7,5	7,6	7,7	7,5	7,4	7,1	26
28		-	-	-	-	-	6,7	6,8	6,8	6,5	6,2	28
30		-	-	-	-	-	6,0	6,1	6,1	5,8	5,4	30
32		-	-	-	-	-	-	5,4	5,4	5,1	4,7	32
34		-	-	-	-	-	-	4,8	4,8	4,5	4,1	34
36		-	-	-	-	-	-	-	4,3	4,0	3,6	36
38		-	-	-	-	-	-	-	3,5	3,5	3,1	38
40		-	-	-	-	-	-	-	-	3,1	2,7	40
42		-	-	-	-	-	-	-	-	2,3	2,3	42
44		-	-	-	-	-	-	-	-	-	2,0	44

Example of load chart identification for SWL

A.	**Lifting Machine:**	AC-100 (100 TON)
	Counter Weight:	25 Ton
B.	**Lifting Gear :**	1) 4 x 5ton x 8M m WEBBING Sling
		2) 4 x 8.5 ton Shackle

C. **Crane Details:**

Crane	**AC-100 (100 TON)**	
Configuration	Main Boom	
Boom Length	33.7	M
Working Radius:	14	M
Corresponding SWL:	18000	KG

D. **Load Details**

Description	Electical Equipment, Transformer with estimated load of 8500kg
Lifting Points	Transformer have 4 lifting points, using 4 Wire sling and webbing sling connected to hook block
Dimension	L 5.25m x W 3.5m x H2.38m
Center of Gravity	■ Given ■ Calculated ☐ Unknown

E. **Load Calculation:**

OLD Transformer Weight:	8500.00	KG
25% add on	3400.00	KG
Lifting Gear Weight :	100.00	KG
Hook Blocks Weight :	700.00	KG
Total Weight :	12700.0	KG
Safety Factor :		1.42
Crane Capacity Usage (Load/SWL):		70.56%

F. **Routine Lift** ☑ **Non Routine Lift** ☐

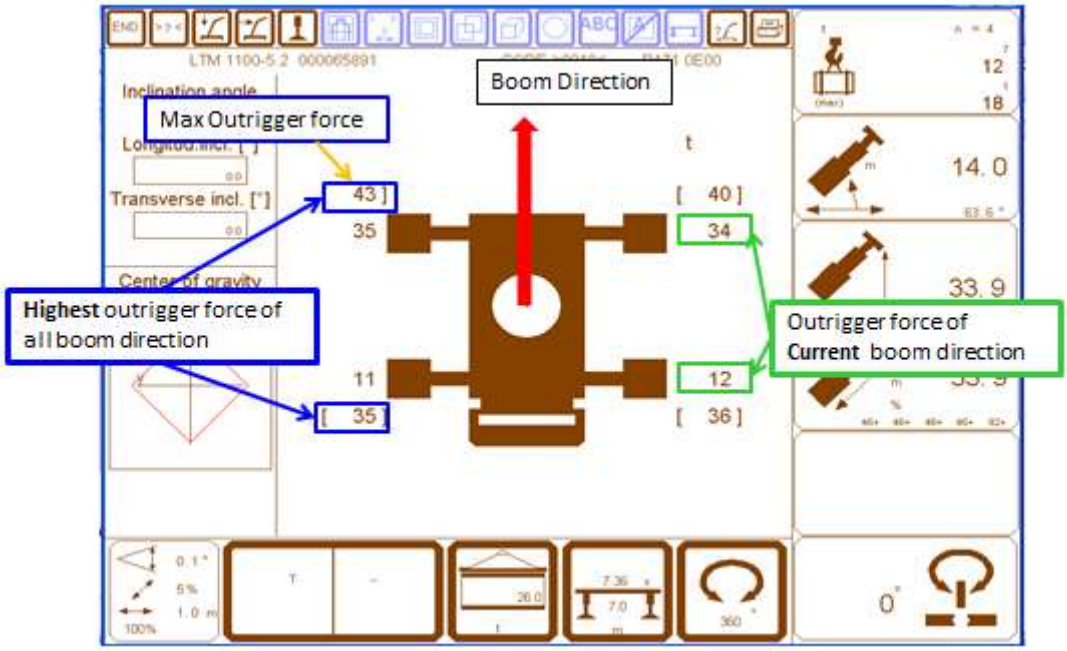
Note: *For lifting old machinery or equipment as load, to add 25% buffer due to unknown substances resided in the machinery or equipment (such as Oil, residue etc) to be lifted

Example of description of Lifting Equipment and Load Calculations

5.2 Bearing Capacity

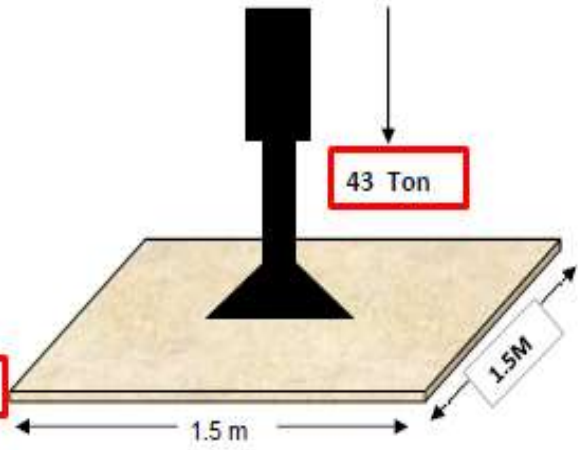
This must be the permissible load bearing capability of the ground at every position where the crane is to be stood, as provided by an appropriate authority with knowledge of the site. The Competent Person will need to determine the area of the outrigger supports/crawler tracks/wheels etc. required to ensure that the maximum given ground pressure is not exceeded. Details of the required supports must be recorded in the Method Statement.

Where the crane is supported by its outriggers during a lifting operation the maximum outrigger load for the specific configuration, whilst lifting the load, will also need to be entered within the Method Statement. These loadings can be obtained from the manufacturer's outrigger load tables.



Example of Identifying highest outrigger force with Load

Crane Model	=	AC-100(100TON)
Counter Weight	=	25 TON
Length of Main Boom	=	33.7 M
Working Radius	=	14 m
Corresponding Safe Working Load	=	18 TON
Total Lifting Load With Gears	=	12.7 ton
Max Outrigger Pressure	=	43 Ton
Effective Area	=	1.5M x 1.5 M
	=	2.25Sq M
Weight of Outrigger Plates	=	1 TON
Total Weight	=	43TON + 1TON
Total Pressure Load	=	44 TON
Required Ground Bearing Capacity	=	44 ton / 2.25 sqm
	=	19.56 Ton / sqm
Max Allowable soil bearing	=	70 Ton / Sqm



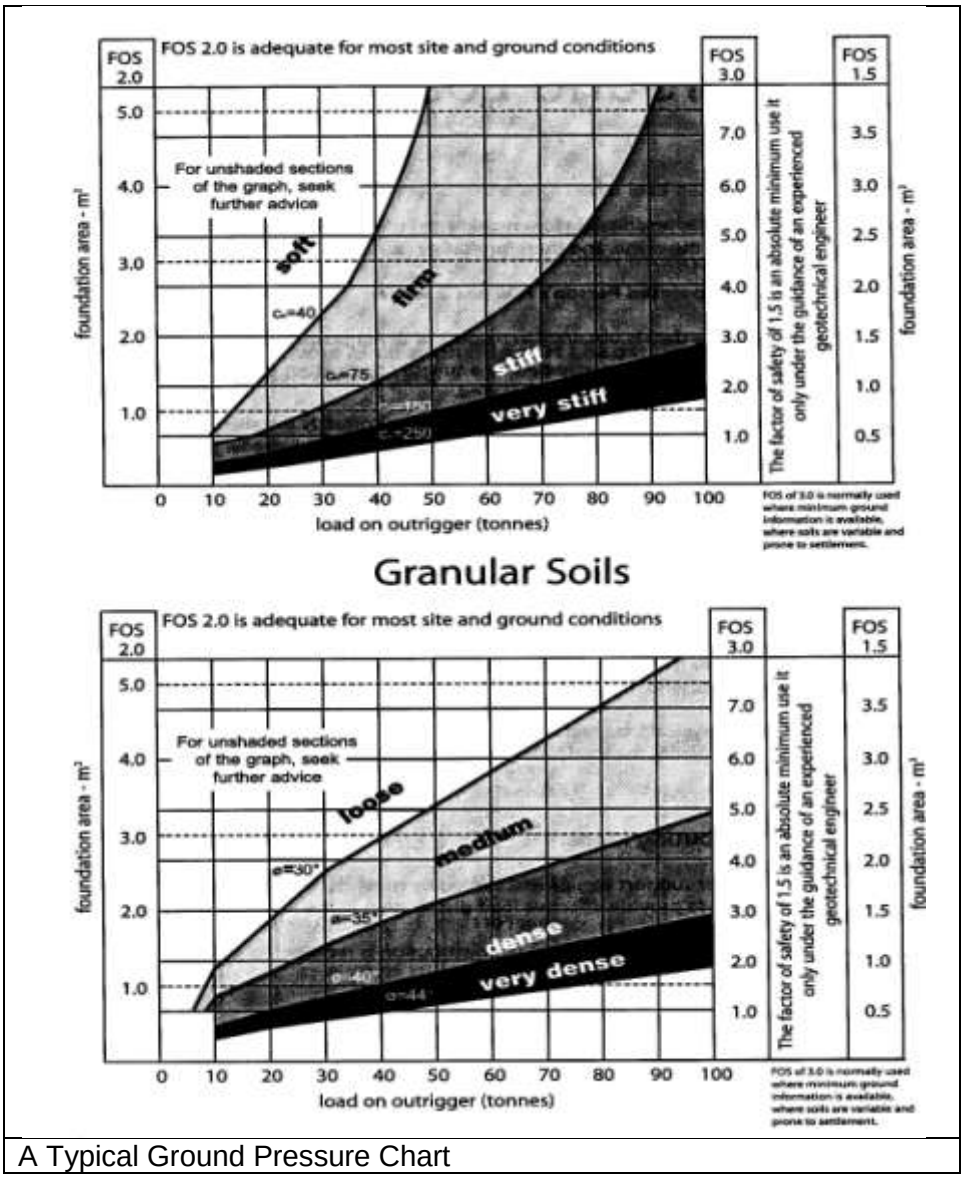
Example of Calculation for Ground Bearing Capacity

5.3 Used Crane Capacity

After crane selection has been made it is important that it is known how much spare capacity there is left within the crane duty chart, this should be recorded within the plan. This is also at times referred to as the “Safety Margin”. It should be remembered that many user, depending on who they might be, will only use 75, 80 or maybe 90% of a rated duty chart. It may well be necessary to select a larger capacity crane.

6. Ground and Surrounding Conditions.

The responsibility for ensuring that the ground beneath the crane can withstand the loads imposed by the crane during lifting should always rest with the user. However the customer may well not have sufficient expertise to carry out an assessment of the ground, therefore the Competent Person should ensure that the customer has consulted an appropriate specialist such as specialist professional engineer in geotechnical engineering (P.E, Geotechnical) to ensure that the ground will sustain the loads imposed by the crane. A typical ground pressure chart in given below.



A Typical Ground Pressure Chart

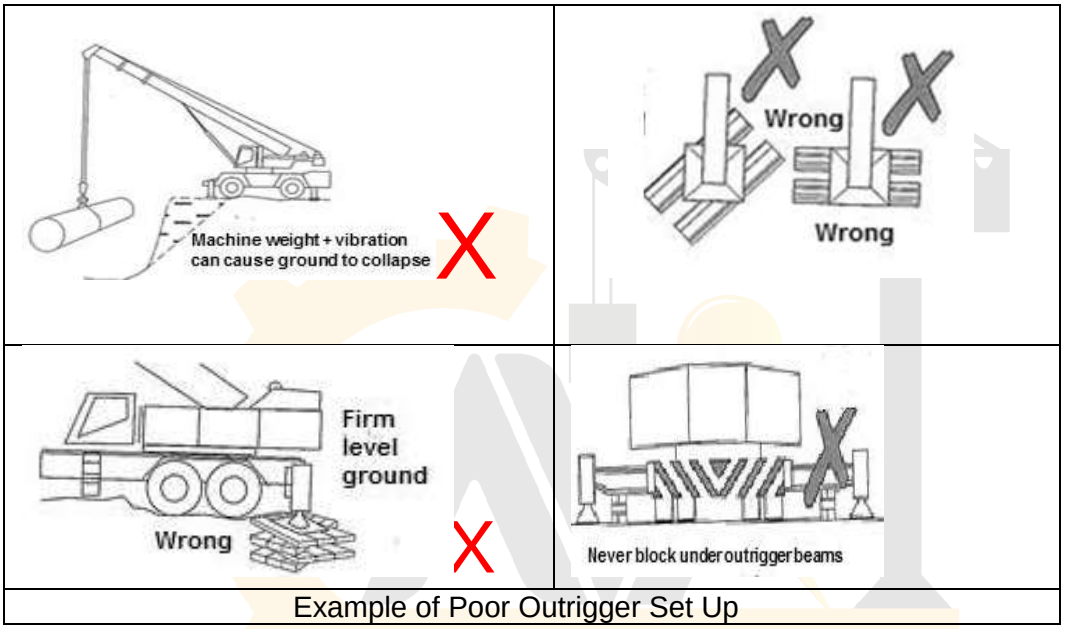
Where the Competent Person has any concerns or doubts about ground conditions it should be noted by the Responsible Person and no lifting should commence until all issues have been satisfactorily resolved.

All Crane Hire/Contracting organizations such as occupiers of work sites or factories must provide their user with the worst case scenarios of pressures that can be applied during a lifting operation with a specific crane type lifting a known load weight.

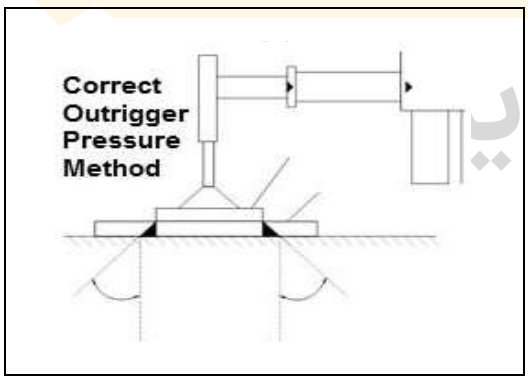
6.1 Ground & Outriggers

When lifting on outriggers the outrigger beams and jacks must be extended in accordance with the manufacturer's instructions for the crane. The Competent Person must ensure that there is sufficient space at the crane siting location for this to be achieved. The crane rated capacity indicator must be set in accordance with the manufacturer's operating instructions.

It is important to realise that ground that has been backfilled without any means of compaction will present a danger and must not be used to support a crane. Sufficient load spreading materials, of adequate size and strength, must be used under each outrigger. Ensure that the crane lifting area has been checked for voids and underground services.



Example of Poor Outrigger Set Up



All normal routine & non-routine lifting operations with hydraulic mobile cranes must have outriggers fully blocked out using appropriate load bearing mats.

Crawler Cranes are designed to walk but careful and particular attention must be given to the ground conditions. At the time of the survey ground conditions should be established. In many cases it will be necessary to lay down large wooden or steel mats for the crawlers to move around a site. During heavy lifting it will always be necessary for the use of large load spreading mats as shown.

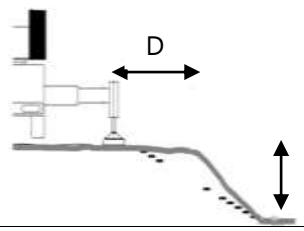
Load Bearing Mat

6.2 Access & Lifting Location

The Competent Person during his survey should take particular note and record the site ground surface conditions on at least 2 occasions, the first relates to access for the crane and transport vehicles (boom/ballast/counterweight carriers) to the site location and the second being the actual location where the crane will be located when lifting the load/s. It is important to discuss with the user the route to be used, as it is their responsibility to ensure that the ground can support the loads that will be applied. The Competent Person must be satisfied with the space provided and the access route to be used, also the nature of the surface (e.g. blacktop, hard-core, concrete). For clarity, the route can be shown on the site plan.

6.3 Excavations

Excavations can be a real hazard to lifting operations. During any survey all excavations in close vicinity to a where a lifting operation will take place must be noted. Also on the day of a lifting operation the area should be re-checked, many times on construction sites excavations get dug without any communication to the lifting team.



Relationship of Safe distance D with Excavation Depth H

a) Where the ground is compact and non-crumbling, the distance of any part of the crane support timbers from the excavation should be at least equal to the depth of the excavation.

b) Where the ground is loose or crumbling, the distance of any part of the crane support timbers from the excavation should be at least twice the depth of the excavation.

Note: Figures 4,5 & 6 of SS536:2008 provides further guidance on Safe distance D from a slope with depth H for various situations

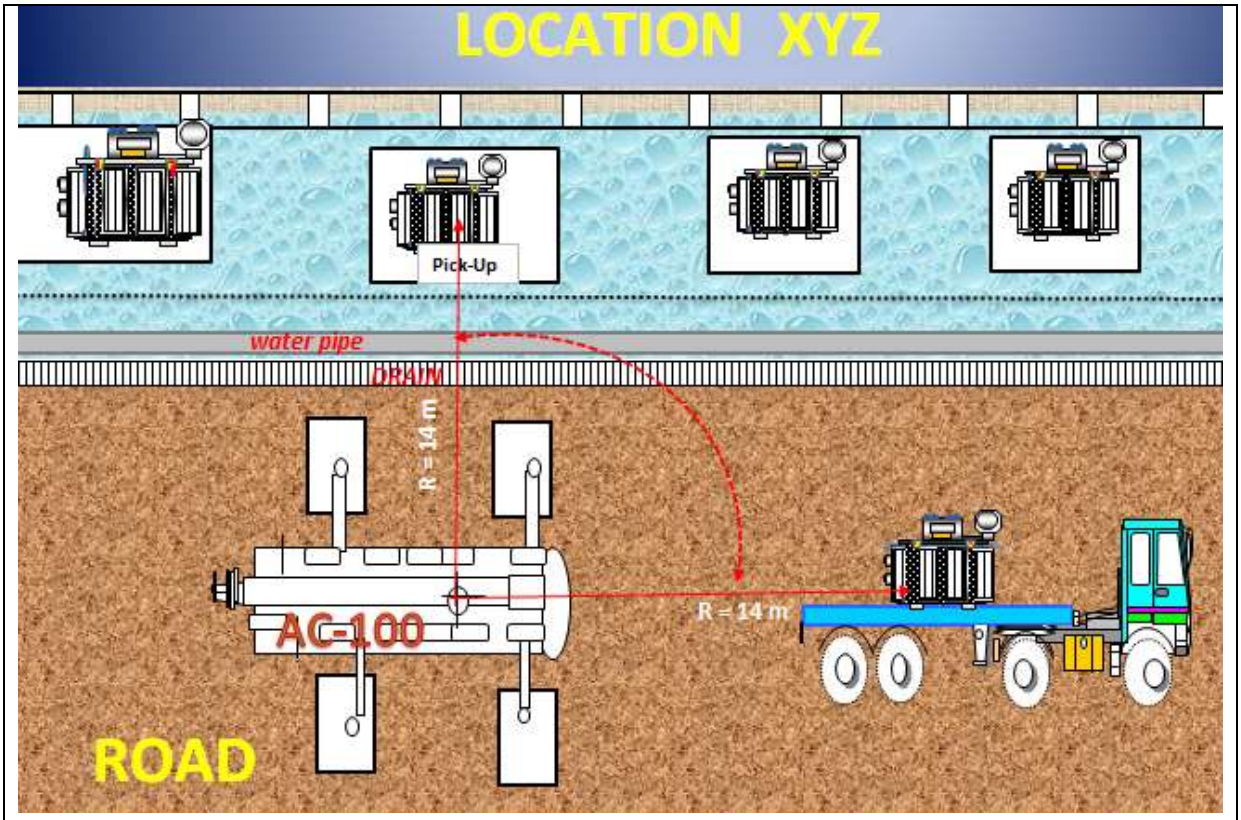
6.4 Overhead Structure

Many serious injuries and fatalities within the Lifting Industry are as a result of crane booms and hoisting ropes coming in contact with overhead structure such as MRT Tracks, building, trees etc. All overhead structures must be noted during the initial survey and provisions made to avoid them during the lifting operation.

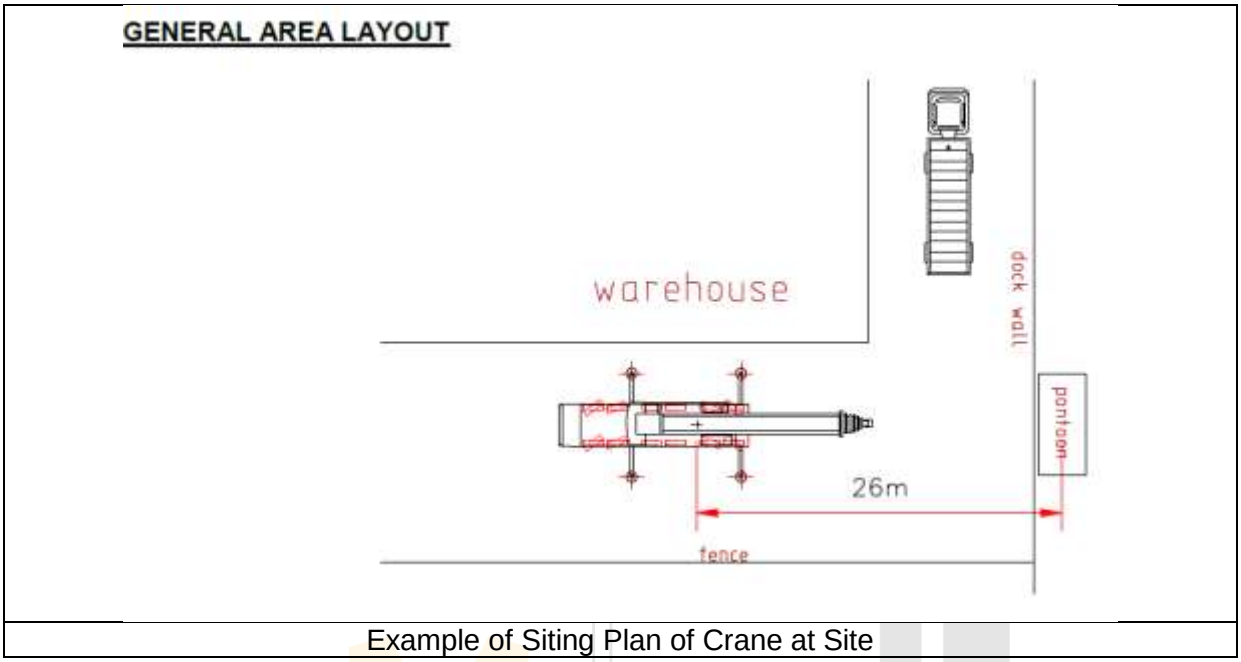
7. Crane(s) Sitting & Lifting Study

All crane/lifting operations must have some form of documents, from the simple lifting operations where all analysis and information may be recorded on a Lifting plan in conjunction with a Permit to Work, all the way up to the very complex lifting operation which will require a very detailed and comprehensive Lifting Study.

The sitting plan can be in the form of a hand drawn sketch for the simple operations, with a detailed engineered drawing for the more difficult and complex operations. In each case the idea of having a sitting plan is to ensure that the crane or lifting machine is positioned on the correct location to safely complete the intended operation. Margins as low as 1m can be the difference between success and failure, it is recommended that a water based spray paint is used to mark out where the crane will be sited for all complex lifting situations. Examples are given below:



Example of Sitting Plan of Crane at Site



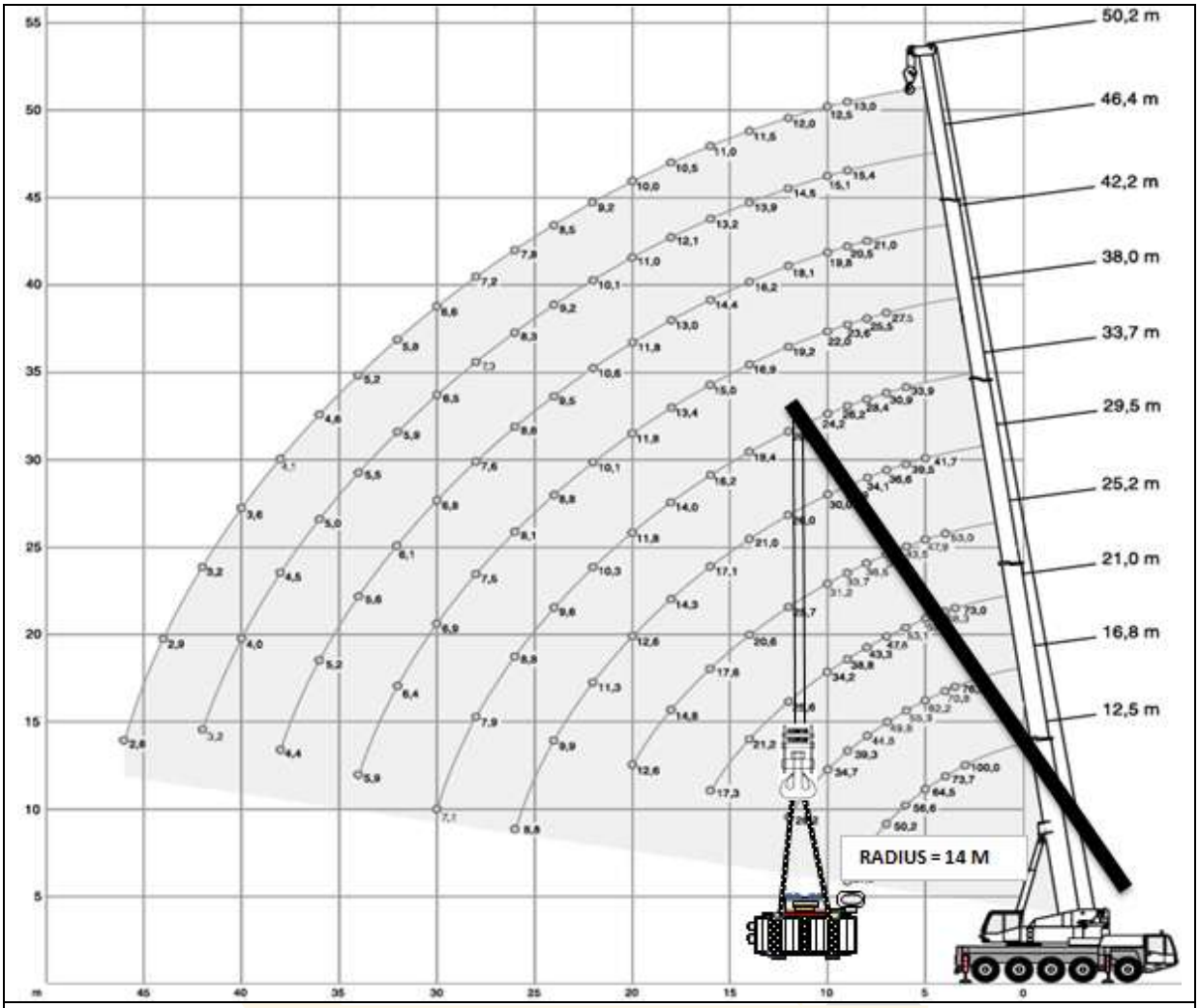
Example of Siting Plan of Crane at Site

7.1 Boom Clearance

It is always necessary to know that there is sufficient boom clearance during any lifting operation, particularly when working in restricted and confined areas. This should be determined during the planning stage and recorded within the lifting plan. Equally the tail swing should be determined.

7.2 Boom Height & Angle

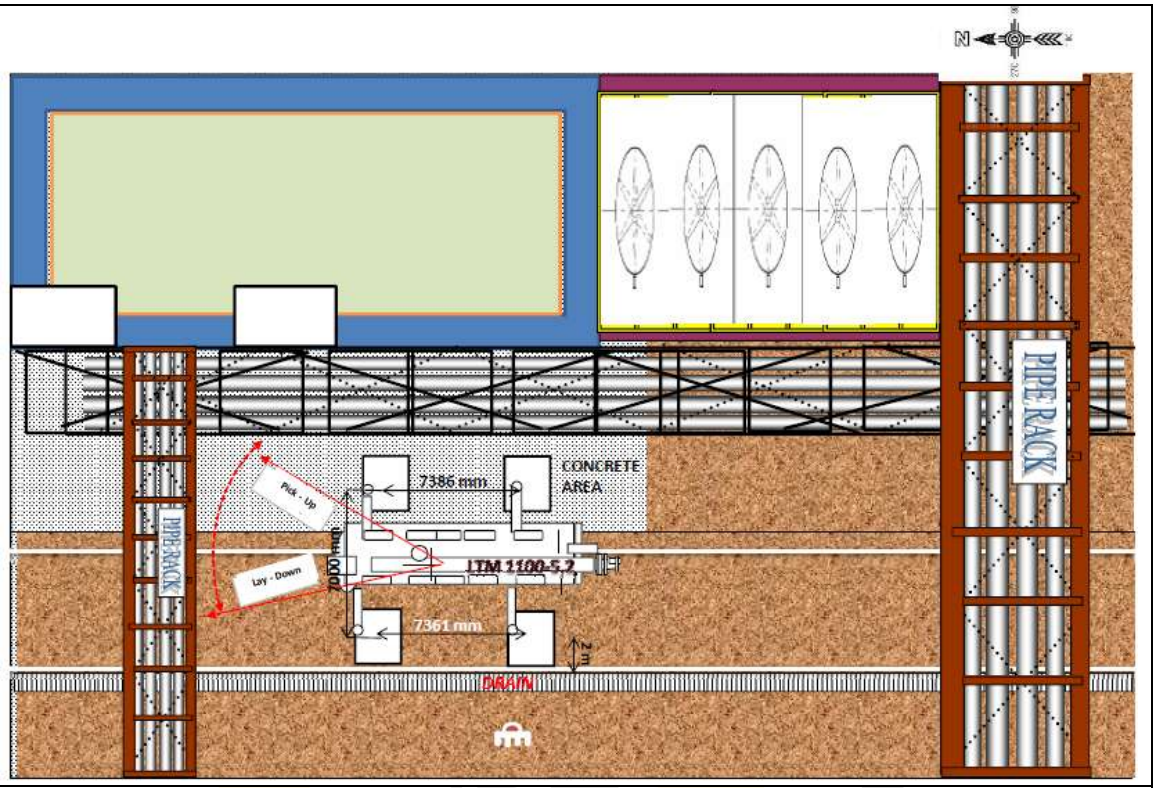
Boom angle and height are pieces of important information that must be recorded within the Lifting Plan. Not only do they help in the correct selection of a suitable crane, they also allow calculation of clearances of buildings and other possible obstructions.



Example of boom height and angle of load chart

7.3 Pick Up & Place Down Radius

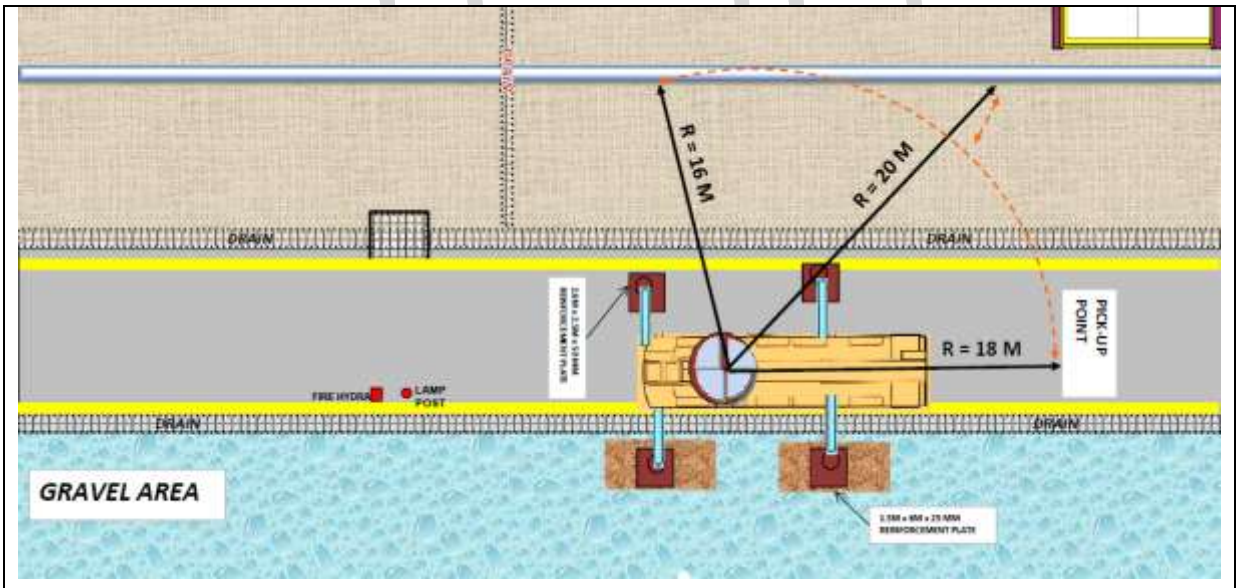
Radius, like all other pieces of information is extremely important and fundamental to safe lifting practices. When measuring radius, which again is part of requirements in the selection of a suitable crane type, ensure that both the “Pick Up and Lay Down” measurements are taken and recorded within the plan.



Example of pick up and place down position

7.4 Unit of Measurement Used in Drawing

Where detailed drawings are being used it is important to mark the drawing with the correct information, such as the unit of weight and dimension being used. Drawings must be of same unit of measurement. All drawings must be signed by the originator and approved by a Responsible Person / Competent Person. Always ensure that drawings are latest and final versions. An example is shown below:



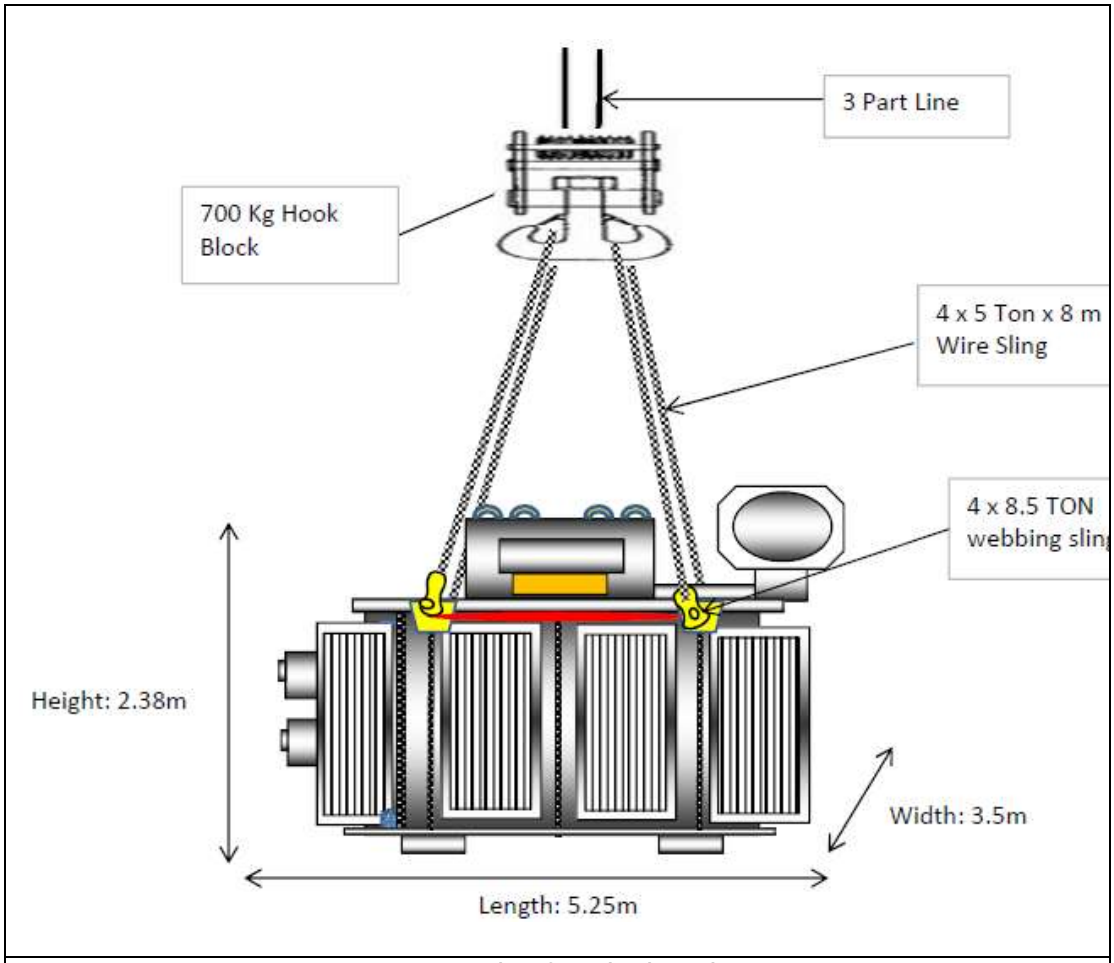
Example of drawing with dimension and standard unit of measurement

8. Creating a Rigging Study/Plan

Along with all the content of Risk Assessments, Sitting Study and, Drawings which all come together to form the Lifting Plan it is also necessary to complete the Lifting Plan by adding a Rigging Study or Rigging Plan.

Essentially the Rigging study, particularly when planning non-routine and complex lifts, is a detailed drawing showing the rigging configuration of all lifting points on the load and details of all slings, beams, shackles, ropes, blocks etc. by size and SWL. It is designed to show all the connection points, the forces applied to each and how it will be slung together.

Normal routine lifting where a Lifting Plan is used the drawing may be a hand drawn sketch showing the rigging configuration. An example of a Rigging plan is show below:



An example of a Rigging plan

8.1 Centre of Gravity of the Lift

When preparing the lift and attaching the rigging it is important to follow the Rigging Study and ensure that the CG is directly under the hook block of the lifting crane.

When a load is lifted by a crane the CG always hangs vertically beneath the hook. If the CG is not under the hook when it is first lifted, then the load will tilt until it is. (see Figure below).

This can be a useful way of locating the CG of a load in the field. We know that the CG is located somewhere along the vertical line through the hook. (See Figure blow again.) We all

know this exercise: the load is lifted and does not stay horizontal. To make sure that the load stays horizontal when lifted, we either change the lift point position of one of the slings or lengthen or shorten one of the slings in such a way that the CG is exactly under the hook when we lilt the load.

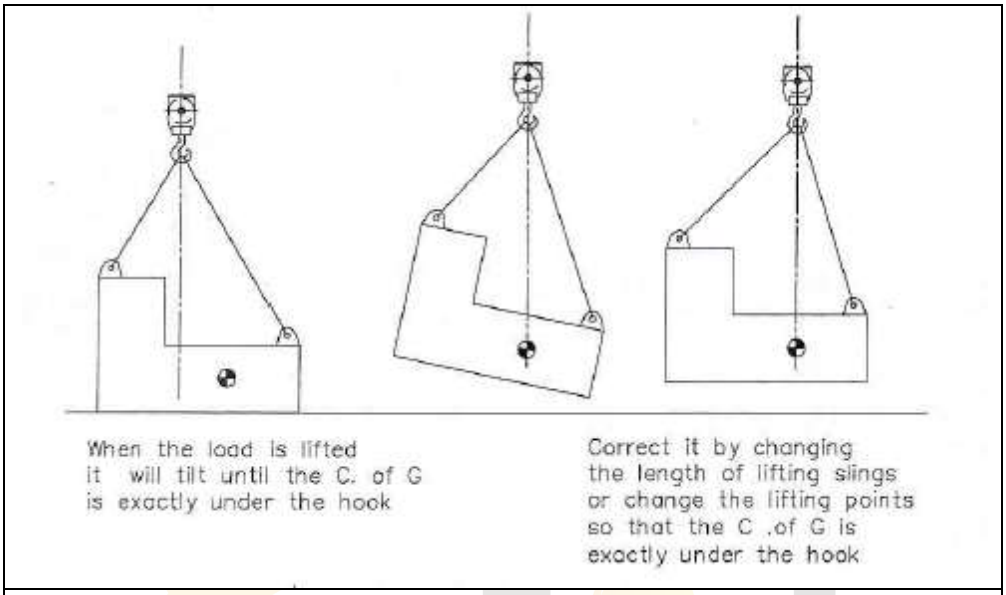
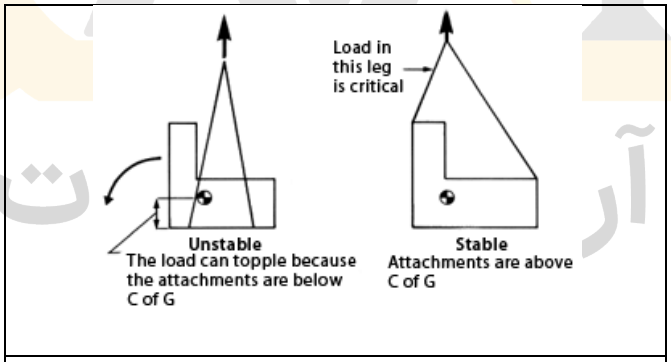


Figure : CG Beneath the Hook

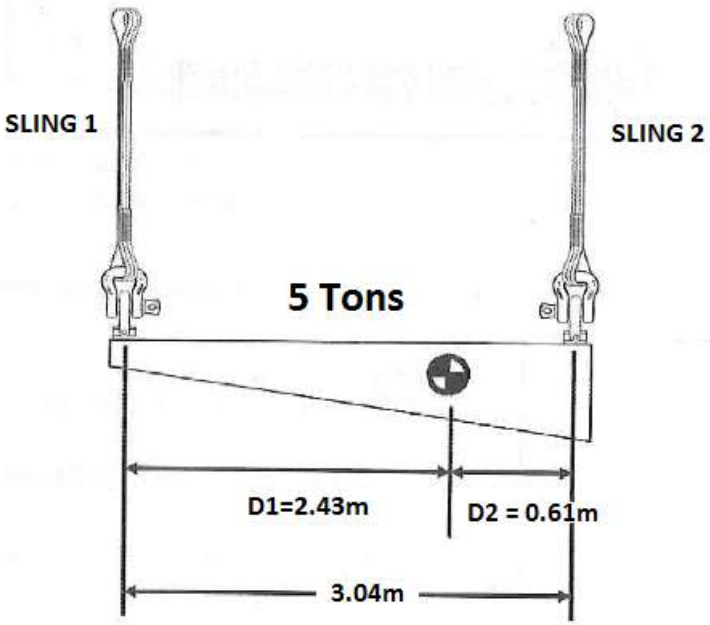
With larger and off-set/off balanced loads the CG is more difficult to determine. Below is an example of a load with an off-set CG. Normally this is the case at non symmetric elements. Note the slinging arrangements and how a load becomes unstable when the CG is not directly below the hook block.



Example of Center of Gravity (CG)

Note: For large objects which are being lifted, the CG. will have to be determined via engineering method. The lifting lugs will also need to be designed for to ensure safe lifting. Specific lifting gear can also be used to ensure that the hook is always above the CG during the lifting operation.

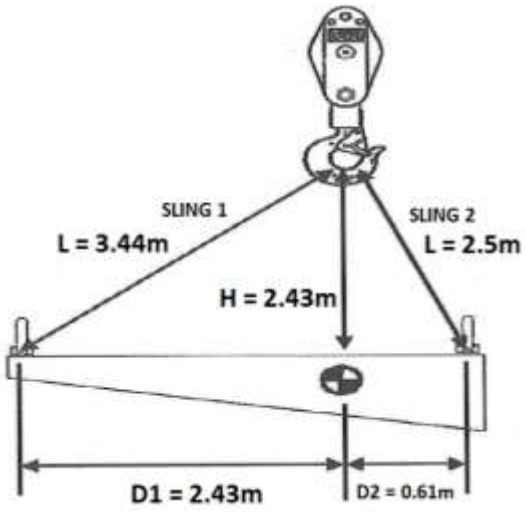
When the CG is not equally spaced between the rigging points, the slings and fittings will not carry an equal share of the load. The sling connected closest to the center of gravity will carry the greatest share of the load.

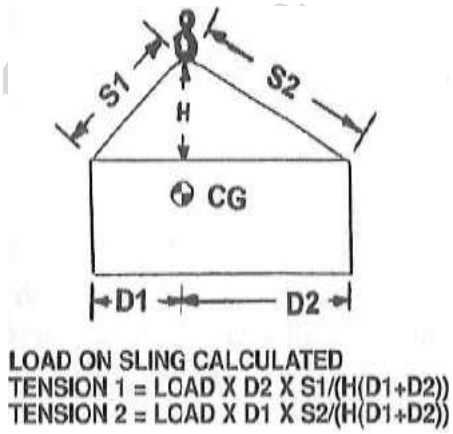


Sample Calculation:

Sling 2 is connected closer to the CG, therefore it will carry the greater share of the load:
Tension in/Load carried by Sling 2 = 5 x 2.43 / 3.04 = 4.0 tons
Tension in/Load carried by Sling 1 = 5 x 0.61 / 3.04 = 1.0 tons

Similarly, for two legged slings joined to the hook,





LOAD ON SLING CALCULATED
TENSION 1 = LOAD X D2 X S1/(H(D1+D2))
TENSION 2 = LOAD X D1 X S2/(H(D1+D2))

Sample Calculation:

Tension in/Load carried by Sling 1 = 5 x 0.61 x 3.44 / (2.43(2.43+0.61)) = 1.42 tons
Tension in/Load carried by Sling 2 = 5 x 2.43 x 2.5 / (2.43(2.43+0.61)) = 4.11 tons

8.2 Lifting Lugs/Pad-Eyes

Attention must be paid to the lifting lugs or pad-eyes on any load that is about to be lifted. In many cases they may be manufactured as an integral part of the load which will be covered by calculation certification as part of item being lifted.

The following example illustrates the design of lifting lugs for lifting of concrete precast element:

The design of the lifting lugs, pad-eyes and similar items shall be based on the concept of global safety factors. The safety factor requires that the action E does not exceed the admissible value of the resistance R. It shall be shown as:

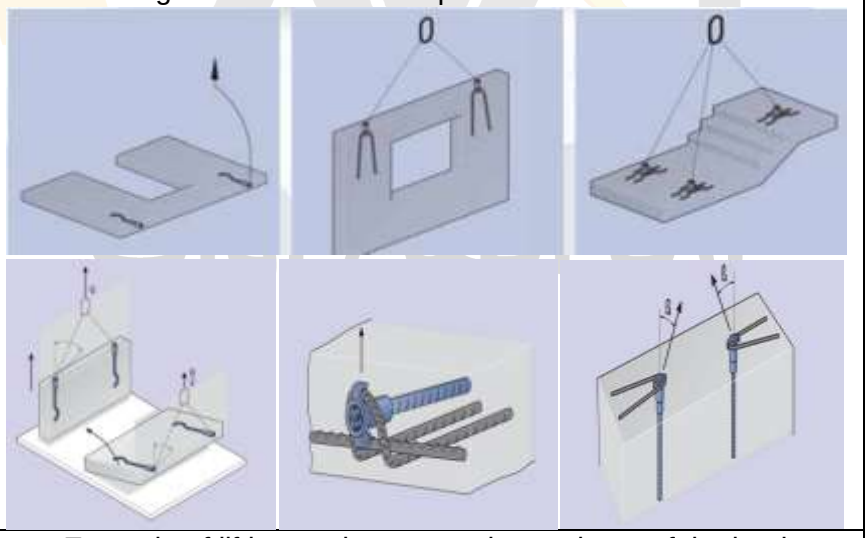
$E \leq R$
E: Action
R: Admissable load (resistance)

The minimum concrete strength at time of lifting is 15 N/mm².

Lifting lugs, pad-eyes and similar items which are intended to be used to lift precast elements have to be considered as lifting anchors or lifting systems. The provisions therefore have to be fulfilled even and especially if the lifting items become integral part of the load.

Ductility is a very important item, which means ripped rebars protruding from the precast element are not covered from these provisions. Smooth bars and prestressing strands have to be ductile to avoid brittle behaviour.

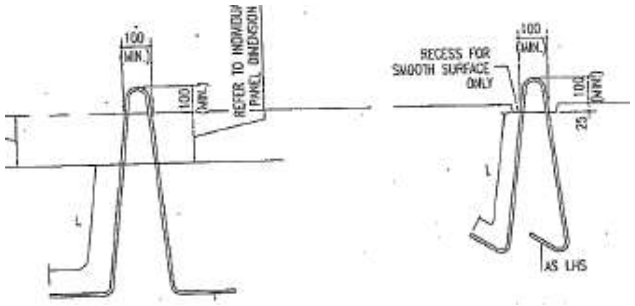
Cast-in lifting anchor with fulfilled provisions**:**



Example of lifting anchors as an integral part of the load

There will be cases where lifting lugs/pad-eyes will not be provided separately, but self-produced in the precast yard. In such cases the Engineer / Competent Person must be sure that they have current certification and are of sufficiently designed and verifiable proven to cope with the lifting effects.

Cast-in lifting anchor – self-produced in precast yard:

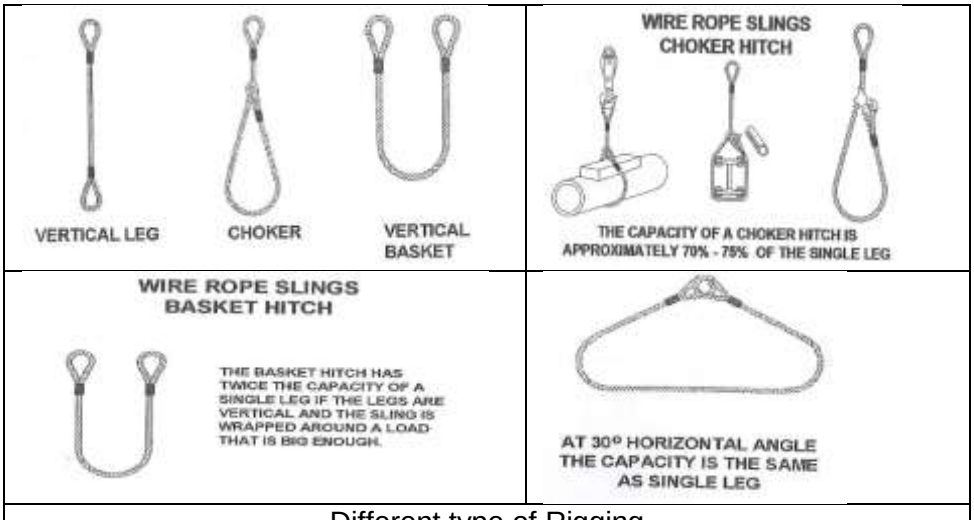


Example of Certified lifting lugs/pad-eyes that are provided separately

To avoid any risks for human life and health and safety of employees in the precast yard and construction site all lifting anchor systems and motions therewith have to be checked, calculated and proven by an constructional engineer e.g. as consultant or technical engineer in the precast yard. The resistance comes from supplier. In case of a given recommendation provided by supplier, the responsible engineer has to check the complete situation of handling too.

8.3 Type of Rigging and Lifting Capacity

Lifting gears or slings generally carry their loads in one of three primary sling hitches. Most slings can be used in all three sling hitches, but some slings are designed for use in only one hitch. Slings have the largest Work Load Limit when used in a basket hitch. The vertical hitch Work Load Limit is 50% of the basket hitch (i.e. WLL of basket hitch = 2 x SWL). The synthetic choker hitch Work Load Limit is a maximum of 80% (typically 70-75%) of the vertical hitch Work Load Limit. Slings must be securely attached to the load and rigged in a manner to provide for load control to prevent slipping, sliding and/or loss of the load. A trained, qualified and knowledgeable user must determine the most appropriate method of rigging to help ensure load control and a safe lift. The manual or the tag on the sling should be referred to for more information on the actual ratings for each hitch type.

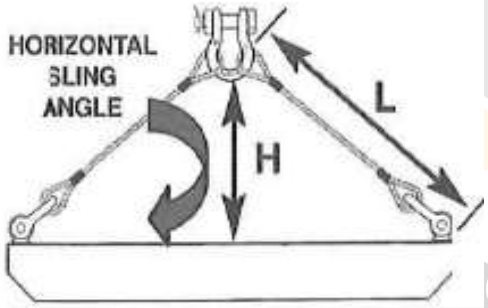


Different type of Rigging

Example of tag on polyester webbing sling showing the WLL factors

8.4 Sling Angles/lengths/SWL

In any lifting operation the rigging equipment will be selected based on the weight of the load to be lifted. However, there are times when the angle of the slings gets overlooked and what appears as the SWL on the tag or certificate is not sufficient to do the job. Every rigging study where slings are part of the lifting gear must be checked to ensure that angles do not reduce the lifting capacity below that of the weight of the load. A simple calculation can be done as follows:



HORIZONTAL SLING ANGLE (A) DEGREE	LOAD ANGLE FACTOR = L/H
90	1.000
60	1.155
50	1.305
45	1.414
30	2.000

LOAD ON EACH LEG OF SLING =
VERTICAL SHARE OF LOAD X LOAD ANGLE FACTOR

Example:

W = weight of load = 5 tons
Share of load on each leg = 2.5 tons
L = Length of sling = 4m
H = Height between hook and load = 3m
T = Tension in each sling = 4/3 x 2.5 = 1.333 x 2.5 = 3.33 tons
The total tension in the slings adds up to 6.66 tons which is much more than the actual weight of load at 5 tons!

Note: Rigging is advised to proceed at 60° as far as possible. Slings should also be selected with at least a 20% extra SWL as lifting is typically carried out at 60° sling angles. When the rigging exceeds this sling angle, detailed calculations should be done to determine the actual load on each leg of sling.

8.5 Shackles/Beams/Links/SWL

The Competent Person must ensure that all lifting gear has current and valid certification prior to the commencement of any lifting operation. Any shackles or links being used to join slings together should also be sized to take into account the actual load that each section will be taking.

9. Method Statement

When writing a Method Statement it is beneficial to write it in such a manner that it follows the sequence of the events and actions required as the lifting operation progresses. This include about personnel, about wind and several other items that are key to successful lifting. Therefore the user is to ensure that all other items that are essential to successful lifting are included in the method statement. If in doubt, consult a Competent Person.

The actual sequence and order of events should be described within the plan in simple easy to read and understand in “one line bullet point style”. A Lifting Plan (as shown in **Appendix 3** for a Routine Lift sample) is an attachment to the Method Statement.

10. Personnel & Training

All personnel involved in any lifting operation must be trained, skilled and competent in their role and have certificated evidence of proof. The Competent Person must ensure that all members of the Lifting Team have the relevant qualifications and certification.

Always ensure that there are sufficient numbers in manpower resources to carry out the work comfortably and without putting undue pressure on any member of the team. In the event that there may be a trainee within the team, the Competent Person must ensure that they are under constant supervision and not allowed to undertake unfamiliar tasks on their own.

11. Operational Requirements

Each Lifting Operation must be planned taking into consideration the operational requirements of the site. In general when lifting operations are taking place there are others involved and other work activities going on in the close vicinity of the lift.

To ensure that the lifting area is secure and free from unauthorized persons the area must be cordoned or barricaded off. During the lift lookouts must be posted to prevent entry into the lifting area, normally these people would be employees of the customer/client as the Lifting Team have sufficient to do taking care of the lift.

12. Customer Provision

It is the responsibility of the customer/client to ensure that all requested requirements are in place on the day of the lift, i.e. good access to the lifting site, that the ground conditions are level, sufficient and capable of withstanding the identified pressures.

13. Weather Conditions

Weather has a major impact on any Lifting Operation. Wind is a major hazard that can disrupt and put a lifting operation at risk. Cranes must never lift at wind speeds beyond those recommended in the crane manufacturer's instructions.

Additional to manufacturer recommendations, the larger the wind sail area of a load the more risk it may bring, therefore it may be necessary to do a calculation to find out what the safe wind operating speed will be. Many times it is very much less than that recommended by the manufacturer.

13.1 Wind conditions in Singapore

Sumatra squall (Monsoon winds)

- Lifting operations are often elevated. In such high rise conditions, stronger winds are expected, especially during the tropical monsoon seasons when strong wind gusts ('Sumatra' squalls) can be experienced.
- The maximum wind gust of up to 100km/h (est. 27.78m/s) has been recorded during a passage of a Sumatra squall.

Mean surface wind speed

- In Singapore, the mean surface wind speed is normally less than 20km/h (est. 5.56m/s).
- The maximum recorded wind speed (in the context of Singapore) is unlikely to exceed 33m/s.
- The following are the wind speeds expected in Singapore.

Wind speed		**relevant Code of Practice**
33m/s	basic wind speed (3 second gust speed)	Code of Basic Data for the Design of Buildings. Loading. Wind Loads – CP3 Chapter V Part 2
22m/s	basic wind speed (hourly mean speed)	Loading for buildings. Code of Practice for Wind Loads – BS 6399:Part2
20m/s	basic wind speed	Actions on structures. General actions – Wind actions – SS EN 1991-1-4
SS ENs will be the only prescribed design standards with effect from 01 Apr 2015.		

13.2 Effect of wind on crane

One of the major factors affecting stability is the effect of wind. However, determining wind speeds can sometimes present difficulties. This guideline recommends the use of a hand-held wind speed device (anemometer). Wind imposes a horizontal load on the crane as well as on the load. These cause instability to both the crane and the load which could result in overturning. In normal safe working conditions, this tendency to overturn is counteracted by the self-weight of the crane, and the stabilizing effect of the outriggers or stabilizers.

The jib or trolley parking position must be done according to the manufacturer's

requirements. This is particularly important for luffing jib cranes. If the jib angle is too high, the risk of the jib being blown backwards over the A-frame is increased. If the jib angle is too low, the forces acting on the crane will be increased.

13.3 Effect of wind on load

It is important to consider the load's shape. Lifting of irregularly shaped loads will require more consideration and possibly the consultation of manufacturer prior to the lift if necessary.

It is also important to consider the load weight to surface area ratio. As a rule of thumb, when the load weight to surface area ratio is found to be significantly less than 1.0tons/m2, particular attention should be paid to the wind conditions in the area. The lifting operation should be stopped if the load is found to be moving about significantly.

Wind conditions in city area can be complex, as a result of the varying urban volumes of adjacent buildings, which can block, channel and/or concentrate the wind as it passes through, and may not concur with the clear directionality as studied in wind tunnel tests.

Where uncertain, the manufacturer of the crane should be consulted on the effects of wind on the operation of the crane.

14. Communications

Failures in communications are often root causes of lifting incidents and can also be the most difficult to detect.

Good training and adherence to correct procedures are vital but checking the actual situation at the worksite is of utmost importance. For example:-

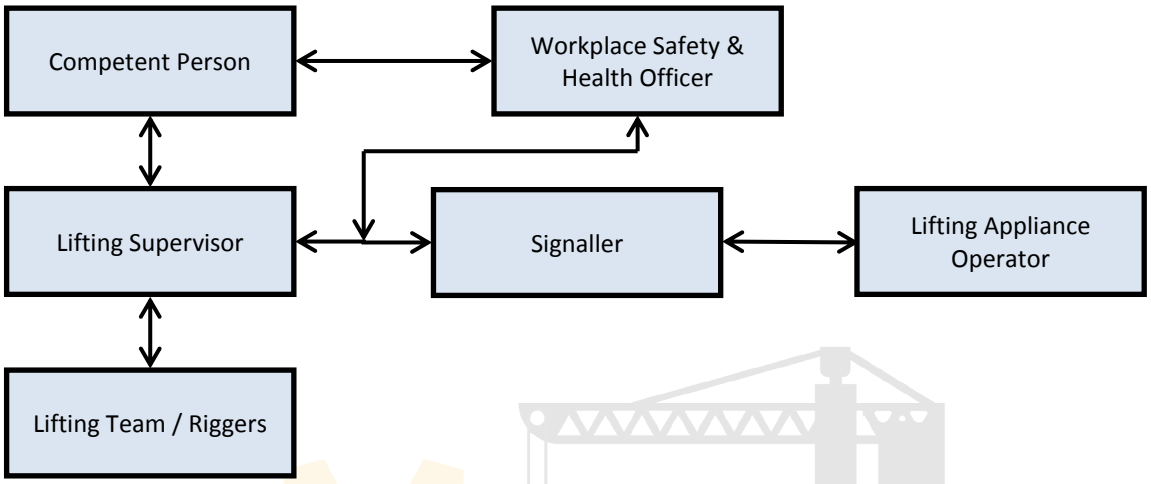
- Are the personnel concerned all from the same company?
- Do they all understand a common language?
- If not is there an established system of signals in strict use that they all know and understand?
- Warning signage is displayed where the personnel are able to see it?
- What different methods of communication are able to be used?
- What communication is required between the worksite and the source of any technical assistance elsewhere?

Communication also extends to warning personnel of the lifting activity and keeping the lift area clear of personnel not involved in the lifting operation.

All members of the lifting team must be sure of their individual tasks and their team members' roles in order to fully and easily communicate with one another. Designated signallers shall be clearly and separately identifiable, by use of reflective jackets or other conspicuous clothing or marking.

Good quality of communications is essential especially when any part of the lift is not clearly visible to any of the team members. If a signal is not clear to a member of the lift team operating any lifting equipment, then the operation shall cease to progress.

Never start any lifting operation until all concerned have been briefed in a Pre-Start Meeting, ensuring that they understand their role and responsibilities and that they have signed onto the Permit-to-Work or record of attendance at the Pre-Start Meeting.



Example of Communication Diagram During Lifting Operations

15. Importance of a Checklist

A checklist can mean the difference between failure and success. It may be only one element in the successful execution of a safe lift, but it is a key element. When all the work has been completed in preparation for the lifting operation it is always recommended and wise to use a final checklist to ensure that all requirements are in place and in a safe condition. The important points given below could form part of your own checklist:

•	Check position of crane(s)
•	Check outrigger positions and conditions of subsoil / supporting structure
•	Check foundation and shim plates of foundation if applicable
•	Check radius at pink-up position of load
•	Check radius at setting position of load and area between pick-up and set position
•	Check boom length of crane and if applicable counterweight and superlift counterweights
•	Check clearances with surrounding structures in connection with tail swing of counterweight and superlift structure when slewing the crane
•	Check reefing of lift block and lift capacity
•	Check shackle pin sizes and lifting lug sizes
•	Check orientation and position of lifting and tail lugs
•	Check sling lengths and SWL
•	Check location of centre of gravity (CG) and verify it with CG on drawings
•	Check weight of load if possible
•	Check lifting trunion size and dimensions
•	Check condition of access road to foundation
•	Check general condition of crane and LMI
•	Check fuel, oil and condition of engines
•	Instruct operators and rigging crew in details about planned operation
•	Clearly mark operation area to stop unauthorised personnel from entering the work area
•	Check medical aid on side in case of accidents
•	Plan your operations in details and think ahead

Note: Clearly these 21 points should be expanded upon, depending on the type and complexity of your project. While they will act as a reminder to your staff, you should remember that having a checklist may not safe-guard your project. For that you need experienced people who attend to details, and staff who will go through that list as automatically as any pilot before a flight.

16. Rigging and De-Rigging of Mobile Hydraulic, Crawler Cranes & Tower Cranes.

The rigging and de-rigging of cranes is correctly classified as" High Risk Activity". Many accidents and indeed in many cases there are more accidents resulting in injury and fatality during these 2 phases of a lifting operation than what occur during the actual lifting process.

Rigging and de-rigging present many challenges and generate many hazards and associated risks. During these phases of any lifting operation extreme caution and vigilance are required. Much heavy work and working at height is required, particularly where larger capacity cranes are in use. Careful documented planning of Hazard and Risk Analysis is required. De-rigging also brings the added factors of rushing at the end of a lift to get clear of the site, equally after a lift is complete and in many cases the crane operator is left to his own devices and alone to complete the task, folding up the Fly – Jib on a small hydraulic is every bit as dangerous as taking of the luffer on a large crawler.

Whilst all phases of a lifting operation require focus, vigilance, monitoring and control, the elements of Rigging and De-rigging are very easily overlooked and taken for granted. Appointed Persons/ Lift Supervisors must ensure that the Lifting Team are alert and familiar with all hazards, associated risks and implemented control measures.

Acknowledgement

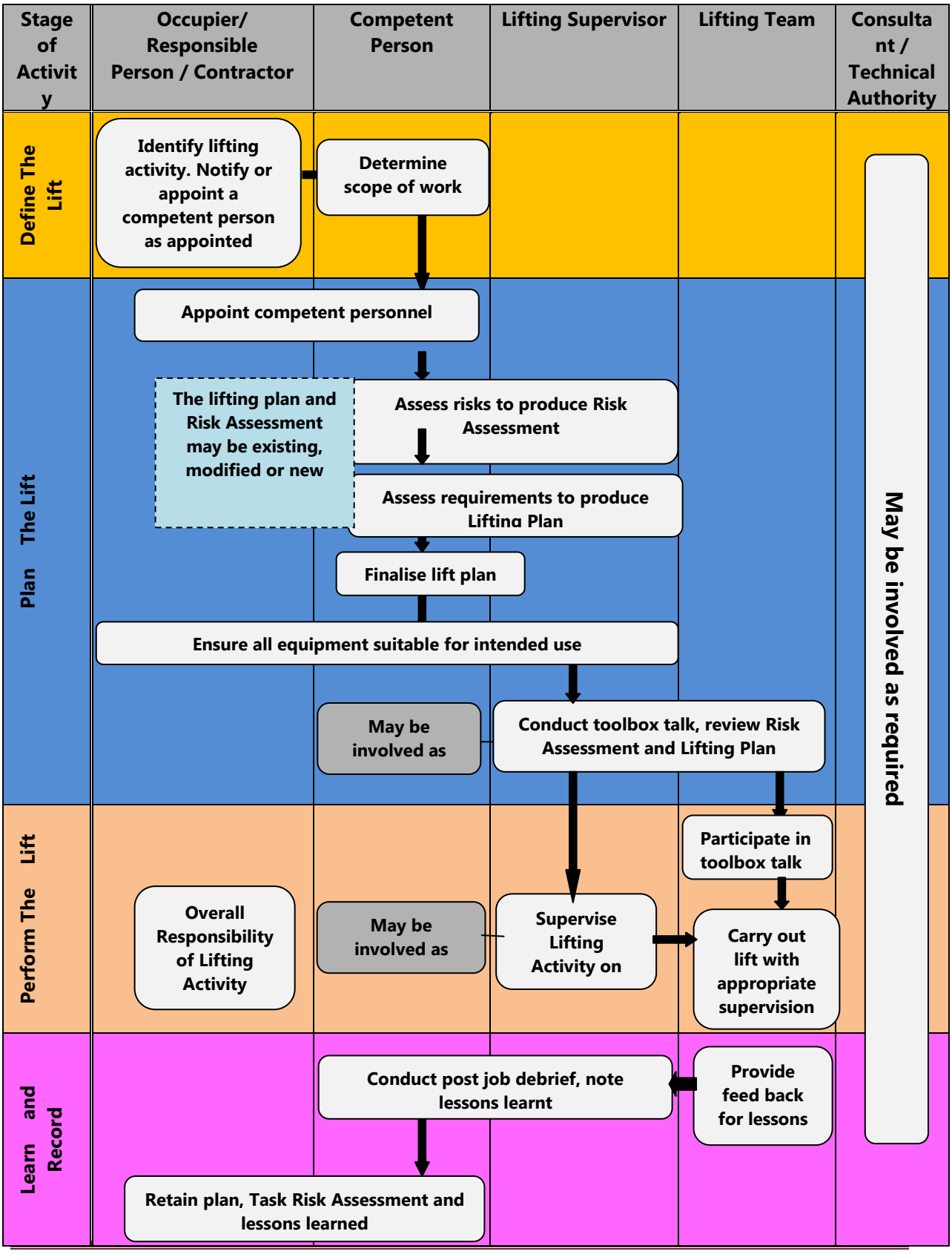
This set of guidelines was developed with inputs from members of the working group. Workplace Safety and Health (WSH) Council would like to thank them for their valuable contributions.

Mr Jimmy Chua - (WG Lead/Chair - Vice-Chairman, Singapore Crane Association)
Mr Yeo Kim Hock – (Gammon Construction Limited, Singapore Branch; Singapore Contractors Association Ltd)
Mr Kok Chun Chiat, Alvin - (Land Transport Authority)
Mr Mohd Zahid bin Wagiman, (ST Marine; Association of Singapore Marine Industries)
Mr Muhd Hidayat – (Huationg (Asia) Pte Ltd)
Mr Ahmad Jais – (Huationg (Asia) Pte Ltd)
Mr Patrick Lian Chin Chye – (Buildmart Industries Pte Ltd)
Mr Ah Singh Gill – (Hiap Tong Crane & Transport Pte Ltd)
Mr Satishkumar Kurusamy - (Ministry of Manpower)
Mr Han Kin Sew - (Workplace Safety and Health Council)

Technical Resource : Mr Bryan Cronie - Mammoet (S) Pte Ltd

Diagrams, Images, Figures, Photographs courtesy of:
Huationg (Asia) Pte Ltd
Gammon Construction Limited, Singapore Branch
Mammoet (S) Pte Ltd
J&P Building Systems Pte Ltd

Appendix 1 -Various stakeholders' involvement in planning a safe lifting operation.



Appendix 2 - Sample of a Risk Assessment

Department: Mobile Crane	RA Leader: Mr Ahmad	Approved by	Reference Number
Process: Mobile Crane Operation	RA Member 1: Han		
Process/Activity Location: Various Site	RA Member 2: Hidayat	Signature:	
Original Assessment date: 1st January 2014	RA Member 3: Murugesan	Name: Jimmy Lee	AXXX-01-01
Last review date: 1st March 2014	RA Member 4: Sathiya	Designation: Project Manager	
Next review date: 28th Feb 2017	RA Member 5: Sani	Date: 28th Feb 2014	

HAZARD IDENTIFICATION				RISK EVALUATION				RISK CONTROL						
Ref	Work Activity	Hazard	Possible injury/ill-health	Existing risk controls	S	L	RPN	Additional Controls	S	L	RPN	Implementation Person	Due Date	Remarks
1	Self driven Mobile Crane (Routine Job)	1. Blindspot of Other vehicles on the road 2. Speeding 3. Road constructions	1. Fatality/severe bodily injury 2. Damage to property	1. To abide to speed limit whilst driving at main road ar 2. w li 3.				1. To determine the route of traveling To escort crane to site vey of tion or	4	2	8	Mobile Crane Operator/ Attendant	3rd March 2014	
2	Crane Inpection (Routine Job)	1. Sharp Object 2. Oily / wet Surface 3. Unattended Tools	1. Sprain / Swollen to legs 2. Injury to hands and fingers	1. Safety boots to be worn. Holding of Handrail when climbing up to cabin. 2. Use gloves when picking up lifting gears or during checks 3. Use proper tools during inpections	4	2	8	1. To ensure 3 contact points at all times if required to use ladder 2. All oily surface to be cleared before inspection	3	2	6	Mobile Crane Operator/ Attendant	3rd March 2014	
3	House keeping (Routine Job)	1. Sharp Object 2. Oily / wet Surface 3. Unattended Tools	1. Sprain / Swollen to legs 2. Injury to hands and fingers	1. Safety boots to be worn. Holding of Handrail when climbing up to cabin. 2. Use gloves when picking up lifting gears 3. Use proper tools during clean up	4	2	8	1. To ensure 3 contact points at all times if required to use ladder 2. All oily surface to be cleared before inspection 3. Proper storage area for all tools and equipment	3	2	6	Mobile Crane Operator/ Attendant	3rd March 2014	

SAMPLE

Appendix 3 - An example of a Routine Lifting Plan

LIFTING PLAN FOR REMOVE TRANSFORMER

A.	**Lifting Machine:**	AC-100 (100 TON)	
	Counter Weight:	25 Ton	
B.	**Lifting Gear :**	1) 4 x 5ton x 8M m WEBBING Sling	
		2) 4 x 8.5 ton Shackle	

C. **Crane Details:**

Crane	AC-100 (100 TON)	
Configuration	Main Boom	
Boom Length	33.7	M
Working Radius:	14	M
Corresponding SWL:	18000	KG

D. **Load Details**

Description	Electical Equipment, Transformer with estimated load of 8500kg
Lifting Points	Transformer have 4 lifting points, using 4 Wire sling and webbing sling connected to hook block
Dimension	L 5.25m x W 3.5m x H2.38m
Center of Gravity	■ Given ■ Calculated ☐ Unknown

SAMPLE

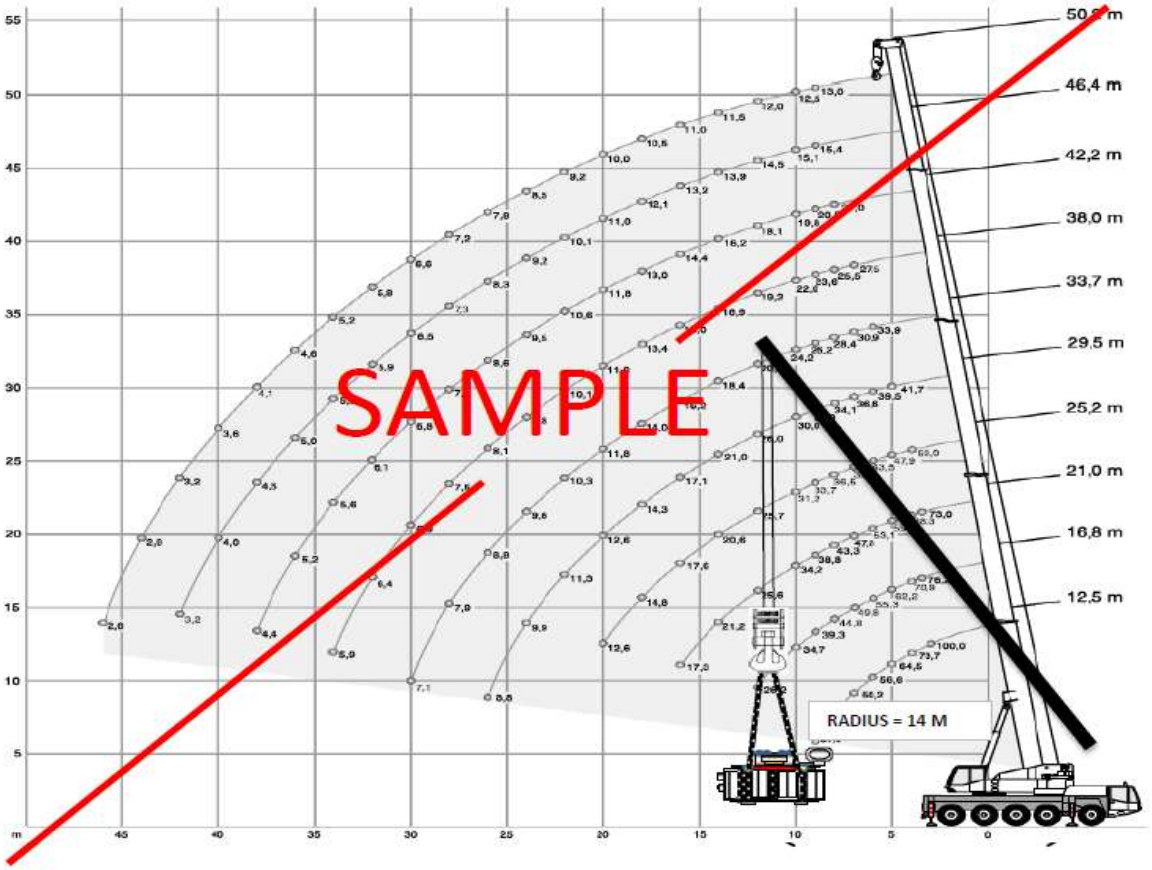
E. **Load Calculation:**

OLD Transformer Weight:	8500.00	KG
25% add on	3400.00	KG
Lifting Gear Weight :	100.00	KG
Hook Blocks Weight :	700.00	KG
Total Weight :	12700.0	KG
Safety Factor :		1.42
Crane Capacity Usage (Load/SWL):		70.56%

F. **Routine Lift** ☑ **Non Routine Lift** ☐

Prepared by:	Kamruzzaman	Signature	Date: 03-03-2014
Approved by:	Ahmad	Signature	Date: 03-03-2014

G. LOAD CHART



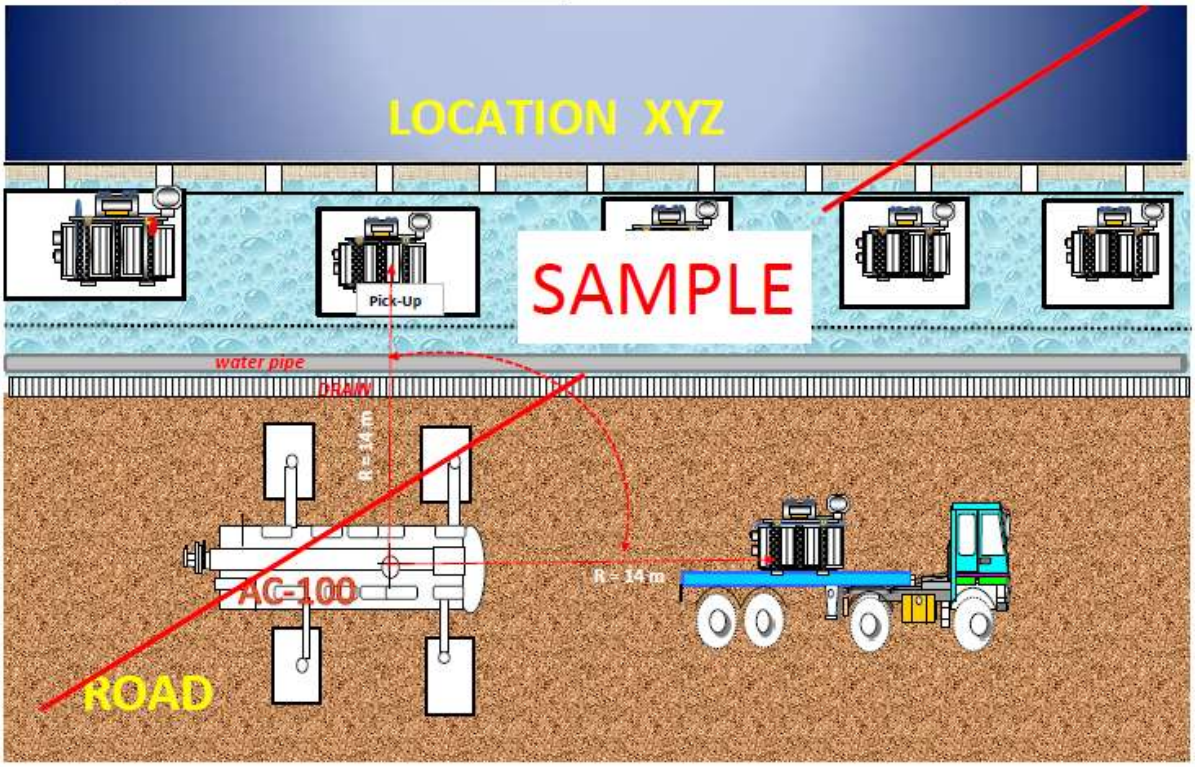
LOAD CHART

25 t | 7,10 m x 7,00 m | 360° | AC-100 | ISO

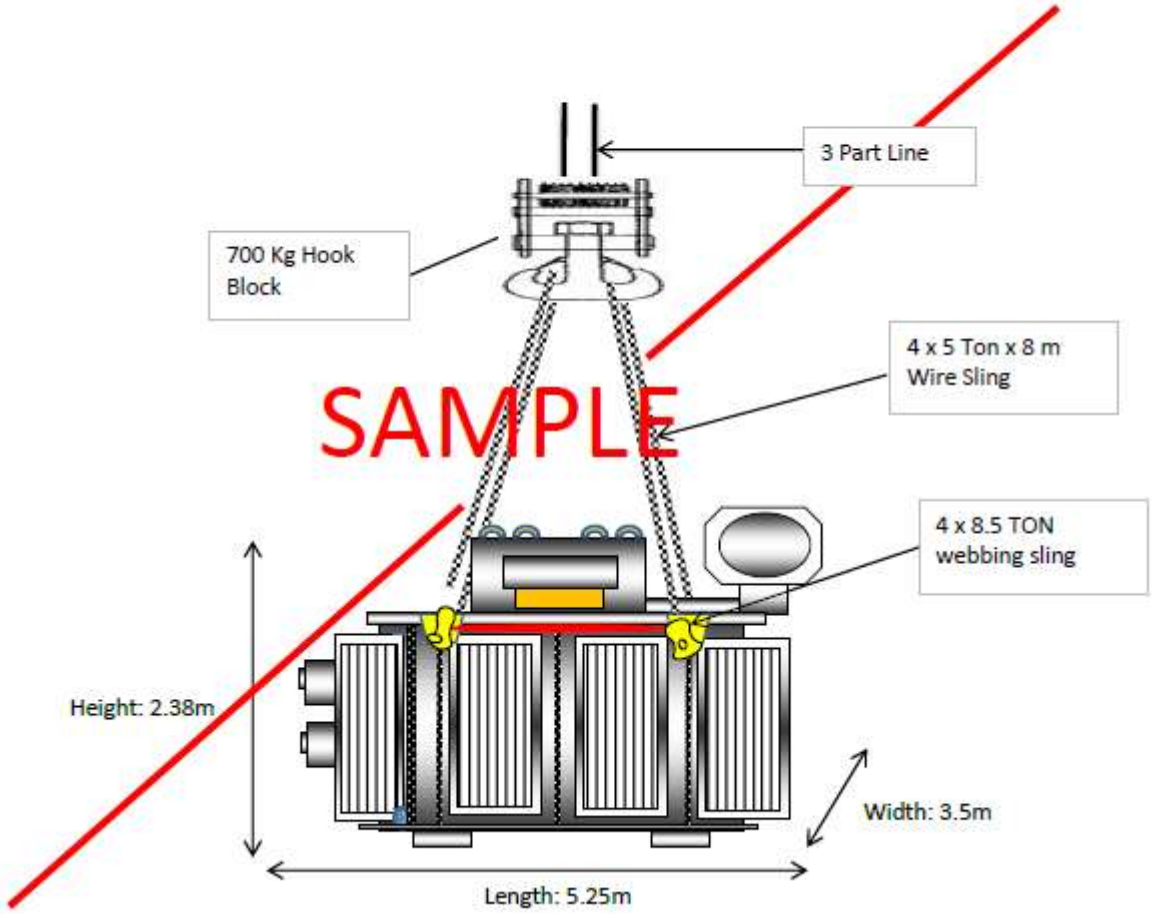
m	12,5	16,8	21,0	25,2	29,5	33,7	38,0	42,2	46,4	50,6	m
	t	t	t	t	t	t	t	t	t	t	
	100,0*	-	-	-	-	-	-	-	-	-	
3	85,5	-	-	-	-	-	-	-	-	-	3
4	73,7	70,8	68,3	53,0	-	-	-	-	-	-	4
5	64,2	62,2	59,8	47,9	41,7	-	-	-	-	-	5
6	56,2	55,3	53,1	43,5	39,5	33,9	-	-	-	-	6
7	49,0	49,1	47,8	39,7	36,6	30,9	27,5	-	-	-	7
8	42,0	42,1	41,6	36,5	34,1	28,4	25,5	21,0	-	-	8
9	36,5	36,6	35,9	33,7	31,9	26,2	23,6	20,5	15,4	13,0	9
10	-	30,7	30,1	30,3	30,0	24,2	22,0	19,8	15,1	12,5	10
12	-	22,9	23,5	23,5	23,4	20,9	19,2	18,1	14,5	12,0	12
14	-	-	18,5	18,8	18,3	18,0	16,9	16,2	13,9	11,5	14
16	-	-	15,0	15,4	15,1	14,5	14,6	14,4	13,2	11,0	16
18	-	-	-	12,8	13,3	12,0	12,0	12,5	12,1	10,5	18
20	-	-	-	10,9	11,3	11,0	10,5	11,2	10,8	10,0	20
22	-	-	-	-	9,9	9,9	9,6	9,6	9,3	9,2	22
24	-	-	-	-	8,5	8,6	8,7	8,4	8,0	8,1	24
26	-	-	-	-	7,5	7,6	7,7	7,5	7,4	7,1	26
28	-	-	-	-	-	6,7	6,8	6,8	6,5	6,2	28
30	-	-	-	-	-	6,0	6,1	6,1	5,8	5,4	30
32	-	-	-	-	-	-	5,4	5,4	5,1	4,7	32
34	-	-	-	-	-	-	4,8	4,8	4,5	4,1	34
36	-	-	-	-	-	-	-	4,3	4,0	3,6	36
38	-	-	-	-	-	-	-	3,5	3,5	3,1	38
40	-	-	-	-	-	-	-	-	3,1	2,7	40
42	-	-	-	-	-	-	-	-	2,3	2,3	42
44	-	-	-	-	-	-	-	-	-	2,0	44
46	-	-	-	-	-	-	-	-	-	1,7	46

SAMPLE

H. PLOT PLAN VIEW FOR REMOVE TRANSFORMER .

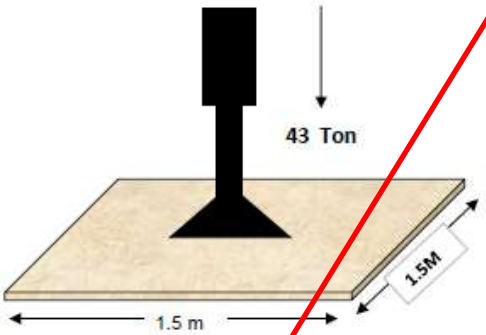


i. RIGGING VIEW FOR REMOVE TRANSFORMER



J. GROUND BEARING PRESSURE FOR TRANSFORMER

Crane Model	=	AC-100(100TON)
Counter Weight	=	25 TON
Length of Main Boom	=	33.7 M
Working Radius	=	14 m
Corresponding Safe Working Load	=	18 TON
Total Lifting Load With Gears	=	12.7 ton
Max Outrigger Pressure	=	43 Ton
Effective Area	=	1.5M x 1.5 M
	=	2.25Sq M
Weight of Outrigger Plates	=	1 TON
Total Weight	=	43TON + 1TON
Total Pressure Load	=	44 TON
Required Ground Bearing Capacity	=	44 ton / 2.25 sqm
	=	19.56 Ton / sqm
Max Allowable soil bearing	=	70 Ton / Sqm



SAMPLE