WSH Guidelines

Lifting Plan Development

Draft for Public Consultation

Comment period is from 1 to 30 November 2002
This is a draft document which is subject to change. Members of the public are invited to submit comments using the consultation form provided.

This draft should NOT be regarded or used as a final guidance document issued by WSH Council. Feedback will be incorporated, and copy-editing/visual layout will be undertaken prior to publication.

WSHCOUNCIL
Tripartite Alliance for Workplace Safety and Health

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1. Introduction

The use of lifting equipment such as cranes to lift large objects is a common activity at construction sites, shipyards, and factories. Good practices and correct lifting methods will ensure that lifting operations are performed safely. However, unsafe lifting practices can lead to accidents resulting in injuries and even fatalities.

The process of carrying out correct and safe lifting operations involves a range of factors which must be considered during the planning process of any lifting operation.

The Workplace Safety and Health (Operations of Cranes) Regulations require a lifting plan to be established and implemented before any lifting operations using cranes. This lifting plan has to be in accordance with the generally accepted principles of safe and sound practice. This guidelines aims to provide practical considerations when developing a lifting plan.

This guidelines should be read in conjunction with the Code of Practice (CP) on Safe Lifting Operations in the Workplaces. The CP is the main guiding document pertaining to safe lifting operations and the safe use of lifting equipment.

1.1 Scope

This set of guidelines provides guidance and explain the essential components and factors which need to be considered when preparing a lifting plan, so as to ensure a safe lifting operation.

1.2 Responsible Person

Under the WSH (Operations of Cranes) Regulations, a Responsible Person refers to the employer of the person operating the crane or the principal under whose direction the operator operates the crane.

It is this Responsible Person's duty to establish and implement a lifting plan which shall be in accordance with the generally accepted principles of safe and sound practice for all lifting operations involving the use of any crane at a workplace.

1.3 Components of a Lifting Plan

The essential elements of a lifting plan can be found in Appendix 1 of this guidelines.
The subsequent sections explain in greater details for each element of a lifting plan.

2 General Information

1. General			
Project			
Location of Lifting Operation			
Contractor carrying out the lifting operation		Date /Time of lifting operation	
		Validity Period of the Lifting Operations	

Table 1 : Part 1 of Appendix 1

The general information required in a lifting plan includes details of the project site, name of contractor, and the location within the site where the lifting operation will be carried out.

Next would be the date and time of the planned lifting operation and the validity period of the lifting plan should be captured. If the lifting plan is no longer valid or the conditions have changed, the plan should be revised accordingly.

3. Details of the Load

2. Details of the Load/s		
Description of load/s		
Overall Dimensions		
Weight of load	Kg / tonne	☐ Known weight ☐ Estimated weight
Centre of Gravity	☐ Obvious ☐ Estimated ☐ Determined by Drawing	

Table 2 : Part 2 of Appendix 1

3.1 Description of Load(s)

The overall description of the load should be given to help identify the load prior to the lifting operation. Load description may include items such as pallet, rebar cage, sand, rubbish skip, empty concrete bucket, full load or half load of wet concrete, precast slab etc.

3.2 Overall Dimensions

The overall dimensions of the load should be recorded in the lifting plan. The dimensions of the load will assist in the determination of the Centre of gravity (CG), which will be covered in another chapter. The dimensions will also help the lifting team to establish the vertical lifting height clearance required, particularly in restricted and confined areas. Load dimensions are also needed to calculate and determine the permissible operating wind speed for handling loads with a large surface area.

3.3 Weight of Load

The most important information for establishing the lifting plan is the weight of the load. It must be established at the beginning of the planning stage of a lifting operation to assist in the selection of crane and other relevant components.

The weight of the load must be accurately determined or closely estimated. The overall gross weight of the load must include the weight of the lifting equipment used in the lifting operation. This includes the boom/jib head downwards, including hook block, wire ropes, beams, shackles, frames, slings, etc.

The crane should never be used as a weighing machine for the loads it is carrying. Lifting loads exceeding the capacity of the crane can potentially lead to toppling of the crane. Therefore, the weight of the loads must be known by other means such as documentation from previous lift, material and product specifications or calculations. At any point during the lift that the load exceeds the estimated weight, the lifting operation must be suspended, and the Responsible Person must review the lifting plan. Guidebook for Lifting Supervisors provides information on the unit weight for common material types.

All details on the load mentioned earlier must be included in the lifting plan. Figure 1 shows an example of description of a load for a typical lift:

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
Lifting Gear Weight:	100	KG
Hook Blocks Weight:	700	KG
Total Weight	9300	KG
Crane Capacity usage (Load/SWL)		70% (Example)
Note: Add in safety factor to the total gross load as required.		

kjhcFigure 1: Example of description of a load for a typical lift

3.4 Centre of Gravity (CG)

To ensure that every lifting operation is safe and can proceed as planned, the centre of gravity (CG) of the load must be known. The CG must be directly below the centre line of the crane hook block when slung.

3.5 Control of Load

Another important aspect about load is that during a lifting operation, a load suspended by the crane may swing back and forth or rotate due to wind or other external factors. The movement of the crane or boom can also cause the load to swing out of the crane's safe operation radius which is a hazard. Therefore, all lifting operations must make use of tag lines, push/pull sticks, and hooks (shown in Figure 2) to limit the movement of the load. The use of such load-handling equipment will also ensure that the lifting crew stand a safe distance away from the load, so as to reduce contact with the load and minimise injuries. The lifting plan must indicate the manner by which the load will be controlled if there is any.

		
Push/Pull Stick	Tag Line	The Cronie Hooker

Figure 2: Load-handling equipment

4. Details of the Lifting Equipment / Lifting Gears

3. Details of the Lifting Equipment / Lifting Gears			
Type of lifting equipment:			
Maximum SWL as certified on the LM cert		Date of last examination	
		Expiry date of certificate	
Max Boom / Jib Length	m	Fly jib / offset	
Type of lifting gears	*Slings / webbing / chains / shackles / spreader beam / receptacle*		
Combined weight of the lifting gears	Kg / tonne	Certification of lifting gears	☐ Yes ☐ No
SWL of LG	Kg / tonne		

Table 3 : Part 3 of Appendix 1

4.1 Type of Lifting Equipment

Selection of the appropriate lifting equipment is critical in ensuring a safe lifting operation.

Very often the question is raised: “Can we lift this 22 tonnes piece with an 80 tonne crane?” Although the question sounds simple, the answer cannot be given until we know about the job to be done such as the following which have been addressed in the earlier sections:

- What weight is to be lifted?
- At what radius will it be lifted?
- At what height must it be lifted?
- What are the dimensions of the load?
- Where the load is to be lifted and where it will be placed?
- Are there any obstacles to avoid?
- What lifting points are available and how should the load be lifted?
- Where is the centre of gravity of the load in relation to the lifting points?

Having known all the above, next step is the selection of the right crane for the job. The selected equipment must have sufficient lifting capacity for the load and adequate reach to transfer the load from the initial location to the intended location.

Note: For good practice, the planned load MUST NOT exceed the SWL but preferably be less than 90% of the SWL.

For equipment such as the tower, mobile, crawler or lorry crane, the lifting capacity is dependent on the load radius of the crane boom. Therefore, it is important to know the distance of the load to the crane when planning a lifting operation. For multiple lifts involving loads of various weights, shapes and sizes, the most critical lift which may not be the heaviest load should be the main consideration for the selection of the crane.
Details of the selected lifting equipment should be included within the lifting plan. Some examples of lifting equipment are mobile crane, crawler crane, tower crane (luffing or saddle jib), portal crane, overhead crane, gantry crane or lorry loader. The following information on the lifting equipment can also be included in the lifting plan.

- Make and model;
- Capacity;
- Jib length (plus fly/luffing jib with offset where required);
- Outrigger spread;
- Outrigger imposed load;
- Maximum ground bearing capacity required;
- Counterweights/super lift counterweight requirements; and
- Weight of the crane.

4.2 Maximum Safe Working Load as Certified on the Lifting Machine Certificate

It is common for cranes to be classified as or referred to according to their capacity. However, the capacity usually refers to its maximum lifting capacity at the closest load radius from the centre of the crane. For e.g., a 60-tonne telescopic mobile crane will have a maximum lifting capacity of 60 tonnes at the closest radius of about 3 metres from the centre of the crane. Thus, this crane will not be able to lift 60 tonnes for larger working radius contrary to its categorisation. Therefore, it is important to state the maximum safe working load (SWL) which is indicated on the crane's lifting machine (LM) certificate in the lifting plan.

4.3 Date of Last Examination & Expiry Date of Certificate

It is also important to check the validity of the Certification of Test / Thorough Visual Examination of Lifting Equipment for the cranes being used at a worksite. The date of the last examination of the crane and expiry date of certificate should be indicated in the lifting plan. This will ensure that the crane has a valid LM certificate and it will be reflected accordingly in the lifting plan.

4.4 Maximum Boom/Jib Length

The maximum boom and jib length are critical information which must be recorded in a lifting plan. For fixed boom length cranes such as crawler cranes, a check on the actual configuration of the crane and whether it conforms to the certificate is important. For variable boom length cranes such as mobile cranes, the crane configuration information would provide some guidance as to whether the selected crane is appropriate for its intended use and may assist to prevent over-reaching.

4.5 Fly Jib/Offset

Fly jibs are common on both crawler and mobile cranes. The installation of the fly jib will affect the SWL of the crane. Therefore, information on the SWL must be reflected in the lifting plan. This is to ensure that the correct load chart is being referred to when determining the SWL for the given radius. It is also common for the fly jibs to be installed with an offset which can also affect the SWL and the SWL should be recorded in the lifting plan for clarity.

4.6 Type of Lifting Gears

The type of lifting gear (LG) selected should be detailed in the lifting plan. It is important that the type of gear selected is compatible for its intended use. For e.g., fabric slings should not be used with loads with sharp edges. Section 6 on creating a rigging method will further explain on different types of lifting gears and their recommended usage

4.6.1 Combined Weight of the Lifting Gears

As mentioned in earlier section on load weight, the weights of the lifting gears have to be included in the overall load weight. Exclusion of the lifting gear weights can lead to overloading of cranes when the load weight was very close to the SWL of the crane. Thus, this is another section which should be included in the lifting plan.

4.6.2 Safe Working Load of Lifting Gears

Similar to the lifting equipment itself, the lifting gear also has an SWL. The SWL for each lifting gear used in the lifting operation should be included in the lifting plan.

4.6.3 Certification of LG

The information on the SWL can be found on the certification of the LG. Lifting gears are required to be inspected at regular intervals as required by the WSH Act and its subsidiary legislations. This is generally one year for normal lifting gears and six months for man cages. Every LG must have a valid tag on the LG for visual check before every lift.

5. Details of the Lift

4. Details of the Lift			
Intended Load Radius of the Lifting Equipment	*Distant between the load and the crane*	SWL of the Lifting Equipment at this radius	
Sketch and description of rigging method			

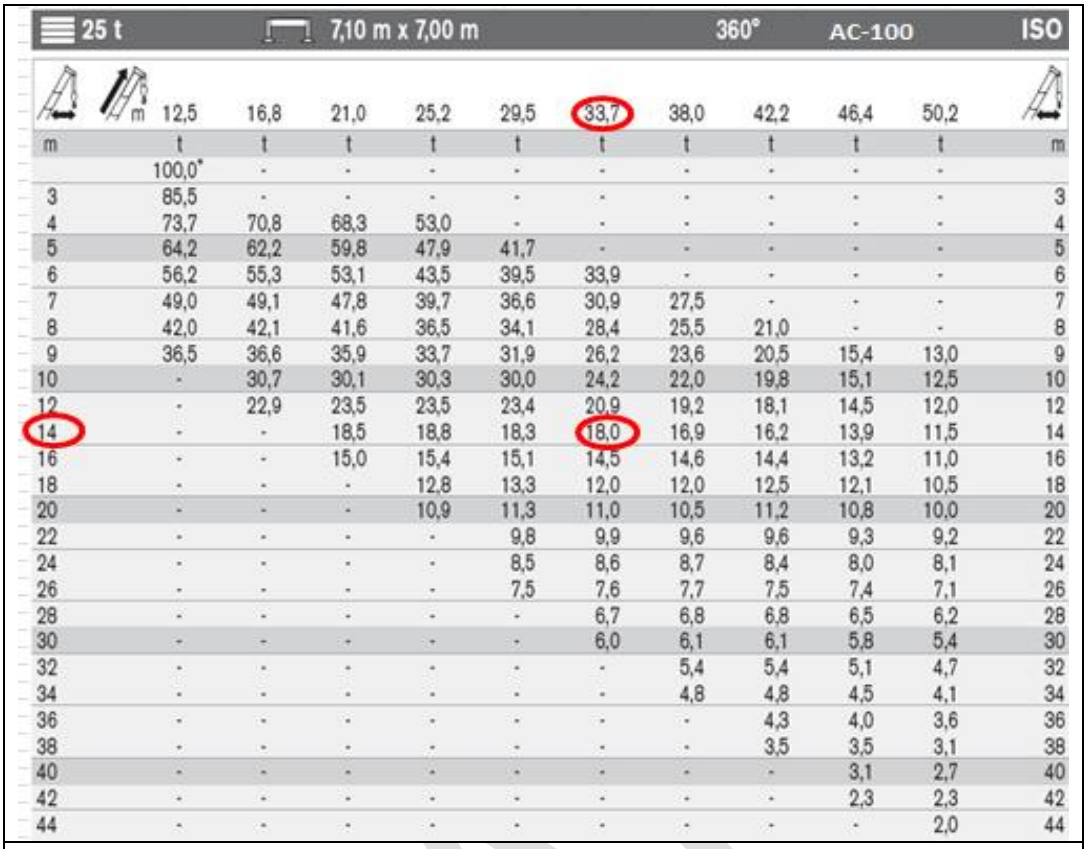
Table 4 : Part 4 of Appendix 1

5.1 Intended Load Radius

In addition to the load weight, the load radius is another important information which needs included to be in the lifting plan. The load radius should be determined accurately. The best method to determine and verify the load radius is to be on site to check. However, if this is not possible, the Responsible Person should refer to a scale drawing to verify. Adequate allowance should be given to ensure that the actual radius is not greater than the calculated or estimated distance.

5.2 Safe Working Load at Specific Radius

Once the intended load radius has been determined, the SWL at this radius can be found by referring to the correct crane load capacity chart (refer to Figure 3 for an example). This information must be included in the lifting plan.



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

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
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	-	-	-	-	9,8	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

Figure 3. Example of a crane load capacity chart identification for SWL

5.3 Sketch and Description of Rigging Method

A comprehensive rigging method must include key information such as the type of lifting gears, factors that can affect the lifting operation and the Centre of Gravity. The rigging method must be enclosed together with the lifting plan.

The rigging method should consist of a detailed drawing of the load indicating the rigging configuration of all the lifting points and information on the slings, beams, shackles, ropes, blocks etc., by size and SWL. The rigging method must show all the connection points, the forces applied to each connection and how it will be slung together.

The drawing can be a hand drawn sketch showing the rigging configuration. However, a computer drawn engineering diagram is recommended for complex lifts. An example of a rigging method is shown in Figure 4.

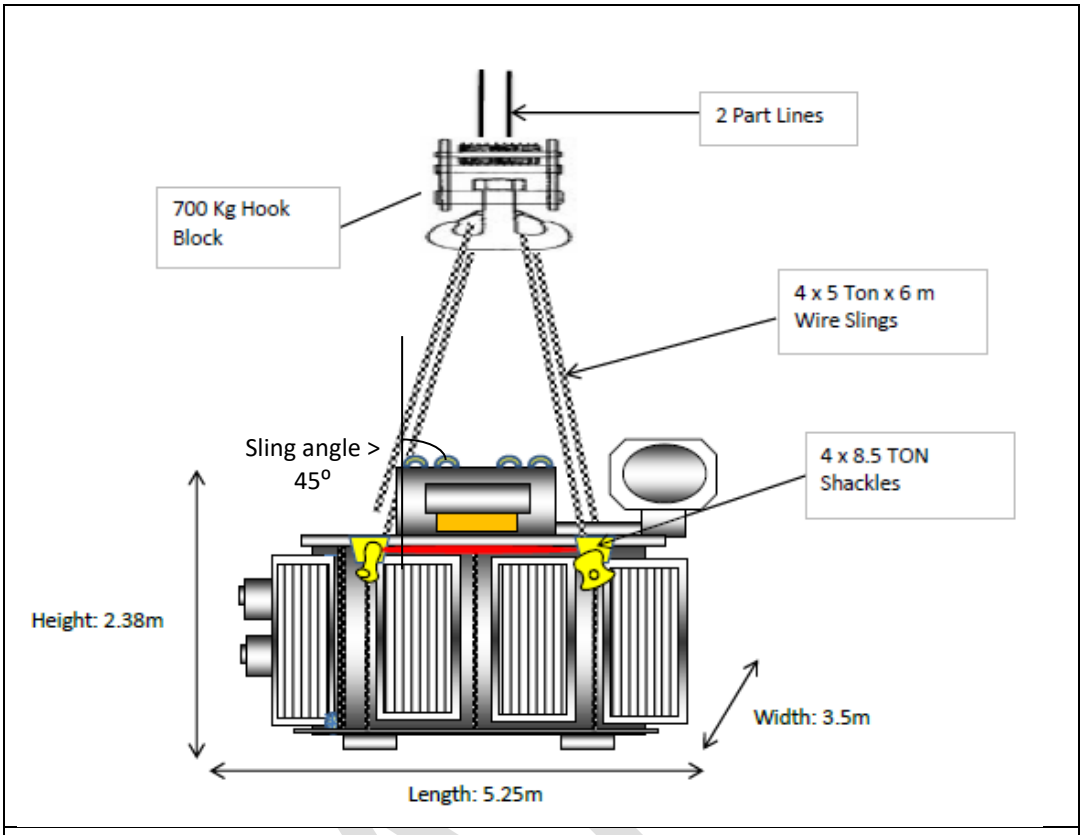


Figure 4. An example of a sketch of a rigging method

6. Further information on Rigging

Correct rigging is another aspect of ensuring a safe lifting operation. Accidents due to rigging can often be traced to a lack of knowledge on the part of a rigger. A safe rigging requires the rigger to know the following:

- the weight of the load and rigging hardware accessories
- the capacity of the lifting or hoisting devices
- the safe working load limit of the slings, webbing and hardware.

After the weights and capacities are known, the rigger must then determine how to rig the load so that it is stable. This should be addressed in the rigging method.

6.1 Valid Certificates and Tags on all Lifting Gears

To begin with, the lifting team must ensure that all lifting gears have valid certificates 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. Synthetic web slings must be labelled to indicate their load rating capacity. Other factors affecting a safe rigging of lifting gears include centre of gravity of load, sling angle and sling configurations (refer to **Appendix 2**).

6.2 Centre of Gravity (CG) of Load

When rigging the load, it is important to follow the rigging method and make sure that the centre of gravity (CG) of the load is vertically below.

When a crane is lifting a load, the CG is always vertically beneath the hook. If the CG is not under the hook when it is being lifted, the load will tilt until the CG is vertically beneath the hook (see Figure 5).

While this method can help to locate the CG of the load, precautions should be taken to ensure that the tilting of the load is minimal, and any movement of the load does not destabilise the crane.

After the CG is located, the load should be adjusted to stay horizontal. This can be done by either changing the lift point position of one of the slings or lengthening/shortening of one of the slings so that the CG is exactly under the hook when lifting the load.

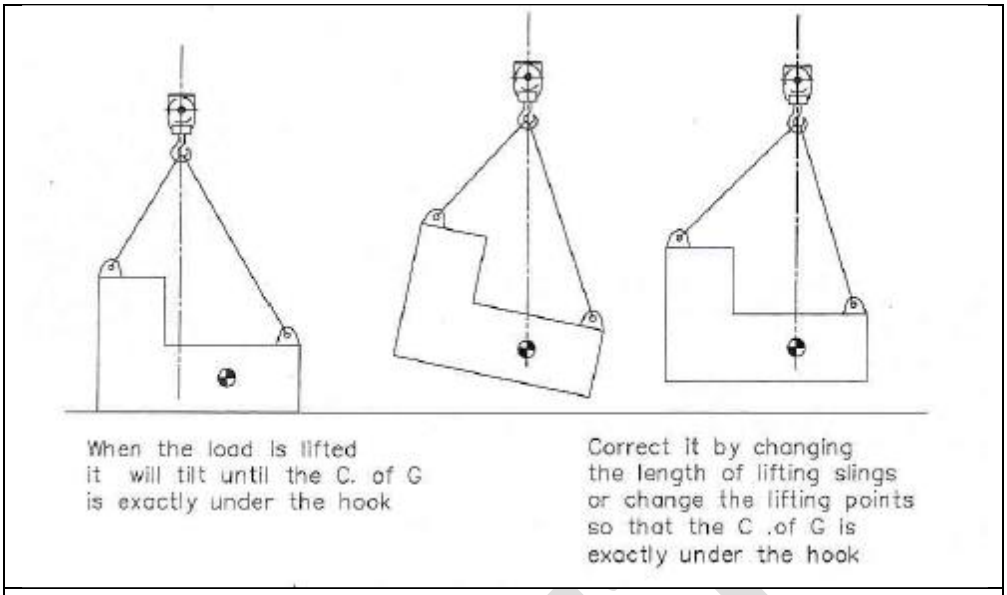


Figure 5: CG beneath the hook

For larger and off-set/off-balanced loads, the CG is more difficult to determine. Figure 6 shows an example of a load with an off-set CG. Note the slinging arrangements and how a load becomes unstable when the CG is not directly below the hook block.

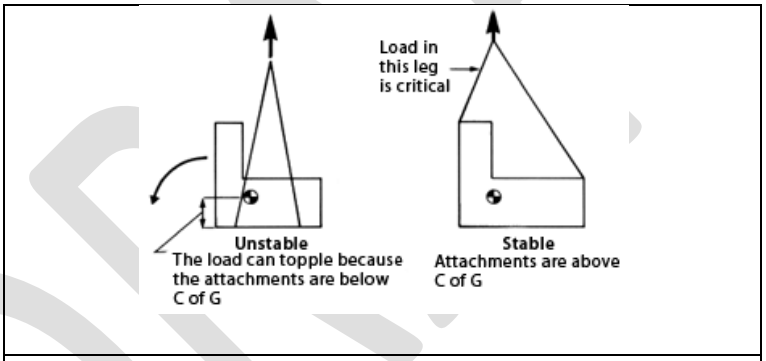


Figure 6. Example of a load with an off-set CG

For lifting large objects, the CG will have to be determined during the design stage by designers. The lifting lugs will also need to be designed to ensure a safe lifting operation. Specific lifting gear may 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, each set of sling and fittings will not carry an equal share of the load. The sling connected closer to the CG will carry the greater share of the load. See the Figures 7 & 8 for reference.

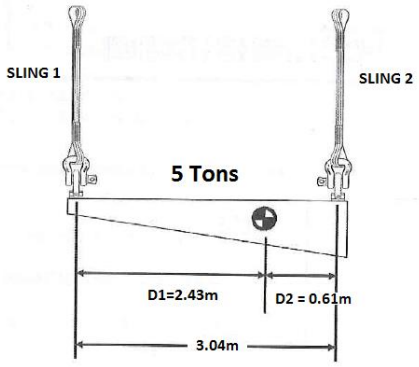


Figure 7: Example of a load with an off-set CG connected by two slings

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 1 = 5 x 0.61 / 3.04 = 1.0 tons
Tension in/Load carried by Sling 2 = 5 x 2.43 / 3.04 = 4.0 tons

For two legged slings joined to the hook, see Figure 8.

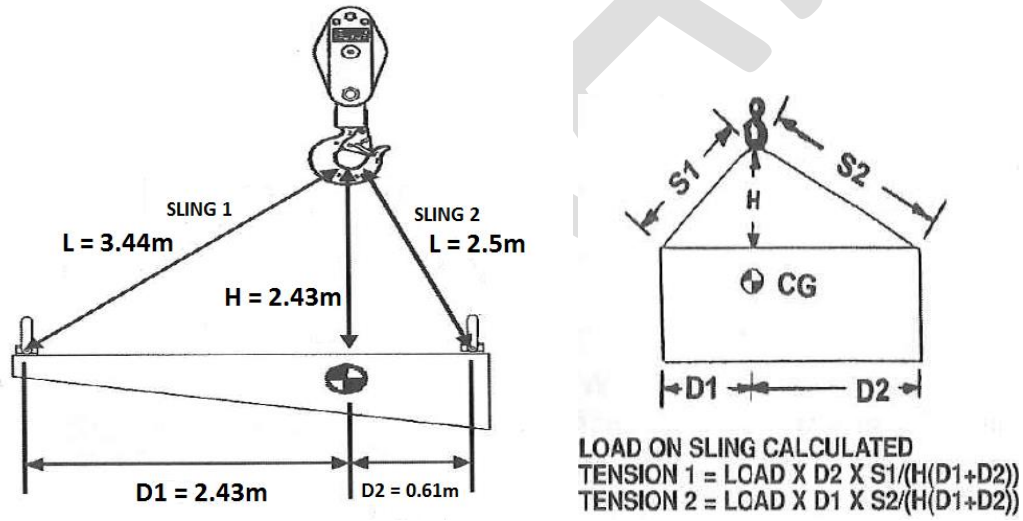


Figure 8: Example of a load with an off-set CG connected by two-legged slings joined to the hook

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

6.3 Sling Angles

In any lifting operation, the rigging equipment will be selected based on the weight of the load to be lifted. It is important to look at the angle of the sling and the SWL indicated on the tag or certificate. Where slings are being used as part of a lifting gear, the slings must be checked to ensure that the rigging angle does not reduce the lifting capacity to lesser than the load.

It is important to note that:

- The total weight that one can pick up with a set of slings is reduced when the slings are used at angles.
- For instance, two slings used to lift 1000 tons will have a 500 ton force on each sling (or leg) at a sling angle of 90 degrees.
- The force on each leg increases as the angle goes down. At 30 degrees the force will be 1000 tons on each leg!
- Keep sling angles greater than 45 degrees whenever possible.
- Using any sling at an angle lower than 30 degrees is extremely hazardous. In such cases, an error of 5 degrees in estimating the sling can be very dangerous.
- The sharp increase in loading at low angles is shown in Figure 9.
- Low sling angles also create large, compressive forces on the load that may cause buckling— especially in longer flexible loads.
- When the rigging exceeds this sling angle, detailed calculations should be done to determine the actual load on each leg of sling.

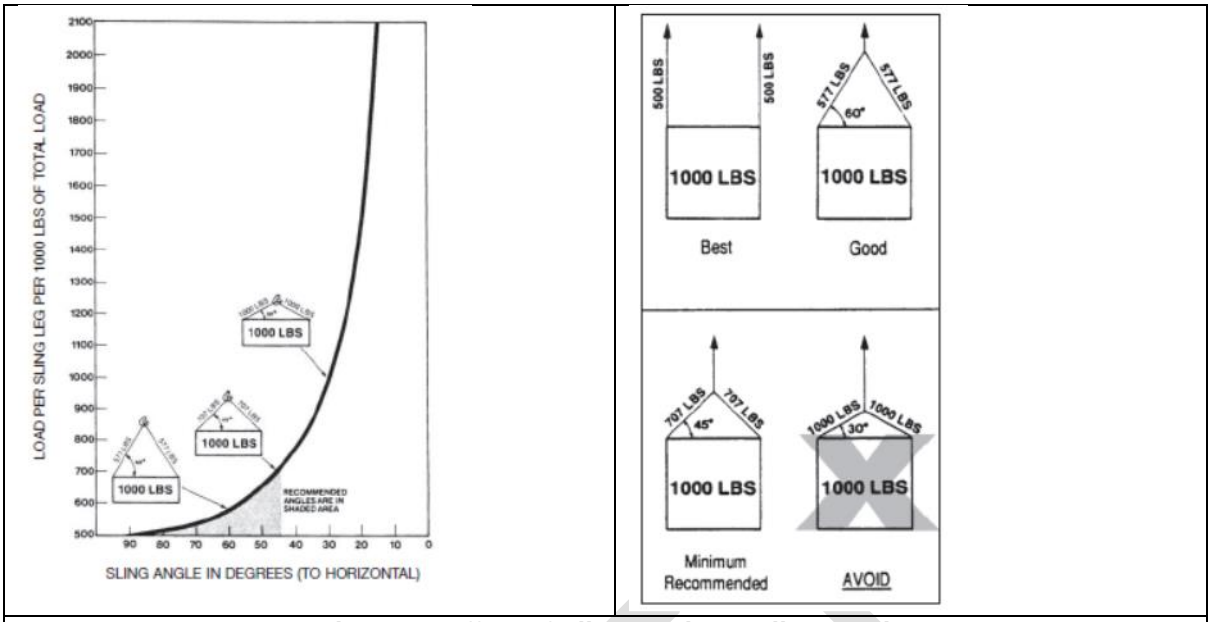
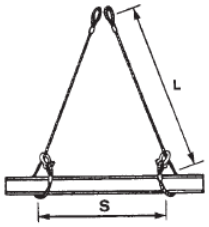


Figure 9 : Effect of Sling Angle on Sling Load

A quick check on sling angle

- If L is greater than S, sling angle is ok
- Ensure that the sling angle is always greater than 45° and preferably greater than 60°. When the horizontal distance between the attachment points on the load is less than the length of the shortest sling leg, then the angle is greater than 60° and generally safe.



If L is greater than S then sling angle is OK.

Safe rigging guidance can also be found in the Worker's Safety Handbook for Rigger and Signalman, and the Guidebook for Lifting Supervisors

7. Means of Communications

5. Means of Communications
Can the operator see the loading and unloading point for the load from his position? ☐ Yes ☐ No What are the means of communication between the lifting crew? ☐ Standard Hand Signals ☐ Radio ☐ Others _____

Table 5 : Part 5 of Appendix 1

Breakdown in communication is often one of the root causes for lifting accidents and it can also be the most difficult to detect.

Good training and adhering to correct procedures are vital. It is important to take into consideration the following factors when establishing a communication approach with workers.

- 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 that the personnel all know and understand?
- Are the warning signages displayed clearly where the personnel are able to see it?
- What different methods of communication can be used?

Communication also includes warning personnel of the lifting activity and keeping the work area clear of personnel who are not involved in the lifting operation.

All members of a lifting team must be clear of the respective tasks and roles of its team members to ensure there is clear communicate with one another during a lifting operation. Designated signallers should be clearly identified by using reflective jackets or other visible clothing or markings.

Clear communication is important when any part of the lifting operation is not clearly visible to any of the lifting team personnel. If a signal is not clear, the operation must be stopped until further instructions have been given.

The lifting team should not start any lifting operation until all relevant personnel have been briefed on their roles and responsibilities in a pre-start meeting. The team must also sign the Permit-to-Work as required, or record of attendance at the pre-start meeting.

Figure 10 shows an example of how communications can take place for all relevant stakeholders during lifting operations.

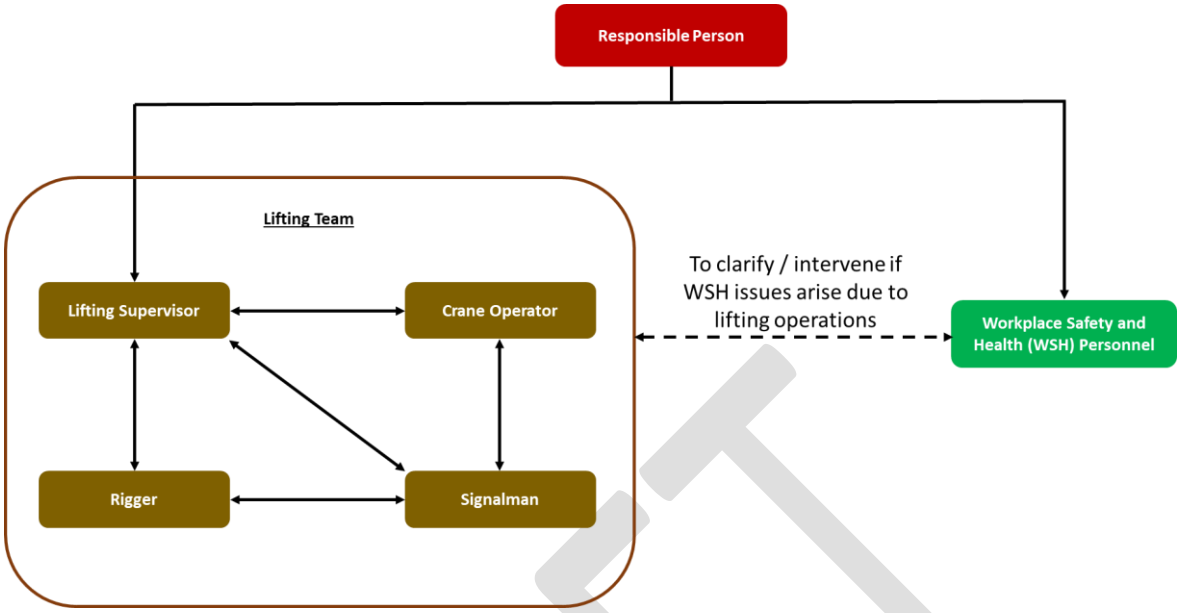


Figure 10: Example of communication diagram during lifting operations

It is important to consider the following information in a lifting plan.

1) Is the crane operator able to see the loading and unloading point for the load from his location?
2) What is the means or platform of communication between the lifting crew?

8. Personnel Involved in Lifting Operations

6. Personnel Involved In Lifting Operation		
Position	**Name**	**Qualification /Experience**
Responsible Person		
Lifting Supervisor		
Crane Operator/ Lifting Equipment Operator		
Rigger		
Signalman		
Others (Please State)		

Table 6 : Part 6 of Appendix 1

The names, qualifications and experience of the lifting team and supervisors should be indicated in the lifting plan to ensure a safe execution of the lifting operation. This includes:

- Responsible Person;
- Lifting Supervisor;
- Crane Operator/Lifting Equipment Operator;
- Rigger;
- Signalman; and
- Others (For e.g., banksmen or general workers assisting with lifting operation).

Lifting Supervisor, Rigger and Signalman must have successfully completed the respective courses (i.e WSQ Supervise Safe Lifting Operations and WSQ Perform Rigger and Signalman Tasks) and be formally appointed for the role.

The responsible person can be someone who has overall control of the worksite (e.g., project manager) or a competent person appointed by the occupier or employer who is able to take full control of the lifting operations (e.g., appointed person as stated in relevant Singapore Standards).

9. Physical and Environmental Considerations

7. Physical and Environmental Consideration (pls include any details in the space provided)		
Ground Conditions:	Is the ground made safe (e.g. placing steel plate)? _____	□ Yes □ No
	Are the outriggers evenly extended? _____	□ Yes □ No
Obstacles:	Are there any overhead obstacles such as power lines? _____	□ Yes □ No
	Are there nearby buildings or structure, equipment or stacked materials that may obstruct lifting operation from being carried out safely? _____	□ Yes □ No
Lighting:	Is the lighting condition adequate? _____	□ Yes □ No
Demarcation:	Has the zone of operation been barricaded (with warning signs and tapes) to prevent unauthorised access? _____	□ Yes □ No
Environment:	Do not proceed with the lifting operation under the following circumstances: □ Thunderstorm and lightning strikes in the area. The ground condition must be checked after a thunderstorm. □ Strong winds that may sway the suspended load. □ Others circumstances (Please specify).	

Table 7 : Part 7 of Appendix 1

9.1 Ground and Surrounding Conditions

The Responsible Person is required to ensure that adequate consideration has been given to the issue of crane outrigger loadings and ground or floor bearing capacities of crane hardstanding areas so that the ground or floor can withstand the anticipated worst case outrigger loadings imposed by the crane carrying the heaviest load during the lifting operation. This information can be found in the manufacturer's outrigger load table. If the Responsible Person does not have the relevant expertise to assess the bearing capacity of the ground, he should engage a specialist with relevant expertise such as a professional in the relevant field.

Consideration must also be given on potential hardstand deterioration due to weather (mudding ground) or construction activity (slope or uneven ground, tunnelling work etc) around the lifting zone which may change of differ from the initial investigation / assessment and that it is still safe to continue to proceed with the lifting operations.

All those involved in the planning and implementation of lifting operations must understand the issue of outrigger loadings and the careful consideration required to ensure the load or

objects can be lifted into position in a safe manner.
Outrigger loadings should be clearly identified on the Lift Plan and the Responsible Person or other competent person (e.g a professional in the relevant field) on their behalf, must sign to confirm adequacy of the hardstanding to receive the stated loading prior to works commencing.

Outriggers or Crane Footing

Lifting operations requiring the use of crane outriggers must follow the manufacturer's instructions with the outriggers beams and jacks extended. When drafting the lifting plan, the Responsible Person must review the proposed crane location to ensure that there is sufficient space at the site for the required crane outriggers configuration. Figure 11 shows examples of some poor outrigger set-up configurations which should be avoided.

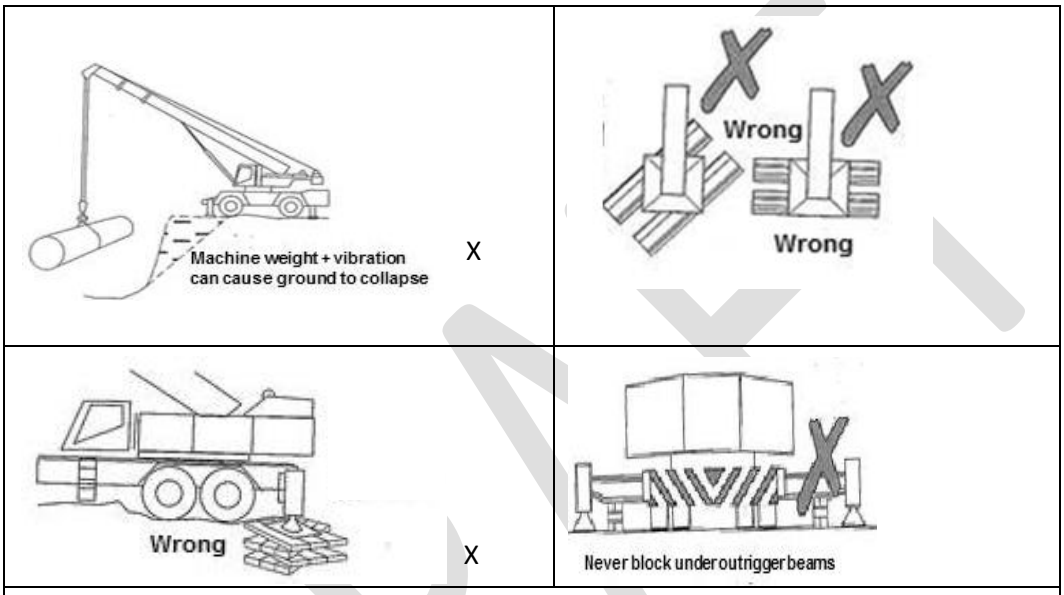


Figure 11: Example of poor outrigger set-up

Crawler and mobile cranes are designed to move from one location to another. The ground needs to be sufficiently strong to withstand the weight of the crane. To ensure the weight of the crane is evenly spread to the ground, ground support such as steel plate or load bearing mats (see Figure 12) should be used.

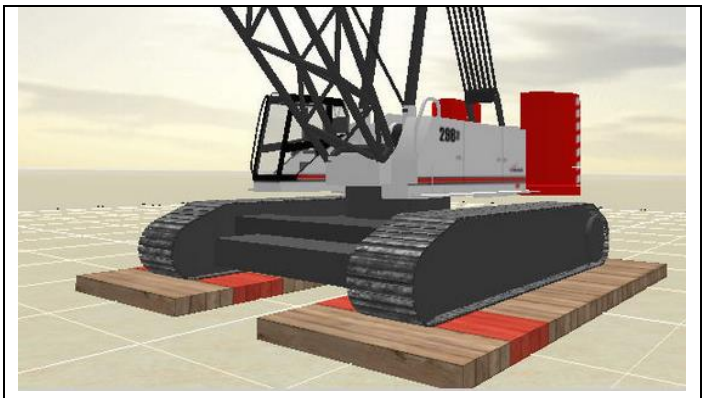


Figure 12: Load Bearing Mat

Bearing Capacity

Bearing capacity refers to the capacity of soil/ground to support the applied load. The area of the contact point between the crane and the ground such as the outrigger supports/crawler tracks/wheels/load bearing mats etc. must be determined to ensure that the bearing capacity is not exceeded. This information should be recorded in the lifting plan.

The Responsible Person should note that ground which has been backfilled without any compaction might not have sufficient bearing capacity for the proposed lifting operations. The Responsible Person should also check the proposed crane location for voids, manholes and underground services to access if the location is suitable for lifting operations. The responsible may refer to external parties (e.g., professional engineer) to assist in such determination.

Access and Lifting Location

To ensure that the public is not in danger during a lifting operation, the crane should be located such that the crane's collapse zone is within the boundaries of the worksite. If this is not possible, a detailed risk assessment should be done to review the risks associated with crane collapse and measures adopted to minimise the risks.

While planning for lifting operations, the Responsible Person should also review the route to transport the crane and its corresponding equipment (such as ballast, boom, counterweights) to the actual crane setup location. The route must also have a firm ground which can support the weight of the crane, transport vehicles and the equipment being transported. For clarity, the route can be shown on the site plan.

Excavations

When planning any lifting operation, the proposed crane location should be away from any excavation sites or soil retaining structures. If this cannot be avoided, the crane should be parked at a minimum safe distance in accordance to relevant standards.

In any event, prior to commencement of lifting operations on the day, the Responsible Person must confirm that the ground / floor has been assessed and adequately prepared to withstand the relevant maximum outrigger loading. In the event that test on the bearing capacity of the ground is to be carried out, it is prudent to apply the relevant factor of safety to all calculations for the allowable bearing capacity according to the relevant standards.

9.2 Obstacles

All obstacles (e.g. overhead structures) must be taken into consideration during the initial survey and provisions must be made to avoid collisions during the lifting operation. It must be clearly indicated in the lifting plan if such obstacles are within the path of the lifting operation.

9.3 Lighting

Sufficient lighting must be provided to ensure adequate visibility during lifting operations. For specific requirements, refer to SRPING Singapore SS 531: Code of Practice for Lighting of Workplaces.

9.4 Demarcation

The lifting operation zone should be clearly barricaded with warning signs and barriers to ensure that personnel who are not involved in the lift are not exposed to any risks.

9.5 Environment

Severe weather conditions can affect the safety of a lifting operation. Wind is a major hazard that can disrupt and put a lifting operation at risk. Cranes should not be conducting any lifting operation at wind speeds beyond the recommended in the crane manufacturer's instructions.

Heavy rain with the possibility of lightning strikes and other severe weather conditions will have to be monitored during lifting operations. The effect of rain on the load and the machine must be taken into consideration during the execution of lifts under these weather conditions. In addition, the presence of water from the rain will affect the ground condition, especially if the lifting location is near a slope. The ground should be inspected prior to the lifting operations to address any doubts about the weather conditions.

Wind Influence on the Crane and the Load

With crane operation the wind conditions can present a potential danger that should not be underestimated. The crane operator must ensure that the crane is not exposed to any wind that could exceed the limits set by the crane manufacturer.

For example, if the wind hits the load then it swings in the direction of the wind. This means that the force of the load no longer acts vertically downwards on the boom. Depending on the strength of the wind, the surface area exposed to wind and the direction of the wind, the radius of the load may increase, or impermissible lateral forces may act on the crane boom. This can cause instability to both the crane and the load which could result in overturning.

10. Sequence/Special Precautions

8. Sequence / Special Precautions

Table 8 : Part 8 of Appendix 1

The sequence of all lifting operation should be recorded in a method statement that provides step–by– step instructions that the lifting team must follow. The method statement should be included in the lifting plan where necessary.

11. Sketch of Zone of Operation/Layout Plan

9. Sketch of the zone of operation:
(It is recommended that you include the initial location of the load, the final location and path of the load. It is also important to indicate any obstructions or equipment that may obstruct the lifting operation).

Table 9 : Part 9 of Appendix 1

The layout plan can be in a form of a sketch for simple operations or a detailed engineered drawing for the difficult and complex operations. In each case, the objective of the layout plan is to ensure that the crane or lifting machine is positioned on the correct location and conduct the lifting operation safely. Refer to Figure 13 for an example of a layout plan.

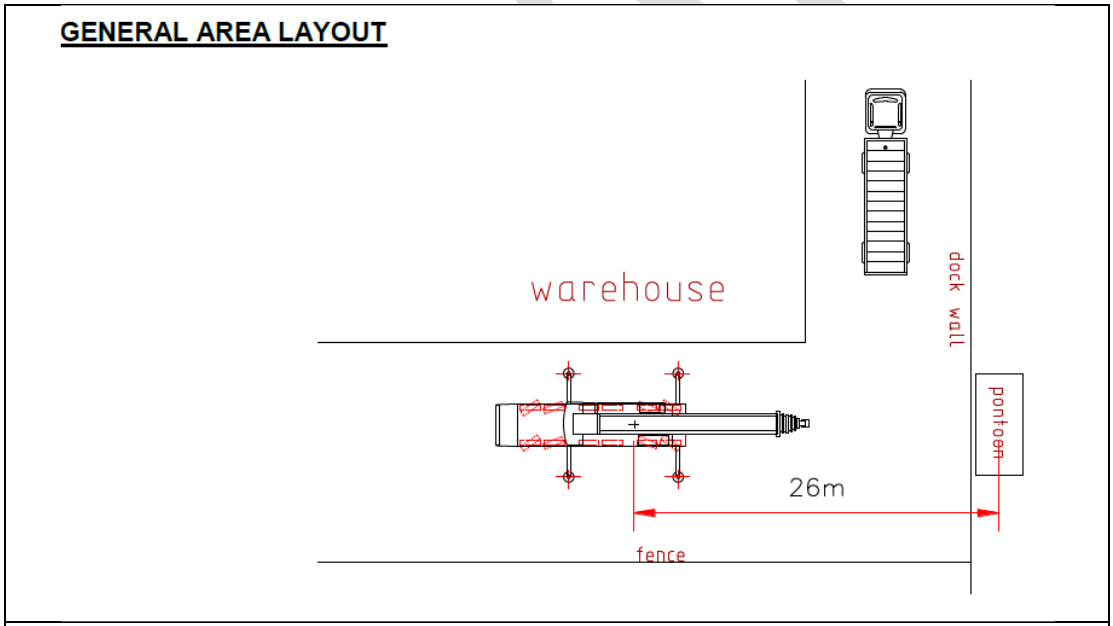


Figure 13: Example of crane layout plan of crane at site

Boom Clearance

It is always important to ensure that there is sufficient boom clearance during any lifting operation, especially in restricted and confined areas. The boom clearance and tail swing should be determined during the planning stage and recorded within the layout plan.

Boom Height and Angle

Boom angle and height are key information that must be recorded within the layout plan. Determining the boom height and angle help in the selection of a suitable crane as well as calculation of clearances of buildings and other possible obstructions. Figure 14 show an example of a load chart showing the boom height and angle.

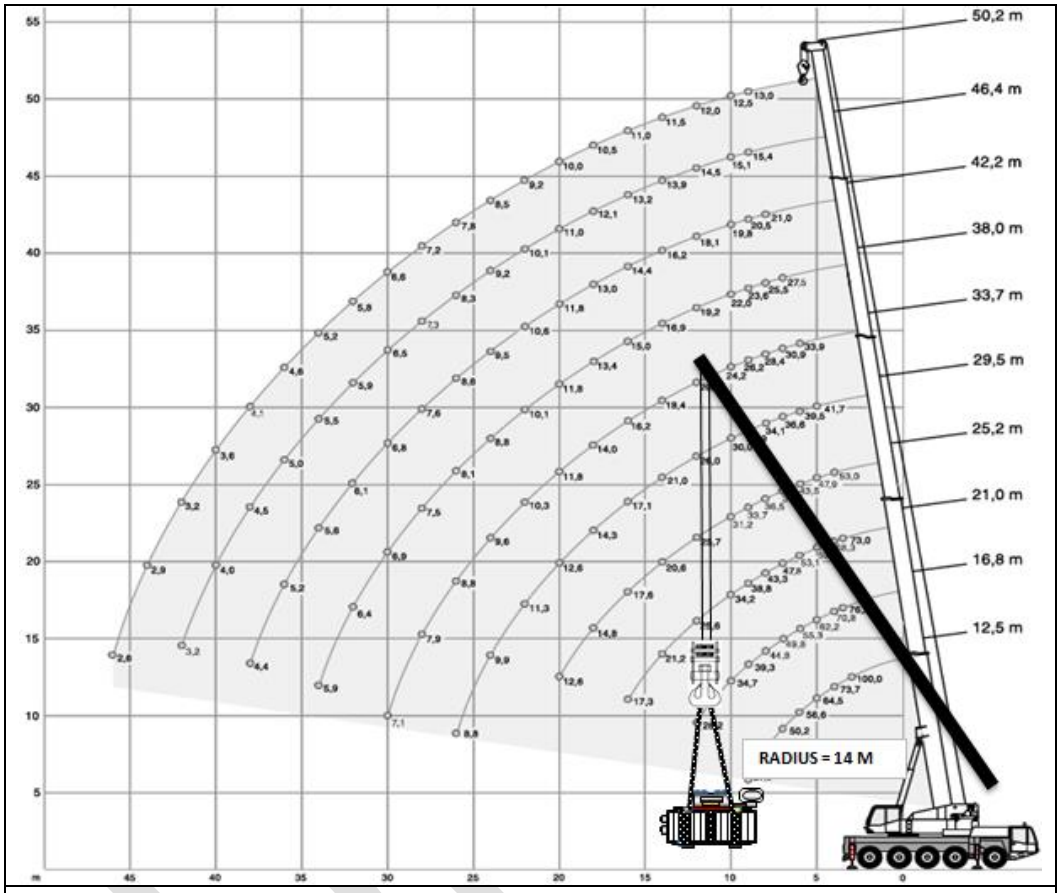


Figure 14: Example of a load chart showing boom height and angle

Pick Up and Place Down Position

Knowing the radius is extremely important and fundamental to safe lifting practices. As part of the requirement when selecting a suitable crane, when measuring the radius, make sure that both the “Pick Up and Place Down” measurements are taken and recorded within the plan.

Unit of Measurement Used in Drawing

It is important to mark the drawings with the correct information such as the unit of the weight and dimensions. Drawings must be of the same units of measurement.

Appendix 1 – Key Elements in a Lifting Plan

1. General			
Project			
Location of Lifting Operation			
Contractor carrying out the lifting operation		Date /Time of lifting operation	
		Validity Period of the Lifting Operations	

2. Details of the Load/s			
Description of load/s			
Overall Dimensions			
Weight of load	Kg / tonne	☐ Known weight	☐ Estimated weight
Centre of Gravity	☐ Obvious	☐ Estimated	☐ Determined by Drawing

3. Details of the Lifting Equipment / Lifting Gears			
Type of lifting equipment:			
Maximum SWL as certified on the LM cert		Date of last examination	
		Expiry date of certificate	
Max Boom / Jib Length	m	Fly jib / offset	
Type of lifting gears	*Slings / webbing / chains / shackles / spreader beam / receptacle*		
Combined weight of the lifting gears	Kg / tonne	Certification of lifting gears	☐ Yes ☐ No
SWL of LG	Kg / tonne		

4. Details of the Lift			
Intended Load Radius of the Lifting Equipment	*Distant between the load and the crane*	SWL of the Lifting Equipment at this radius	
Sketch and description of rigging method			

5. Means of Communications
Can the operator see the loading and unloading point for the load from his position? ☐ Yes ☐ No What are the means of communication between the lifting crew? ☐ Standard Hand Signals ☐ Radio ☐ Others _____

6. Personnel Involved In Lifting Operation		
Position	**Name**	**Qualification /Experience**
Responsible Person		
Lifting Supervisor		
Crane Operator/ Lifting Equipment Operator		
Rigger		
Signalman		
Others (Please State)		

7. Physical and Environmental Consideration (pls include any details in the space provided)		
Ground Conditions:	Is the ground made safe (e.g. placing steel plate)? _____	☐ Yes ☐ No
	Are the outriggers evenly extended? _____	☐ Yes ☐ No
Obstacles:	Are there any overhead obstacles such as power lines? _____	☐ Yes ☐ No
	Are there nearby buildings or structure, equipment or stacked materials that may obstruct lifting operation from being carried	☐ Yes ☐ No

	out safely? _____	
Lighting:	Is the lighting condition adequate? _____	□ Yes □ No
Demarcation:	Has the zone of operation been barricaded (with warning signs and tapes) to prevent unauthorised access? _____	□ Yes □ No
Environment:	Do not proceed with the lifting operation under the following circumstances: □ Thunderstorm and lightning strikes in the area. The ground condition must be checked after a thunderstorm. □ Strong winds that may sway the suspended load. □ Others circumstances (Please specify).	

8. Sequence / Special Precautions	**9. Sketch of the zone of operation:**
	(It is recommended that you include the initial location of the load, the final location and path of the load. It is also important to indicate any obstructions or equipment that may obstruct the lifting operation).

Applied by: Name:	Signature:	Date: Time :
Prepared by: Name:	Signature:	Date: Time:
Assessed by: Name:	Signature:	Date: Time:
Approved by: Name:	Signature:	Date: Time:

Note:

1. This is only a sample Lifting Plan which highlights the key elements that should be considered The content is by no mean comprehensive. Users would have to include key critical document and information such as load capacity chart, range diagram, rigging method, sling angle etc to ensure safe lifting operations.

2. Further guidance can be obtained from the following collaterals:
   - *Guidebook for Lifting Supervisors*
   - *Crane Operator's Handbook*
   - *Riggers and Signalman's Handbook*

Appendix 2 – Sling Configurations

The term “sling” covers a wide variety of configurations for fibre ropes, wire ropes, chains and webs. Correct application of slings commonly used in rigging for different purposes include the following configurations:

Single Vertical Hitch

- The Single Vertical Hitch supports a load by a single vertical part or leg of the sling.
- The total weight of the load is carried by a single leg, the sling angle is 90° (sling angle is measured from the horizontal) and the weight of the load can equal the working load limit of the sling and fittings.
- End fittings can vary but thimbles should be used in the eyes.
- The eye splices on wire ropes should be Mechanical-Flemish Splices for best security.
- The single vertical hitch must not be used for lifting loose material, lengthy material or anything difficult to balance.
- This hitch provides absolutely no control over the load because it permits rotation.
- Use single vertical hitches on items equipped with lifting eyebolts or shackles.

Bridle Hitch

- Two, three or four single hitches can be used together to form a bridle hitch for hoisting an object with the necessary lifting lugs or attachments.
- Used with a wide assortment of end fittings, bridle hitches provide excellent load stability when the load is distributed equally among the legs, the hook is directly over the load’s centre of gravity and the load is raised level.
- To distribute the load equally it may be necessary to adjust the leg lengths with turnbuckles.
- Proper use of a bridle hitch requires that sling angles be carefully measured to ensure that individual legs are not overloaded.
- Because the load may not be distributed evenly when a four-leg sling lifts a rigid load, assume that the load is carried by two of the legs only and “rate” the four-leg sling as a two-leg sling.

3-legged and 4- legged slings load distribution

- The loads can be properly distributed if the sling length can be adjusted?
- The load in 4-legged slings may only be supported by 3 legged while the 4th legged is used to balance the load.
- Unequal length sling legs may be one reason, off-centre or buckling loads another.
- The user must evaluate each lift taking into consideration the type of load, and the type of sling. Same capacity sling legs will stretch unequally if loaded unequally.

Single Basket Hitch

- The Single Basket Hitch is used to support a load by attaching one end of the sling to the hook, then passing the other end under the load and attaching it to the hook.
- Ensure that the load does not turn or slide along the rope during a lift.

Double Basket Hitch

- The Double Basket Hitch consists of two single basket hitches placed under the load.
- On smooth surfaces the legs will tend to draw together as the load is lifted. To counter this, brace the hitch against a change in contour, or other reliable means, to prevent the slings from slipping.
- One must keep the legs far enough apart to provide balance, but not so far apart that they create angles below 60 degrees from the horizontal.
- On smooth surfaces, a Double Wrap Basket Hitch may be a better choice.

Double Wrap Basket Hitch

- The Double Wrap Basket Hitch is a basket hitch wrapped completely around the load and compressing it rather than merely supporting it, as does the ordinary basket hitch.
- The double wrap basket hitch can be used in pairs like the double basket hitch. This method is excellent for handling loose material, pipe, rod or smooth cylindrical loads because the sling is in full 360° contact with the load and tends to draw it together.

Single Choker Hitch

- The Single Choker Hitch forms a noose in the rope. It does not provide full 360° contact with the load, however, and therefore should not be used to lift loads difficult to balance or loosely bundled.
- Choker hitches are useful for turning loads and for resisting a load that wants to turn.
- Consideration to be taken on the reduction capacity based on angle of the choke. When the angle of choke is less than 120 degrees, the slings choker hitch capacity is affected. To determine the actual choker capacity at a given angle of choke, multiply the slings choker rating by the appropriate reduction factor as per manufacturers recommendations.
- Using a choker hitch with two legs provides stability for longer loads.
- Like the single choker, this configuration does not completely grip the load. You must lift the load horizontally with slings of even length to prevent the load from sliding out.
- One should lift loosely-bundled loads with a Double Wrap Choker Hitch.

Double Wrap Choker Hitch

- A Double Wrap Choker Hitch is formed by wrapping the sling completely around the load and hooking it into the vertical part of the sling.
- This hitch is in full 360° contact with the load and tends to draw it tightly together.
- It can be used either singly on short, easily balanced loads or in pairs on longer loads.

Endless Slings or Grommet Slings

- Endless Slings or Grommet Slings are useful for a variety of applications.
- Endless chain slings are manufactured by attaching the ends of a length of chain with a welded or mechanical link. Endless web slings are sewn.
- An endless wire rope sling is made from one continuous strand wrapped onto itself to form a six-strand rope with a strand core.
- The end is tucked into the body at the point where the strand was first laid onto itself.
- These slings can be used in a number of configurations, as vertical hitches, basket hitches, choker hitches and combinations of these basic arrangements.
- They are very flexible but tend to wear more rapidly than other slings because they are not normally equipped with fittings and thus are deformed when bent over hooks or choked.

Braided Slings

- Braided Slings are usually fabricated from six to eight small-diameter ropes braided together to form a single rope that provides a large bearing surface, tremendous strength, and flexibility in every direction.
- They are easy to handle and almost impossible to kink.
- The braided sling can be used in all the standard configurations and combinations but is especially useful for basket hitches where low bearing pressure is desirable or where the bend is extremely sharp.

Synthetic web slings

- Synthetic web slings offer a number of advantages for rigging purposes.
- Their relative softness and width create much less tendency to mar or scratch finely machined, highly polished or painted surfaces and less tendency to crush fragile objects than fibre rope, wire rope or chain slings
- Because of their flexibility, they tend to mold themselves to the shape of the load
- They do not rust and thus will not stain ornamental precast concrete or stone.
- They are non-sparking and can be used safely in explosive atmospheres.
- They minimize twisting and spinning during lifting.
- Their light weight permits ease of rigging, their softness precludes hand cuts, and the danger of harm from a free-swinging sling is minimal.
- They are elastic and stretch under load more than either wire rope or chain and can thus absorb heavy shocks and cushion loads. In cases where sling stretching must be minimized, a sling of larger load capacity or a polyester sling should be used.
- Synthetic web slings are available in a number of configurations useful in lifting

Endless or Grommet Slings

- Both ends of one piece of webbing lapped and sewn to form a continuous piece.
- They can be used as vertical hitches, bridle hitches, in choker arrangements or as basket hitches. Because load contact points can be shifted with every lift, wear is evenly distributed, and sling life extended

Standard Eye-and-Eye

- Webbing assembled and sewn to form a flat body sling with an eye at each end and eye openings in the same plane as the sling body.
- The eyes may be either full web width or tapered by being folded and sewn narrower than the webbing width

Twisted Eye

- An eye-and-eye with twisted terminations at both ends.
- The eye openings are at 90° to the plane of the sling body.
- This configuration is available with either full-width or tapered eyes

Web slings with metal end fittings

- In place of sewn eyes, web slings are available with metal end fittings.
- The most common are triangle and choker hardware.
- Combination hardware consists of a triangle for one end of the sling and a triangle/rectangle (choker attachment) for the other end.
- With this arrangement, choker, and basket as well as straight hitches may be rigged. Such attachments help reduce wear in the sling eyes and thus lengthen sling life

Cautions when using synthetic web slings

- Despite their inherent toughness, synthetic web slings can be cut by repeated use around sharp cornered objects and abraded by continually hoisting rough-surfaced loads.
- Protective devices offered by most sling manufacturers can minimize these effects.
- Although manufacturers provide tables for bridle and basket configurations, these should be used with extreme caution. At low sling angles one edge of the web will be overloaded and the sling will tend to tear
- Slings with aluminium fittings should never be used in acid or alkali environments.
- Nylon and polyester slings must not be used at temperatures above 194°F (90°C).

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