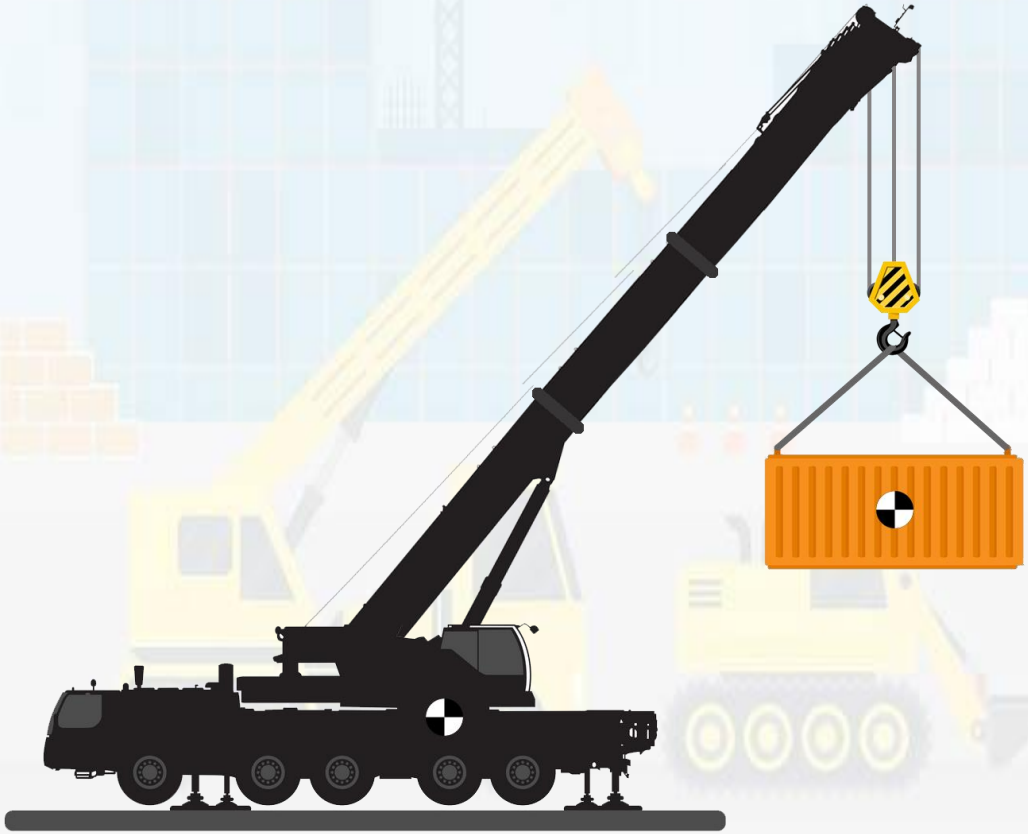
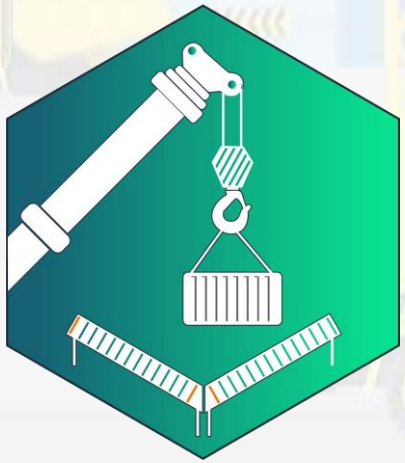
LIFTING OPERATION & RIGGING SAFETY





Why is Safe Lifting Operation Important?

Ensuring safety in lifting operations is not just a good practice; it's a necessity.

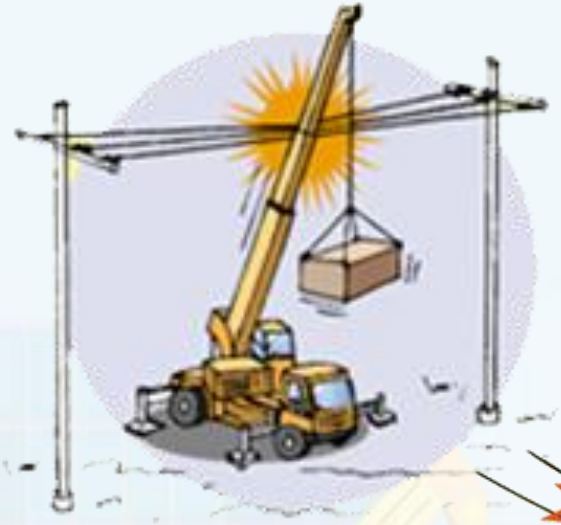
A safe operation ensures:

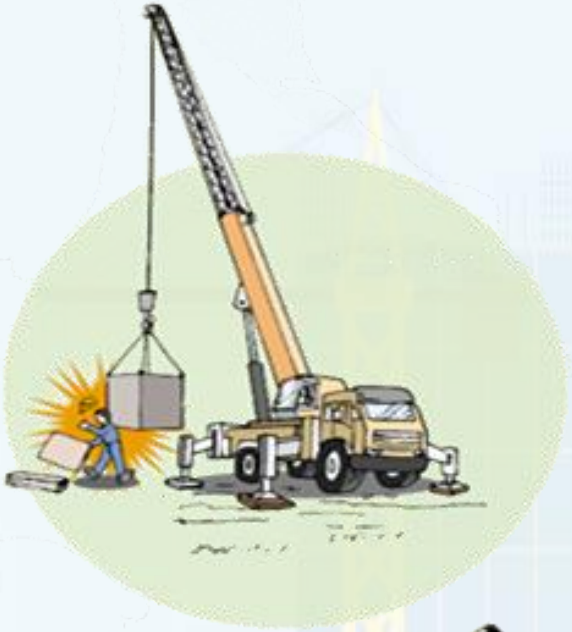
Protection of Human Lives : The primary concern is always human safety. Proper lifting operations safety minimizes the chances of fatal accidents.

Reduction in Financial Losses : Accidents can lead to equipment damage, legal liabilities, and compensation, which can be financially draining.

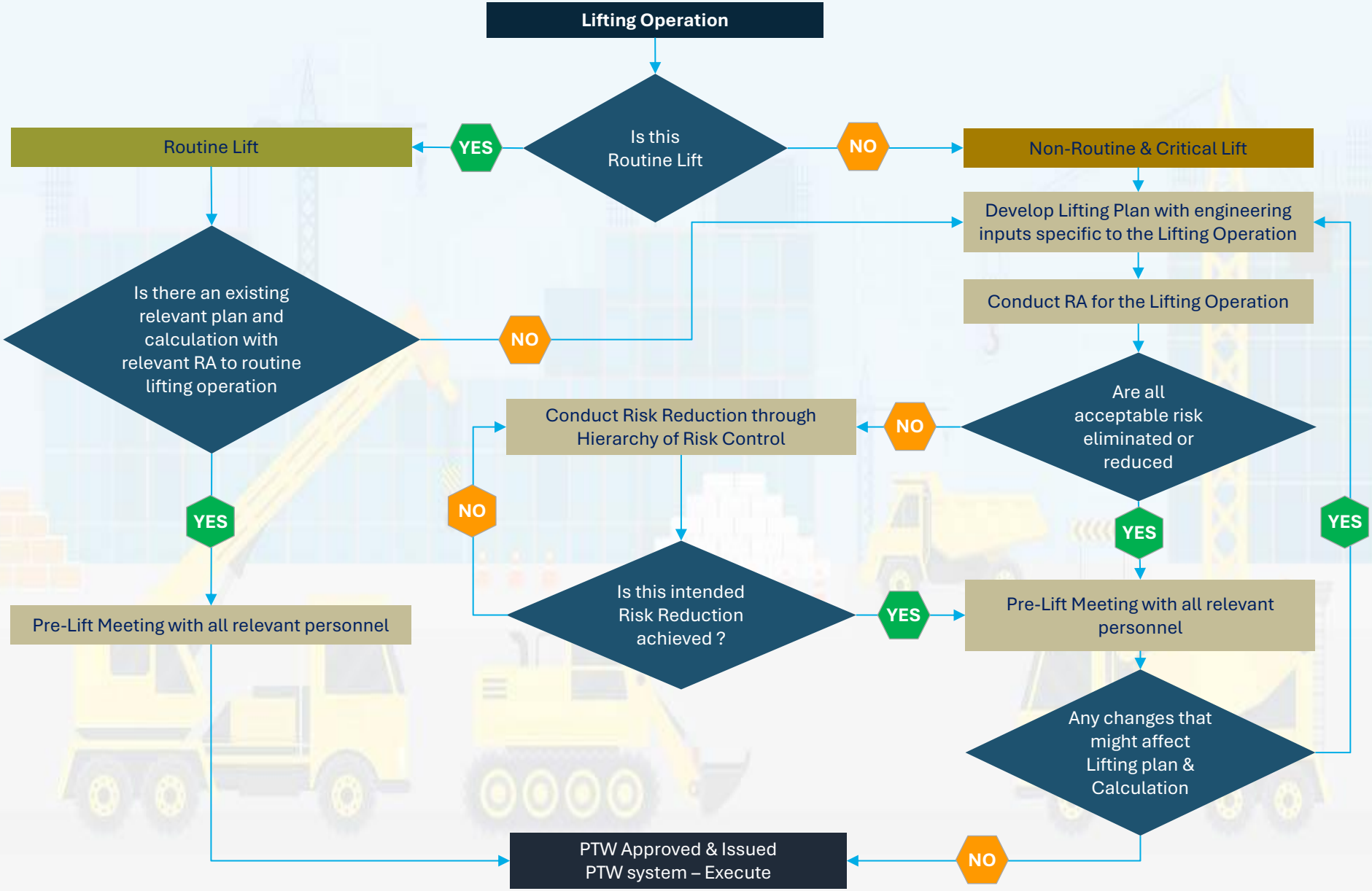
Efficiency and Productivity : A well-executed, safe operation avoids delays, equipment downtimes, and unnecessary costs.

Hazards during Lifting Operation



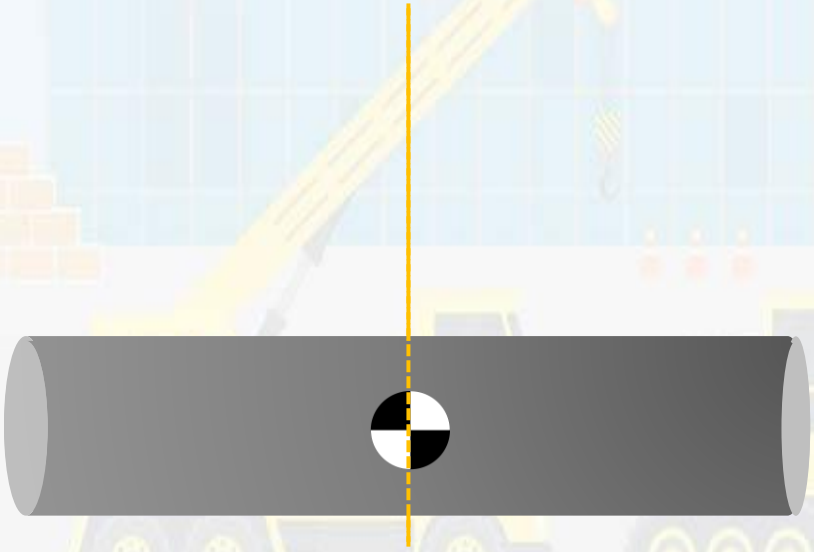


Lifting Operation - Flow Chart

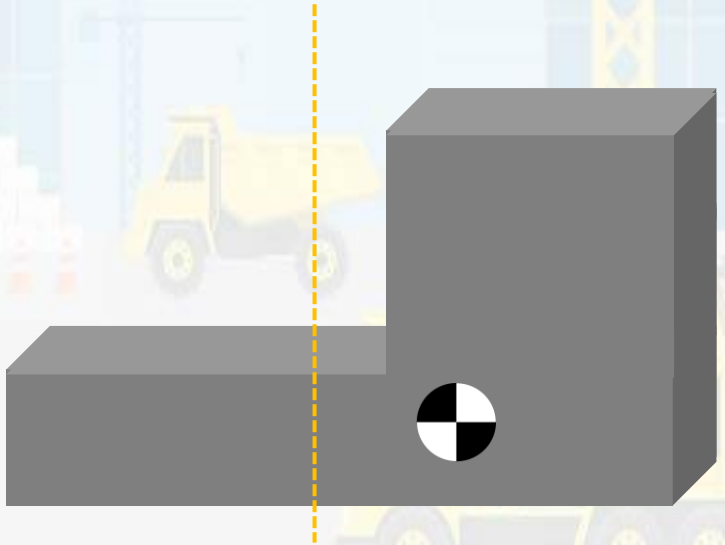


What is Center of Gravity (CoG)

The point at which the entire weight of a body may be considered as concentrated so that if supported at this point the body would remain in equilibrium in any position. CoG is not always in center of load. CoG will change according to body dimension of load

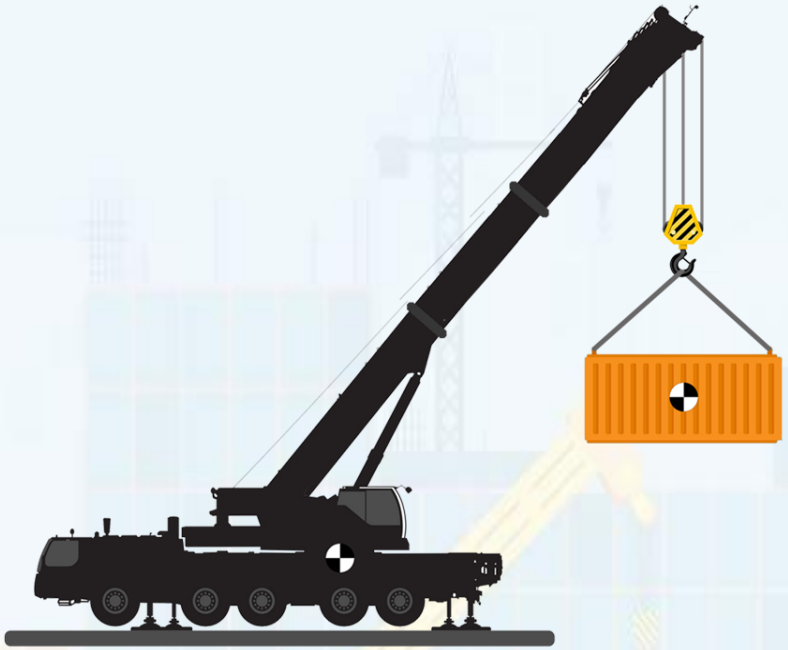


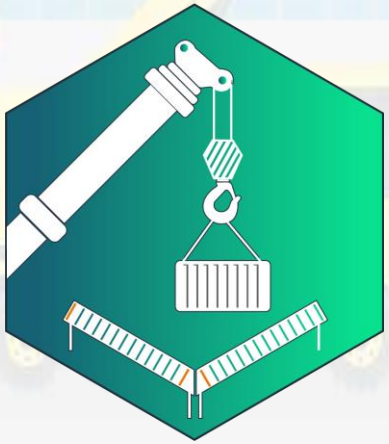
Symmetrical Load –
The CoG alone the load center line



Asymmetrical Load -
The CoG is not alone the load center line

Lifting Operation - MSRA





- Scope of Work
- Weight and Dimension of Load
- Roles & Responsbilities
- Ground condition & Underground Utilities
- Communication - Radio & Hand Signals
- Environmental Factors
- Regular & Periodic Inspections
- Type and Capacity of Crane & Load Chart
- Lifting Gears Type & WLL
- Training & Competency
- Exclusion zone & Signboards
- Lifting Gears Angle & Stability
- Permit to Work
- Regular Check-up & Periodic Maintenance

Safe Lifting Operation – 6S

Know the Load - Dimension, CoG , structural stability, Susceptibility to crushing or compression, Combination of materials, like fluids, Weight distribution, etc.

Select type, Crane which have Crane Leverage greater than Load Leverage. Consider the Lift height/ distance, Frequency of lifts, Ground conditions & obstacles, etc.

Lifting Gears(LG) capacity, lenght/size. LG safe lifting Angle.All LG load tension factor must weigh below LG rate WLL. Validity of LG certificate. Stability, Inspection, etc.

Ensure all lifting team are Trained & Competent, including Appointed Person, Rigger,etc. Establish radio communication or Hand signals.

Establish Exclusion zone with barriers according to Crane working radius. Install Safety signboards to avoid Unauthorized entry to Lifing Exclusion Zone.

Ensure Lift plan & Calculation developed. Ensure all Safe System of Work in placed. Confirm validity of all documents.

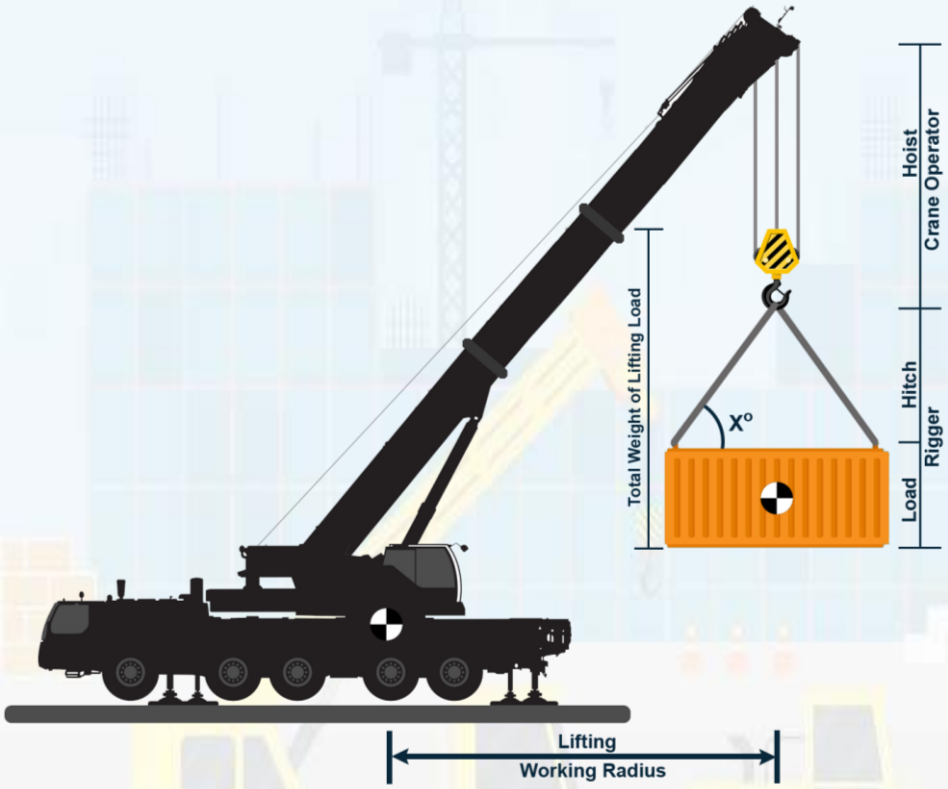
Factors to consider to calculate Load Weight

Before Rig a load to lift, consider these factors that may affect the load are,

- Heavy winds/wind gusts against the load
- Distribution of load weight.
- Shock loading.
- Weight of lifting gears & Hook block
- Friction or resistance cause by a load being lifted off of a muddy surface, or a load that's being dipped in and out
- When load lifted off (like manhole removal) from the erected place, consider the weight of materials which is adhere on load like, soil, waterproofing sheet, blinding concrete, etc.
- Loads snagging, If any.
- Dynamic side-to-side movements.
- A load being lifted off of a sloped surface.

Mobile Crane - Working Radius

Working Radius V/s Lifting Capacity



Load weight must include the weight of all lifting gears associated with the lift, including the hook block weight

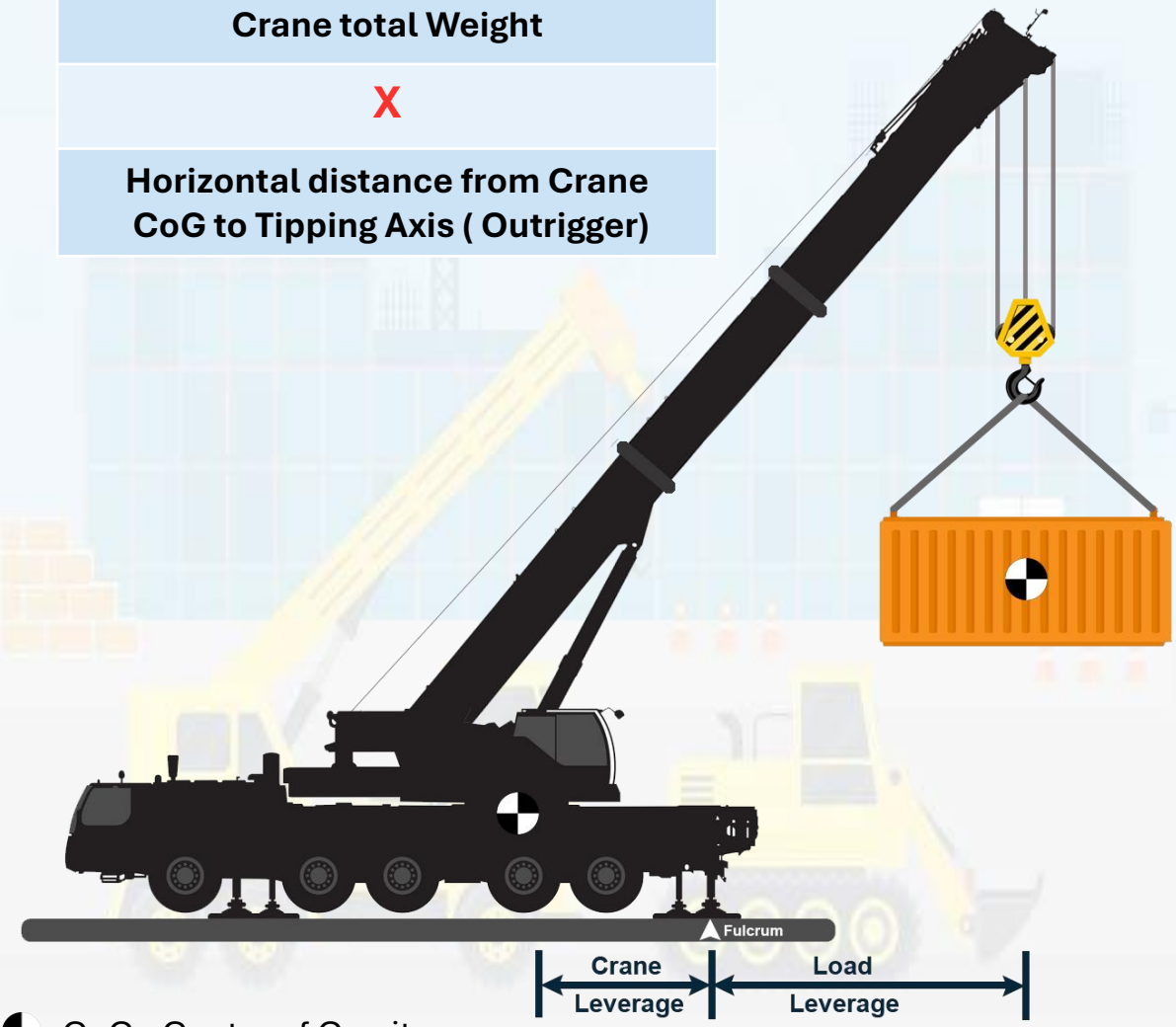
When Boom angle decreases crane working radius increase and the Safe Working Load (SWL) capacity decreases. Above 80^0 angle load will be so close to crane and risk is high, where the load will hit the crane due to any reason

When Crane Working Radius Increases Safe Working Load (SWL) capacity of Crane Decreases.

Tipping Point - Fulcrum

Crane Leverage
Crane total Weight
X
Horizontal distance from Crane CoG to Tipping Axis (Outrigger)

Load Leverage
Horizontal distance from Tipping Axis (outrigger) to Load CoG
X
Load Weight (including Lifting Gears)



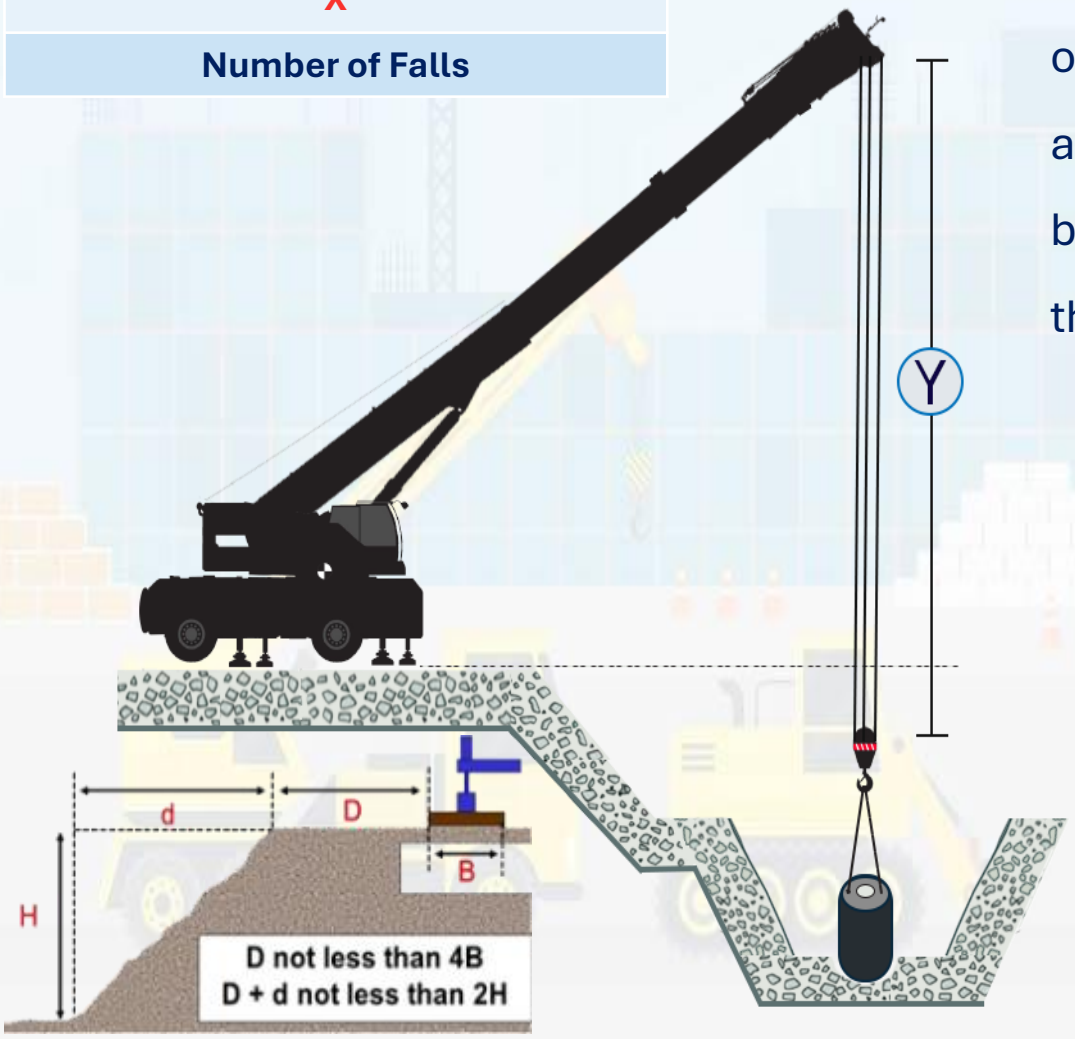
CoG - Center of Gravity

For Safe Lifting Operation
Crane Leverage > Load Leverage

Crane Tipping Condition
Crane Leverage <= Load Leverage

Weight of Lifting Load while Descent

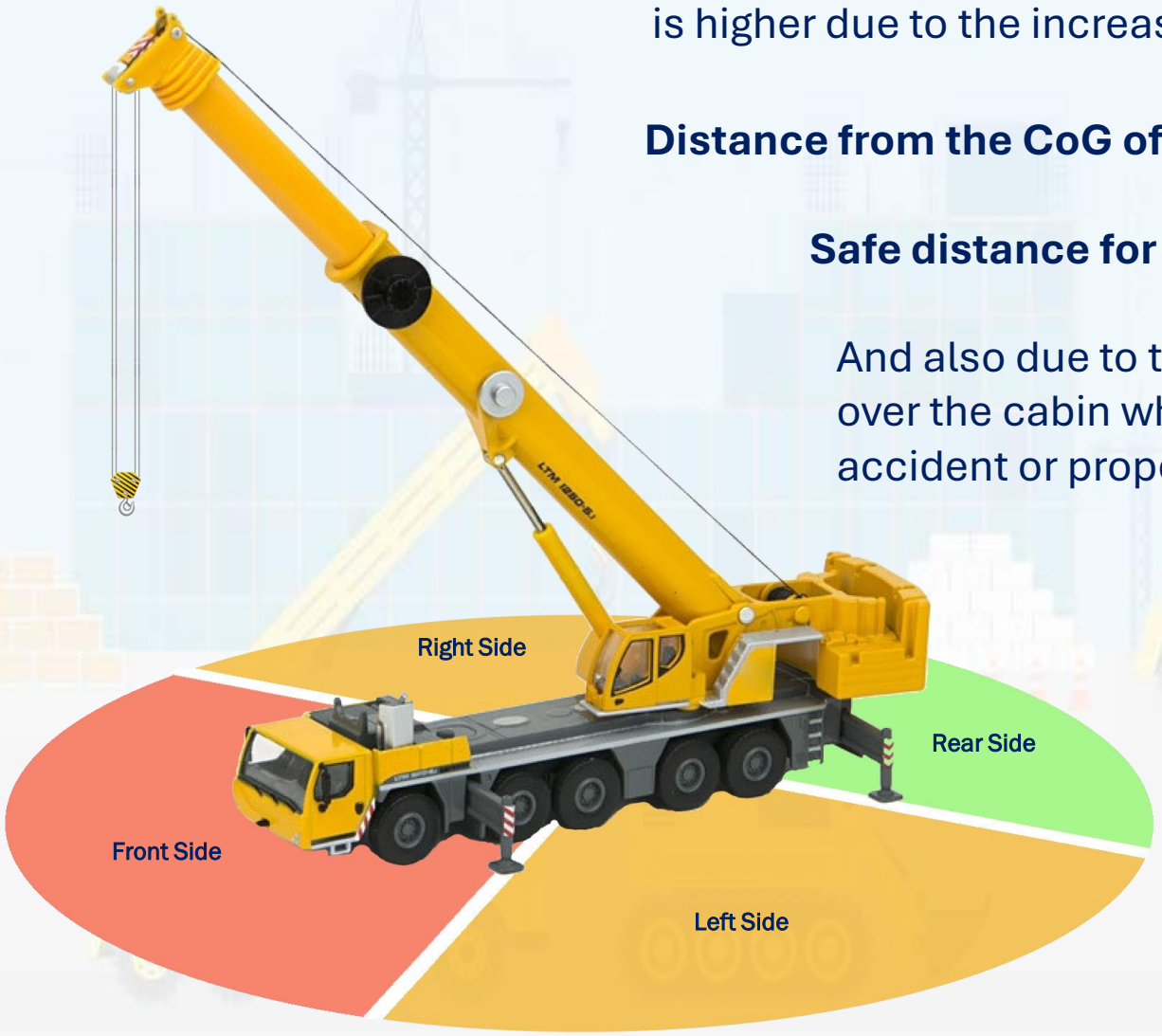
Weight of Falls
Weight of Each falls per Meter (Y)
X
Number of Falls



When crane hook block Descent below the level of crane outrigger total weight of the lifting load will be more than the actual weight of load. Due to, while hook block moving down below the outrigger the lengths of each falls increases.

Total Weight of Lifting Load
Total Weight of Falls
+
Crane Hook Block
+
Lifting Gears
+
Weight of Load

Truck Mounted Crane – 360° Working Zone



Lifting over the crane's Front side (driver cabin) risk factor is higher due to the increase of working radius

Distance from the CoG of the crane to its front bumper

+

Safe distance for load from crane body

And also due to the risk of the load moving over the cabin which can cause serious accident or property damage

Outrigger Pad Size

Outrigger floats, shall meet the following requirements:

- sufficient strength to prevent crushing, bending, or shear failure
- such thickness, width, and length, as to completely support the float, transmit the load to the supporting surface, and prevent shifting, toppling, or excessive settlement under load

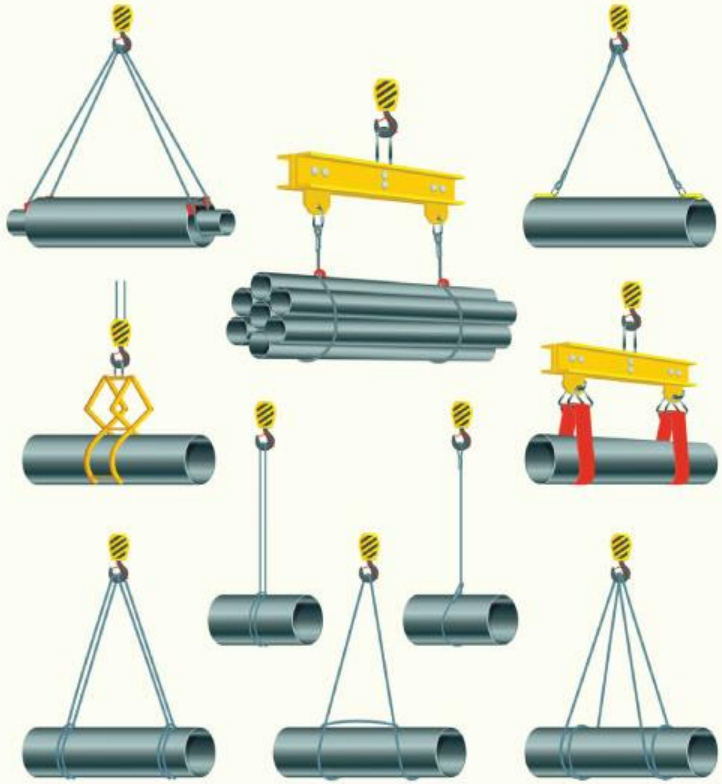
$$\text{Area} = \text{Force (kN)}$$

$$\text{Required crane mat bearing area } (m^2) = \frac{(\text{Crane load} + \text{Total weight of load}) \times 9.8 m/s^2}{\text{Maximum permissible ground pressure}}$$

Crane Mat Strength & Stiffness

The strength and stiffness of the crane mats will depend on the material and the thickness, shear strength, bearing capacity and bending strength.

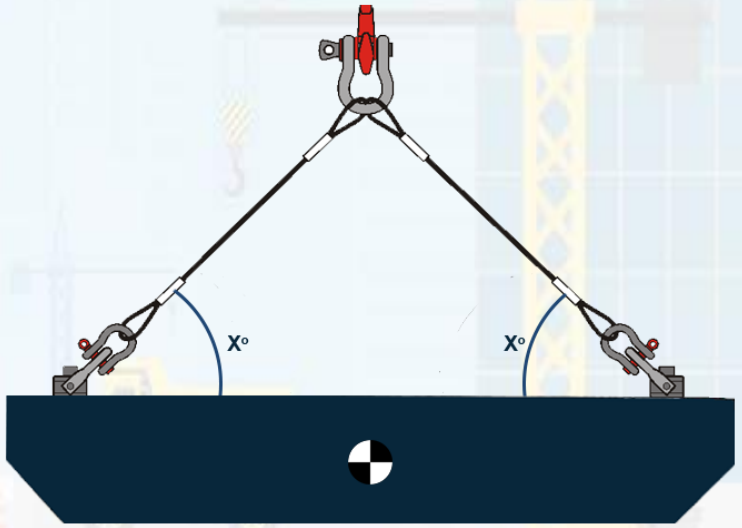
Sling Safety



Sling Angle Factor

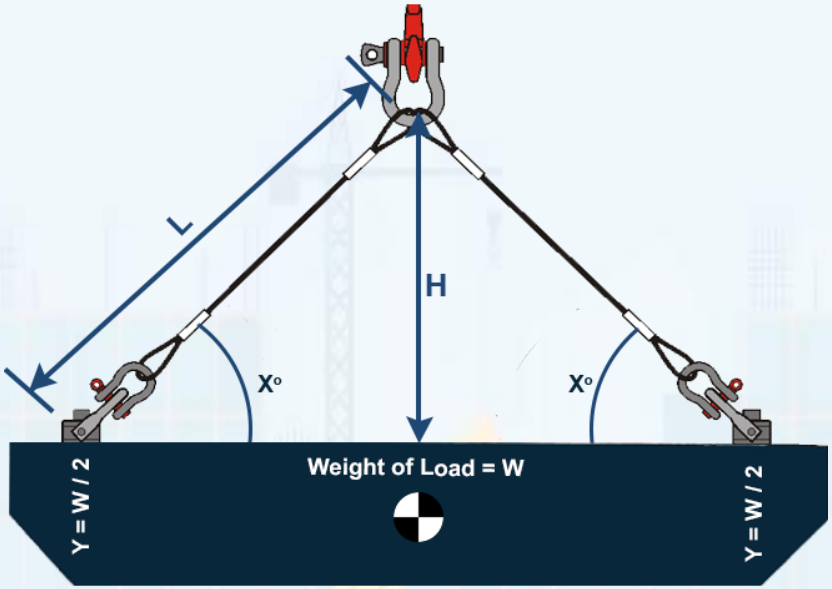
The Sling Angle Factor is a multiplier used to determine the additional tension on a sling when angle formed between sling and load is less than 90°

The rated capacity of a multiple leg sling is directly affected by the angle of the sling leg with the load. As this angle (X°) decreases, the stress on each leg increases with the same load. If the sling angle is known, the capacity can be readily determined by multiplying the sling's vertical capacity by the appropriate load angle factor.



Avoid rigging loads where angle (X°)is less than 45°

Load Angle Factor – Sling Tension



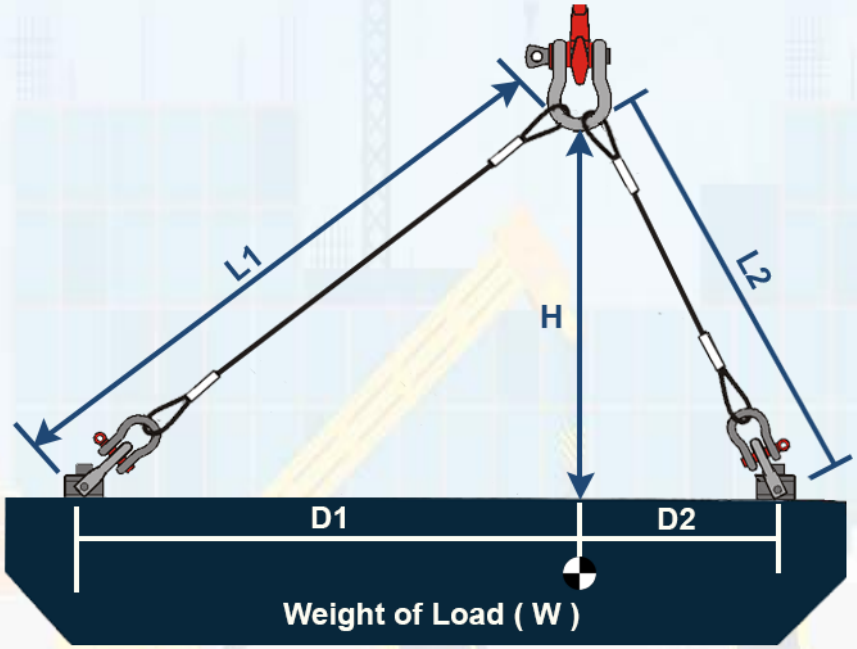
When the CoG is equal between pick points, the sling and fittings will carry an equal share of the load.

Load on Each Leg of Sling
$\frac{W \times \text{Load Angle Factor } (X^{o})}{\text{Number of Legs}}$

Load Angle Factor (Sling tension) = Sin X^{O}

Load Angle (X)	Tension Factor	Remarks
90º	1.000	GOOD
85º	1.004	
80º	1.015	
75º	1.035	
70º	1.064	
65º	1.104	
60º	1.155	
55º	1.221	CAUTION
50º	1.305	
45º	1.414	
40º	1.55	WARNING
35º	1.742	
30º	2.000	

CoG & Load Weight on each Unequal Sling

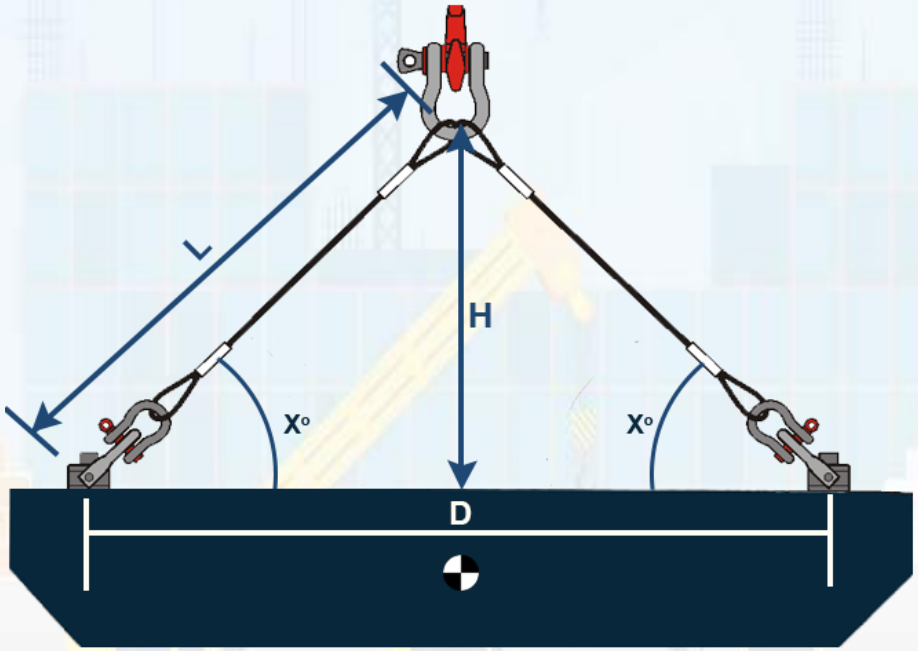


When the CoG isn't equal between pick points, the sling and fittings won't carry an equal share of the load.

The sling attached to the closest to the CoG will carry the greatest share of the load.

Load Weight on Each Leg of Sling
S1 = W X D2 X L1 / { H (D1+D2) }
S2 = W X D1 X L2 / { H (D1+D2) }

Determining Sling Angle



A good thumb rule is to always have

L (Length of sling)

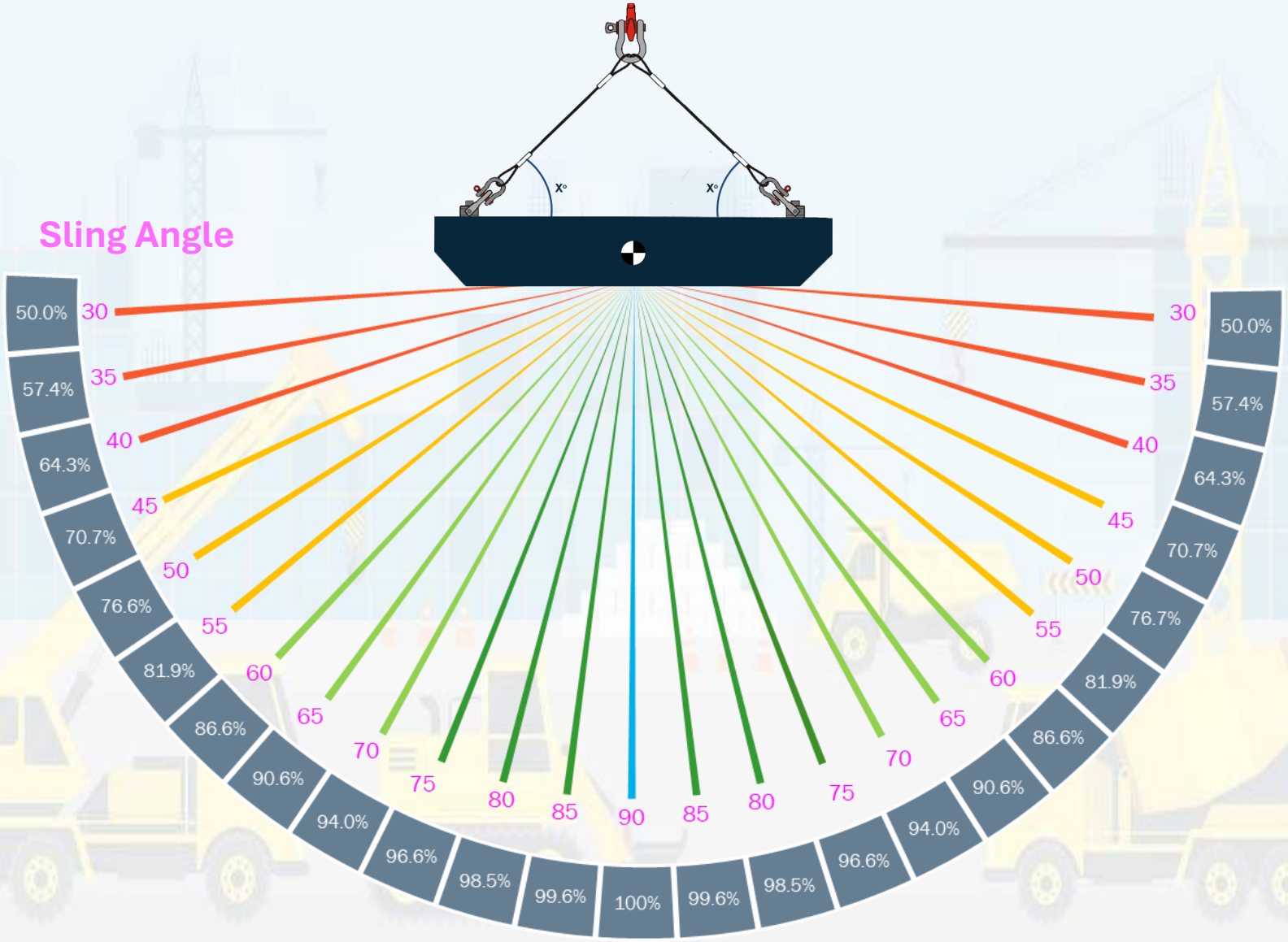
>=

D (Distance between the lift point)

The length of sling is longer than between the lift points, then sling angle will be more than 60º angle .

If using more than 2 lift point at a time, then consider the distance between two longer lift points.

Sling Angle V/S Sling Load Capacity



Sling Load Capacity %

Sling Angle – Choker Hitch

Sling Angle Loss Factor.

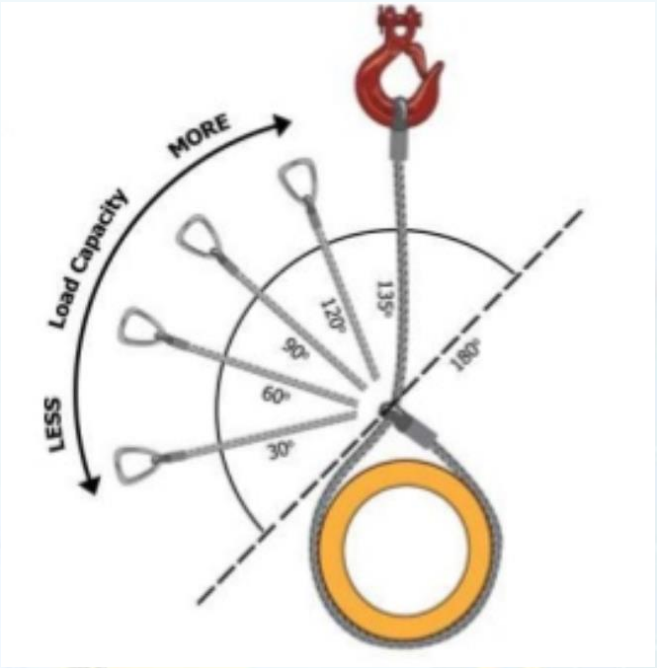
The use of choker hitches reduce a sling's load limit.

The angle of choke can reduce the load limit further.

Once angle of choke has been determined multiply the appropriate loss factor to slings capacity to determine the reduced load limit.

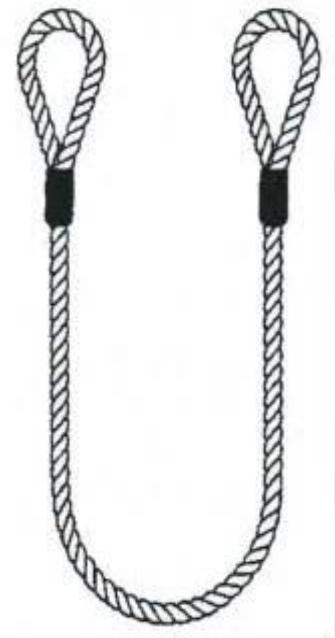
The total load weight must not exceed the reduced load limit.

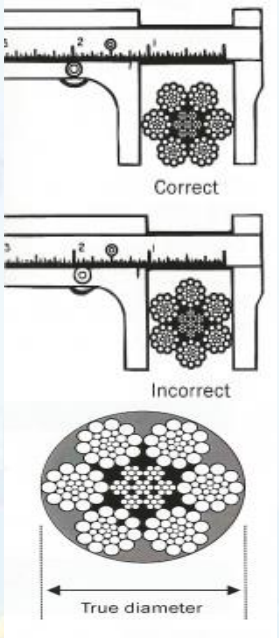
Choker Hitch Rated Capacity - A choker hitch will have 75% of the capacity of a single leg vertical hitch only if the corners are softened and the horizontal angle is greater than 30°.

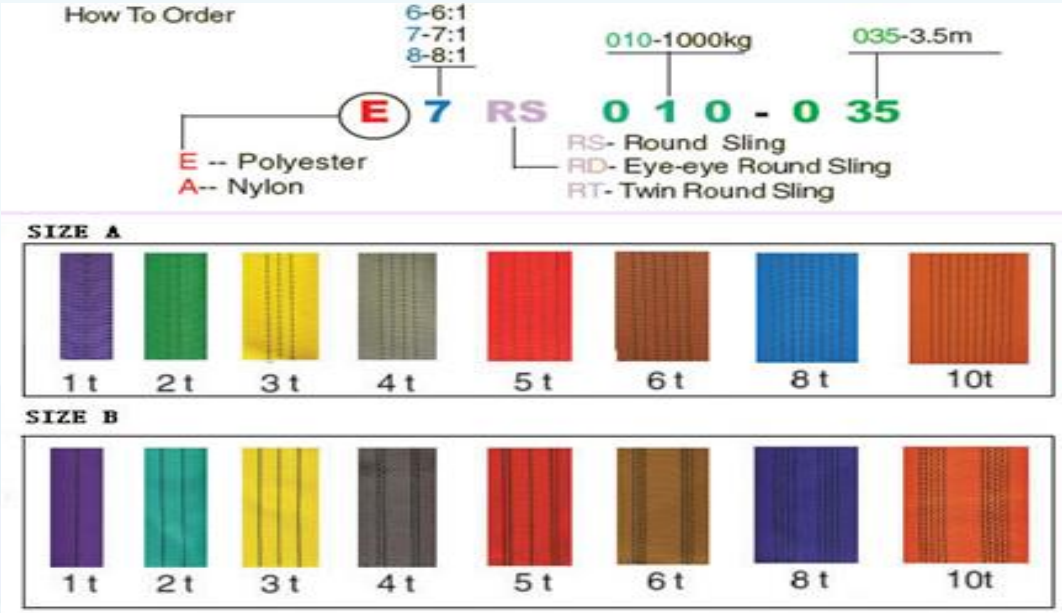


Angle of Choke (Degree)	Loss Factor	Remarks
> 120	1.000	GOOD
120 - 90	0.870	
89 - 60	0.740	CAUTION
59 – 30	0.620	
29 – 0	0.490	DANGER

WLL of Sling





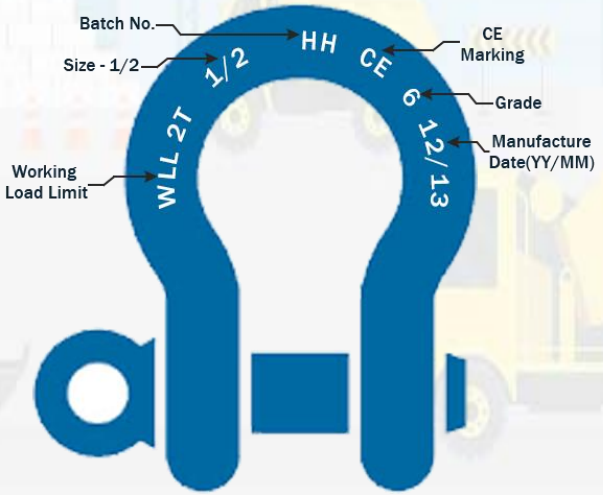


WLL of Wire Rope Sling

=

Diameter X Diameter X 8

(D^2 X 8)



When wire rope diameter calculate in

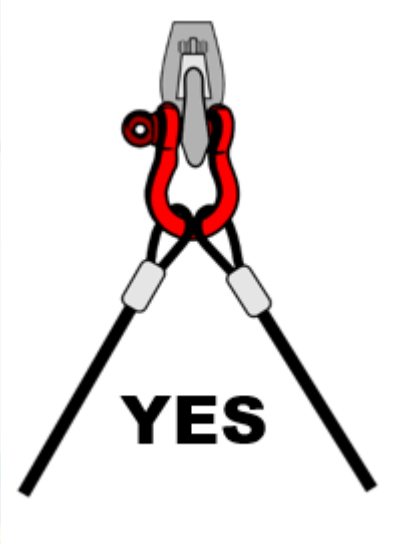
Inch = WLL calculated in Ton

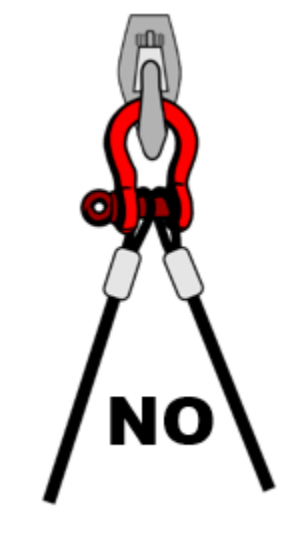
mm = WLL calculated in Kg

Safe position of Lifting Gears

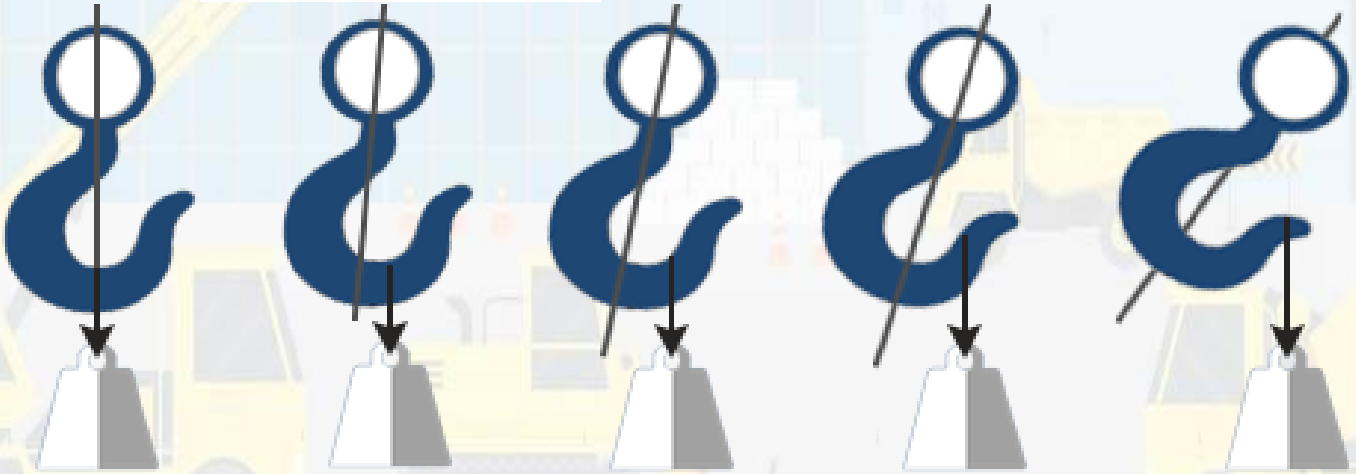
Washer can be used to take up the space between the Shackle & Hook

Pin should be tight, not backed off.





Shackle spread and sling eyes can be damage



Can Carry 100% of Rated Load

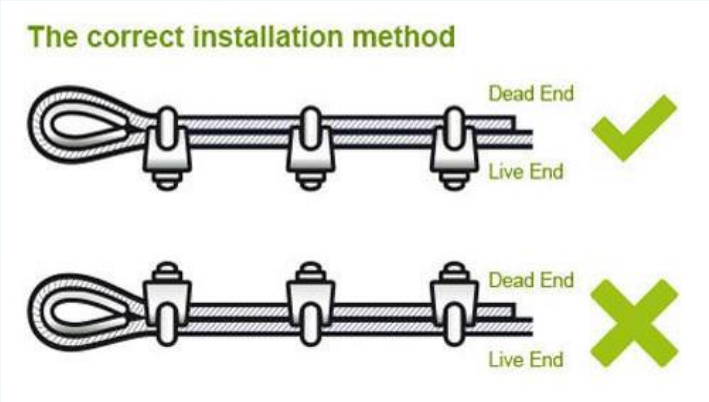
Can Carry apporx 86% of Rated Load

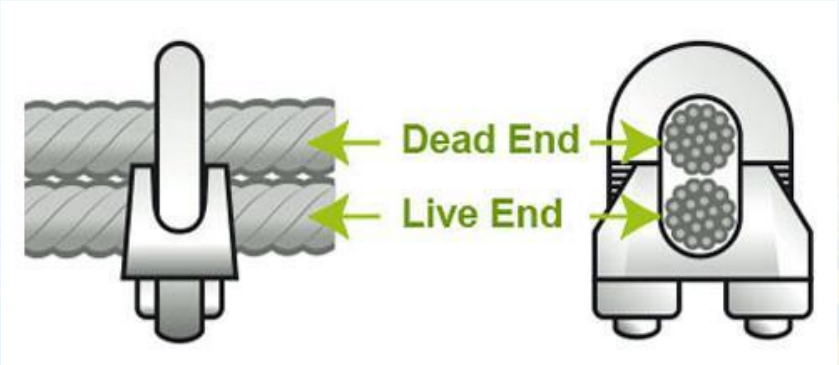
Can Carry apporx 80% of Rated Load

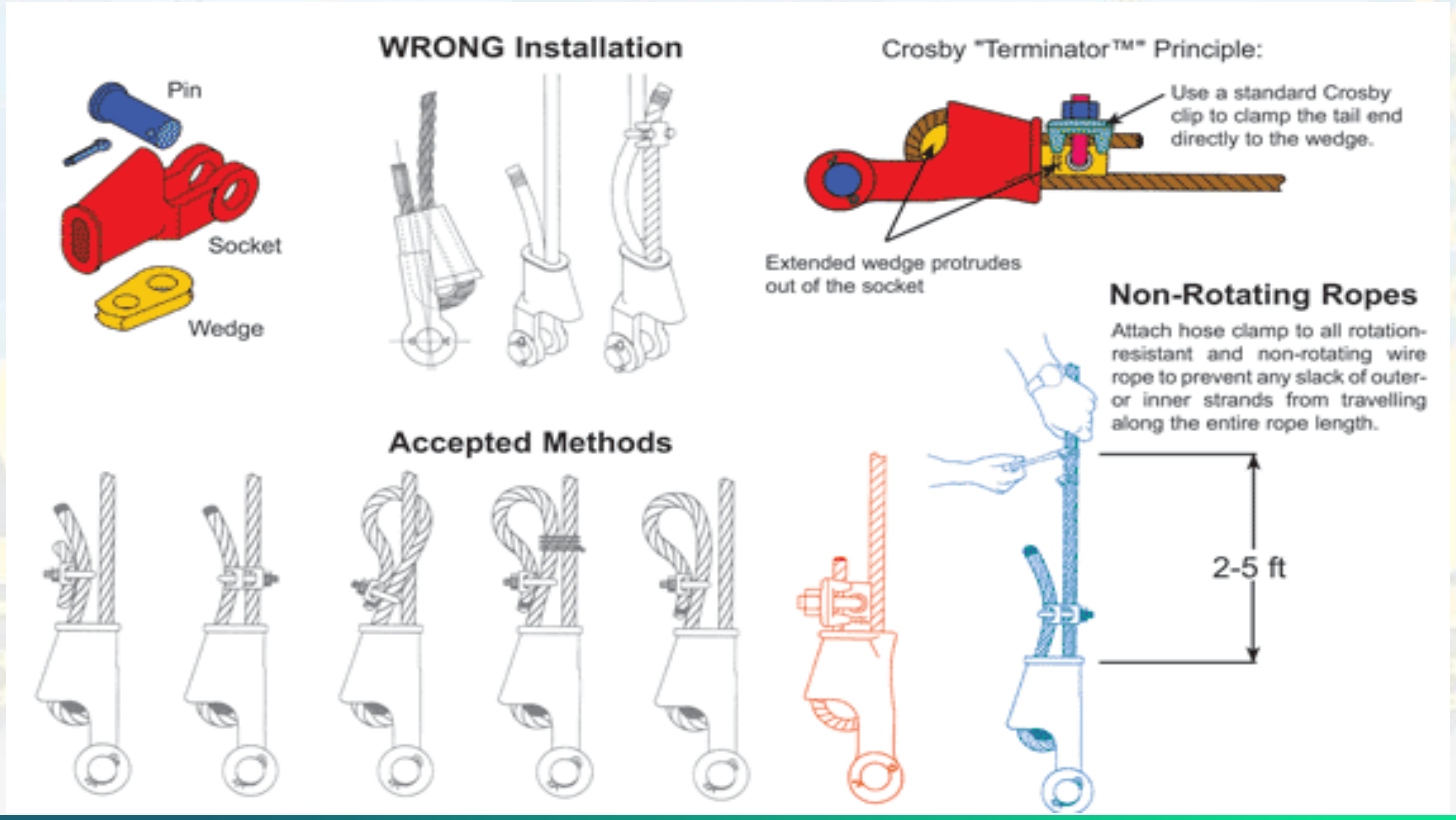
Can Carry apporx 70% of Rated Load

Can Carry apporx 40% of Rated Load

Wire Clip Safe position







Safe Rigging - SLING

S

Shape & Weight of Lifting Load

Know Load :

Weight
Dimension
Center of Gravity
Structural Stability
Nature of the load
Uneven Shape

L

Length & Type of Lifting Gears

Factors to Consider

Working Load Limit
Length
Size (Dia)
Type
Durability
Flexibility

I

Inspection of Lifting Gears

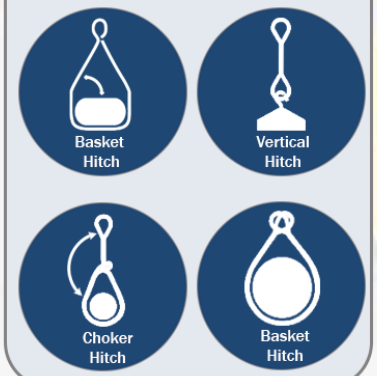
Factors to Consider

Cuts & Crack
Cracks & Contusion
Downgrading
Abrasion
Kinks or Bent
Load Test

N

Nature of Lifting Gears Angle

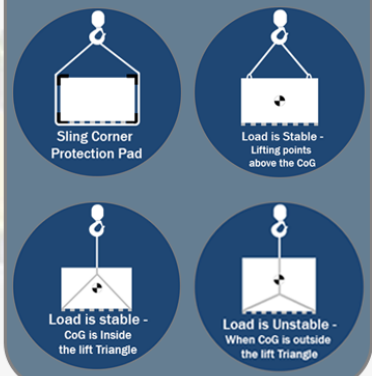
The Sling-to-Load Angle is the angle formed between a horizontal line and the sling leg or body. The Sling-to-Load Angle has a dramatic effect on Sling Working Load Limits.



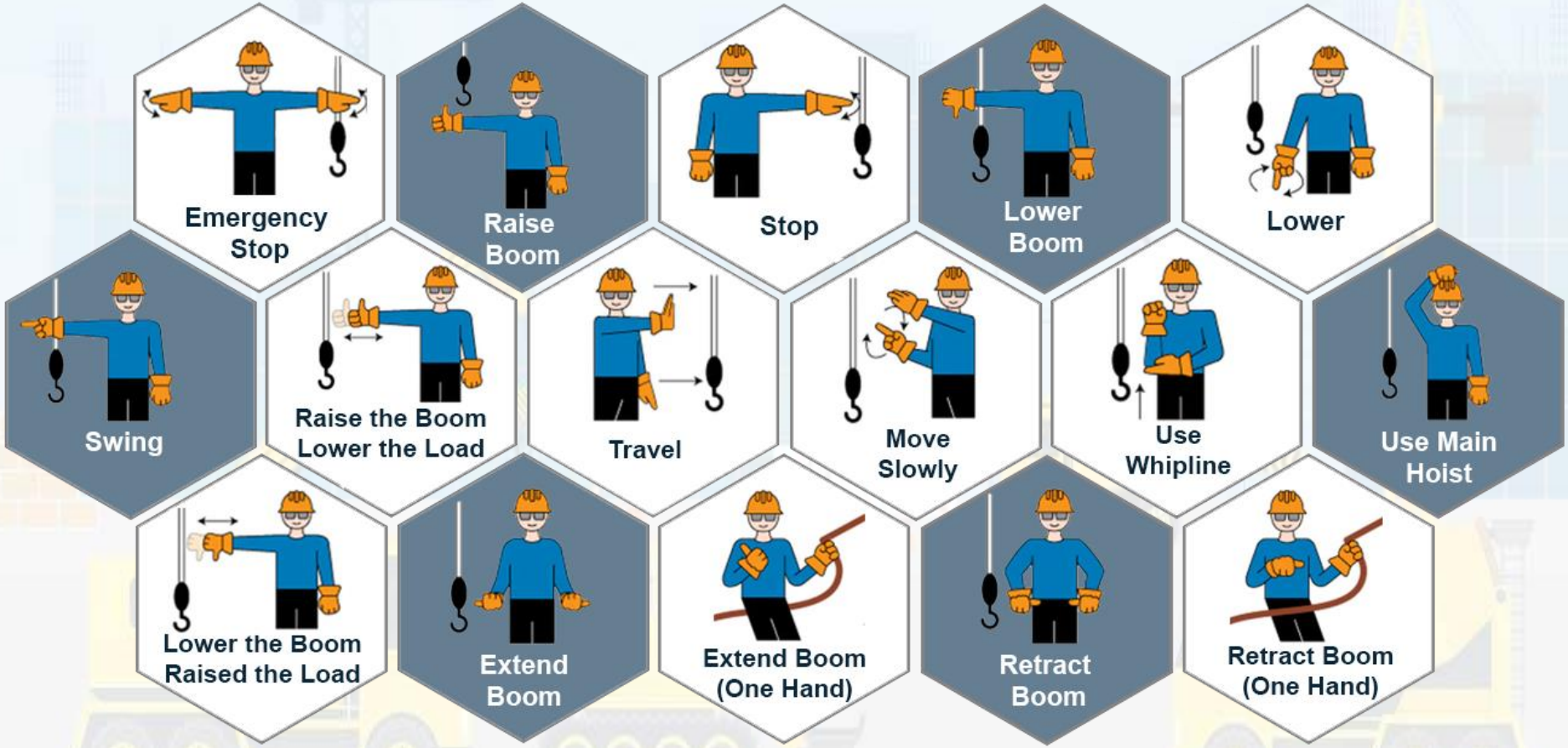
G

Grip & Stability of Lifting Load

Load stability is achieved by determining the location of CoG. To achieving , load CoG and Sling lifting point CoG align in a straight line & Sling lifting point above the load CoG



Mobile Crane - Hand Signals



What Size of Crane required for Safe Lifting

Crane Chart (Load X Working Radius)

Radius / Load	7m	8m	9m	10m	12m	14m	16m	18m	20m	22m	24m	26m	28m	30m	32m	34m	36m	38m	40m	42m	44m	46m	48m	50m	52m	54m
0.5T	20T	20T	20T	20T	20T	20T	20T	20T	20T	20T	25T	25T	35T	35T	50T	50T	70T	70T	80T	80T	80T	90T	120T	120T	120T	120T
1T	20T	20T	20T	20T	20T	20T	20T	20T	25T	25T	35T	35T	50T	50T	60T	70T	70T	70T	80T	80T	90T	100T	120T	120T	120T	120T
2T	20T	20T	20T	20T	20T	20T	25T	25T	35T	35T	50T	50T	60T	60T	70T	80T	80T	80T	90T	100T	100T	120T	120T	160T	160T	160T
3T	20T	20T	20T	20T	20T	25T	35T	35T	50T	50T	60T	70T	70T	80T	80T	90T	90T	100T	100T	120T	120T	160T	160T	160T	200T	200T
4T	20T	20T	20T	20T	25T	35T	35T	50T	50T	60T	70T	80T	80T	90T	90T	100T	100T	120T	120T	160T	160T	160T	160T	200T	225T	225T
5T	20T	20T	25T	25T	35T	35T	50T	50T	60T	70T	80T	80T	90T	100T	100T	120T	120T	160T	160T	160T	160T	200T	200T	225T	250T	300T
6T	25T	25T	25T	25T	35T	50T	50T	60T	70T	80T	90T	90T	100T	100T	120T	160T	160T	160T	160T	160T	200T	225T	225T	225T	250T	300T
7T	25T	25T	25T	35T	50T	50T	60T	70T	80T	90T	100T	100T	120T	120T	160T	160T	160T	160T	200T	200T	225T	225T	250T	250T	300T	300T
8T	25T	35T	35T	35T	50T	60T	60t	80T	90T	90T	100T	120T	120T	160T	160T	160T	200T	200T	225T	225T	250T	250T	250T	300T	300T	800T
9T	35T	35T	35T	50T	50T	60T	70T	80T	90T	100T	120T	120T	160T	160T	160T	200T	225T	225T	225T	250T	250T	250T	300T	300T	800T	800T
10T	35T	35T	35T	50T	60T	70T	80T	90T	100T	120T	160T	160T	160T	160T	200T	225T	225T	225T	250T	250T	250T	300T	800T	800T	800T	800T
11T	35T	35T	50T	50T	60T	80T	90T	100T	100T	120T	160T	160T	160T	200T	225T	225T	250T	250T	250T	300T	300T	300T	800T	800T	800T	800T
12T	35T	50T	50T	50T	70T	80T	100T	100T	120T	120T	160T	160T	160T	200T	225T	225T	250T	250T	300T	300T	300T	400T	800T	800T	800T	800T
13T	35T	50T	50T	50T	80T	80T	100T	120T	120T	160T	160T	160T	200T	225T	225T	250T	250T	250T	300T	300T	400T	400T	800T	800T	800T	800T
14T	50T	50T	50T	50T	80T	90T	100T	120T	120T	160T	160T	200T	200T	250T	250T	250T	250T	250T	300T	400T	400T	400T	800T	800T	800T	800T
15T	50T	50T	60T	70T	80T	100T	100T	120T	160T	160T	160T	200T	225T	250T	250T	250T	250T	300T	400T	400T	400T	400T	800T	800T	800T	800T
16T	50T	50T	60T	70T	80T	100T	120T	120T	160T	160T	200T	200T	225T	250T	250T	250T	300T	400T	400T	400T	400T	400T	800T	800T	800T	800T
17T	50T	60T	70T	70T	90T	100T	120T	160T	160T	160T	200T	225T	225T	250T	250T	300T	300T	400T	400T	400T	400T	400T	800T	800T	800T	800T
18T	60T	70T	70T	80T	90T	100T	120T	160T	160T	200T	200T	225T	250T	250T	250T	300T	400T	400T	400T	400T	400T	500T	800T	800T	800T	800T
19T	60T	70T	70T	80T	100T	120T	120T	160T	160T	200T	200T	225T	250T	250T	300T	400T	400T	400T	400T	400T	400T	500T	800T	800T	800T	800T
20T	60T	70T	80T	80T	100T	120T	160T	160T	200T	200T	225T	225T	250T	250T	300T	400T	400T	400T	400T	400T	400T	500T	800T	800T	800T	800T

Mobile Crane Lift Calculation Sheet

Contractor Logo	On - Site Mobile Crane - Lift Calculation	

Contract Name :		**Date & Time** :	
Project No. & Name :		**Location** :	

SET UP CHECKLIST

To be completed by Appointed Person / Lifting Supervisor

SN	Description	Yes	No	Remarks
1	Mobile Crane set on level ground & Suitable Outrigger Pad provided ?			
2	Lifting swing route identified and free from obstacles ?			
3	Is the swing working area of the Mobile Crane identified & barricaded ?			
4	Pre-start Inspection checklist of the crane complete and safe to commence work ?			

** If answer is NO to any of these questions, DO NOT COMMENCE LIFT **

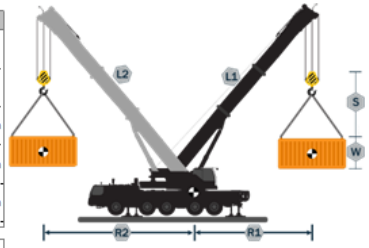
Details of Load		
Type of Load	:	

Dimension of Load		
Length		M
Width		M
Height		M
Lifting Points		No's

Details of Lifting / Rigging Gears					
Description	Weight Per Piece	Qty	Total Weight (Ton)	Capacity - WLL* / each	
Wire Rope					Ton
Web Sling					Ton
Spreader Beam					Ton
D Shackle					Ton
Chain Sling					Ton

*WLL - Working Load Limit

Offloading		
L2		
Boom Length	=	M
R2		
Working Radius	=	M
W		
Load Weight	=	Ton
S		
Lifting Gears + Hook	=	Ton
W+S		
Total Weight	=	Ton



Loading		
L1		
Boom Length	=	M
R1		
Working Radius	=	M
W		
Load Weight	=	Ton
S		
Lifting Gears + Hook	=	Ton
W+S		
Total Weight	=	Ton

Crane Load Capacity (Load Safe Indicator / Load Chart) = Ton with R2 & L2	Counter weight = Ton	Crane Load Capacity (Load Safe Indicator / Load Chart) = Ton with R1 & L1
(%) Mobile Crane Capacity Utilized: Total Weight / Crane Load Capacity x 100 = %	Weight of Hook = Ton	(%) Mobile Crane Capacity Utilized: Total Weight / Crane Load Capacity x 100 = %
	No. of Falls (Wire Rope) = No's	
Size of Outrigger Pad =	Crane Boom Angle = Deg	Wind Speed = Km/Hr

Crane Type & Make	Crane Model	Cane Lifting Capacity (Max)	Body Plate No.
		Ton	

SIGN OFF SECTION

Designation	Name	Signature	Date	Time
Operator				
Lifting Supervisor				
Appointed Person				

Mobile Crane Lift Calculation Sheet Rev.03

MY SAFETY PLEDGE

Thank You