**Step 7: Rounding Final Pad Size (Always Round Up)**
Since the design of a crane and its pad will normally not be made using irregular measurement intervals it is important to **round all values to the nearest meter**.

***NOTE:****Since rounding down could result in a "**Pad Size**" that would be below the minimum safe requirements **it is important that all values are rounded UP**.*

| **Square Pad:** | **Circular Pad:** |
|---|---|
| **Side = 3.73m** | **Radius = 2.11m** |
| **Side = 4m** | **Radius = 3m** |

**Step 8: Determine the Outrigger Point Load**
The final step is to determine the **"Outrigger Point Load" (OPL)** for the final design of the crane. The OPL value takes into consideration the weight of the crane, the load, pad size, and the stability of ground that the crane has been placed on. The equation is:

***Outrigger Point Load = Ground Pressure / Final Pad Size***

***OPL = GP / FPS***
***OPL = 106.75t / (4m x 4m)***
***OPL = 106.75t / 16m²***
***OPL = 6.67t/m²***

In conclusion, if the final "outrigger point load" for the crane based on the specified value is 6.67t/m². As long as the **"Outrigger Point Load" OPL** value is less than "ground bearing pressure" GBP the crane can safely be used.

**Extension Activity:**

1. Calculate the **Pad Size (PS)** that would be needed if:
   a) The crane has a **Point Load (PL)** of 125t, an **Irregular Load (IL)** of 50t, and the crane will be installed on **dense gravel**.
   b) The crane has a **Point Load (PL)** of 125t , an **Irregular Load (IL)** of 50t, and the crane will be installed on **soft clay or silts**.
   c) Determine the **Outrigger Point Load (OPL)** for both scenarios.

2. Determine if the **Pad Size (PS)** of your crane is large enough.
   a) Can you operate your crane under a wide variety of scenarios? Why?
      i. What is the required **Pad Size (PS)** that is needed for your crane to operation under all situations? ***NOTE:*** *this will the the largest pad size that you calculated which will allow the crane to be use on unstable ground.*
      ii. What would the necessary pad size be for your model (scale is 1:500)?
   b) Think about what you could do if the **Pad Size** in your proposed crane design is not large enough. What modifications could make your crane safer?

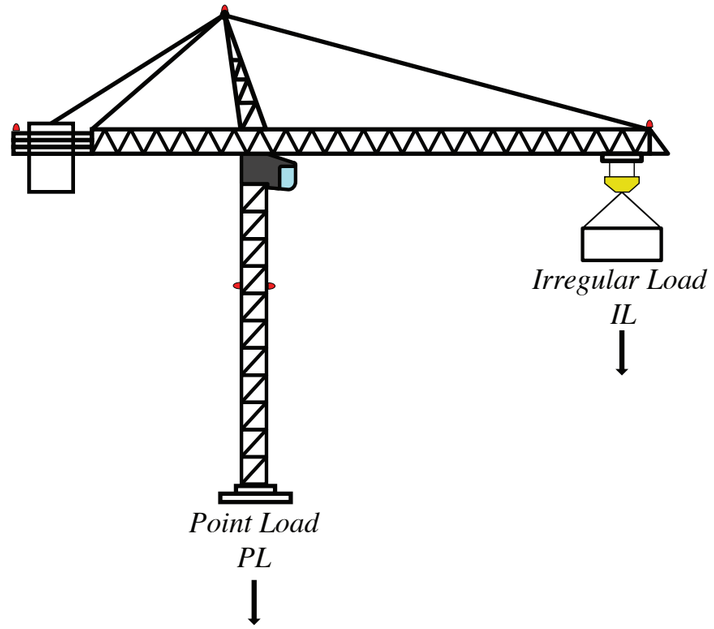


# Crane Theory: Calculating Pad Size

Name: _____ Date: _____

**Introduction:**

Determining the safe operation limits for a large structure such as a crane is a very important skill that all engineers would need to be able to do. The math needed to perform these calculations is not overly difficult; however, there are a several steps that need to be calculated in order to complete the necessary calculations. This activity guid will walk you through each step while also explaining the purpose for each step.




The bottom of a column presents a point load on a structure.
For a crane the combined weight of the "tower", "jib", and "counterweight" presents a point load on the "pad".

**Step 1: Determine the Weight of the Crane (Point Load)**
The weight of the crane will include the the combined weight of the "tower", "jib" and the "counter weight". These weights remain constant during operation and will create a downward "point force" at the centre of the tower.

| | |
|---|---|
| ***Weight of Crane (Tower + Jib)*** | ***75t*** |
| ***Weight of Counter Weight*** | ***50t*** |
| ***Point Load*** | ***125t*** |

**Step 2: Determine the Weight of Irregular Loads (Irregular Loads)**
The second value that needs to be calculated is the combined total of any irregular weight that can change during operation. These weights include the “load”, “hook block”, and a “fly jib” if it has been installed. These weights are considered irregular because they can change during operation. This is because the size of the load can change. Moreover, the position of the hook block and load can also change as the hook block moves forwards and backwards along the “jib”.

| | |
|---|---|
| ***Weight of Load (variable)*** | ***12.5t*** |
| ***Hook Block / Tackle*** | ***1.0t*** |
| ***Fly Jib (if Fitted)*** | ***0.5t*** |
| | ***13.0t*** |

**Step 3: Determine Ground Pressure**
Once you have completed the calculations from **steps 1 & 2** you can substitute values into the “**Ground Pressure” (GP)** equation. To calculate **GP** you Use the formula:

***Ground Pressure = (Point Load x 0.75 ) + (Irregular Loads)***

***GP = (PL x 0.75) + (IL)***
***GP = (125t x 0.75) + (13t)***
***GP = 93.75t + 13t***
***GP = 106.75t***

**(GBP) Ground Bearing Pressure Table:**

| | | |
|---|---|---|
| **Non Cohesive Soils - Gavel, or Sand and Gravel Mixtures:** | | |
| Dense gravel, or a mixture of both | > 61.2 t/m² | > 600 kN/m² |
| Medium dense gravel, or a mixture of both | 20.4 ~ 61.2 t/m² | 200 ~ 600 kN/m² |
| Loose gravel, or a mixture of both | < 20.4 t/m² | < 200 kN/m² |
| **Non Cohesive Soils - Sand Only:** | | |
| Compact sand | > 30.6 t/m² | > 30 kN/m² |
| Medium Dense Sand | 10.2 ~ 30.6 t/m² | 100 ~ 300 kN/m² |
| Lose sand | < 10.2 t/m² | < 100 kN/m² |
| **Cohesive Soils - Clay:** | | |
| Very Stiff Boulder Clays and Hard Clays | > 61.2 t/m² | > 600 kN/m² |
| Stiff Clays | 15.3 ~ 30.6 t/m² | 150 ~ 300 kN/m² |
| Firm Clay | 7.6 ~ 15.3 t/m² | 75 ~ 150 kN/m² |
| Soft Clays and Silts | < 7.6 t/m² | < 75 kN/m² |



**Step 4: Determine the “Ground Bearing Pressure” Constant**
**Ground Bearing Pressure (GBP)** is a mathematical constant that can be looked up using the provided table. The value for **GBP** varies based on different types of surface conditions that your crane will be used. So make sure you lookup the most suitable **GBP** constant for each unique situation that your crane will be used. Lets’ assume the crane will be insulated on a layer of “***soft clay or silts”***. We will look up the constant for this type of ground surface and then use this value for our next calculation.

**GBP: Soft Clays and Silts** **< 7.6 t/m²** **< 75 kN/m²**

**Step 5: Determine the Minimum Acceptable Pad Size**
To determine the minimum acceptable pad size for your crane you simply divide the “**Ground Pressure (GP)**” from step 3 by the “**Ground Bearing Pressure (GBP)**” that you looked up in step 4. Then use the following equation to determine “**Pad Size (PS)**”.

***Pad Size = Ground Pressure / Ground Bearing Pressure***

***PS = GP / GBP***
***PS = 106.75t / 7.6 t/m²***
***PS = 13.95 m²***

**Step 6: Determine the Dimensions of the Pad (Side Length or Radius)**
Depending on the design of your crane you may have either a square or circular base. Different calculations are needed to determine the dimensions of a pad since the formulas for the area of a square and circle are different.

**Area of a Square:**
**Area = $S^2$**

**Area of a Circle:**
**Area = $\pi r^2$**

Since the “**Pad Size**” has already been pre-determined in step 5 the equations for finding the area of a square or circle need to rewritten to isolate “**S**” for side length, or “**r**” for radius. Once you rewrite the equation you can substitute the value for “**Pad Size**” and then solve the equation. This will give you the necessary values. This will be the side length for a square pad or the radius if the pad is circular.

**Square Pad:**
$Side = \sqrt{PadSize}$
$Side = \sqrt{13.95m^2}$
$Side = 3.73m$

**Round Pad:**
$Radius = \sqrt{PadSize/\pi}$
$Radius = \sqrt{13.95m^2/\pi}$
$Radius = \sqrt{4.44m^2}$
$Radius = 2.11m$