ROYMECH



Home
Mechanics Index

**Loaded Flat Platess**



**Introduction**

This page includes simple formula for the calculation of the maximum stress and deflection for thin flat plates under a variety of support and loading conditons. The equations are only valid if the deflection is small compared to the plate thickness. The plates are all assumed to be steel with a poisson's ratio of 0,3. The equations are also only reasonably accurate if the thickness is less than 10% of the diameter. The results can be used for initial estimates - For more accurate results it is recommended that quality reference books are used i.e "Roark's Formulas for Stress and Strain". I also recommend Mitcalc.com see link 1 below - a suite of calculators based on Excel.

The loading scenario for the simply supported rectangular plates assume that the upper edges of the loaded surface are restrained from lifting such that all of the edges are in contact during the the loading condition.

Note:
I have checked the results from some of the equations against results using Mitcalc.com . The deflections and stresses resulting are generally resonably accurate. I have checked my results against Roark and they seem to be OK. I would recommend that for more comprehensive calculations including greater detail with more accuracy standard reference texts are used e.g Roarks book.

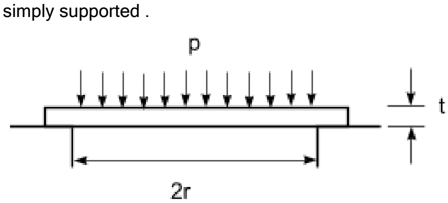
I have created a excelcalcs based spreadsheet for convenient access to all of the equations on this page. This is located at ExcelCalcs.com calculation Plates There are also other detailed calcs/ tables/ graphs for a number of different plate configurations on the excelcalcs site ref. Excelcalcs Plates

**Symbols / Units**

r = radius of circular plate (m)
a = major length of rectangular plate (m)
a = outside dia or ring (m)
b = minor length of rectangular plate (m)
b = inside dia of ring(m)
t = plate thickness (m)
p = uniform surface pressure on plate (compressive) ($N/m^2$)
P = Single concentrated force (compressive) (N)
$\sigma_m$ = maximum stress($N/m^2$)
$y_m$ = maximum deflection (m)
E = Young's moudulus of elasticity ($N/m^2$)
$\nu$ = Poissan's ratio -Assumed to be 0,3 for steel.
D = Flexural rigidity = $E.t^3 / 12 (1-v^2)$

**Circular Plates**

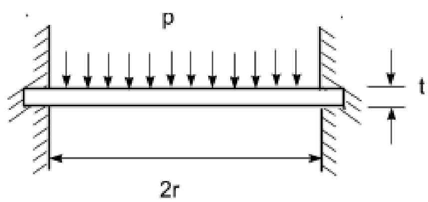
Circular Plate , uniform load , edges simply supported .



$$\sigma_m = \frac{3(3+\nu)\,pr^2}{8\,t^2} = \frac{1{,}238\,pr^2}{t^2} \qquad \text{At centre}$$

$$y_m = \frac{(5+\nu)\,pr^4}{64(1+\nu)\,D} = \frac{0{,}696\,pr^4}{E.t^3} \qquad \text{At centre}$$

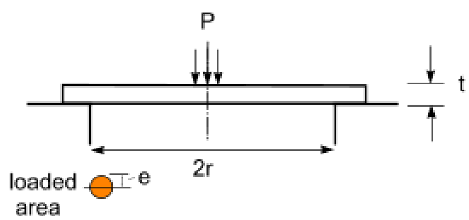
Circular Plate , uniform load , edges clamped .




$$\sigma_m = \frac{3\,pr^2}{4\,t^2} \qquad \text{At Edges}$$

$$y_m = \frac{pr^4}{64\,D} = \frac{0{,}171\,pr^4}{E.t^3} \qquad \text{At centre}$$

Circular Plate , Centre Load , edges simply supported .




If e is small then use e' as calculated below

$$e' = \left(\sqrt{1{,}6e^2 + t^2}\right) - 0{,}675t \quad \text{if } e < 0{,}5t \text{ else use } e' = e$$

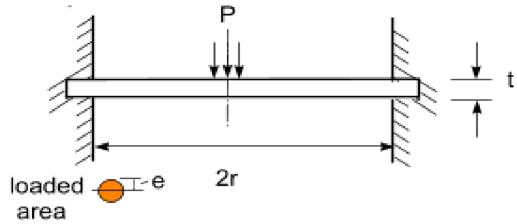
$$\sigma = \frac{6M}{t^2} \qquad M_{max} = \frac{P}{4\pi}\left((1+\nu)\ln\left(\frac{r}{e'}\right) + 1\right)$$

$$\text{Therefore } \sigma_{max} = \frac{6P}{4\pi\,t^2}\left((1+\nu)\ln\left(\frac{r}{e'}\right) + 1\right) \quad \text{At centre}$$

$$\text{Assuming } \nu = 0 \qquad \sigma_{max}\ \frac{P}{t^2}\left(0{,}6201\ln\left(\frac{r}{e'}\right) + 0{,}477\right)$$

$$y_m = \frac{(3+\nu)\,Pr^2}{16\pi(1+\nu)\,D} = \frac{0{,}552\,Pr^2}{E.t^3} \qquad \text{At centre}$$

Circular Plate , Centre Load , edges clamped .




If e is small then use e' as calculated below

$$e' = \left(\sqrt{1{,}6e^2 + t^2}\right) - 0{,}675t \quad \text{if } e < 0{,}5t \text{ else use } e' = e$$

$$\sigma = \frac{6M}{t^2} \qquad M_{max} = \frac{P}{4\pi}(1+\nu)\ln\left(\frac{r}{e'}\right)$$

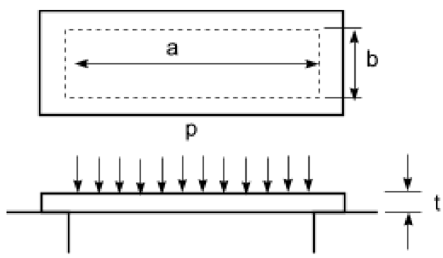
Therefore $\sigma_{max} = \dfrac{6P}{4\pi t^2}(1+\nu)\ln\left(\dfrac{r}{e'}\right)$ At centre

Assuming $\nu = 0$ $\quad \sigma_{max}\ \dfrac{P}{t^2}\ 0{,}6201\ \ln\left(\dfrac{r}{e'}\right)$

$$y_m = \frac{Pr^2}{16\pi D} = \frac{0{,}217\ Pr^2}{E.t^3}$$ At centre

## Rectangular Plates

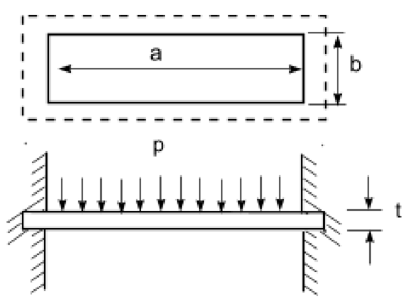
Rectangular Flat Plate , uniform load ,edge simply supported.




$$\sigma_m = \frac{0{,}75\ pb^2}{t^2\,[1{,}61(b/a)^3 + 1\,]}$$ At centre

$$y_m = \frac{0{,}142\ pb^4}{Et^3[2{,}21(b/a)^3 + 1]}$$ At centre

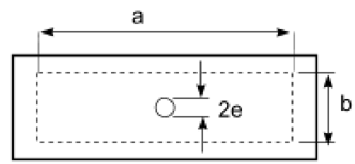
Rectangular Flat Plate , uniform load ,edge clamped.

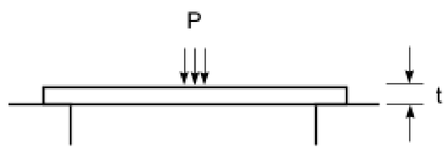


$$\sigma_m = \frac{pb^2}{2t^2\,[0{,}623(b/a)^6 + 1\,]} \quad \text{At mid edge a}$$

$$y_m = \frac{0{,}0284\ pb^4}{Et^3[1{,}056(b/a)^5 + 1]} \quad \text{At centre}$$

Rectangular Flat Plate , concentrated load at centre,edge simply supported.




If e is small then use e' as calculated below

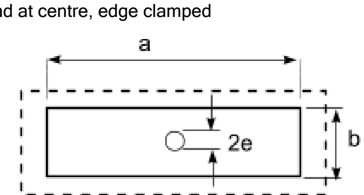
$$e' = \left(\sqrt{1{,}6e^2 + t^2}\right) - 0{,}675t \quad \text{if } e < 0{,}5t \text{ else use } e' = e$$

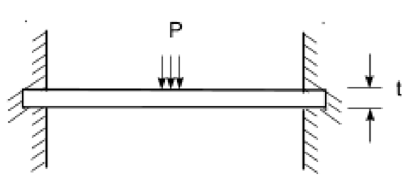
$$\sigma_m = \frac{1{,}5P}{\pi t^2}\left((1+\nu)\ \ln\left(\frac{2b}{\pi e'}\right) + k_2\right) \quad \text{At centre}$$

$$y_m = k_1\ \frac{Pb^2}{Et^3} \quad \text{At centre}$$

| | a/b | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1,0 | 1,1 | 1,2 | 1,4 | 1,6 | 1,8 | 2,0 | 3,0 | 4 -> |
| $k_1$ | 0,127 | 0,138 | 0,148 | 0,162 | 0,17 | 0,177 | 0,180 | 0,185 | 0,185 |
| $k_2$ | 0,435 | 0,565 | 0,650 | 0,789 | 0,875 | 0,927 | 0,958 | 1,000 | 0,000 |

Rectangular Flat Plate , concentrated load at centre, edge clamped



If e is small then use e' as calculated below

$$e' = \left(\sqrt{1{,}6e^2 + t^2}\right) - 0{,}675t \quad \text{if } e < 0{,}5t \text{ else use } e' = e$$

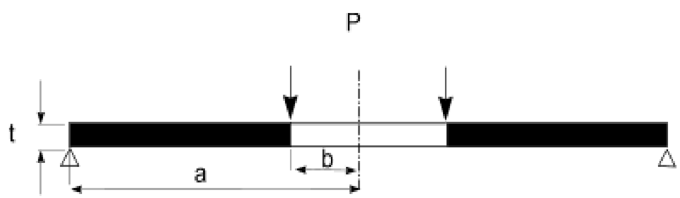
$$\sigma_{mc} = \frac{1{,}5P}{\pi t^2}\left((1+\nu)\ \ln\left(\frac{2b}{\pi e}\right) + k_3\right) \quad \text{At centre}$$

$$\sigma_m = k_2 \frac{P}{t^2} \quad \text{Middle of edge a}$$

$$y_m = k_1 \frac{Pb^2}{Et^3} \quad \text{At centre}$$

| | a/b | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1,0 | 1,2 | 1,4 | 1,6 | 1,8 | 2,0 | 3 -> |
| $k_1$ | 0,061 | 0,071 | 0,076 | 0,078 | 0,0786 | 0,0788 | 0,0791 |
| $k_2$ | 0,754 | 0,894 | 0,962 | 0,991 | 1,000 | 1,004 | 1,008 |
| $k_3$ | -0,238 | -0,0078 | 0,011 | 0,053 | 0,068 | 0,067 | 0,067 |

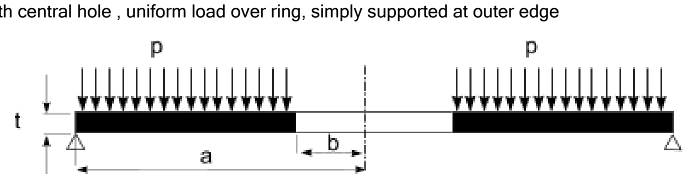
Circular Flat Plate with central hole , concentrated load at hole, simply supported at outer edge




$$\sigma_m = k_2 \frac{P}{t^2} \qquad y_m = k_1 \frac{Pa^2}{Et^3}$$

| a/b | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1,25 | | 1,5 | | 2 | | 33 | | 4 | | 5 | |
| $k_1$ | $k_2$ | $k_1$ | $k_2$ | $k_1$ | $k_2$ | $k_1$ | $k_2$ | $k_1$ | $k_2$ | $k_1$ | $k_2$ |
| 0,341 | 0,100 | 0,519 | 1,26 | 0,672 | 1,48 | 0,734 | 1,88 | 0,724 | 2,17 | 0,704 | 2,34 |

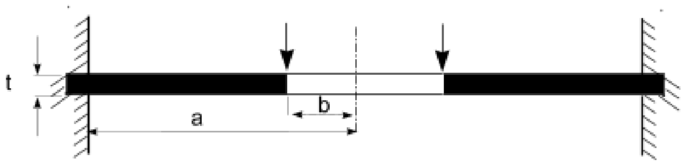
Circular Flat Plate with central hole , uniform load over ring, simply supported at outer edge




$$\sigma_m = k_2 \frac{pa^2}{t^2} \qquad y_m = k_1 \frac{pa^4}{Et^3}$$

| a/b | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1,25 | | 1,5 | | 2 | | 3 | | 4 | | 5 | |
| $k_1$ | $k_2$ | $k_1$ | $k_2$ | $k_1$ | $k_2$ | $k_1$ | $k_2$ | $k_1$ | $k_2$ | $k_1$ | $k_2$ |
| 0,184 | 0,592 | 0,414 | 0.976 | 0,664 | 1,44 | 0,824 | 1,88 | 0,830 | 2,08 | 0,813 | 2,190 |

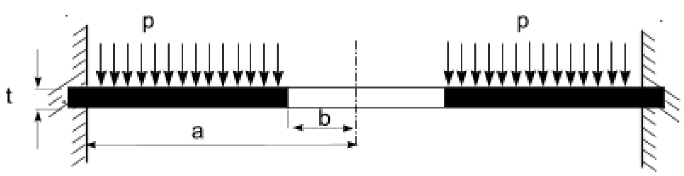
Circular Flat Plate with central hole , Concentrated load at hole, clamped at outer edge




$$\sigma_m = k_2 \frac{P}{t^2} \qquad y_m = k_1 \frac{Pa^2}{Et^3}$$

| a/b | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1,25 | | 1,5 | | 2 | | 3 | | 4 | | 5 | |
| $k_1$ | $k_2$ | $k_1$ | $k_2$ | $k_1$ | $k_2$ | $k_1$ | $k_2$ | $k_1$ | $k_2$ | $k_1$ | $k_2$ |
| 0,00504 | 0,194 | 0,0242 | 0.320 | 0,0810 | 0,454 | 0,172 | 0,673 | 0,217 | 1,021 | 0,238 | 1,305 |

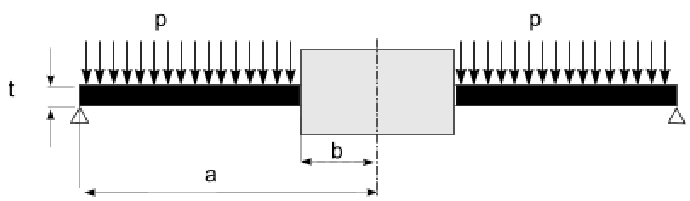
Circular Flat Plate with central hole , uniform load over ring, clamped at outer edge




$$\sigma_m = k_2 \frac{pa^2}{t^2} \qquad y_m = k_1 \frac{pa^4}{Et^3}$$

| a/b | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1,25 | | 1,5 | | 2 | | 3 | | 4 | | 5 | |
| $k_1$ | $k_2$ | $k_1$ | $k_2$ | $k_1$ | $k_2$ | $k_1$ | $k_2$ | $k_1$ | $k_2$ | $k_1$ | $k_2$ |
| 0,00199 | 0,105 | 0,0139 | 0.259 | 0,0575 | 0,480 | 0,130 | 0,657 | 0,162 | 0,710 | 0,175 | 0,730 |

Circular Flat Plate with guided central hole , uniform distributed load, simply supported at outer edge

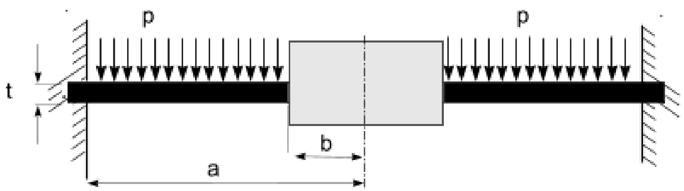



$$\sigma_m = k_2 \frac{pa^2}{t^2} \qquad y_m = k_1 \frac{pa^4}{Et^3}$$

| a/b | | | | | |
|---|---|---|---|---|---|
| 1.25 | 1,5 | 2 | 3 | 4 | 5 |

| k1 | k2 | k1 | k2 | k1 | k2 | k1 | k2 | k1 | k2 | k1 | k2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0,00343 | 0,122 | 0,0313 | 0,336 | 0,125 | 0,740 | 0,221 | 1,210 | 0,417 | 1,450 | 0,492 | 1,590 |

Circular Flat Plate with guided central hole , uniform distributed load, fixed at outer edge




$$\sigma_m = k_2 \frac{pa^2}{t^2} \qquad y_m = k_1 \frac{pa^4}{Et^3}$$

| a/b | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 10 | | 3 | | 2 | | 1,5 | | 1,1 | |
| k1 | k2 | k1 | k2 | k1 | k2 | k1 | k2 | k1 | k2 |
| 0,149 | 0,728 | 0,074 | 0,58 | 0,023 | 0,36 | 0,003 | 0,151 | - | 0,019 |

Additional notes to be added



**Relevant Links**

1. Mitcalc.com Plates Detailed Calculations for a very resonable cost
2. Wikipeadia - Plate theory.. Quite detailed - difficult to follow notes
3. excelcalcs Plates.. Very detailed a comprehensive coverage of the subject.

This Page is being developed

Home
Mechanics Index

Send Comments to Roy Beardmore

Last Updated 20/02/2013