Units & Dimensions.
SI units & U.S. Customary units.

يوجد للتصميم فى مصر نوعان من الوحدات :

١ـ النظام القديم *Metric System* و نستخدم فيه Ton , Kg , m & cm

٢ـ النظام الحديث (*S I*) و هو حاليا النظام العالمى (*System International*)

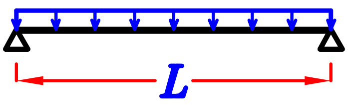
و يوجد نظام ثالث غير مستخدم فى مصر لكن يستخدم فى أوربا و أمريكا
يسمى (*British units* or *U.S. Customary units.*)

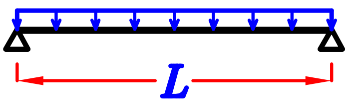
للتحويل من *Metric System* الى *S I* ←

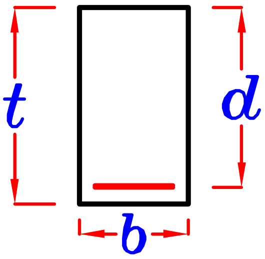
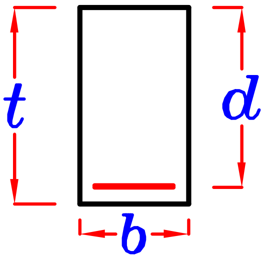
Kg = 9.81 N ≃ 10.0 N
ton = 9.81 kN ≃ 10.0 kN

و الجدول التالى يوضح كيفيه التحويل من النظام *Metric System* الى *S I* مع أمثلة لتوضيح ذلك

	Metric System	*S I*
Concentrated Load	*Kilogram* (Kg)	*Newton* (N)
	1 Kg ≃ 10 N	
	Ton (t)	*kilo Newton* (kN)
	1 ton ≃ 10 kN	
Length	*meter* (m)	*meter* (m)
	centimeter (cm)	*millimeter* (mm)
	1 cm = 10 mm	
Distributed Load (w)	w t/m` ; $w$ (t/m`)	w kN/m` ; $w$ (kN/m`)
	1 t/m` = 10 kN/m`	





	Metric System	SI
Bending Moment (M)	 M (t.m) عند حساب الاحمال M (Kg.cm) فى معادلات التصميم لتحويل قيمه العزم من (t.m) الى (Kg.cm) يتم ضرب قيمه العزم فى 10^5	 M (kN.m) عند حساب الاحمال M (N.mm) فى معادلات التصميم لتحويل قيمه العزم من (kN.m) الى (N.mm) يتم ضرب قيمه العزم فى 10^6
	1 t.m. = 10 kN.m	
	1 Kg.cm = 100 N.mm	
Dimensions of sections.	 b, d & t (m) عند حساب الاحمال b, d & t (cm)	 b, d & t (m) عند حساب الاحمال b, d & t (mm) فى معادلات التصميم
Area of Steel Bars (A_s)	cm^2	mm^2
	1.0 cm^2 = 100 mm^2 EX. 1 ϕ 16 ≃ 2.01 cm^2 ≃ 201 mm^2	
Distributed	$t\backslash m^2$	$kN\backslash m^2$
Load at m^2	1 $t\backslash m^2$ ≃ 10.0 $kN\backslash m^2$ EX. L.L. = 0.20 $t\backslash m^2$ ≃ 2.0 $kN\backslash m^2$ EX. F.C. = 0.15 $t\backslash m^2$ ≃ 1.50 $kN\backslash m^2$	

	Metric System	SI
Stress	kg\cm^2	N\mm^2 = MPa = *Mega Pascal*
	1 kg\cm^2 $\simeq$ 0.10 N\mm^2 EX. $f_{cu} = 250$ kg\cm^2 $\simeq$ 25 N\mm^2 EX. $f_y = 3600$ kg\cm^2 $\simeq$ 360 N\mm^2	
density	t\m^3	kN\m^3
	t\m^3 $\simeq$ 10.0 kN\m^3 EX. $\gamma_c = 2.50$ t\m^3 $\simeq$ 25.0 kN\m^3 EX. $\gamma_{wall} = 1.80$ t\m^3 $\simeq$ 18.0 kN\m^3	
modules of Elasticity (E)	*For Concrete* $E_c = 14000\sqrt{f_{cu}}$ (kg\cm^2) *For Steel* $E_s = 2 \times 10^6$ (kg\cm^2)	*For Concrete* $E_c = 4400\sqrt{f_{cu}}$ (N\mm^2) *For Steel* $E_s = 2 \times 10^5$ (N\mm^2)
المقاومه المميزه للخرسانه chrasaristics strength (f_{cu})	f_{cu} (kg\cm^2) 200 | 250 | 300 | 350 | 400 | 450	f_{cu} (N\mm^2) = (MPa) 20 | 25 | 30 | 35 | 40 | 45
اجهاد الخضوع أو اجهاد الضمان للحديد yield stress or proof stress (f_y)	f_y (kg\cm^2) st. 24\35 $f_y = 2400$ (kg\cm^2) st. 36\52 $f_y = 3600$ (kg\cm^2) st. 40\60 $f_y = 4000$ (kg\cm^2)	f_y (N\mm^2) = (MPa) st. 240\350 $f_y = 240$ (N\mm^2) st. 360\520 $f_y = 360$ (N\mm^2) st. 400\600 $f_y = 400$ (N\mm^2)

SI & Metric System قوانين تصميم القطاعات بوحدات

ملحوظة : تصميم القطاعات فى هذه الملفات بطريقه حالات الحدود L.S.D.M.
Limits States Design Method

<table>
<tr><th></th><th>Metric System</th><th>S I</th></tr>
<tr><td rowspan="2">Design of section subjected to Bending Moment using First Principles</td><td colspan="2">$$0.67\frac{f_{cu}}{\gamma_c}\,a\,b = A_s\frac{f_y}{\gamma_s}$$ $$M_{U.L.} = 0.67\frac{f_{cu}}{\gamma_c}\,a\,b\,(d-\frac{a}{2})$$ $$M_{U.L.} = A_s\frac{f_y}{\gamma_s}(d-\frac{a}{2})$$</td></tr>
<tr><td>Where:
a , b & d (cm)
A_s & A_c (cm^2)
f_{cu} & f_y (Kg\cm^2)
$M_{U.L.}$(cm.Kg) = $M_{U.L.}$(m.t) × 10^5
$A_{s\,min.} = \frac{1.1}{f_y}A_c$</td><td>Where:
a , b & d (mm)
A_s & A_c (mm^2)
f_{cu} & f_y (N\mm^2)
$M_{U.L.}$(mm.N) = $M_{U.L.}$(m.kN) × 10^6
$A_{s\,min.} = \frac{11}{f_y}A_c$</td></tr>
<tr><td rowspan="2">Design of section subjected to Bending Moment using Charts
C_1 & J Chatr</td><td colspan="2">$$d = C_1\sqrt{\frac{M_{U.L.}}{f_{cu}\,b}}$$ $$A_s = \frac{M_{U.L.}}{J\,f_y\,d}$$</td></tr>
<tr><td>Where:
b & d (cm)
A_s & A_c (cm^2)
f_{cu} & f_y (Kg\cm^2)
$M_{U.L.}$(cm.Kg) = $M_{U.L.}$(m.t) × 10^5
$A_{s\,min.} = \frac{1.1}{f_y}A_c$</td><td>Where:
b & d (mm)
A_s & A_c (mm^2)
f_{cu} & f_y (N\mm^2)
$M_{U.L.}$(mm.N) = $M_{U.L.}$(m.kN) × 10^6
$A_{s\,min.} = \frac{11}{f_y}A_c$</td></tr>
</table>

	Metric System	SI
Design of section subjected to Compression Force only	$P_{U.L.} = 0.35\, A_c\, f_{cu} + 0.67\, A_s\, f_y$	
	Where: $P_{U.L.}$ (Kg) A_c & A_s (cm^2) f_{cu} & f_y ($Kg\backslash cm^2$)	Where: $P_{U.L.}$ (N) A_c & A_s (mm^2) f_{cu} & f_y ($N\backslash mm^2$)
Design of section subjected to Tension Force only	$A_s = \frac{T_{U.L.}}{f_y/\gamma_s}$ $A_c \simeq (20 \longrightarrow 40)\, A_s$	
	Where: $T_{U.L.}$ (Kg) A_c & A_s (cm^2) f_y ($Kg\backslash cm^2$)	Where: $T_{U.L.}$ (N) A_c & A_s (mm^2) f_y ($N\backslash mm^2$)
Design of section subjected to Compression Force & Bending Monent $M_{U.L.}$ & $P_{U.L.}$ Tension Failure	$e = \frac{M_{U.L.}}{P_{U.L.}}$ $e_s = e + \frac{t}{2} - c$ $M_{su} = P_{U.L.} \times e_s$ $A_s = \frac{M_{su}}{J\, f_y\, d} - \frac{P_{U.L.}}{f_y/\gamma_s}$	
	Where: e , e_s , c , d & t (cm) $P_{U.L.}$ (Kg) $M_{su}(cm.Kg) = M_{su}(m.t) \times 10^5$ f_y ($Kg\backslash cm^2$) A_s (cm^2)	Where: e , e_s , c , d & t (mm) $P_{U.L.}$ (N) $M_{su}(mm.N) = M_{su}(m.kN) \times 10^6$ f_y ($N\backslash mm^2$) A_s (mm^2)

	Metric System	SI
Design of section subjected to Compression Force & Bending Moment $M_{U.L.}$ & $P_{U.L.}$	$\frac{P_{U.L.}}{f_{cu}\, b\, t}$, $\frac{M_{U.L.}}{f_{cu}\, b\, t^2}$ $\mu = \rho \times f_{cu} \times 10^{-5}$ $A_s = \mu\, d\, t$ $A_s' = \alpha\, A_s$	$\frac{P_{U.L.}}{f_{cu}\, b\, t}$, $\frac{M_{U.L.}}{f_{cu}\, b\, t^2}$ $\mu = \rho \times f_{cu} \times 10^{-4}$ $A_s = \mu\, d\, t$ $A_s' = \alpha\, A_s$
Compression Failure using Interaction Diagram	**Where:** b & t (cm) $P_{U.L.}$ (Kg) $M_{U.L.}$(cm.Kg) = $M_{U.L.}$(m.t) $\times 10^{5}$ A_s (cm^2) f_{cu} & f_y (Kg\cm^2)	**Where:** b & t (mm) $P_{U.L.}$ (N) $M_{U.L.}$(mm.N) = $M_{U.L.}$(kN.m) $\times 10^{6}$ A_s (mm^2) f_{cu} & f_y (N\mm^2)
Check Shear	$q_u = \frac{Q_{U.L.}}{b\, d}$ $q_{cu} = 0.75 \sqrt{\frac{f_{cu}}{\gamma_c}}$ $q_{u\,max} = 2.20 \sqrt{\frac{f_{cu}}{\gamma_c}}$ $q_u - \frac{q_{cu}}{2} = \frac{n\, A_s\, (f_y/\gamma_s)}{b\, S}$ $= \frac{n\, A_s}{b\, S} \geq \frac{0.4}{f_y}$ $\frac{A_{sb}}{b\, S} = \frac{q_{sub}}{(f_y/\gamma_s)(\sin\alpha + \cos\alpha)}$	$q_u = \frac{Q_{U.L.}}{b\, d}$ $q_{cu} = 0.24 \sqrt{\frac{f_{cu}}{\gamma_c}}$ $q_{u\,max} = 0.70 \sqrt{\frac{f_{cu}}{\gamma_c}}$ $q_u - \frac{q_{cu}}{2} = \frac{n\, A_s\, (f_y/\gamma_s)}{b\, S}$ $= \frac{n\, A_s}{b\, S} \geq \frac{4.0}{f_y}$ $\frac{A_{sb}}{b\, S} = \frac{q_{sub}}{(f_y/\gamma_s)(\sin\alpha + \cos\alpha)}$
	Where: b & d (cm) $Q_{U.L.}$ (Kg) q_u, q_{cu}, $q_{u\,max}$ (Kg\cm^2) A_s (cm^2) f_{cu} & f_y (Kg\cm^2)	**Where:** b & d (mm) $Q_{U.L.}$ (N) q_u, q_{cu}, $q_{u\,max}$ (N/mm^2) A_s (mm^2) f_{cu} & f_y (N\mm^2)

	Metric System	SI
Check Shear + Torsion	$q_{tu} = \frac{M_{tu}}{2 A_o t_e}$ $q_{tu} = \frac{M_{tu}(x_1 + y_1)}{0.85\,(x_1^2 + y_1^2)}$ For R-sec.	
	$q_{tu_{min}} = 0.19 \sqrt{\frac{f_{cu}}{\gamma_c}}$ $q_{tu_{max}} = 2.20 \sqrt{\frac{f_{cu}}{\gamma_c}}$	$q_{tu_{min}} = 0.06 \sqrt{\frac{f_{cu}}{\gamma_c}}$ $q_{tu_{max}} = 0.70 \sqrt{\frac{f_{cu}}{\gamma_c}}$
	$A_{str} = \frac{M_{tu}\ S_t}{1.7\ x_1\ y_1\ (f_y/\gamma_s)}$ $A_{sl} = 2 A_{str} \frac{(x_1 + y_1)}{S_t} \left(\frac{f_{y\ str.}}{f_{y\ L.b.}}\right)$	
	Where: x_1, y_1 & S_t (cm) M_{tu} (cm.Kg) $q_{tu_{min}}$, $q_{tu_{max}}$ (Kg\cm^2) A_{str}, A_{sl} (cm ^{2}) f_{cu} & f_y (Kg\cm^2)	Where: x_1, y_1 & S_t (mm) M_{tu} (mm.N) $q_{tu_{min}}$, $q_{tu_{max}}$ (N\mm^2) A_{str}, A_{sl} (mm^2) f_{cu} & f_y (N\mm ^{2})

SI units ⟶ U.S. Customary units

يوجد حاليا فى معظم دول العالم نوعان من الوحدات :

١ـ النظام الحديث (S I) و هو حاليا النظام العالمى (System International)

و يستخدم N , mm & °C و هذا هو النظام المستخدم فى مصر حاليا .

٢ـ النظام الانجليزى و هو النظام الغالب ايضا فى امريكا .

و يسمى (British units or U.S. Customary units.)

و يستخدم lb, in & °F

للتحويل بين النظامين

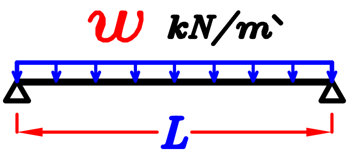
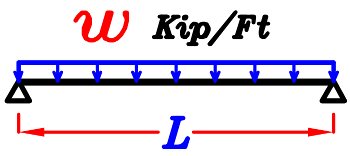
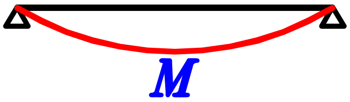
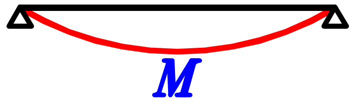
1 N ≃ 0.225 lb	
1 m ≃ 39.37 in	

و الاسهل للتذكر

1 Kg ≃ 2.20 lb	
1 in ≃ 2.54 cm	

و الجدول التالى يوضح كيفيه التحويل من النظام SI الى U.S. Customary

	S I	U.S. Customary
Concentrated Load	Newton (N)	Pounds (lb)
	1 N ≃ 0.225 lb	
	kilo Newton (kN)	kilo Pound (Kip)
	1 kN ≃ 0.225 Kips	
Length	Meter (m)	Feet (ft)
	1 m ≃ 3.28 ft	
	centimeter (cm)	inch (in)
	1 cm ≃ 0.39 in	
	2.54 cm ≃ 1 in	
	Meter (m)	yard (yd)
	1 m ≃ 1.094 yd	

	SI	U.S. Customary
Distributed Load (w)		
	1 N/m` ≃ 0.068 lb/ft	
	1 kN/m` ≃ 0.068 Kip/ft	
Bending Moment (M)	 M (kN.m) عند حساب الاحمال M (N.mm) فى معادلات التصميم	 M (Kip.ft) عند حساب الاحمال M (lb.in) فى معادلات التصميم
	1 kN.m ≃ 0.737 Kip.ft	
	1 N.m ≃ 8.85 lb.in	
Dimensions of sections.	b, d & t (m) عند حساب الاحمال	b, d & t (ft) عند حساب الاحمال
	1 m ≃ 3.28 ft	
	b, d & t (mm) فى معادلات التصميم	b, d & t (in) فى معادلات التصميم
	1 mm ≃ 0.04 ft	
Area of Steel Bars (A_s)	mm^2	in^2
	1 mm^2 ≃ 0.00155 in^2	
	الطريقه المستخدمه لتصنيف اقطار حديد التسليح مختلفه تماما فى النظام الامريكى . حيث الوحده تقاس ب ($\frac{١}{٨}$) بوصه	
	EX. 1∅16 ⟶ Diameter = 16 mm $A_s = \frac{\pi * 16^2}{4} = 201$ mm^2	EX. #5 ⟶ Diameter = $\frac{5}{8}$ in $A_s = \frac{\pi * (\frac{5}{8})^2}{4} = 0.306$ in^2
Area Distributed Load	kN\m ^{2}	lb/in ^{2}
	1 kN\m ^{2} ≃ 0.145 lb/in ^{2}	

	S I	U.S. Customary
Stress	$N\backslash mm^2$ = MPa = *Mega Pascal*	$Kips/in^2$ = Ksi lb/in^2 = Psi
	1 $N\backslash mm^2 \simeq$ 0.145 Ksi	
	1 $N\backslash mm^2 \simeq$ 145 Psi	
	EX. $f_{cu} = 25$ $N\backslash mm^2 \simeq$ 3625 Psi EX. $f_y = 360$ $N\backslash mm^2 \simeq$ 52.2 Ksi عند توصيف الحديد نوصفه بـ Ksi و عند توصيف الخرسانه نوصفها بـ Psi و فى جميع الاحوال يجب استخدام Psi فى معادلات التصميم	
Density	kN/m^3	lb/ft^3
	1 $kN/m^3 \simeq$ 6.24 lb/ft^3	
	EX. $\gamma_c = 25.0$ $kN/m^3 \simeq$ 156 lb/ft^3 EX. $\gamma_{wall} = 18.0$ $kN/m^3 \simeq$ 112 lb/ft^3	
modules of Elasticity (E)	*For Concrete* $E_c = 4400\sqrt{f_{cu}}$ $(N\backslash mm^2)$ *For Steel* $E_s = 2 \times 10^5$ $(N\backslash mm^2)$	*For Concrete* $E_c = 33 * \gamma_c^{1.5} * \sqrt{f_{cu}}$ (Psi) *For Steel* $E_s = 290 \times 10^5$ (Psi)
المقاومة المميزه للخرسانه *chrasaristics strength* (f_{cu})	f_{cu} $(N\backslash mm^2)$ = (MPa) 20 | 25 | 30 | 35 | 40 | 45	f_{cu} (lb/in^2) = (Psi) 2900 | 3625 | 4350 | 5075 | 5800 | 6525
اجهاد الخضوع أو اجها د الضمان للحديد *yield stress* *or proof stress* (f_y)	f_y $(N\backslash mm^2)$ = (MPa)	f_y $(N\backslash mm^2)$ = (MPa)
	st. 240\350 $f_y = 240$ $(N\backslash mm^2) \simeq$ 34800 (Psi) st. 360\520 $f_y = 360$ $(N\backslash mm^2) \simeq$ 52200 (Psi) st. 400\600 $f_y = 400$ $(N\backslash mm^2) \simeq$ 58000 (Psi)	

	SI	U.S. Customary
Rebars	رقم السيخ هو قطر السيخ بال mm EX. 1ϕ16 ⟶ Diameter = 16 mm $A_s = \frac{\pi * 16^2}{4} = 201\ mm^2$	رقم السيخ هو قطر السيخ بال in لكن مقسوم على ٨ EX. #5 ⟶ Diameter = $\frac{5}{8}$ in $A_s = \frac{\pi * (\frac{5}{8})^2}{4} = 0.306\ in^2$

ϕ	A_s	#	A_s
ϕ 6	28.2 mm^2	# 2	0.049 in^2
ϕ 8	50.3 mm^2	# 3	0.110 in^2
ϕ 10	78.5 mm^2	# 4	0.196 in^2
ϕ 12	113 mm^2	# 5	0.306 in^2
ϕ 16	201 mm^2	# 6	0.441 in^2
ϕ 18	254 mm^2	# 7	0.601 in^2
ϕ 20	314 mm^2	# 8	0.785 in^2
ϕ 22	380 mm^2	# 9	0.994 in^2
ϕ 25	490 mm^2	# 10	1.227 in^2
ϕ 28	615 mm^2	# 11	1.485 in^2
ϕ 32	804 mm^2	# 12	1.767 in^2