■Bolt strength

1) When bolt is subjected to tensile load

$Pt = \sigma t \times As \cdots\cdots$ (1)

$\quad = \pi d^2 \sigma t/4 \cdots$ (2)

Pt : Tensile load in axial direction [kgf]
σ b : Bolt yield stress [kgf/mm²]
σ t : Bolt maximum allowable stress [kgf/mm²]
$\quad$ (σ t= σ b/(safety factor α))
As : Bolt effective cross-section area [mm²]
$\quad$ As= π d²/4
d : Bolt effective diameter (root diameter) [mm]

Example: Find a suitable size for a single hexagon socket head cap screw that will be subjected to repeated (pulsating) tensile loads of P＝200 kgf. (Hexagon socket head cap screw material: SCM435, 38～43 HRC, strength class 12.9)
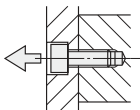From formula (1) :
$\quad$ As=Pt/ σ t
$\quad\quad$ =200/22.4
$\quad\quad$ =8.9 [mm²]
∴ Finding the effective cross-section area larger than this value from the table at right shows that a 14.2 [mm²] M5 cap screw should be selected.
With additional consideration for the fatigue strength, and based on the strength class of 12.9 in the table, we select an M6 screw with maximum allowable load of 213 kgf.

2) For stripper bolts and others which are subjected to tensile impact loads, the selection is made based on the fatigue strength. (The bolt is subjected to 200 kgf loads in the same way. Stripper bolt material: SCM 435 33～38 HRC, strength class 10.9.)

From the table at right, for a strength class of 10.9 and a maximum allowable load of 200 kgf, the suitable bolt is a 318 [kgf] M8. Therefore we select a 10 mm MSB10 with an M8 thread section. When the bolt is subjected to shear load, also use a dowel pin.

■Screw plug strength

Find the maximum allowable load P when a MSW30 screw plug is subjected to impact load. (MSW30 material: S45C, tensile strength σ b at 34～43 HRC 65 kgf/mm²)

Assuming fracture due to shear occurs at the MSW root diameter location, the maximum allowable load P= τ t×A.
$\quad$ =3.9×107.4
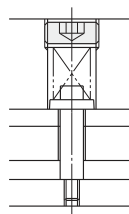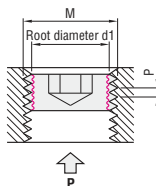$\quad$ =4190 [kgf]

When the tap is a soft materials, find the maximum allowable shear from the inside thread root diameter.

Shear cross-section area A=Root diameter d₁× π ×L
$\quad$ (Root diameter d₁≒M−P)
$\quad$ A=(M−P) π L=(30−1.5) π ×12
$\quad\quad$ =1074 [mm²]
Yield stress≒0.9×Tensile strength σ b=0.9×65=58.2
Shear stress≒0.8×Yield stress
$\quad\quad$ =46.6
Maximum allowable shear stress τ t=Shear stress / (Safety factor 12)
$\quad\quad$ =46.6/12=3.9 [kgf/mm²]

■Dowel pin strength

Find a suitable size for a single dowel pin which is subjected to repeated (pulsating) shear loads of 800 kgf. (Dowel pin material: SUJ2   hardness 58 HRC or higher)

$P = A \times \tau$
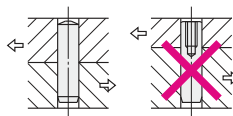$\quad = \pi D^2 \tau /4$
$D = \sqrt{(4P)/(\pi \tau)}$
$\quad = \sqrt{(4 \times 800)/(3.14 \times 19.2)}$
$\quad ≒ 7.3$

SUJ2 yield stress capability σ b=120 [kgf/mm²]
Maximum allowable shear strength τ = σ b×0.8/(Safety factor α)
$\quad\quad$ =120×0.8/5
$\quad\quad$ =19.2 [kgf/mm²]

∴ For an MS dowel pin, select a size of D8 or larger.
In addition, selecting a single size for all dowel pins makes it possible to reduce items such as tools and inventory.

■Unwin safety factor α based on tensile strength

Ⓜ	Static load	Repeated load		Impact load
		Pulsating	Alternating	
Steel	3	5	8	12
Cast iron	4	6	10	15
Copper, soft metals	5	5	9	15

Shear stress= $\dfrac{\text{Standard strength}}{\text{Safety factor } \alpha}$ Standard strength: For ductile materials＝Yield stress
$\quad\quad$ For brittle materials＝Fracture stress

Yield stress for strength class 12.9 σ b=112 [kgf/mm²]
Maximum allowable stress σ t= σ b/(safety factor)
(From table above, safety factor=5)
$\quad\quad$ =112/5
$\quad\quad$ =22.4 [kgf/mm²]

■Bolt fatigue strength (For threads: fatigue strength ＝ count of 2 million)

Nominal thread size	Effective cross-section area As mm²	Strength class			
		12.9		10.9	
		Fatigue strength[*] kgf/mm²	Maximum allowable load kgf	Fatigue strength[*] kgf/mm²	Maximum allowable load kgf
M 4	8.78	13.1	114	9.1	79
M 5	14.2	11.3	160	7.8	111
M 6	20.1	10.6	213	7.4	149
M 8	36.6	8.9	326	8.7	318
M10	58	7.4	429	7.3	423
M12	84.3	6.7	565	6.5	548
M14	115	6.1	702	6	690
M16	157	5.8	911	5.7	895
M20	245	5.2	1274	5.1	1250
M24	353	4.7	1659	4.7	1659

Fatigue strengths[*] have been excerpted from "Estimated values of fatigue limits for metal threads of small screws, bolts, and nuts" (Yamamoto) and modified.

Do not use in such a way that load is applied to the threads.