

STRENGTH OF BOLTS, SCREW PLUGS AND DOWEL PINS

Strength of bolts

1) When tensile load is applied to the bolt

$$P_t = \sigma_t \times A_s \dots \dots \dots (1)$$

$$= \pi d^2 \sigma_t / 4 \dots \dots \dots (2)$$

P_t : Tensile load in the axial direction [kgf]
 σ_b : Yield stress of bolt [kgf/mm²]
 σ_t : Allowable stress of bolt [kgf/mm²]
 ($\sigma_t = \sigma_b / \text{safety factor } \alpha$)
 A_s : Effective sectional area of bolt [mm²]
 $A_s = \pi d^2 / 4$
 d : Effectiveness of bolt (core diameter) [mm]

Safety factor α of Unwin based on tensile strength

Material	Static load	Repeated load		Impact load
		Pulsating	Reversed	
Steel	3	5	8	12
Cast iron	4	6	10	15
Copper, soft metal	5	5	9	15

Allowable stress = $\frac{\text{Reference strength}}{\text{Safety factor } \alpha}$ Reference strength : Yield stress for ductile materials
 Fracture stress for brittle materials

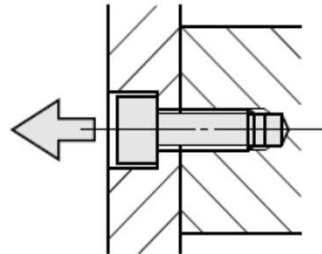
(Example) Find a suitable size when a socket head cap screw receives tensile load of $P=200\text{kgf}$ repeatedly (pulsating).
 (Socket head cap screw material : SCM435, 38~43HRC, strength class : 12.9)

From equation (1)

$$A_s = P_t / \sigma_t$$

$$= 200 / 22.4$$

$$= 8.9 \text{ [mm}^2\text{]}$$



∴ Find an effective sectional area greater than this value from the table at the right.
 M4 of 14.2 [mm²] will be the selection.

If fatigue strength is taken into account, M6 of allowable load 213kgf in 12.9 should be selected.

2) Selection must be based on fatigue strength for the bolts such as the stripper bolt which receives impact load from tension. (As the above example, 200kgf load is applied. Stripper bolt material : SCM435, 33~38HRC, strength class 10.9)

From the table at the right, M8 of 318(kgf) is found when allowable load of strength class 10.9 is over 200kgf. Accordingly, MSB10 having M8 screw and axial diameter of 10mm is the selection. Use dowel pins when shearing load is applied.

Yield stress in strength class 12.9 is $\sigma_b = 112 \text{ [kgf/mm}^2\text{]}$.
 Allowable stress $\sigma_t = \sigma_b / \text{safety factor}$ (safety factor is 5 from the above table)
 $= 112 / 5$
 $= 22.4 \text{ [kgf/mm}^2\text{]}$

Fatigue strength of bolts (In case of screws : Fatigue strength is 2 million times)

Nominal diameter of thread	Effective sectional area A_s [mm ²]	Strength rank			
		12.9		10.9	
		Fatigue strength* [kgf/mm ²]	Allowable load [kgf]	Fatigue strength* [kgf/mm ²]	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 strength* is corrected excerpt from "Estimated values of fatigue limit of metric screw threads for machine screws, bolts and nuts" (Yamamoto).

Strength of screw plugs

Find allowable load P when screw plug MSW30 receives impact load.

(MSW30 material : S45C, tensile strength σ_b for 34~43HRC is 65kgf/mm².)

If MSW breaks by shearing force applied to the core diameter part, allowable load

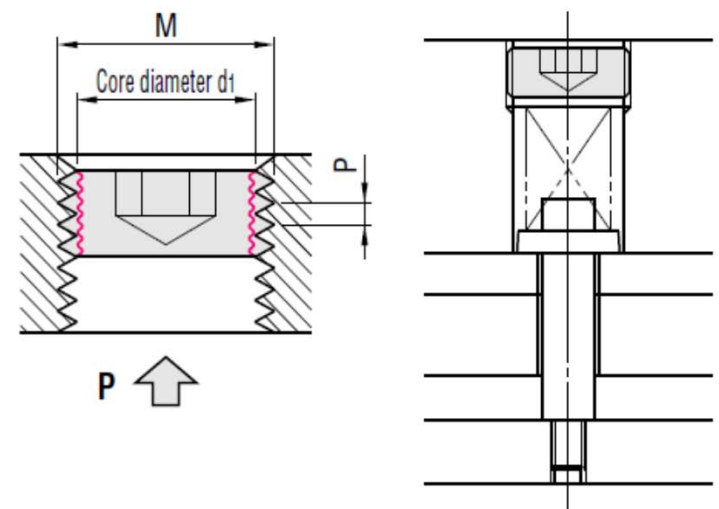
$$P = \tau \times A$$

$$= 3.9 \times 107.4$$

$$= 4190 \text{ [kgf]}$$

Find the allowable shearing force based on the core diameter of internal thread if tapping is made of soft material.

Shearing sectional area $A = \text{Core diameter } d_1 \times \pi \times L$
 (Core diameter $d_1 \approx M - P$)
 $A = (M - P) \pi L = (30 - 1.5) \pi \times 12$
 $= 1074 \text{ [mm}^2\text{]}$
 Yield stress $\approx 0.9 \times \text{Tensile strength } \sigma_b = 0.9 \times 65 = 58.2$
 Shearing stress $\approx 0.8 \times \text{Yield stress}$
 $= 46.6$
 Allowable shearing stress $\tau = \text{Shearing stress} / \text{safety factor } 12$
 $= 46.6 / 12 = 3.9 \text{ [kgf/mm}^2\text{]}$



Strength of dowel pins

Find a suitable size when a dowel pin receives 800kgf repetitive (pulsating) shearing load. (Dowel pin material : SUJ2 • Hardness 58HRC or more)

$$P = A \times \tau$$

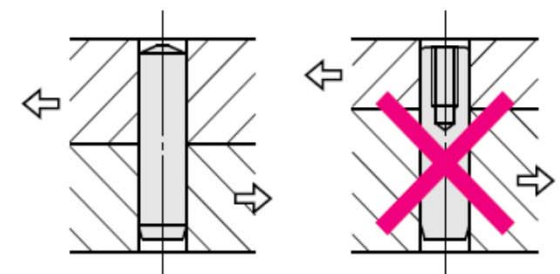
$$= \pi D^2 \tau / 4$$

$$D = \sqrt{(4P) / (\pi \tau)}$$

$$= \sqrt{(4 \times 800) / (3.14 \times 19.2)}$$

$$\approx 7.3$$

σ_b for yield stress of SUJ2 = 120 [kgf/mm²]
 Allowable shearing strength $\tau = \sigma_b \times 0.8 / \text{safety factor } \alpha$
 $= 120 \times 0.8 / 5$
 $= 19.2 \text{ [kgf/mm}^2\text{]}$



Avoid using the dowel pins in such a way as load is applied to the screw part.

∴ For MS dowel pin, select D8 or larger size.

When larger size dowel pins are used, tools and stocks can be reduced.

The calculations shown above are only examples of finding strength. For actual calculation, various conditions, such as accuracy of inter-hole pitch, perpendicularity of holes, surface roughness, circularity, plate materials, parallelism, quenching, precision of press machine, quantity of production, and wear of tools, should be taken into account. Use these examples as a reference for calculating strength. (They are not guaranteed values.)