

# Tragwerksentwurf II

## Formeln und Tabellen

### Legende / Legend

#### Kräfte (innere und äussere) / Forces

- A, B = Auswirkung, Auflagerkraft [kN]  
*Internal member force, reaction force*  
 N = Normalkraft / Axial force [kN]  
 V = Querkraft / Shear force [kN]  
 M = Moment / Moment [kNm]

#### Lasten / Loads

- F = Einwirkung (Einzellast) [kN]  
*Action (applied load / single load)*  
 G = Einzellast, ständig / Dead point load [kN]  
 Q = Einzellast, veränderlich / Live point load [kN]  
 s = Linienlast allgemein / Line load general [kN/m]  
 $\bar{s}$  = Flächenlast allgemein / Area load general [kN/m<sup>2</sup>]  
 g = Linienlast ständig / Dead line load [kN/m]  
 q = Linienlast veränderlich / Live line load [kN/m]  
 $\bar{g}$  = Flächenlast ständig / Dead area load [kN/m<sup>2</sup>]  
 $\bar{q}$  = Flächenlast veränderlich / Live area load [kN/m<sup>2</sup>]

#### Sicherheitsfaktoren für Lasten / Safety factors for loads:

- Ständige Lasten/ Dead load:  $\gamma_G = 1.35$   
 Veränderliche Lasten/ Live load:  $\gamma_Q = 1.50$

#### Geometrie / Geometry

- A = Querschnittsfläche / Cross-sectional area [mm<sup>2</sup>]  
 W = Widerstandsmoment / Section modulus [mm<sup>3</sup>]  
 I = Trägheitsmoment / Moment of inertia [mm<sup>4</sup>]  
 l = Länge / Length [mm]  
 r = Radius / Radius [mm]  
 d = Durchmesser / Diameter [mm]  
 t = Wandstärke / Thickness [mm]  
 b = Breite / Width [mm]  
 h = Höhe / Height [mm]

#### Index / Indices

- k = Charakteristischer Wert / Characteristic value  
 d = Wert auf Bemessungsniveau / Design value  
 q = veränderliche Last / Live load  
 g = ständige Last / Dead load  
 allow = Zulässige ... / Allowable ...  
 cr = Kritische Knicklast / Critical buckling load  
 req = erforderliche ... / Required ...  
 ef = effektive ... / Effective ...  
 t = Zug ... / Tension ...  
 c = Druck ... / Compression ...  
 m = Moment ... / Moment ...

### Materialkennwerte / Material properties

Holz Timber	Elastizitätsmodul E Modulus of Elasticity E [N/mm <sup>2</sup> ]	Zugfestigkeit $f_{tk}$ Allowable tensile stress $f_{tk}$ [N/mm <sup>2</sup> ]	Druckfestigkeit $f_{tk}$ Allowable compressive stress $f_{tk}$ [N/mm <sup>2</sup> ]	Biegefestigkeit $f_{mk}$ Allowable bending strength $f_{mk}$ [N/mm <sup>2</sup> ]	Raumlast $\gamma_k$ Material density $\gamma_k$ [kN/m <sup>3</sup> ]	Widerstandsbeiwert $\gamma_M$ Material safety factor $\gamma_M$
Fichte Spruce	11'000	14	20	24	3.5	1.7
Buche Beech	11'000	24	26	30	5	
Eiche Oak	11'000	26	26	40	5.5	
BSH Glulam	11'000	18	22	29	4	

Stahl Steel	Elastizitätsmodul E Modulus of elasticity E [N/mm <sup>2</sup> ]	Zugfestigkeit $f_{tk}$ Allowable tensile stress $f_{tk}$ [N/mm <sup>2</sup> ]	Druckfestigkeit $f_{tk}$ Allowable compressive stress $f_{tk}$ [N/mm <sup>2</sup> ]	Biegefestigkeit $f_{mk}$ Allowable bending stress $f_{mk}$ [N/mm <sup>2</sup> ]	Raumlast $\gamma_k$ Material density $\gamma_k$ [kN/m <sup>3</sup> ]	Widerstandsbeiwert $\gamma_M$ Material safety factor $\gamma_M$
S235	210'000	235	235	235	80.0	1.05
S355		355	355	355		
S500		500	500	500		

Beton Concrete	Elastizitätsmodul E Modulus of elasticity E [N/mm <sup>2</sup> ]	Zugfestigkeit $f_{tk}$ (unbewehrt) Allowable tensile stress $f_{tk}$ (unreinforced) [N/mm <sup>2</sup> ]	Druckfestigkeit $f_{tk}$ Allowable compressive stress $f_{tk}$ [N/mm <sup>2</sup> ]	Raumlast $\gamma_k$ Material density $\gamma_k$ [kN/m <sup>3</sup> ]	Widerstandsbeiwert $\gamma_M$ Material safety factor $\gamma_M$
C 12/15	28'000	1.1	12	25	1.5
C20/25	30'000	1.5	20		
C35/45	34'000	2.2	35		
C55/65	37'000	2.9	55		

# Tragwerksentwurf II

## Formeln und Tabellen

### Tragfähigkeitsformeln / Formulas of load-bearing capacity:

Bemessungswert der Zugfestigkeit  
 Design value allowable tensile stress  $f_{td} = f_{tk} / \gamma_M$  [N/mm<sup>2</sup>]

Bemessungswert der Druckfestigkeit  
 Design value allowable compressive stress  $f_{cd} = f_{ck} / \gamma_M$  [N/mm<sup>2</sup>]

Bemessungswert der Biegefestigkeit  
 Design value allowable bending strength  $f_{md} = f_{mk} / \gamma_M$  [N/mm<sup>2</sup>]

Spannung / Stress  $f = N_d / A$  [N/mm<sup>2</sup>]

Bemessungswert der Kraft  
 Design value of force  $F_d = F_k \cdot \gamma$  [kN]

### Bemessungsformeln / Dimensioning Formulas

Belastungsart / Nature of force:

Bemessen / Dimension:

Nachweis / Proof:

Zug / Tension:

$$A_{req} = \frac{N_d}{f_{td}} \quad [\text{mm}^2]$$

$$N_d \leq N_{allow} = f_{td} \cdot A_{ef} \quad [\text{N}]$$

Druck / Compression:

- Materialversagen / Material failure:

$$A_{req} = \frac{N_d}{f_{cd}} \quad [\text{mm}^2]$$




$$N_d \leq N_{allow} = f_{cd} \cdot A_{ef} \quad [\text{N}]$$

Biegung / Bending:

$$W_{req} = \frac{M_d}{f_{md}} \quad [\text{mm}^3]$$

$$f_{m\,ef} = \frac{M_d}{W_{ef}} \leq f_{md} \quad [\text{N/mm}^2]$$

### Querschnittswerte / Section properties:

Rechteck/ Rectangular		$A = b \cdot h$ [mm <sup>2</sup> ]	$I_y = \frac{b \cdot h^3}{12}$ [mm <sup>4</sup> ] $I_z = \frac{h \cdot b^3}{12}$ [mm <sup>4</sup> ]	$W_y = \frac{b \cdot h^2}{6}$ [mm <sup>3</sup> ] $W_z = \frac{h \cdot b^2}{6}$ [mm <sup>3</sup> ]
Kreis/ Circle		$A = r^2 \cdot \pi$ [mm <sup>2</sup> ]	$I = \frac{\pi \cdot r^4}{4}$ [mm <sup>4</sup> ]	$W = \frac{\pi \cdot r^3}{4}$ [mm <sup>3</sup> ]
Kreisring/ Circular ring		$A = (R^2 - r^2) \cdot \pi$ [mm <sup>2</sup> ]	$I = \frac{\pi \cdot (R^4 - r^4)}{4}$ [mm <sup>4</sup> ]	$W = \frac{\pi \cdot (R^4 - r^4)}{4R}$ [mm <sup>3</sup> ]

### Trigonometrie / Trigonometry:

$$\gamma = 90^\circ \quad \begin{array}{lll} \sin \beta = b/c & \cos \beta = a/c & \tan \beta = b/a \\ \sin \alpha = a/c & \cos \alpha = b/c & \tan \alpha = a/b \end{array}$$

