Connection Profiles 8 160 und 8 240

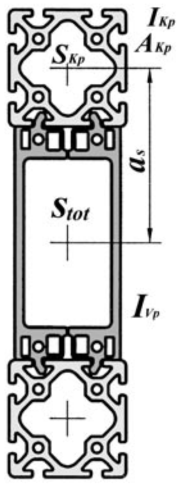
Method for an approxinate calculation of deflection and maximum load with regard to the 8 160 and 8 240 connection profiles and the corresponding struts! There is also an example to demonstrate how the method is used in practice. The sample calculation also shows how deflection changes for different profiles.

Calculating deflection

Engineering literature* contains numerous formulae for calculating the deflection of determinate and indeterminate girders with constant cross-sections under differing types of load and, in particular, for calculating the elastic line and the maximum deflection. On the basis of the superposition principle, these load types can be superimposed over one another to provide a close approximation to the real load. Using the elastic line, we can then calculate the deflection at any desired point along the girder. Fig. 1 shows four typical load situations with the corresponding formulae for the elastic line and maximum deflection. The parameters required are the modulus of elasticity, the length, the geometrical moment of inertia of the girder and the load. The modulus of elasticity of aluminium is known. The length of the girder (here, the profile) and the forces acting on it are known from the application. The geometrical moment of inertia can be read from the catalogue for a single profile. If the girder structure consists of a number of profiles together, the geometrical moment of inertia can be calculated mathematically using Steiner's principles.

In the case of a straight-through connecting profile, the geometrical moment of inertia is calculated as follows:

$$I_{tot} = 2 \cdot \left(I_{vp} + I_{kp} + a_s^2 \cdot A_{kp} \right) \qquad [I]$$



If the girder is made up of struts, the geometrical moment of inertia is thus:

$$I_{totSt} = \frac{2}{3} \cdot I_{tot} \qquad [II]$$

or

$$I_{totSt} = \frac{4}{3} \cdot \left(I_{vp} + I_{kp} + a_s^2 \cdot A_{kp} \right) \qquad [III]$$

I_{tot}: geom. moment of inertia of the enclosed girder

I_{totSt}: geom. moment of inertia of the girder made of struts

I_{Vp}: geom. moment of inertia of the connecting profile

I_{Kp}: geom. moment of inertia of the construction profile

A_{Kp}: Cross-sectional area of the construction profile

a_s: Distance between centres of inertia of construction girder

Calculating the maximum load

In contrast to an individual profile, the load capacity of a constructed girder is not limited by the permissible bending stress. The load limit of an assembly made up of parts is characterised by the movement of the component parts at the points of contact relative to one another. This shift is caused by the shearing strains around the points of contact cannot be compensated for by the clamping forces of the screw joints.

In order to calculate the maximum load capacity, the shearing force in the girder must first be calculated:

$$F_Q = \frac{F_{screw} \cdot n_{screw} \cdot I_{tot}}{A_{rest} \cdot a_s \cdot l} \qquad [IV]$$

F_{screw}: Screw force 3500N for closed box construction

n_{screw}: Number of screws in one shear plane

I_{tot}: Geometrical moment of inertia

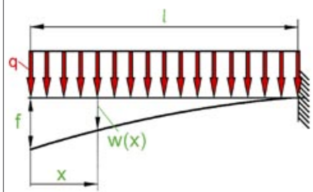
A_{rest}: Remaining surface (surface beyond a shear plane)

a_s: Distance between points of inertia

l: Length of girder

Once the shearing force is known, the maximum load capacity can be calculated using cutting condition calculations.

Case 1

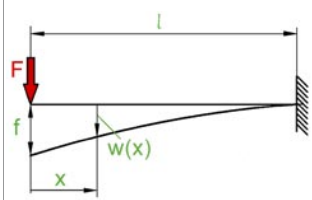


$$w(x) = \frac{q \cdot l^4}{24 \cdot E \cdot I_y} \cdot \left[3 - 4\frac{x}{l} + \left(\frac{x}{l}\right)^4 \right]$$

$$f = \frac{q \cdot l^4}{8 \cdot E \cdot I_y}$$

$$q = \frac{F_Q}{l}$$

Case 2

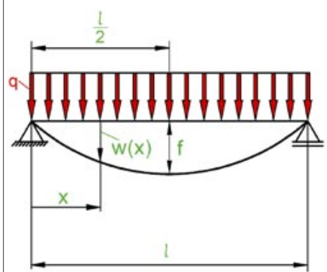


$$w(x) = \frac{F \cdot l^3}{6 \cdot E \cdot I_y} \left[2 - 3\frac{x}{l} + \left(\frac{x}{l}\right)^3 \right]$$

$$f = \frac{F \cdot l^3}{3 \cdot E \cdot I_y}$$

$$F = F_Q$$

Case 3

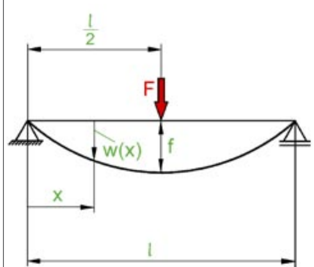


$$w(x) = \frac{q \cdot l^4}{24 \cdot E \cdot I_y} \cdot \left[\frac{x}{l} - 2\left(\frac{x}{l}\right)^3 + \left(\frac{x}{l}\right)^4 \right]$$

$$f = \frac{5 \cdot q \cdot l^4}{384 \cdot E \cdot I_y}$$

$$q = \frac{2 \cdot F_Q}{l}$$

Case 4



$$w(x) = \frac{F \cdot l^3}{48 \cdot E \cdot I_y} \cdot \left[3\frac{x}{l} + 4\left(\frac{x}{l}\right)^3 \right]$$

$$f = \frac{F \cdot l^3}{48 \cdot E \cdot I_y}$$

$$F = 2 \cdot F_Q$$

w(x): formula of elastic line

f : max. deflection

F_Q: max.shearing force

Fig. 1

* Dubbel „Taschenbuch für den Maschinenbau“

Note:

In order to prevent the profiles sliding in relation to each other, the mating surfaces should be degreased thoroughly before fixing together. Also, to ensure that maximum possible normal force is applied, the nuts and bolts should be greased. Friction under the head and on the thread is thus reduced considerably. We recommend applying a tightening torque of 30Nm.

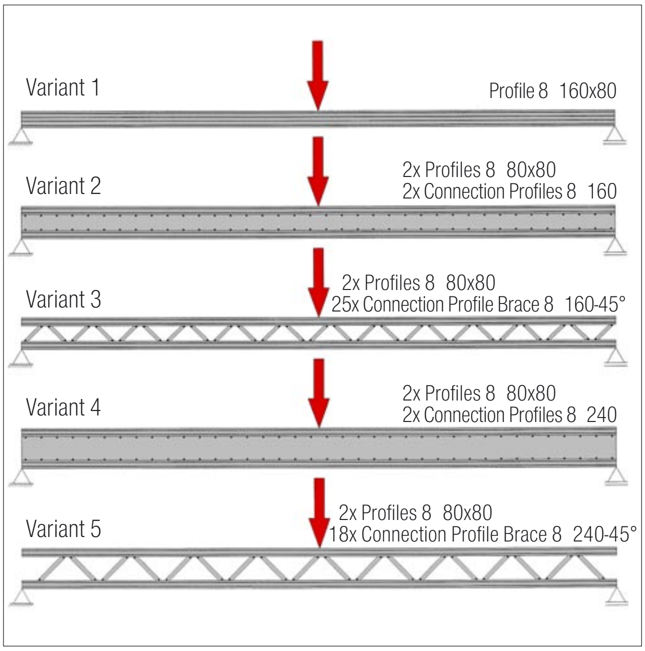


Fig. 2

Sample calculation

Assume a 6m girder is supported as in case 4. A static force of 300kg is applied to the girder at the middle. The task is to calculate the deflection and the safety of the variants shown in Fig. 2 as regards slipping.

Calculating the geometrical moment of inertia

The geometrical moments of inertia for each profile can be seen from the catalogue. The constructed girders are calculated as follows using formula I/III:

Geometrical moments of inertia					
Variante	1	2	3	4	5
I_{tot} [cm^4]	1228.33	9266.08	6177.39	17633.32	11755.55

Calculation of deflection resulting from the girder's deadweight

First the line load has to be calculated. This is, in effect, given in the catalogue for Profile 8 160x80 as mass per metre. With closed box-girders, the mass per metre of the connecting and construction profiles are added together. Then, add the individual masses of the screws used and divide this total by length of the girder. The overall line load is the sum of these two values.

If connecting struts are used, add the masses of the individual struts and fasteners divided by the length of the girder and add to this the weights per metre of the construction profiles.

Deflection as a result of the girder's deadweight is calculated using the formula in case 3.

Deflection from own deadweight					
Variante	1	2	3	4	5
q [N/m]	132.63	236.46	161.01	279.82	165.97
f [mm]	2.60	0.62	0.63	0.38	0.34

with

E_{Al} = 70,000 N/mm^2
m_{160x80} = 13.52 kg/m
m_{80x80} = 7.19 kg/m
m_{Vp160} = 4.76 kg/m
m_{160x80} = 6.97 kg/m
$M_{Strut160}$ = 0.488 kg
$M_{Strut240}$ = 0.846 kg
$M_{screw+M}$ = 0.034 kg

Deflection under load

Depending on the type of load assumed, the formula for deflection is as follows:

Deflection under load					
Variante	1	2	3	4	5
f [mm]	15.70	2.08	3.12	1.09	1.64

Fig. 3 shows the deflection under load for these variants

Calculating maximum load and safety margins

The maximum shearing force is calculated using formula IV. The external force that generates the shearing force in this case, is twice as large. If we divide the maximum permissible load by the actual load, we obtain the safety factor S.

Maximum load of linked girders					
Variante	1	2	3	4	5
n_{screw}		74	50	74	36
$n_{screwShearplane}$		37	25	37	18
A_{rest} [cm^2]		26.66	26.66	26.66	26.66
F_{qmax} [N]		6251	2816	8922	2894
F_{max} [N]		12503	5632	17844	5787
S		4.2	1.9	5.9	1.9

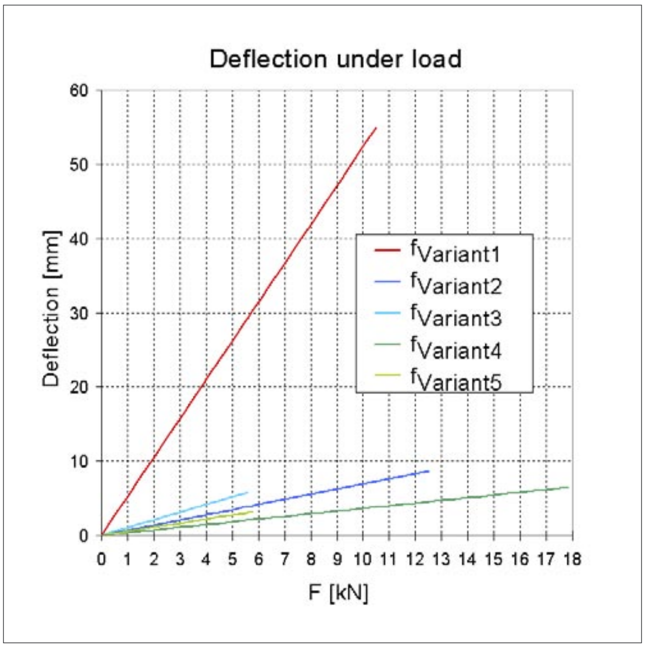


Fig. 3