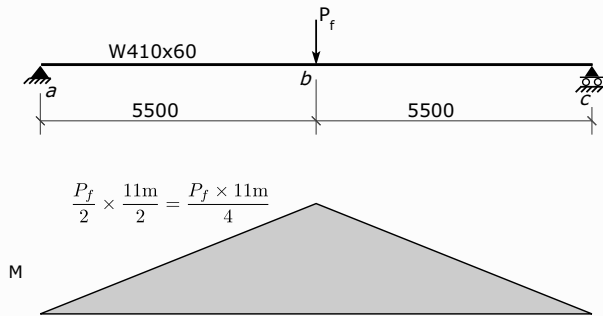```
from Designer import SST, figure, show
from math import sqrt
```

```
figure("eg-F10.svg")
```

```
phi = 0.9
Fy = 345.
Dsg,d,b,t,w,Ix,Zx,Iy,J,Cw = SST.section('W410x60','Dsg,D,B,T,W,Ix,Zx,Iy,J,Cw')
h = d - 2*t
show('Dsg,d,b,t,w,h,*10**6,Ix,Iy,*10**3,Zx,J,*10**9,Cw,*,Fy')
```

```
Dsg = W410x60
d   = 407
b   = 178
t   = 12.8
w   = 7.7
h   = 381.4
Ix  = 216 * 10**6
Iy  = 12 * 10**6
Zx  = 1190 * 10**3
J   = 328 * 10**3
Cw  = 468 * 10**9
Fy  = 345
```

Check Local Buckling

```
show('bel/t = b/(2*t), 170/sqrt(Fy)')  # check flange against class 2 limits
```

```
bel/t         = 6.953
170/sqrt(Fy) = 9.152
```

```
show('h/w, 1700/sqrt(Fy)')  # check web against class 2 limits
```

```
h/w           = 49.53
1700/sqrt(Fy) = 91.52
```

Therefore section is class 2 (or perhaps class 1 - that doesn't matter)

Case a) fully braced

From § 13.5: $M_r = \phi M_p = \phi F_y Z_x$

```
Mr = phi*Fy*Zx * 1E-6   # * 1E-6 converts from N-mm to kN-m
Pf = Mr * 4. / 11.
show('Mr,Pf')
```

```
Mr = 369.5
Pf = 134.4
```

For case a), maximum P_f = 134 kN.

Case b) lateral bracing at supports only

The last paragraph of § 13.6 a) says the following:

> _For unbraced beam segments loaded above the shear centre between brace points, where the method of load delivery to the member provides neither lateral nor rotational restraint to the member, the associated destabilizing effect shall be taken into account using a rational method. For loads applied at the level of the top flange, in lieu of a more accurate analysis, M_u may be determined using $\omega_2 = 1.0$ and using an effective length, for pin-ended beams, of $1.2L$ and for all other cases, $1.4L._$

It seems reasonable that the above should apply to this case, so use an unbraced length of compression flange equal to 1.2 times the distance between supports.

S16-16 § 13.6 a) ii) gives the following for calculating M_u:

$$M_u = \frac{\omega_2 \pi}{L} \sqrt{EI_y GJ + \left(\frac{\pi E}{L}\right)^2 I_y C_w}$$

Often, we re-write that to make it a little simpler to apply manually:

$$A = EI_y GJ$$

$$B = \left(\frac{\pi E}{L}\right)^2 I_y C_w$$

$$M_u = \frac{\omega_2 \pi}{L} \sqrt{A + B}$$

In [7]:

```
pi = 3.14159
E = 200000.
G = 77000.
```

In [8]:

```
omega2 = 1.0
L = 1.2*11000
A = E*Iy*G*J
B = Iy*Cw*(pi*E/L)**2
Mu = (omega2*pi/L)*sqrt(A+B) * 1E-6   # for result in kN-m

Mp = Fy*Zx * 1E-6

show('omega2,L,A,B,Mu,Mp,0.67*Mp')
```

```
omega2   = 1
L        = 13200
A        = 6.061e+22
B        = 1.272e+22
Mu       = 64.45
Mp       = 410.6
0.67*Mp  = 275.1
```

As $M_u \leq 0.67 M_p$, $M_r = \phi M_u$:

In [9]:

```
Mr = phi*Mu
Pf = Mr * 4. / 11.
show('Mr,Pf')
```

```
Mr = 58.01
Pf = 21.09
```

For case b), maximum P_f = 21.1 kN.

Case c) Lateral bracing at ends and at centre

From Figure 2-17 in the commentary, $\omega_2 = 1.75$.

Or, the long way from § 13.6 a) ii):

$\kappa = 0$

(because in the beam segments between the brace points, *ab* and *bc*, the smallest end moment is 0, and $0/anything$ is zero, as long as $anything \neq 0$).

And then:

$\omega_2 = 1.75 + 1.05\kappa + 0.3\kappa^2 = 1.75$

In [10]:

```
omega2 = 1.75
L = 5500.
A = E*Iy*G*J
B = Iy*Cw*(pi*E/L)**2
Mu = (omega2*pi/L)*sqrt(A+B) * 1E-6    # for result in kN-m

Mp = Fy*Zx * 1E-6

show('omega2,L,A,B,Mu,Mp,0.67*Mp')
```

```
omega2   = 1.75
L        = 5500
A        = 6.061e+22
B        = 7.329e+22
Mu       = 365.8
Mp       = 410.6
0.67*Mp  = 275.1
```

In this case, $M_u > 0.67 M_p$ and thus M_r is given by § 13.6 a) i):

In [11]:

```
Mr = min( 1.15*phi*Mp*(1 - 0.28*Mp/Mu), phi*Mp )
Pf = Mr * 4. / 11.
show('Mr,Pf')
```

```
Mr = 291.4
Pf = 106
```

For case c) maximum P_f = 106 kN.

In [ ]: