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```
clear all
close all
clc
```

Variabels

```
Fvx=1600; Fvy=2250; Fvz=500; Raz=0; %forces
rk=0.08; a=0.05; b=0.14; c=0.07; d1=0.1; L=a+b+c+d1; %distances
D=45; B=25; an=20; %angels
Lx=0.05; Ly=0; %distances

%Effekt=2pi*n*M
n=70/60; P=3200;
Mv=P/(2*pi*n);

%Cone-length
R1=rk/sind(D);

Fp=Mv/(rk); Fa=Fp*tand(B); Fr=Fp*tand(an)/cosd(B);
```

Equation-system

```
%Rax Ray Rbx Rby Rbz
A1= [1 0 1 0 0;
    0 1 0 1 0;
    0 0 0 0 1;
    0 0 -1*(a+b) 0 0;
    0 0 0 1*(a+b) 0];

q1=[-Fvx-Fp;
    Fvy-Fa/sqrt(2)+Fr/sqrt(2);
```

```
    -Fvz-Fa/sqrt(2)-Fr/sqrt(2);
    Fvx*(a+b+c+d1)+Fp*a-Fvz*Lx;
    Fvy*(a+b+c+d1)-Fvz*Ly+Fr*cosd(D)*a-Fr*sind(D)*rk-Fa*cosd(D)*rk-
Fa*sind(D)*a];

R1=A1\q1;
Rax1=R1(1,1); Ray1=R1(2,1);
Rbx1=R1(3,1); Rby1=R1(4,1); Rbz1=R1(5,1);
```

Calculations

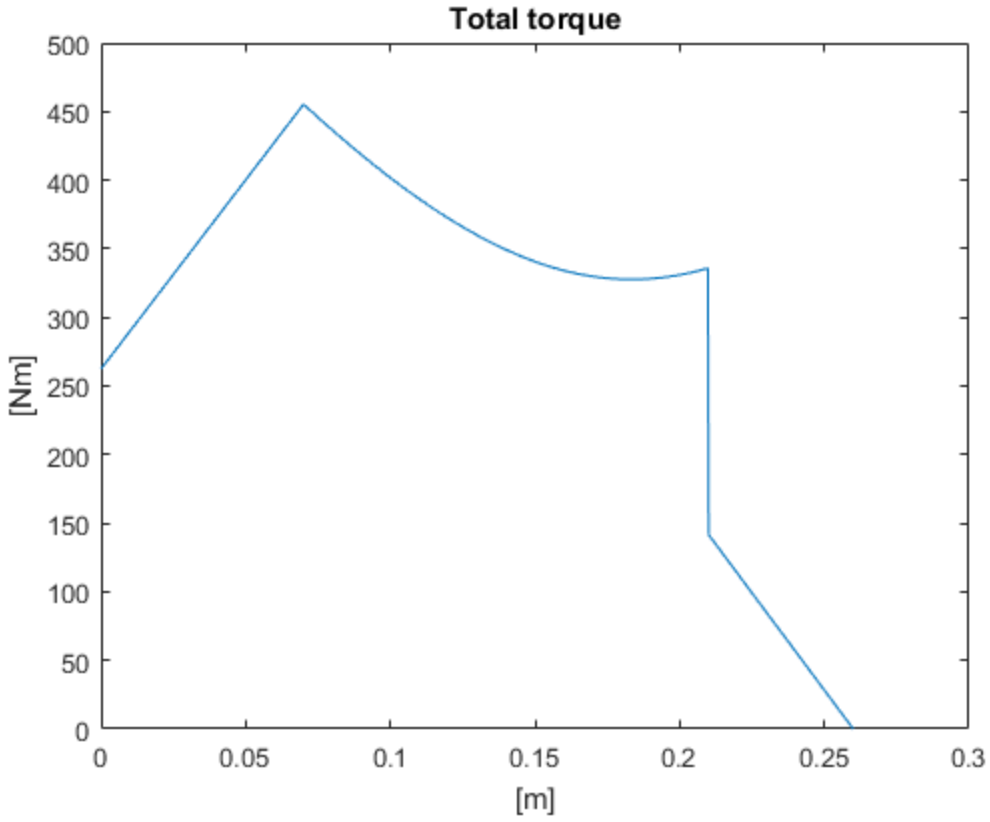
```
z=linspace(0,(a+b+c),1000);
for i=1:length(z)
    if z(i)>=0 && z(i)<(c)
        Tx(i) = Fvx;
        Ty(i) = -Fvy;
        Mx(i) = Fvz*Lx-Fvx*(z(i)+d1);
        My(i) = Fvy*(z(i)+d1);
        Mtot(i)=sqrt(Mx(i).^2+My(i).^2);
        Ttot(i)=sqrt(Tx(i).^2+Ty(i).^2);
    elseif z(i)>=(c) && z(i)<(c+b)
        Tx(i) = Fvx+Rbx1;
        Ty(i) = Rby1-Fvy;
        Mx(i) = Fvz*Lx-Fvx*(z(i)+d1)-Rbx1*(z(i)-c);
        My(i) = Fvy*(z(i)+d1)-Rby1*(z(i)-c);
        Mtot(i)=sqrt(Mx(i).^2+My(i).^2);
        Ttot(i)=sqrt(Tx(i).^2+Ty(i).^2);
    elseif z(i)>=(c+b) && z(i)<=(a+b+c)
        Tx(i) = Fvx + Rbx1 + Fp;
        Ty(i) = Rby1-Fvy-Fr*cosd(D)+Fa*sind(D);
        Mx(i) = Fvz*Lx-Fvx*(z(i)+d1)-Rbx1*(z(i)-c)-Fp*(z(i)-(c+b));
        My(i) = Fvy*(z(i)+d1)-Rby1*(z(i)-c)+Fr*cosd(D)*(z(i)-(c+b))-
Fr*sind(D)*rk-Fa*cosd(D)*rk-Fa*sind(D)*(z(i)-(c+b));
        Mtot(i)=sqrt(Mx(i).^2+My(i).^2);
        Ttot(i)=sqrt(Tx(i).^2+Ty(i).^2);
    end
end
```

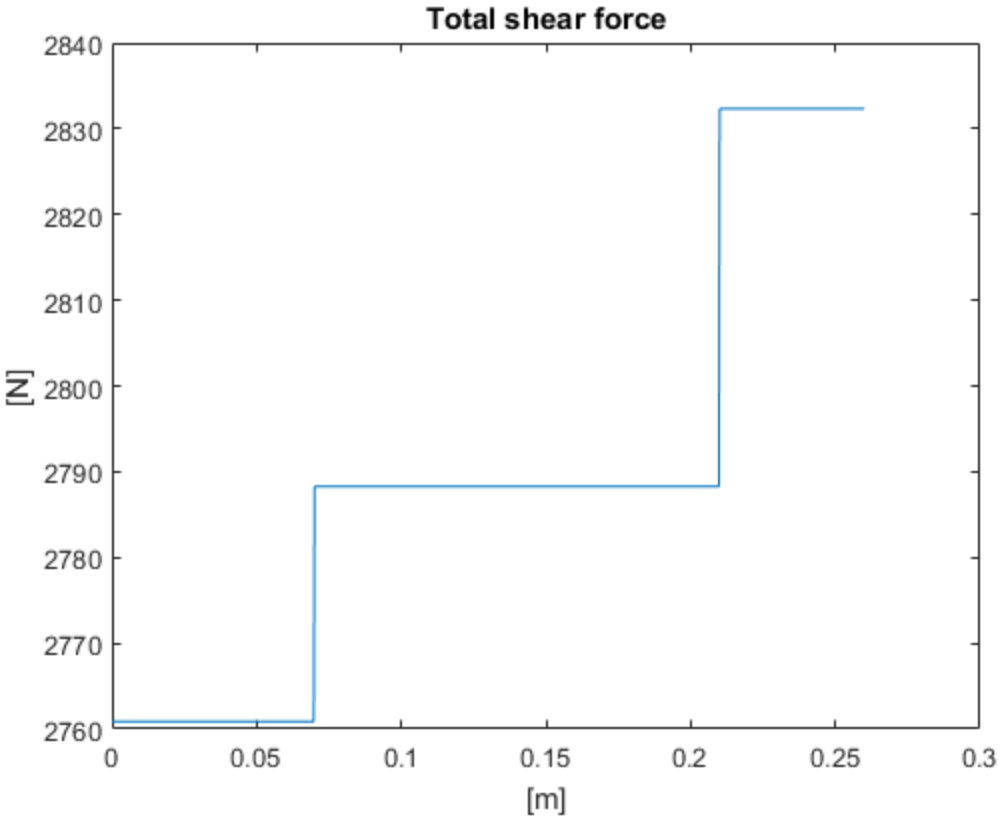
Plot

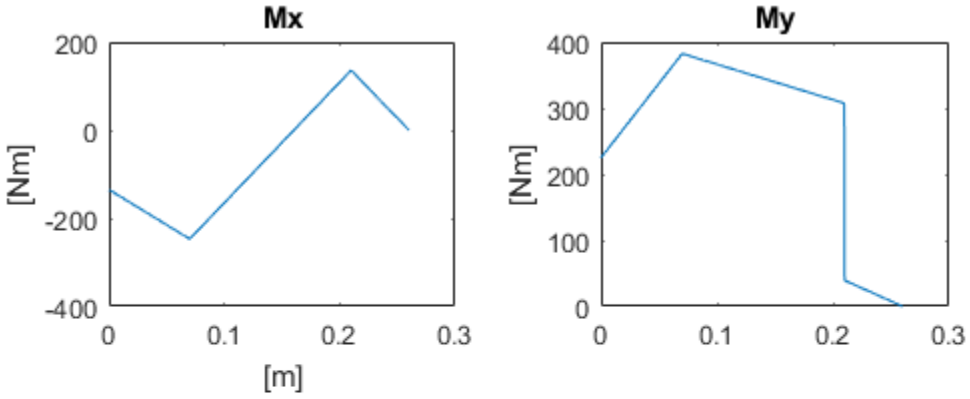
```
plot(z,Mtot);
title('Total torque');
ylabel('[Nm]'); xlabel('[m]');
figure;
plot(z,Ttot);
title('Total shear force');
ylabel('[N]'); xlabel('[m]');

figure;
Mxp=subplot(2,2,1);
plot(Mxp,z,Mx);
title(Mxp,'Mx');
```

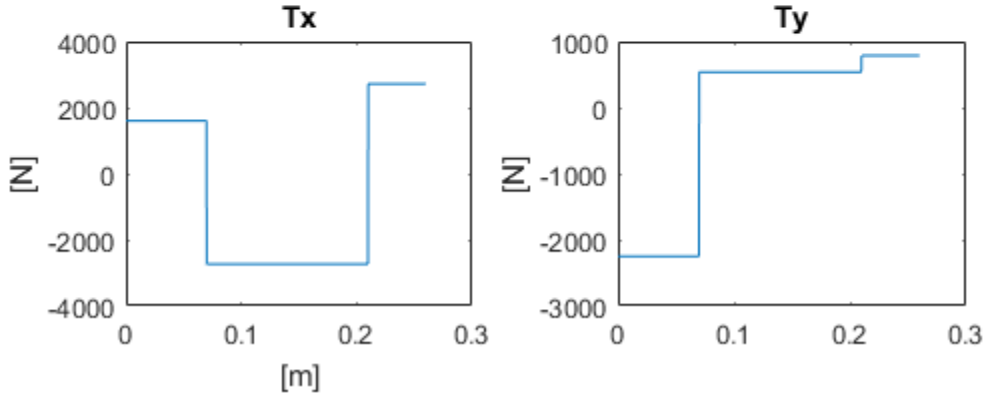
```
ylabel(Mxp,'[Nm]'); xlabel('[m]');
Myp=subplot(2,2,2);
plot(Myp,z,My);
title(Myp,'My');
ylabel(Myp,'[Nm]');
Txp=subplot(2,2,3);
plot(Txp,z,Tx);
title(Txp,'Tx');
ylabel(Txp,'[N]'); xlabel('[m]');
Typ=subplot(2,2,4);
plot(Typ,z,Ty);
title(Typ,'Ty');
ylabel(Typ,'[N]');
```




Total shear force
2840
2830
2820
2810
2800
2790
2780
2770
2760
[N]
0
0.05
0.1
0.15
0.2
0.25
0.3
[m]


Mx
200
0
-200
-400
[Nm]
0
0.1
0.2
0.3
[m]

My
400
300
200
100
0
[Nm]
0
0.1
0.2
0.3


Tx
4000
2000
0
-2000
-4000
[N]
0
0.1
0.2
0.3
[m]

Ty
1000
0
-1000
-2000
-3000
[N]
0
0.1
0.2
0.3

Dimension Stress

```
sigma_B=640e6; %Beteckning 141650-01 (KTH s.386)
sigma_y=390e6;
E=206e9;
rho=7780;
kt=2;
dy_s=0.033;
diai_s=0.032;

for i=1:length(z)
        Mb=Mtot(i);
        m=rho*L*pi*((dy_s/2).^2-(diai_s/2).^2);
        Wv=pi*(dy_s.^4-diai_s.^4)/(16*dy_s);
        Wb=pi*(dy_s.^4-diai_s.^4)/(32*dy_s);
        tao=Mv/Wv*kt;
        sigma_n=Mb/Wb*kt;
        sigma_Vm=sqrt(sigma_n.^2+3*tao.^2);

        while sigma_y < sigma_Vm
           dy_s=dy_s+0.0001;
           m=rho*L*pi*((dy_s/2).^2-(diai_s/2).^2);
           Wv=pi*(dy_s.^4-diai_s.^4)/(16*dy_s);
           Wb=pi*(dy_s.^4-diai_s.^4)/(32*dy_s);
           tao=Mv/Wv*kt; %Multiplie with kf (formfaktor)
           sigma_n=Mb/Wb*kt; %-||-
           sigma_Vm=sqrt(sigma_n.^2+3*tao.^2);
        end
        diay_s(i)=dy_s;
end
```

Dimension Fatigue

```
sigma_ub=270e6;
sigma_e=270e6; tao_e=sigma_e/sqrt(3);
ks=0.92; q=0.73; kf=1+q*(kt-1);
dy_f=0.033; diai_f=0.032;
Wv=pi*(dy_f.^4-diai_f.^4)/(16*dy_f); Wb=pi*(dy_f.^4-diai_f.^4)/
(32*dy_f);
sigma_a=Mtot(1)/Wb*kf/(kd(dy_f)*ks); tao_a=((Mv/Wv)*kf/
(kd(dy_f)*ks))/2;

for i=1:length(z)
    Wv=pi*(dy_f.^4-diai_f.^4)/(16*dy_f); Wb=pi*(dy_f.^4-diai_f.^4)/
(32*dy_f);
    sigma_a=Mtot(i)/Wb*kf/(kd(dy_f)*ks); tao_a=((Mv/Wv)*kf/
(kd(dy_f)*ks))/2;
    while sqrt((sigma_a/sigma_e).^2+(tao_a/tao_e).^2) > 1
        dy_f=dy_f+0.0001;
        Wv=pi*(dy_f.^4-diai_f.^4)/(16*dy_f); Wb=pi*(dy_f.^4-
diai_f.^4)/(32*dy_f);
```

```
        sigma_a=Mtot(i)/Wb*kf/(kd(dy_f)*ks); tao_a=((Mv/Wv)*kf/
(kd(dy_f)*ks))/2;
    end
    diay_f(i)=dy_f;
end
```

Dimension Bendning

```
d_max=50e-6;
diay_b=0.033; diai_b=0.032;
I=pi*(diay_b.^4-diai_b.^4)/64;
M1x=Fvx*(c+d1)-Fvz*Lx; M2x=0; M_ubx=0; Px=-Fp;
M1y=-Fvy*(c+d1); M2y=0; M_uby=-rk*(Fr*sind(D)+Fa*cosd(D));
 Py=Fr*cosd(D)-Fa*sind(D);
alpha=(b+c+d1)/L; beta=a/L;
delta=1;

while delta > d_max
    diay_b=diay_b+0.0001;
    I=pi*(diay_b.^4-diai_b.^4)/64;

    m1x=M1x*L/(3*E*I)+M2x*L/(6*E*I)+M_ubx*L/
(6*E*I)*(1-3*beta.^2)+Px*L.^2/(6*E*I)*alpha*beta*(1+beta);
    m1y=M1y*L/(3*E*I)+M2y*L/(6*E*I)+M_uby*L/
(6*E*I)*(1-3*beta.^2)+Py*L.^2/(6*E*I)*alpha*beta*(1+beta);
    delta_x=(d1+c)*sin(m1x); delta_y=(d1+c)*sin(m1y);
    delta=norm([delta_x delta_y]);
end

dia=[max(diay_s) max(diay_f) diay_b; diai_s diai_f diai_b];
```

Case 2

```
d2=0.06;
Ffa2=6000;

%Rax Ray Rbx Rby Rbz
A2= [1 0 1 0 0;
    0 1 0 1 0;
    0 0 0 0 1;
    0 0 1*(a+b) 0 0;
    0 0 0 1*(a+b) 0];

q2=[-Fp;
    -Fa*sind(D)+Fr*cosd(D);
    -Ffa2-Fa*cosd(D)-Fr*sind(D);
    -Fp*a;
    -Fa*cosd(D)*rk-Fa*sind(D)*a+Fr*cosd(D)*a-Fr*sind(D)*rk];
R2=A2\q2;
Rax2=R2(1,1); Ray2=R2(2,1);
Rbx2=R2(3,1); Rby2=R2(4,1); Rbz2=R2(5,1);
```

Case 3

```
d3=0.05;
Ffp=1400; Ffr=1400; Ffa=700; rt3=0.02; fi=45;

%Rax Ray Rbx Rby Rbz
A3= [1 0 1 0 0;
    0 1 0 1 0;
    0 0 0 0 1;
    0 0 1*(a+b) 0 0;
    0 0 0 1*(a+b) 0];

q3=[-Fp;
    -Fa*sind(D)+Fr*cosd(D)+(Ffr*sind(fi)+Ffp*cosd(fi));
    -Fr*sind(D)-Fa*cosd(D)+Ffa;
    -Fp*a-Ffa*rt3*cosd(fi);
    (Ffr*sind(fi)+Ffp*cosd(fi))*(a+b+c
+d3)+Ffa*rt3*cosd(fi)+Fr*cosd(D)*a-Fr*sind(D)*rk-Fa*cosd(D)*rk-
Fa*sind(D)*a];
R3=A3\q3;
Rax3=R3(1,1); Ray3=R3(2,1);
Rbx3=R3(3,1); Rby3=R3(4,1); Rbz3=R3(5,1);
```

Bearing calculations

```
k=3/2; %om R>0.90
ny=2.8; %Viskocitet sm?rjolja (Free)
ata=0.5; %normalt rena f?rh?llanden SKFs.66
a1=1;
%Case A 40%, Case 2 20%, Case 3 40%
```

Bearing A Variabels: SKF NU1014ECP s.616

```
CA=76.5e3; C0A=93e3; PuA=12e3; nA=7000/60; dA=0.070; DA=0.110;
pA=10/3; %rullager

%A har ingen axialkraft -> PA=FrA
FrA1=norm([Rax1 Ray1]); FrA2=norm([Rax2 Ray2]); FrA3=norm([Rax3
 Ray3]);
PA1=FrA1; PA2=FrA2; PA3=FrA3;

%KappaA and aSKF
dmA=(dA+DA)/2; %dmA=0.09 nA=7000 rpm -> ny1A=6.5 mm.^2
ny1A=6.5;
kappaA=ny/ny1A;
aSKFA1=aSKF_rollerbearings(kappaA,ata*PuA/PA1);
aSKFA2=aSKF_rollerbearings(kappaA,ata*PuA/PA2);
aSKFA3=aSKF_rollerbearings(kappaA,ata*PuA/PA3);

%Livsl?ngd
L10A1=a1*aSKFA1*(CA/PA1).^pA; L10A2=a1*aSKFA2*(CA/PA2).^pA;
 L10A3=a1*aSKFA3*(CA/PA3).^pA; L10A=[L10A1 L10A2 L10A3];
```

```
L10Am=1/(0.4/L10A1+0.2/L10A2+0.4/L10A3); %delskadeteori
L5Am=(log(0.95)/log(0.9)).^(1/k)*L10Am;
```

Bearing B Variabels: SKF 22318E s.906

```
CB=610e3; C0B=695e3; PuB=67e3; nB=2600/60; dB=0.090; DB=0.190;
 eB=0.33;
y1=2; y2=3; y0=2;
pB=10/3; %rullager

FrB1=norm([Rbx1 Rby1]); FrB2=norm([Rbx2 Rby2]); FrB3=norm([Rbx3
 Rby3]); Fr=[FrA1 FrA2 FrA3; FrB1 FrB2 FrB3];
FaB=abs([Rbz1 Rbz2 Rbz3]);

for i=1:3
    et(i)=FaB(i)/Fr(2,i);
    if et <= eB
        PB(i)=Fr(2,i)+y1*FaB(i);
    elseif et > eB
        PB(i)=0.67*Fr(2,i)+y2*FaB(i);
    end
end

%KappaB and aSKF
dmB=(dB+DB)/2; %dmB=0.1400 nB=2600 rpm -> ny1B=7 mm.^2
ny1B=7;
kappaB=ny/ny1B;
aSKFB1=aSKF_rollerbearings(kappaB,ata*PuB/PB(1));
aSKFB2=aSKF_rollerbearings(kappaB,ata*PuB/PB(2));
aSKFB3=aSKF_rollerbearings(kappaB,ata*PuB/PB(3));

%Livsl?ngd
L10B1=a1*aSKFB1*(CB/PB(1)).^pB; L10B2=a1*aSKFB2*(CB/PB(2)).^pB;
 L10B3=a1*aSKFB3*(CB/PB(3)).^pA; L10B=[L10B1 L10B2 L10B3];
L10Bm=1/(0.4/L10B1+0.2/L10B2+0.4/L10B3); %delskadeteori
L5Bm=(log(0.95)/log(0.9)).^(1/k)*L10Bm;
```

Bearing A&B

```
L10tot=(L10Am.^(-k)+L10Bm.^(-k)).^(-1/k);
L5tot=(log(0.95)/log(0.90)).^(1/k)*L10tot;
```

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