```
clear; close all;
L = 1200;
n = 1200;
P = 400;
locations = 292;
x = linspace(0, L, n+1);

x_train = [52 228 392 568 732 908];
P_train = [1 1 1 1 1 1] * P/6;

SFDi = zeros(locations, n+1);
BMDi = zeros(locations, n+1);

% technically, starting position is when back
% wheel is at the start of the bridge, so starting position is really -52
% This does not make much of a difference, you can test it out urself as
% well.

% With -52, max shear is 257 N amd moment is 6.96 * 10 ^ 4
% With 0, shear is 240 N and moment is 6.95 * 10 ^ 4
% So we are actually being extra safe :)

start = -52;
load = x_train + start;

% Calculate Shear and Bending

for i = 1:locations

    start = start + 1;

    Ry = ((P/6)*sum(load))/L;
    Ly = P - Ry;

    for j = 1:n+1
        if x(j) <= load(1)
            SFDi(i,j) = Ly;
        elseif x(j) <= load(2)
            SFDi(i,j) = Ly - (1*(P/6));
        elseif x(j) <= load(3)
            SFDi(i,j) = Ly - (2*(P/6));
        elseif x(j) <= load(4)
            SFDi(i,j) = Ly - (3*(P/6));
        elseif x(j) <= load(5)
            SFDi(i,j) = Ly - (4*(P/6));
        elseif x(j) <= load(6)
            SFDi(i,j) = Ly - (5*(P/6));
        else
            SFDi(i,j) = Ly - P;
        end
```

```
    BMDi(i,:) = cumsum(SFDi(i,:)*1);
    end
    load = x_train + start;
end

% SFD BMD Envelope
SFD = max(abs(SFDi));
BMD = max(abs(BMDi));

% CODE AND OUTPUTS FOR DESIGN 0 %

% Geometry for design 0
% x_c, tfw, tft, bfw, bft, wh, wt, mfw, mft
param = [0, 100, 1.27, 80, 1.27, 72.46, 1.27, 6.27, 1.27;
         400, 100, 1.27, 80, 1.27, 72.46, 1.27, 6.27, 1.27;
         800, 100, 1.27, 80, 1.27, 72.46, 1.27, 6.27, 1.27;
         L, 100, 1.27, 80, 1.27, 72.46, 1.27, 6.27, 1.27];

% x_c = cross section change
% tfw = top flange width
% tft = top flange thickness
% bfw = bottom flange width
% bft = bottom flange thickness
% wh = web height
% wt = web thickness (width since it's vertical)
% mfw = mid flange width
% mft = mid flange thickness

% User input interpolation
tfw = interp1(param(:,1), param(:,2), x);
tft = interp1(param(:,1), param(:,3), x);
bfw = interp1(param(:,1), param(:,4), x);
bft = interp1(param(:,1), param(:,5), x);
wh = interp1(param(:,1), param(:,6), x);
wt = interp1(param(:,1), param(:,7), x);
mfw = interp1(param(:,1), param(:,8), x);
mft = interp1(param(:,1), param(:,9), x);

% 3. Cross sectional properties (at each mm)
y_bar = zeros(1, n+1);
I = zeros(1, n+1);
Q_cent = zeros(1, n+1);
Q_glue = zeros(1, n+1);
b = zeros(1, n+1);
y_top = zeros(1, n+1);
y_bot = zeros(1, n+1);

% Computing Cross Sectional Properties.
for i = 1:n+1
```

```
    A1 = tft(i)*tfw(i);
    A2 = mfw(i)*mft(i);
    A3 = wh(i)*wt(i);
    A4 = bfw(i)*bft(i);

    maxH(i) = tft(i) + mft(i) + wh(i) +bft(i);

    y1b = bft(i) + wh(i) + mft(i) + tft(i)/2;
    y2b = bft(i) + wh(i) + mft(i)/2;
    y3b = bft(i) + wh(i)/2;
    y4b = bft(i)/2;

    y_bar(i) = (A1*y1b + 2*(A2*y2b) + 2*(A3*y3b) + A4*y4b)/(A1+2*A2+2*A3+A4);

    y_top(i) = bft(i) + wh(i) + mft(i) + tft(i) - y_bar(i);
    y_bot(i) = y_bar(i);

    I1o = (tfw(i)*(tft(i)^3))/12;
    I2o = (mfw(i)*(mft(i)^3))/12;
    I3o = (wt(i)*(wh(i)^3))/12;
    I4o = (bfw(i)*(bft(i)^3))/12;

    d_1sq = (y1b - y_bar(i))^2;
    d_2sq = (y2b - y_bar(i))^2;
    d_3sq = (y3b - y_bar(i))^2;
    d_4sq = (y4b - y_bar(i))^2;

    Itot(i) = I1o + 2*I2o + 2*I3o + I4o + A1*d_1sq + 2*(A2*d_2sq) + 2*(A3*d_3sq) + A4*

    d_4 = sqrt(d_4sq);
    d_3 = sqrt(d_3sq);
    d_2 = sqrt(d_2sq);
    d_1 = sqrt(d_1sq);

    b_ult(i) = wt(i)*2;
    b_glue(i) = 10;

    Q_cent(i) = A4*d_4 +2*(wt(i)*(y_bar(i)-bft(i))*(y_bar(i)-bft(i))/2);

    Q_glue(i) = A1*d_1;

    b1(i) = bfw(i)-wt(i);
    b2(i) = (tfw(i)-b1(i))/2;
    b3(i) = mft(i)+wh(i)+bft(i) - y_bar(i) - mft(i)/2;
    b4(i) = wh(i)+wt(i);

    a(i) = 400;

end
```

```
% 4. Calculate applied stresses
S_top = BMD.*y_top./Itot;
S_bot = BMD.*y_bot./Itot;
T_cent = SFD.*Q_cent./Itot./b_ult;
T_glue = SFD.*Q_glue./Itot./b_glue;

% 5. Material and Thing Plate Buckling Capacities
E = 4000;
mu = 0.2;
S_tens = 30*ones(1,n+1);
S_comp = 6*ones(1,n+1);
T_max= 4*ones(1,n+1);
T_gmax = 2*ones(1,n+1);
k1 = 4;
k2 = 0.425;
k3 = 6;
k4 = 5;
S_buck1 = ((k1*(pi^2*E))/(12*(1-mu^2))*((tft(i)/b1(i))^2))*ones(1, n+1);
S_buck2 = ((k2*(pi^2*E))/(12*(1-mu^2))*((tft(i)/b2(i))^2))*ones(1, n+1);
S_buck3 = ((k3*(pi^2*E))/(12*(1-mu^2))*((wt(i)/b3(i))^2))*ones(1, n+1);
S_buck4 = ((k4*(pi^2*E))/(12*(1-mu^2))*((wt(i)/b4(i))^2+(wt(i)/a(i))^2))*ones(1, n+1);

% 6. FOS
FOS_tens = S_tens./S_bot;
FOS_comp = S_comp./S_top;
FOS_shear = T_max./T_cent;
FOS_glue = T_gmax./T_glue;
FOS_buck1 = S_buck1./S_top;
FOS_buck2 = S_buck2./S_top;
FOS_buck3 = S_buck3./S_top;
FOS_buck4 = S_buck4./T_cent;

% 7. Min FOS
min_FOS_tens = min(FOS_tens);
min_FOS_comp = min(FOS_comp);
min_FOS_shear = min(FOS_shear);
min_FOS_glue = min(FOS_glue);
min_FOS_buck1 = min(FOS_buck1);
min_FOS_buck2 = min(FOS_buck2);
min_FOS_buck3 = min(FOS_buck3);
min_FOS_buck4 = min(FOS_buck4);

% 8. Failure Loads
Mf_tens = FOS_tens.*BMD;
Mf_comp = FOS_comp.*BMD;
Vf_shear = FOS_shear.*SFD;
Vf_glue = FOS_glue.*SFD;
Mf_buck1 = FOS_buck1.*BMD;
Mf_buck2 = FOS_buck2.*BMD;
Mf_buck3 = FOS_buck3.*BMD;
```

```
Vf_buck4 = FOS_buck4.*SFD;

% 9. Graphs for Max Capacities

%{
hold on; grid on; grid minor;
plot(x, Mf_tens, '--b', 'LineWidth', 2)
plot(x, Mf_comp, '--r', 'LineWidth', 2)
plot(x, BMD, 'k');
plot([0, L], [0, 0], 'k', 'LineWidth', 2)
title('Flexural Stress Capacities')
legend('Flexural Tension', 'Flexural Compression')
xlabel('Distance (mm)')
ylabel('Bending Moment (Nmm)')
set(gca,'ydir','reverse')
%}

%{
hold on; grid on; grid minor;
plot(x, Vf_shear, '--r', 'LineWidth', 2)
plot(x, SFD, 'k');
plot([0, L], [0, 0], 'k', 'LineWidth', 2)
title('Shear Capacity - Centroid')
legend('Shear Failure')
xlabel('Distance (mm)')
ylabel('Shear Force (N)')
%}

%{
hold on; grid on; grid minor;
plot(x, Vf_glue, '--r', 'LineWidth', 2)
plot(x, SFD, 'k');
plot([0, L], [0, 0], 'k', 'LineWidth', 2)
title('Shear Capacity - Glue')
legend('Glue Shear Failure')
xlabel('Distance (mm)')
ylabel('Shear Force (N)')
%}

%{
hold on; grid on; grid minor;
plot(x, Mf_buck1, 'b', 'LineWidth', 2)
plot(x, Mf_buck2, 'r', 'LineWidth', 2)
plot(x, BMD, 'k');
plot([0, L], [0, 0], 'k', 'LineWidth', 2)
title('Thin Plate Buckling Capacities - Top Flange')
legend('Buckling Case 1', 'Buckling Case 2')
xlabel('Distance (mm)')
ylabel('Bending Moment(Nmm)')
set(gca,'ydir','reverse')
```

```
%}

%{
hold on; grid on; grid minor;
plot(x, Mf_buck3, 'r', 'LineWidth', 2)
plot(x, BMD, 'k');
plot([0, L], [0, 0], 'k', 'LineWidth', 2)
title('Thin Plate Buckling Capacitiy - Web Buckling')
legend('Buckling Failure 3')
xlabel('Distance (mm)')
ylabel('Bending Moment (Nmm)')
set(gca,'ydir','reverse')
%}

%{
hold on; grid on; grid minor;
plot(x, Vf_buck4 , '--r', 'LineWidth', 2)
plot(x, SFD, 'k');
plot([0, L], [0, 0], 'k', 'LineWidth', 2)
title('Bucking Case 4 Capacities')
legend('Buckling Failure 4')
xlabel('Distance (mm)')
ylabel('Shear Force (N)')
%}
```