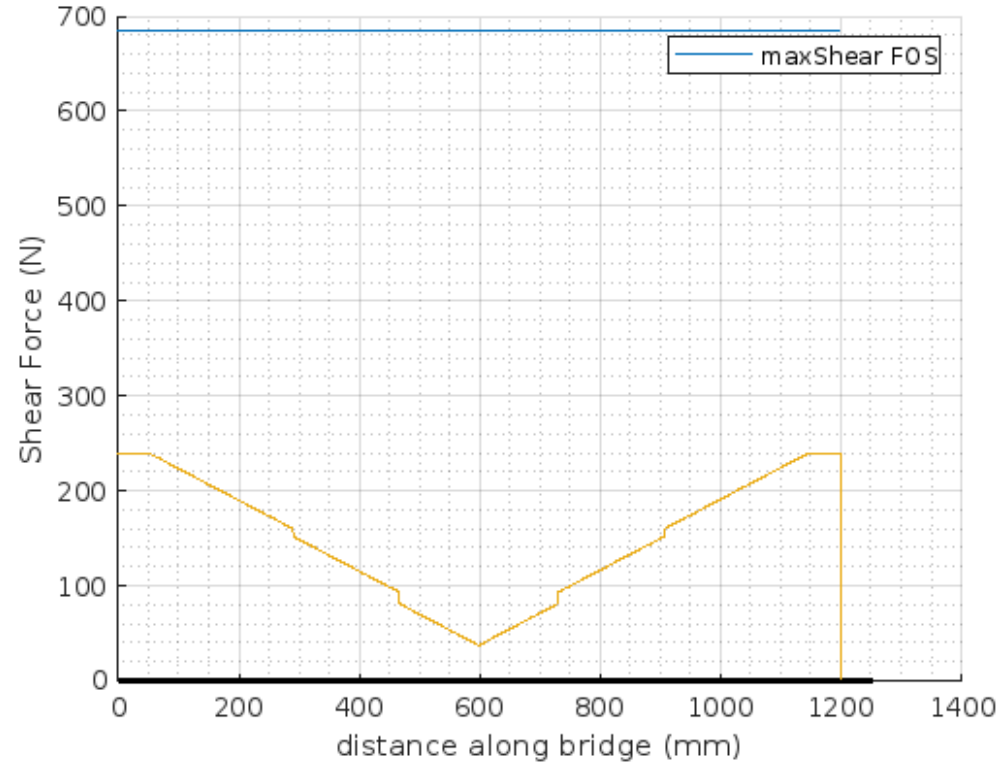
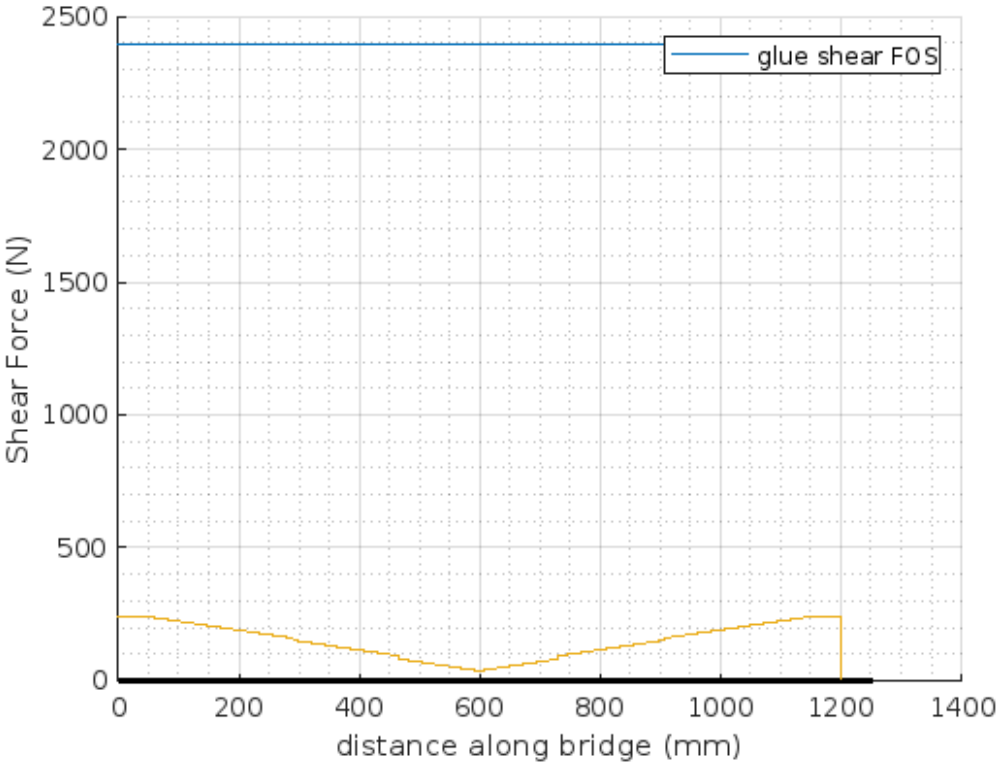
```
clear; close all;

% SFD and BMD

L = 1255; %length of board
n = 1200; %deiscretize by 1mm
P = 400; %total loading
u = 0; %uniform load
x = linspace(0, 1200, n+1); %x-axis

wheelLoc = [52 228 392 568 732 908]; %wheel location of train
wheelLoad = [-1 -1 -1 -1 -1 -1] * P/6; %load on each wheel

numStart = 241; % all 241 starting locations (0 - 240)
SFDi = zeros(numStart, n + 1);
BMDi = zeros(numStart, n + 1);

for i = 1:numStart
    reactionB = -(sum(wheelLoc .* wheelLoad) + 1200 * u * 600)/1200;
    reactionA = P - 1200 * u - reactionB;
    weight = zeros(1, n + 1); %weight function
    weight(1) = reactionA; % first element is reactionA
    weight(1201) = reactionB; % last element is reactionB
    for j = 1:length(wheelLoc)
        weight(wheelLoc(j)) = wheelLoad(j); % add applied load to weight
 function
    end
    SFDi(i, 1) = weight(1);
    for j = 2:n+1
        SFDi(i, j) = SFDi(i, j - 1) + weight(j) + u; % shear force of every
 increment = last SFD value + this weight value + UDL
    end
    for j = 2:n+1
        BMDi(i, j) = BMDi(i, j - 1) + SFDi(i, j); % bending moment of every
 increment = last BMD value + current SFD value
    end
    wheelLoc = wheelLoc + 240/(numStart - 1); % change starting location
end

SFD = max(abs(SFDi)); %SFD absoulte value envelope
BMD = max(BMDi); %BMD envelope

% Material and Sectional Properties

E = 4000;
mu = 0.2;
stressTens = 30;
stressComp = 6;
shearMax = 4;
shearGlueMax = 2;
dimensions = [1.27 72.46 72.46 1.27 1.27 1.27; 75 1.27 1.27 6.27 6.27
 100]; %R1 is height, R2 is width
```

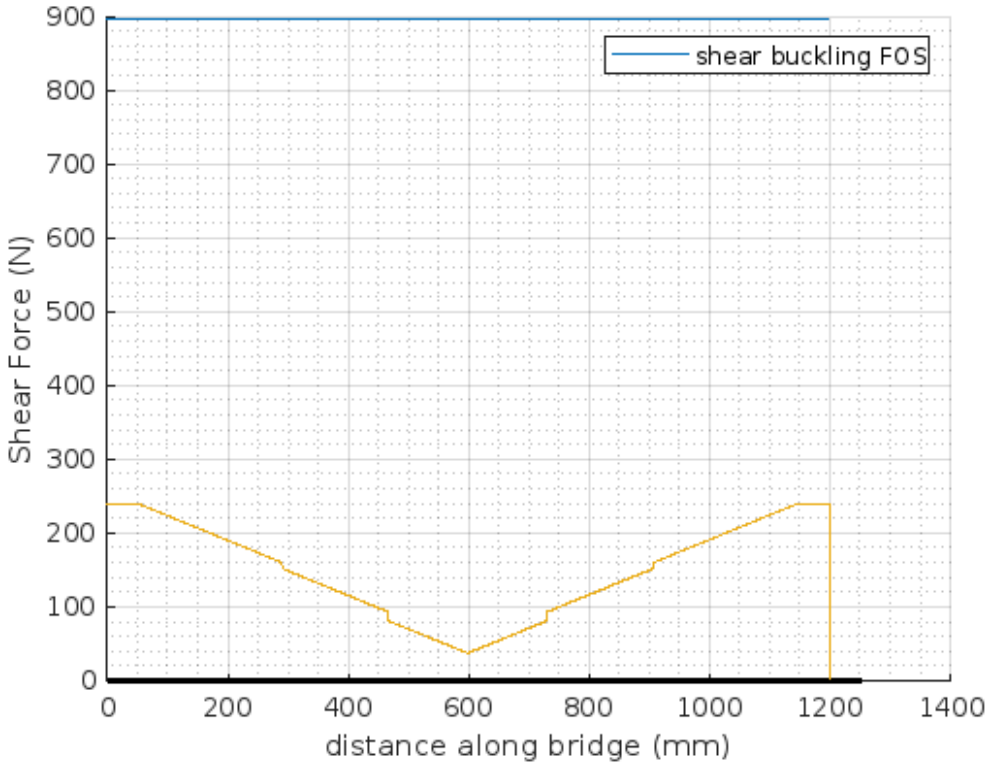
```
totHeight = dimensions(1,1) + dimensions(1,2) + dimensions(1,4) +
 dimensions(1,6);
ybarLocal = [dimensions(1,1)/2, dimensions(1,2)/2 + dimensions(1,1),
 dimensions(1,3)/2 + dimensions(1,1), dimensions(1,4)/2 + dimensions(1,2)
 + dimensions(1,1), dimensions(1,5)/2 + dimensions(1,3) + dimensions(1,1),
 dimensions(1,6)/2 + dimensions(1,4) + dimensions(1,2) + dimensions(1,1)];

% ybar
ybarNumerator = dot(dimensions(1,:) .* dimensions(2,:), ybarLocal);
ybarDenominator = dot(dimensions(1,:), dimensions(2,:));
ybar = ybarNumerator/ybarDenominator;

% I
I = sum(dimensions(1,:).^3 .* dimensions(2,:) / 12 + dimensions(1,:) .*
 dimensions(2,:) .* ((ybarLocal - ybar).^2));
Qmax = dimensions(1,1) * dimensions(2,1) * (ybar - ybarLocal(1,1)) + 2 * (ybar
 - dimensions(1,1)) * dimensions(2,2) * (ybar - ((ybar - dimensions(1,1))/2 +
 dimensions(1,1)));
Qglue = dimensions(1,6) * dimensions(2,6) * (totHeight - ybar -
 dimensions(1,6)/2);

%Applied Stresses
stressTop = BMD * (totHeight - ybar) / I; %compression
stressBot = BMD * (ybar) / I; %tension
shearCent = SFD * Qmax / (I * (dimensions(2, 2) + dimensions(2,
 3))); %maxShear
shearGlue = SFD * Qglue / (I * (dimensions(2, 4) +
 dimensions(2,5))); %shearGlue

% Thin plate buckling

flexBuck1 = (4 * pi^2 * E) / (12 * (1 - mu^2)) * (dimensions(1, 6) /
 (dimensions(2,1) - dimensions(2,2)/2 - dimensions(2,3)/2))^2;
flexBuck2 = (0.425 * pi^2 * E) / (12 * (1 - mu^2)) * (dimensions(1, 6) /
 ((dimensions(2,6) - dimensions(2,1))/2 + dimensions(2,2)/2))^2;
flexBuck3 = (6 * pi^2 * E) / (12 * (1 - mu^2)) * (dimensions(2, 2) /
 ((dimensions(1,1) + dimensions(1,2) + dimensions(1,4)/2) - ybar))^2;
shearBuck = (5 * pi^2 * E) / (12 * (1 - mu^2)) * ((dimensions(2,2)/
(dimensions(1,1) + dimensions(1,2)))^2 + (dimensions(2,2)/(L/3))^2);

% FOS of every location

FOS_tens_ALL = stressTens * stressBot.^(-1);
FOS_comp_ALL = stressComp * stressTop.^(-1);
FOS_shear_ALL = shearMax * shearCent.^(-1);
FOS_glue_ALL = shearGlueMax * shearGlue.^(-1);
FOS_buck1_ALL = flexBuck1 * stressTop.^(-1);
FOS_buck2_ALL = flexBuck2 * stressTop.^(-1);
FOS_buck3_ALL = flexBuck3 * stressTop.^(-1);
FOS_buckV_ALL = shearBuck * shearCent.^(-1);

% min FOS
FOS_tens = stressTens/max(stressBot);
FOS_comp = stressComp/max(stressTop);
```

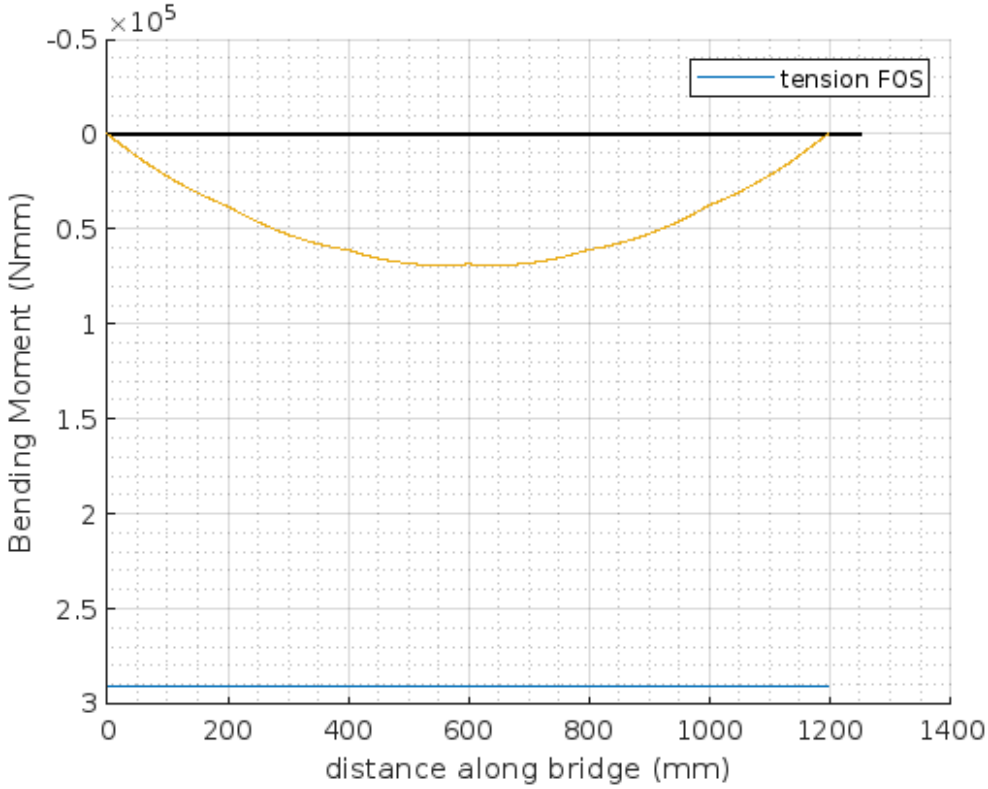
```
FOS_shear = shearMax/max(shearCent);
FOS_glue = shearGlueMax/max(shearGlue);
FOS_buck1 = flexBuck1/max(stressTop);
FOS_buck2 = flexBuck2/max(stressTop);
FOS_buck3 = flexBuck3/max(stressTop);
FOS_buckV = shearBuck/max(shearCent);

% Minimum FOS = stress allowable/max stress

stressTop = max(stressTop);
stressBot = max(stressBot);
shearCent = max(shearCent);
shearGlue = max(shearGlue);

%Plot

figure()
hold on; grid on; grid minor;
plot(x, FOS_shear_ALL .* SFD);
plot([0, L], [0, 0], 'k', 'LineWidth', 2)
plot(x, SFD);
legend("maxShear FOS");
xlabel("distance along bridge (mm)");
ylabel("Shear Force (N)");
hold off;

figure()
hold on; grid on; grid minor;
plot(x, FOS_glue_ALL .* SFD);
plot([0, L], [0, 0], 'k', 'LineWidth', 2)
plot(x, SFD);
legend("glue shear FOS");
xlabel("distance along bridge (mm)");
ylabel("Shear Force (N)");
hold off;

figure()
hold on; grid on; grid minor;
plot(x, FOS_buckV_ALL .* SFD);
plot([0, L], [0, 0], 'k', 'LineWidth', 2)
plot(x, SFD);
legend("shear buckling FOS");
xlabel("distance along bridge (mm)");
ylabel("Shear Force (N)");
hold off;

figure()
hold on; grid on; grid minor;
set(gca, "YDir", "reverse");
plot(x, FOS_tens_ALL .* BMD);
plot([0, L], [0, 0], 'k', 'LineWidth', 2)
plot(x, BMD);
legend("tension FOS");
xlabel("distance along bridge (mm)");
```

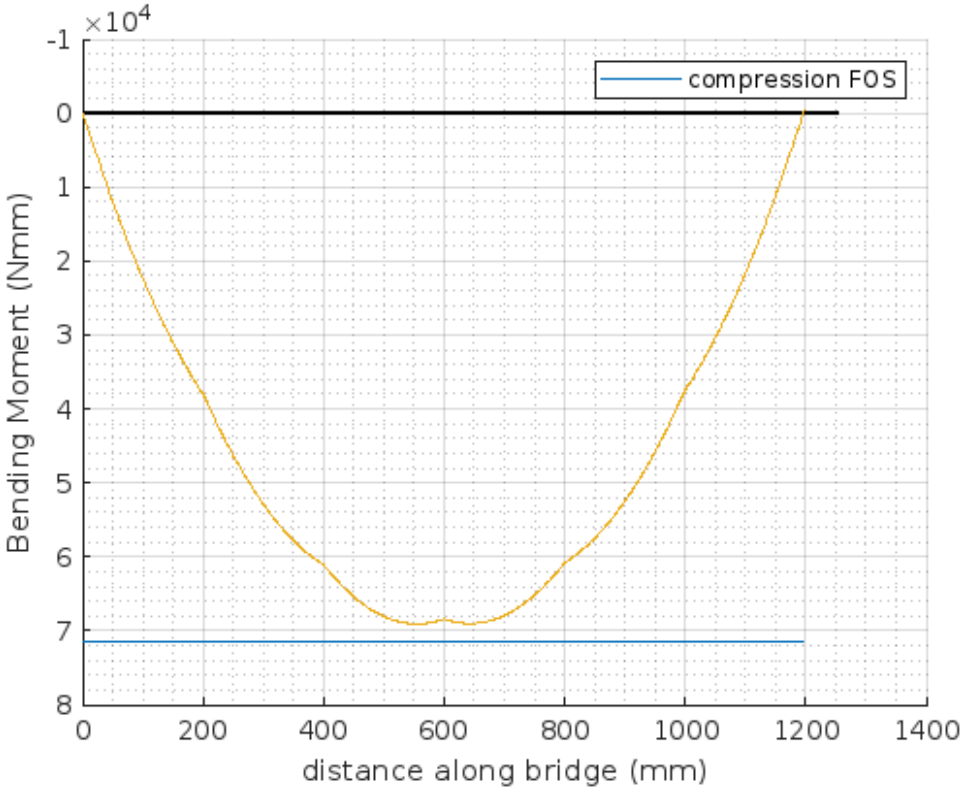
```
ylabel("Bending Moment (Nmm)");
hold off;

figure()
hold on; grid on; grid minor;
set(gca, "YDir", "reverse");
plot(x, FOS_comp_ALL .* BMD);
plot([0, L], [0, 0], 'k', 'LineWidth', 2)
plot(x, BMD);
legend("compression FOS");
xlabel("distance along bridge (mm)");
ylabel("Bending Moment (Nmm)");
hold off;

figure()
hold on; grid on; grid minor;
set(gca, "YDir", "reverse");
plot(x, FOS_buck1_ALL .* BMD);
plot([0, L], [0, 0], 'k', 'LineWidth', 2)
plot(x, BMD);
legend("case 1 buckling FOS");
xlabel("distance along bridge (mm)");
ylabel("Bending Moment (Nmm)");
hold off;

figure()
hold on; grid on; grid minor;
set(gca, "YDir", "reverse");
plot(x, FOS_buck2_ALL .* BMD);
plot([0, L], [0, 0], 'k', 'LineWidth', 2)
plot(x, BMD);
legend("case 2 buckling FOS");
xlabel("distance along bridge (mm)");
ylabel("Bending Moment (Nmm)");
hold off;

figure()
hold on; grid on; grid minor;
set(gca, "YDir", "reverse");
plot(x, FOS_buck3_ALL .* BMD);
plot([0, L], [0, 0], 'k', 'LineWidth', 2)
plot(x, BMD);
legend("case 3 buckling FOS");
xlabel("distance along bridge (mm)");
ylabel("Bending Moment (Nmm)");
hold off;
```

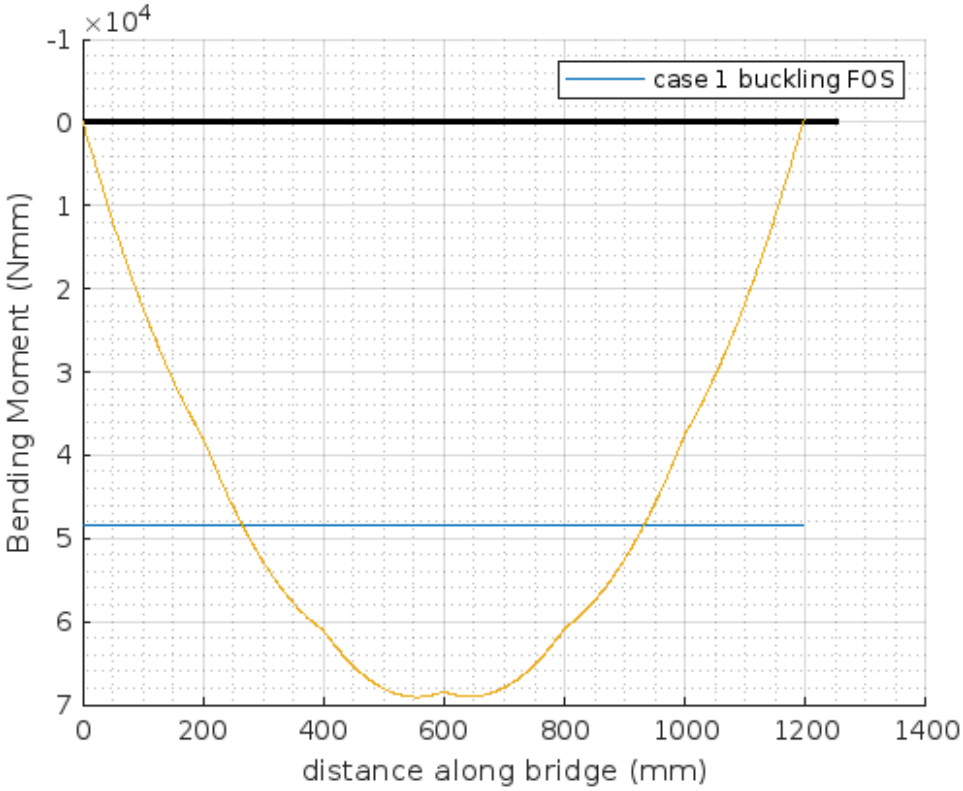

maxShear FOS
Shear Force (N)
distance along bridge (mm)
0
100
200
300
400
500
600
700
0
200
400
600
800
1000
1200
1400

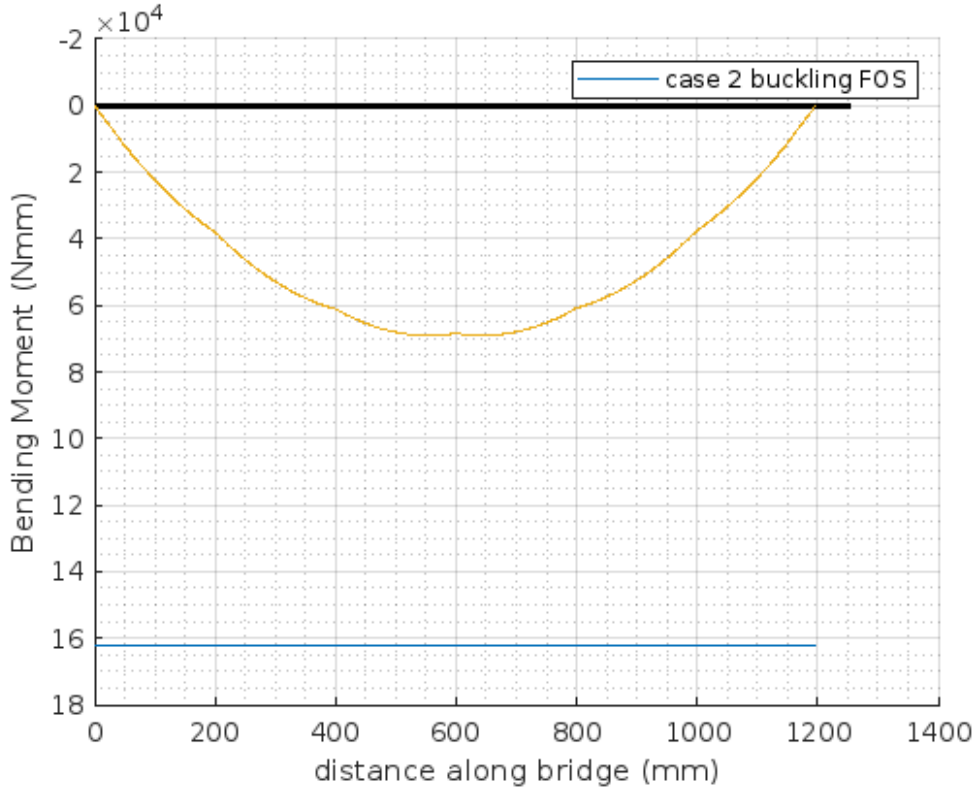

glue shear FOS
Shear Force (N)
distance along bridge (mm)
0
500
1000
1500
2000
2500
0
200
400
600
800
1000
1200
1400

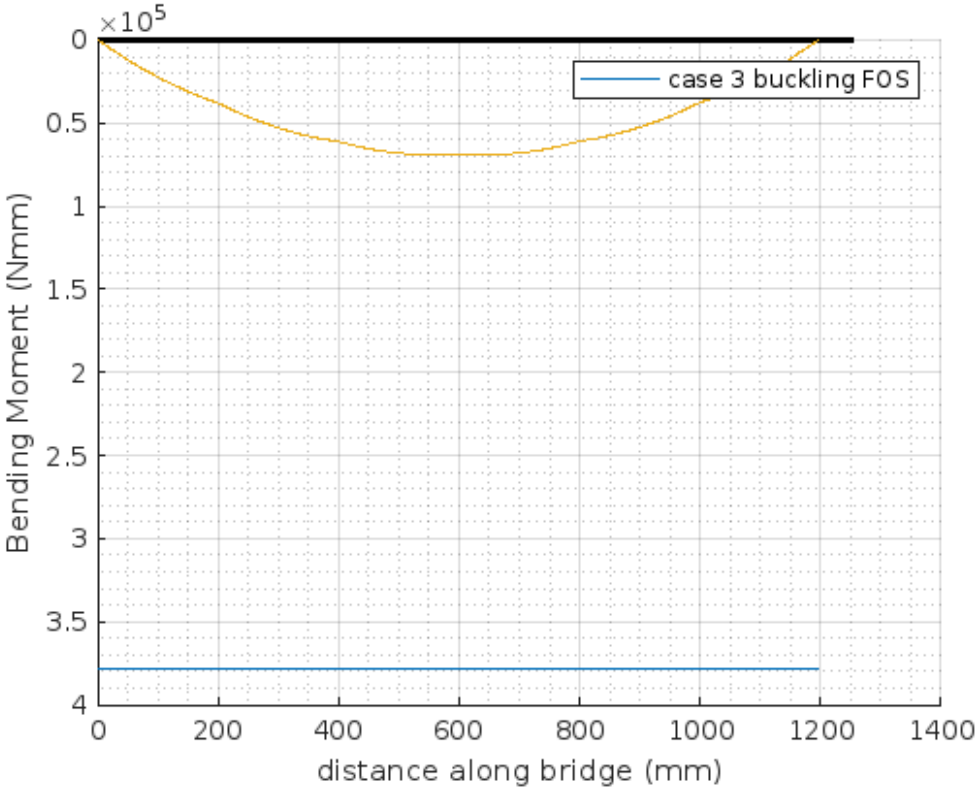

shear buckling FOS
Shear Force (N)
distance along bridge (mm)
0
100
200
300
400
500
600
700
800
900
0
200
400
600
800
1000
1200
1400


tension FOS
×10^5
Bending Moment (Nmm)
distance along bridge (mm)
-0.5
0
0.5
1
1.5
2
2.5
3
0
200
400
600
800
1000
1200
1400


×10^4
-1
0
1
2
3
4
5
6
7
8
Bending Moment (Nmm)
compression FOS
0
200
400
600
800
1000
1200
1400
distance along bridge (mm)


×10^4
-1
0
1
2
3
4
5
6
7
Bending Moment (Nmm)
case 1 buckling FOS
0
200
400
600
800
1000
1200
1400
distance along bridge (mm)


×10^4
-2
0
2
4
6
8
10
12
14
16
18
Bending Moment (Nmm)
case 2 buckling FOS
0
200
400
600
800
1000
1200
1400
distance along bridge (mm)


×10^5
0
0.5
1
1.5
2
2.5
3
3.5
4
Bending Moment (Nmm)
case 3 buckling FOS
0
200
400
600
800
1000
1200
1400
distance along bridge (mm)

Published with MATLAB® R2022b