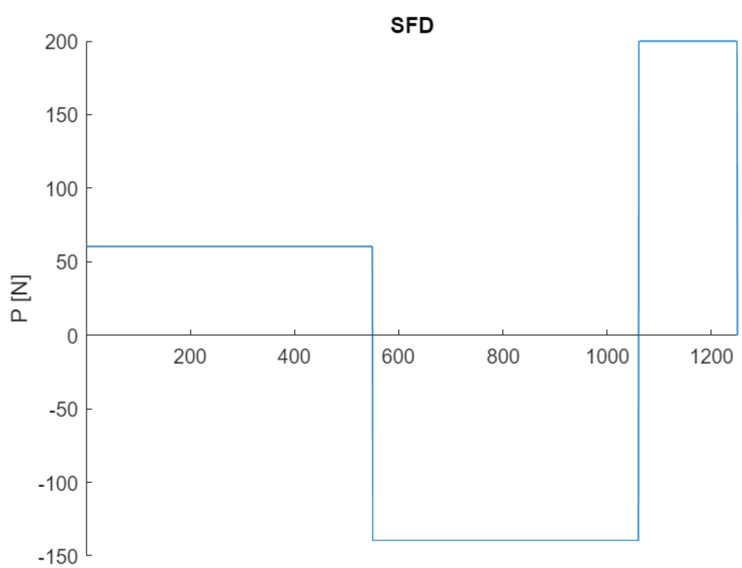
Initialize Parameters

```
n = 1000;                % number of locations to evaluate
L = 1250;                % length of bridge
x = linspace(0, L, n);   % create coordinate system
SFD_PL = zeros(1, n);    % Initialize SFD(x) for point loads
```

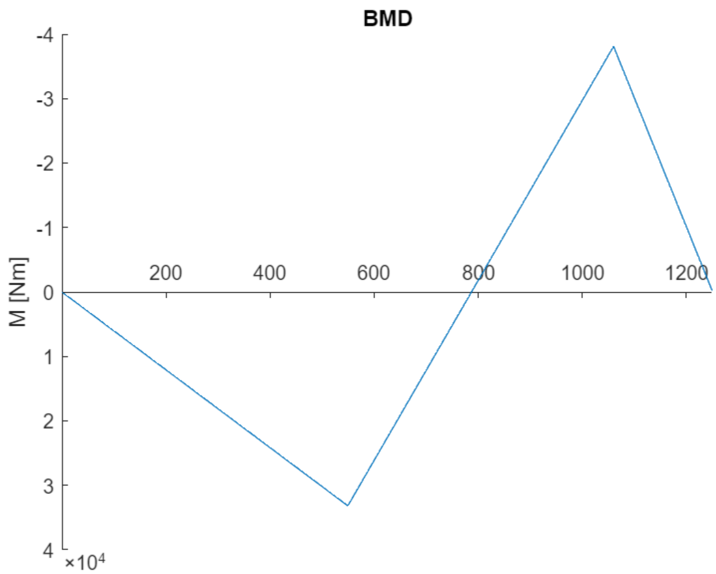
Point Loading Analysis (SFD, BMD)

```
P = 200;
[SFD_PL, ~] = ApplyPL(550, P, x, SFD_PL);  % Construct SFD, BMD
[SFD_PL, BMD_PL] = ApplyPL(L, P, x, SFD_PL);     % Construct SFD, BMD

% Plot SFD
figure;
hold on;
title("SFD");
ylabel("P [N]");
plot(x, SFD_PL);
ax = gca;
ax.XAxisLocation = 'origin';
xlim([0, x(n)]);
hold off;
```



```
% Plot BMD
figure;
hold on;
title("BMD");
ylabel("M [Nm]");
plot(x, BMD_PL);
ax = gca;
ax.XAxisLocation = 'origin';
ax.YDir = 'reverse';
xlim([0, x(n)]);
hold off;
```



Define Cross-Sections

```
xc = [0 786 L];             % Location, x, of cross-section change FIRST VALUE
MUST BE 0 AND LAST VALUE MUST BE L
bft = [100 100 100];        % Top Flange Width
tft = [1.27 1.27 1.27];     % Top Flange Thickness
hw = [75 75 75];            % Web Height
tw = [1.27 1.27 1.27];      % Web Thickness (Assuming 2 separate
bfb = [80 80 80];           % Bottom Flange Width
tfb = [1.27 1.27 1.27];     % Bottom Flange Thickness
amax = 520;                 % Largest Diaphragm Spacing override
tt = [10 10 10];            % Thickness of glue tab
% NOTE: Glue tabs are not considered for Section properties calculations
% Only used for Glue shear calculations

[ybar, I, Qcent, Qglue] = SectionProperties(xc, tft, bft, hw, tw, tfb, bfb, x)
```

```
ybar = 1×1000
         0   41.0812   41.0812   41.0812   41.0812   41.0812   41.0812 ⋯
I = 1×1000
10^5 ×
         0    4.1954    4.1954    4.1954    4.1954    4.1954    4.1954 ⋯
Qcent = 1×1000
10^3 ×
         0    6.1222    6.1222    6.1222    6.1222    6.1222    6.1222 ⋯
Qglue = 1×1000
10^3 ×
         0    4.5496    4.5496    4.5496    4.5496    4.5496    4.5496 ⋯
```

Visualize Bridge

Define Material Properties

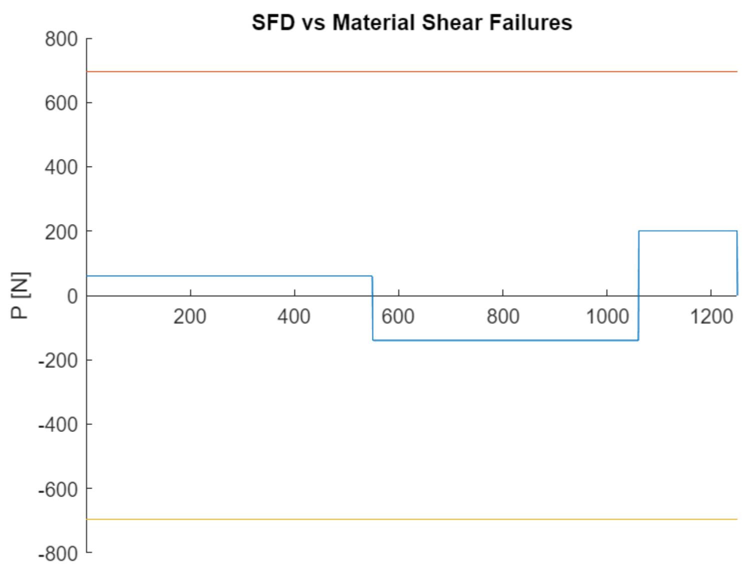
```
SigT = 30;
SigC = 6;
E = 4000;
TauU = 4;
TauG = 2;
mu = 0.2;
```

Calculate Failure Moments and Shear Forces

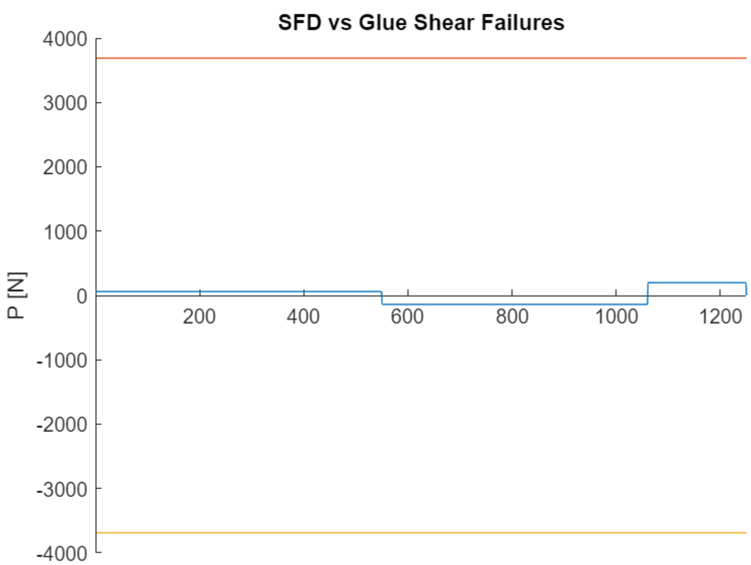
```
V_Mat = Vfail(I, Qcent, tw, x, xc, TauU); % Assume y_bar lies on the web, so b
= tw * 2
V_Glue = Vfail(I, Qglue, tt, x, xc, TauG);
V_Buck = VfailBuck(x, xc, tw, hw, E, mu, amax, I, Qcent);

[M_MatT, M_MatC] = MfailMatTC(I, tft, tfb, hw, xc, x, ybar, SigT, SigC,
BMD_PL); % only for point load
[M_BuckMid, M_BuckSide, M_BuckWeb] = MfailBuck(I, tft, tfb, tw, hw, bft, bfb,
ybar, xc, x, E, mu, BMD_PL );
```

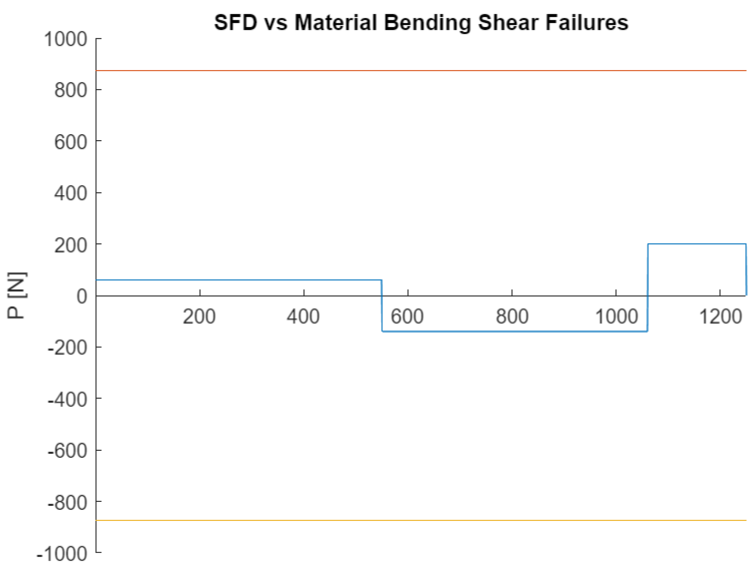
```
% plot material shear failure
figure;
hold on;
title("SFD vs Material Shear Failures");
ylabel("P [N]");
plot(x, SFD_PL);
plot(x, V_Mat);
plot(x, -V_Mat);
ax = gca;
ax.XAxisLocation = 'origin';
xlim([0, x(n)]);
hold off;
```



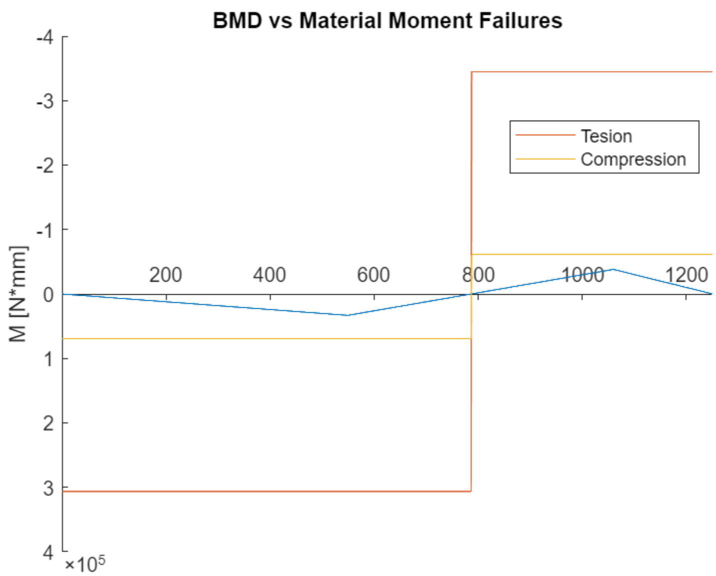
```
% plot glue shear failure
figure;
hold on;
title("SFD vs Glue Shear Failures");
ylabel("P [N]");
plot(x, SFD_PL);
plot(x, V_Glue);
plot(x, -V_Glue);
ax = gca;
ax.XAxisLocation = 'origin';
xlim([0, x(n)]);
hold off;
```



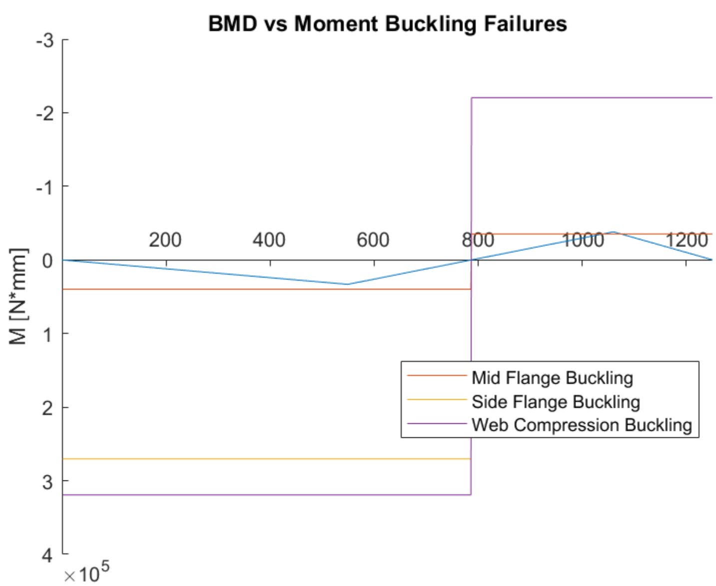
```
% plot material bending shear failure
figure;
hold on;
title("SFD vs Material Bending Shear Failures");
ylabel("P [N]");
plot(x, SFD_PL);
plot(x, V_Buck);
plot(x, -V_Buck);
ax = gca;
ax.XAxisLocation = 'origin';
xlim([0, x(n)]);
hold off;
```



```matlab
% plot material moment tension and compression failures
figure;
hold on;
title("BMD vs Material Moment Failures");
ylabel("M [N*mm]");
plot(x, BMD_PL);
plot(x, M_MatT);
plot(x, M_MatC);
legend("","Tesion", "Compression", Location="best")
ax = gca;
ax.XAxisLocation = 'origin';
ax.YDir = 'reverse';
xlim([0, x(n)]);
hold off;
```



```
% plot material moment Buckling failures
figure;
hold on;
title("BMD vs Moment Buckling Failures");
ylabel("M [N*mm]");
plot(x, BMD_PL);
plot(x, M_BuckMid);
plot(x, M_BuckSide);
plot(x, M_BuckWeb);
legend("","Mid Flange Buckling", "Side Flange Buckling", "Web Compression
Buckling", Location="best")
ax = gca;
ax.XAxisLocation = 'origin';
ax.YDir = 'reverse';
xlim([0, x(n)]);
hold off;
```



Calculate Failure Load

```
% Gives the failure load and says where the bridge had failed
[Pf] = FailLoad(P, SFD_PL, BMD_PL, V_Mat, V_Glue, V_Buck, M_MatT, M_MatC,
M_BuckMid, M_BuckSide, M_BuckWeb)
```

```
M_BuckMid
Pf = 186
```

Train Loading Analysis

```
% Construct SFD, BMD for train loading
P_train = 400 / 6;
SFD_train = zeros(1, n);  % Initialize SFD(x) for train
bridge_failed = false;
FOS = 100;
i = 0;
% Checks for every position of the trains on the bridge
while 856 + i < L
    [SFD_train, ~] = ApplyPL(52 - 52 + i, P_train, x, SFD_train);
    [SFD_train, ~] = ApplyPL(228 - 52 + i, P_train, x, SFD_train);
    [SFD_train, ~] = ApplyPL(392 - 52 + i, P_train, x, SFD_train);
    [SFD_train, ~] = ApplyPL(568 - 52 + i, P_train, x, SFD_train);
    [SFD_train, ~] = ApplyPL(732 - 52 + i, P_train, x, SFD_train);
    [SFD_train, BMD_train] = ApplyPL(908 - 52 + i, P_train, x, SFD_train);
    % check if bridge fails under train load
    [Pf_train] = FailLoad(P_train, SFD_train, BMD_train, V_Mat, V_Glue, V_Buck,
M_MatT, M_MatC, M_BuckMid, M_BuckSide, M_BuckWeb);
    % checks as assigns the lowest FOS during the train loading
    if Pf_train/P_train < FOS
        FOS = Pf_train/P_train;
    end
    if Pf_train < P_train
        disp("Bridge will FAIL under train load.")
        bridge_failed = true;
        break
    end
    i = i + 1;
    SFD_train = SFD_train .* 0;
end
```

```
M_BuckMid
Bridge will FAIL under train load.
```

```
if bridge_failed == false
    disp("Bridge will NOT FAIL under train load.")
end
disp("FOS: "+FOS)
```

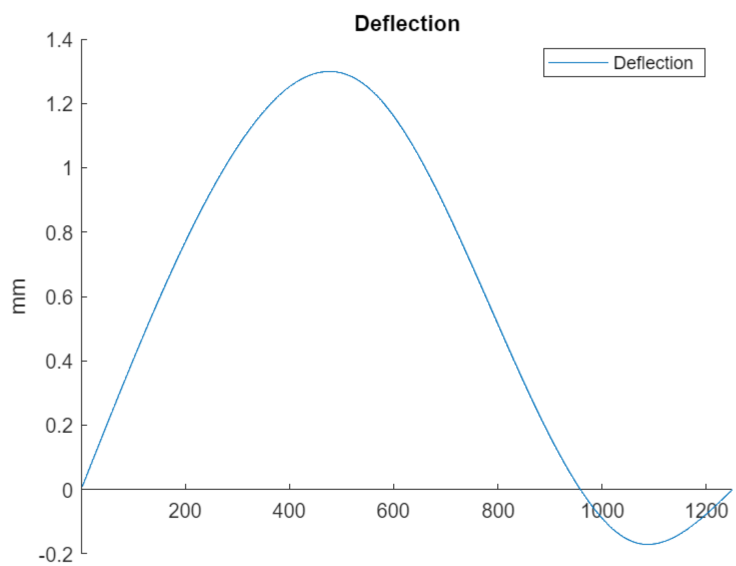
```
FOS: 0.735
```

Curvature, Slope, & Deflections

```
[deflection] = Deflections(x, BMD_PL, I, E, L)
```

```
deflection = 1×1000
       NaN          NaN      0.0102      0.0153      0.0205      0.0256      0.0307 ···
```

```
figure;
hold on;
title("Deflection");
ylabel("mm");
plot(x(1:size(deflection,2)), deflection);
legend("Deflection", Location="best")
ax = gca;
ax.XAxisLocation = 'origin';
xlim([0, x(n)]);
hold off;
```




```
% Gets deflection at midspan (between supports)
deflection_mid = deflection(1,(1060/2)/(L/n))
```

```
deflection_mid = 1.2747
```

Functions

```
function [SFD, BMD] = ApplyPL(xP, P, x, SFD)
     % Constructs SFD and BMD from application of 1 Point Load. Assumes fixed
location of supports
     % Input: location and magnitude of point load. The previous SFD can be
entered as input to construct SFD of multiple point loads
     % Output: SFD, BMD both 1-D arrays of length n
     location_1 = 0;  % Location of support A
     location_2 = location_1 + 1060; % Location of support B
     reaction_1 = (location_2 - xP) * P / (location_2 - location_1); % Force
excerted by support A
     reaction_2 = P - reaction_1; % Force excerted by support B
     sz = size(x, 2);
     for i = 1:sz
         % Find value of SFD at location x
         if x(i) >= location_1
             SFD(i) = SFD(i) + reaction_1;
         end
         if x(i) >= xP
             SFD(i) = SFD(i) - P;
         end
         if x(i) >= location_2
             SFD(i) = SFD(i) + reaction_2;
         end
     end
     BMD = zeros(1, sz);
     for i = 2:sz
         % Find value of BMD at location x
         BMD(i) = BMD(i - 1) + SFD(i) * (x(i) - x(i - 1));
     end
end

function [ybar, I, Qcent, Qglue] = SectionProperties(xc, tft, bft, hw, tw, tfb,
bfb, x)
     % Calculates important sectional properties: ybar, I, Qcent, Qglue
     % Input: Geometric Inputs
     % Output: Sectional Properties at every value of x. Each property is a 1-D
array of length n
     % Ignores diaphragms
     sz = size(x, 2);
     section_number = size(xc, 2) - 1;
     % Calculate ybar
     ybar = zeros(1, sz);
     area_total = zeros(1, sz);
     y_0_t = zeros(1, sz);
```

```
    y_0_w = zeros(1, sz);
    y_0_b = zeros(1, sz);
    A_t = zeros(1, sz);
    A_w = zeros(1, sz);
    A_b = zeros(1, sz);
    for i = 1:sz
        for j = section_number : -1 : 1
            if x(i) > xc(j)
                A_t(i) = tft(j) * bft(j);
                A_w(i) = hw(j) * tw(j);
                A_b(i) = tfb(j) * bfb(j);
                y_0_b(i) = tfb(j) / 2;
                y_0_w(i) = tfb(j) + hw(j) / 2;
                y_0_t(i) = tfb(j) + hw(j) + tft(j) / 2;
                area_total(i) = A_t(i) + 2 * A_w(i) + A_b(i);
                ybar(i) = (A_b(i) * y_0_b(i) + 2 * A_w(i) * y_0_w(i) + A_t(i) *
y_0_t(i)) / area_total(i);
                break
            end
        end
    end
    % calculate I
    I = zeros(1, sz);
    I_0_t = zeros(1, sz);
    I_0_w = zeros(1, sz);
    I_0_b = zeros(1, sz);
    d_0_t = zeros(1, sz);
    d_0_w = zeros(1, sz);
    d_0_b = zeros(1, sz);
    for i = 1:sz
        for j = section_number : -1 : 1
            if x(i) > xc(j)
                d_0_t(i) = abs(y_0_t(i) - ybar(i));
                d_0_w(i) = abs(y_0_w(i) - ybar(i));
                d_0_b(i) = abs(y_0_b(i) - ybar(i));
                I_0_t(i) = bft(j) * tft(j) ^ 3 / 12;
                I_0_w(i) = tw(j) * hw(j) ^ 3 / 12;
                I_0_b(i) = bfb(j) * tfb(j) ^ 3 / 12;
                I(i) = I_0_t(i) + d_0_t(i) ^ 2 * A_t(i) + 2 * (I_0_w(i) +
d_0_w(i) ^ 2 * A_w(i)) + I_0_b(i) + d_0_b(i) ^ 2 * A_b(i);
                break
            end
        end
    end
    % calculate Qcent
    Qcent = zeros(1, sz);
```

```
    for i = 1:sz
        for j = section_number : -1 : 1
            if x(i) > xc(j)
                %Qcent(i) = d_0_t(i) * A_t(i) + 2 * (tfb(j) + hw(j) - ybar(i))
/ 2 * A_w(i);
                Qcent(i) = d_0_b(i) * A_b(i) + 2 * (ybar(i)-tfb(j)) / 2 *
(tw(j)*(ybar(i)-tfb(j)));
                break
            end
        end
    end
    % calculate Qglue
    Qglue =  zeros(1, sz);
    for i = 1:sz
        for j = section_number : -1 : 1
            if x(i) > xc(j)
                Qglue(i) = d_0_t(i) * A_t(i);
                break
            end
        end
    end
end

function [V_fail] = Vfail(I, Qcent, tw, x, xc, TauU)
    % Calculates shear forces at every value of x that would cause a matboard
shear failure
    % Input: Sectional Properties (list of 1-D arrays), TauU (scalar material
property)
    % Output: V_fail a 1-D array of length n
    sz = size(x, 2);
    section_number = size(xc, 2) - 1;
    b = zeros(1, sz);
    for i = 1:sz
        for j = section_number : -1 : 1
            if x(i) > xc(j)
                b(i) = tw(j) * 2;
                break
            end
        end
    end
    V_fail = TauU .* I .* b ./ Qcent;
end

function [V_Buck] = VfailBuck(x, xc, tw, hw, E, mu, amax, I, Qcent)
    % Calculates shear forces at every value of x that would cause a shear
buckling failure
```

```
    % Input: Sectional Properties (list of 1-D arrays), E, mu (material property)
    % Output: V_Buck, a 1-D array of length n
    sz = size(x, 2);
    section_number = size(xc, 2) - 1;
    V_Buck = nan(1, sz);
    for i = 1:sz
        for j = section_number : -1 : 1
            if x(i) > xc(j)
                V_Buck(i) = 5 * pi ^ 2 * E / 12 / (1 - mu ^ 2) * ((tw(j) / hw(j)) ^ 2 + (tw(j) / amax) .^ 2) * I(i) * (tw(j)*2) / Qcent(i);
                break
            end
        end
    end
end

function [ M_MatT, M_MatC ] = MfailMatTC(I, tft, tfb, hw, xc, x, ybar, SigT, SigC, BMD)
    % Calculates bending moments at every value of x that would cause a matboard tension failure
    % Input: Sectional Properties (list of 1-D arrays), SigT (material property), BMD (1-D array)
    % Output: M_MatT and M_MatC, 1-D arrays of length n
    section_number = size(xc, 2) - 1;
    sz = size(x, 2);
    M_MatT = nan(1, sz);
    M_MatC = nan(1, sz);
    for i = 1 : sz
        for j = section_number : -1 : 1
            if x(i) > xc(j)
                ytop(i) = tfb(j) + hw(j) + tft(j) - ybar(i);
                ybot(i) = ybar(i);
                if BMD(i) > 0 % If the moment is positive, the tension is at the bottom compression is at the top
                    M_MatT(i) = SigT * I(i) / ybot(i);
                    M_MatC(i) = SigC * I(i) / ytop(i);
                elseif BMD(i) < 0 % If the moment is negative, the tension is at the top compression is at the bottom
                    M_MatT(i) = -SigT * I(i) / ytop(i);
                    M_MatC(i) = -SigC * I(i) / ybot(i);
                end
                break
            end
        end
    end
```

```
 end

 function [ M_BuckMid, M_BuckSide, M_BuckWeb ] = MfailBuck(I, tft, tfb, tw, hw,
bft, bfb, ybar, xc, x, E, mu, BMD )
     % Calculates bending moments at every value of x that would cause a plate
buckling failure
     % Input: Sectional Properties (list of 1-D arrays), E, mu (material
property), BMD (1-D array)
     % Output: M_BuckMid, M_BuckSide, M_BuckWeb, 1-D arrays of length n
     section_number = size(xc, 2) - 1;
     sz = size(x, 2);
     M_BuckMid = nan(1, sz);
     M_BuckSide = nan(1, sz);
     M_BuckWeb = nan(1, sz);
     for i = 1 : sz
         for j = section_number : -1 : 1
             if x(i) > xc(j)
                 ytop(i) = tfb(j) + hw(j) + tft(j) - ybar(i);
                 ybot(i) = ybar(i);
                 if BMD(i) > 0 % If the moment is positive, the compression is
on the top
                     M_BuckMid(i) = 4 * pi ^ 2 * E / 12 / (1 - mu ^ 2) * (
tft(j) / bfb(j)) ^ 2 * I(i) / ytop(i);
                     M_BuckSide(i) = 0.425 * pi ^ 2 * E / 12 / (1 - mu ^ 2) *
(tft(j) / ( (bft(j)-bfb(j)) /2)) ^ 2 * I(i) / ytop(i);
                     M_BuckWeb(i) = 6 * pi ^ 2 * E / 12 / (1 - mu ^ 2) * (tw(j)
/ (ytop(i)-tft(j)) ) ^ 2 * I(i) / (ytop(i)-tft(j));
                 elseif BMD(i) < 0 % If the moment is negative, the compression
is on the bottom
                     M_BuckMid(i) = -4 * pi ^ 2 * E / 12 / (1 - mu ^ 2) *
(tfb(j) / bfb(j)) ^ 2 * I(i) / ybot(i);
                     %M_BuckSide(i) = 0;
                     M_BuckWeb(i) = -6 * pi ^ 2 * E / 12 / (1 - mu ^ 2) * (tw(j)
/ (ybot(i)-tfb(j)) ) ^ 2 * I(i) / (ybot(i)-tfb(j));
                 end
                 break
             end
         end
     end
 end

 function [Pf] = FailLoad(P, SFD_PL, BMD_PL, V_Mat, V_Glue, V_Buck, M_MatT,
M_MatC, M_BuckMid, M_BuckSide, M_BuckWeb)
     % Calculates the magnitude of the load P that will cause one of the failure
mechanisms to occur
```

```
    % Input: SFD, BMD under the currently applied points loads (P) (each 1-D
array of length n)
    % {V_Mat, V_Glue, … M_MatT, M_MatC, … } (each 1-D array of length n)
    % Output: Failure Load value Pf
    sz = size(SFD_PL, 2);
    Pf = 0;
    found_failure_load = false;
    while found_failure_load == false
        Pf = Pf + 1;
        for j = 1:sz
            if abs(SFD_PL(j)) * Pf / P >= abs(V_Mat(j)) && V_Mat(j) ~= 0
                found_failure_load = true;
                disp("V_Mat");
                break
            end
            if abs(SFD_PL(j)) * Pf / P >= abs(V_Glue(j)) && V_Glue(j) ~= 0
                found_failure_load = true;
                disp("V_Glue");
                break
            end
            if abs(SFD_PL(j)) * Pf / P >= abs(V_Buck(j)) && V_Buck(j) ~= 0
                found_failure_load = true;
                disp("V_Buck");
                break
            end
            if abs(BMD_PL(j)) * Pf / P >= abs(M_MatT(j)) && M_MatT(j) ~= 0
                found_failure_load = true;
                disp("M_MatT");
                break
            end
            if abs(BMD_PL(j)) * Pf / P >= abs(M_MatC(j)) && M_MatC(j) ~= 0
                found_failure_load = true;
                disp("M_MatC");
                break
            end
            if abs(BMD_PL(j)) * Pf / P >= abs(M_BuckMid(j)) && M_BuckMid(j) ~=
0
                found_failure_load = true;
                disp("M_BuckMid");
                break
            end
            if abs(BMD_PL(j)) * Pf / P >= abs(M_BuckSide(j)) && M_BuckSide(j)
~= 0
                found_failure_load = true;
                disp("M_BuckSide");
                break
```

```
            end
            if abs(BMD_PL(j)) * Pf / P >= abs(M_BuckWeb(j)) && M_BuckWeb(j) ~=
0
                found_failure_load = true;
                disp("M_BuckWeb");
                break
            end
        end
    end
end

function [deflection] = Deflections(x, BMD, I, E, L)
    % Calculates deflections for every value of x on the bridge
    % Input: I(1-D arrays), E (material property), BMD (1-D array)
    % Output: Deflection, a 1-D array of length n
    fi = BMD ./ E ./ I;
    deflection = nan(1,size(x,2));
    integrand1 = (L - x) .* fi;
    delta1 = sum(integrand1(2:end).*(x(6)-x(5))); % x(6)-x(5) is delta x, 6 and
5 are just random numbers
    for i = 3:size(x,2)
        x_to_i = x(1:i);
        fi_to_i = fi(1:i);
        integrand2 = (x(i) - x_to_i) .* fi_to_i;
        delta2 = sum(integrand2(2:end).*(x(6)-x(5))); % x(6)-x(5) is delta x, 6
and 5 are just random numbers
        deflection(i) = delta1 * (x(i)/L) - delta2;
    end
end
```

Hand Calculations

November 26, 2021 7:12 AM

$$\bar{y} = \frac{\sum_i A_i y_{0,b}}{A_{tot}}$$

$$= \frac{\left(100\times1.27\left(1.27+75+\frac{1.27}{2}\right)\right) + 2\left(75\times1.27\left(1.27+\frac{75}{2}\right)\right) + \left(80\times1.27\left(\frac{1.27}{2}\right)\right)}{100\times1.27+2(75\times1.27)+80\times1.27}$$

$$= 41.0812 \text{ mm}$$

$$Q_{cent} = \sum_i A_i d_i$$

$$= 2\left(1.27\left((41.0812-1.27)/2\right)\times(41.0812-1.27)\right) + \left(80\times1.27\left(41.0812-\frac{1.27}{2}\right)\right)$$

$$= 6122.20 \text{ mm}^3$$

$$Q_{glue} = \sum_i A_i d_i$$

$$= 100\times1.27\times\left(1.27+75+\frac{1.27}{2}-41.0812\right)$$

$$= 4549.62 \text{ mm}^3$$

$$I = \sum_i I_{0_i} + A_i d_i^2$$

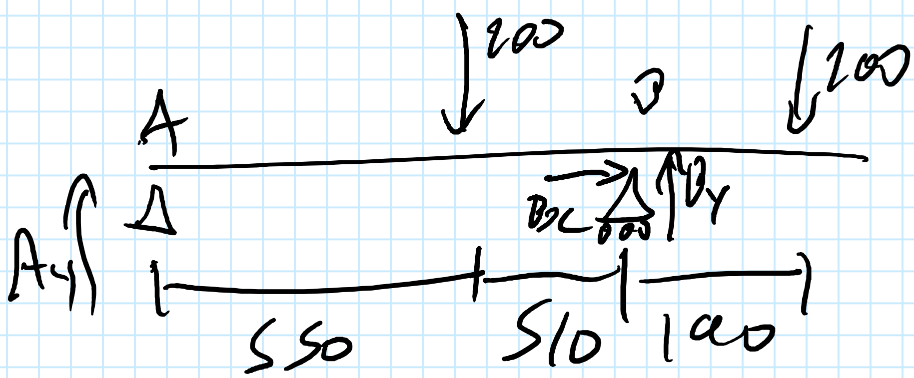
$$= \frac{100 \times 1.27^3 + 2 \times 1.27 \times 75^3 + 80 \times 1.27^3}{12}$$

$$+ 100 \times 1.27 \times \left(1.27 + 75 + \frac{1.27}{2} - 41.0812\right)^2$$

$$+ 2\left(1.27 \times 75 \times \left(41.0812 - 1.27 - \frac{75}{2}\right)^2\right)$$

$$+ \left(80 \times 1.27 \left(41.0812 - \frac{1.27}{2}\right)^2\right)$$

$$= 419536.90 \text{ mm}^4$$



$B_x = 0$

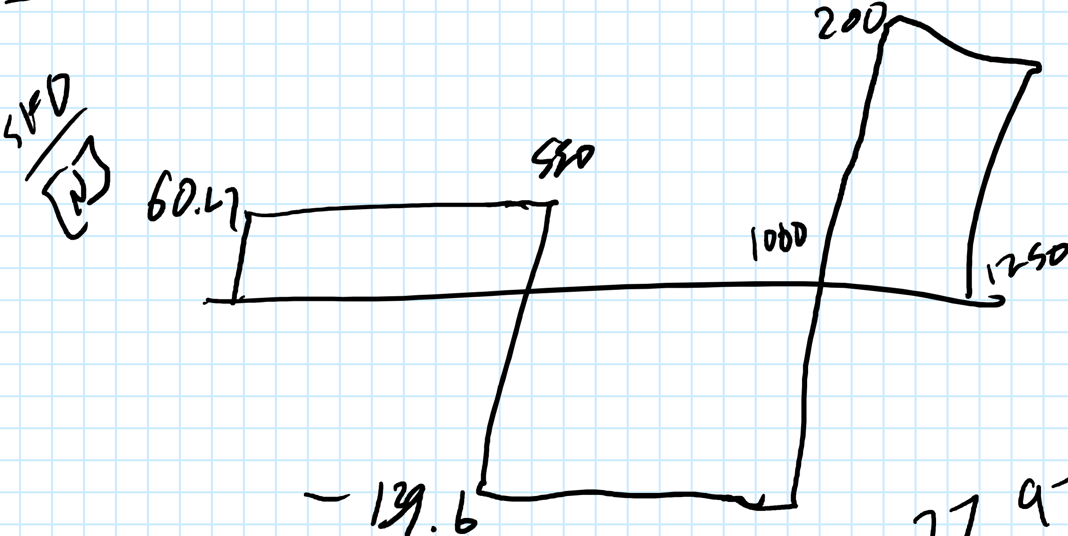
$\Sigma M_A = 0$

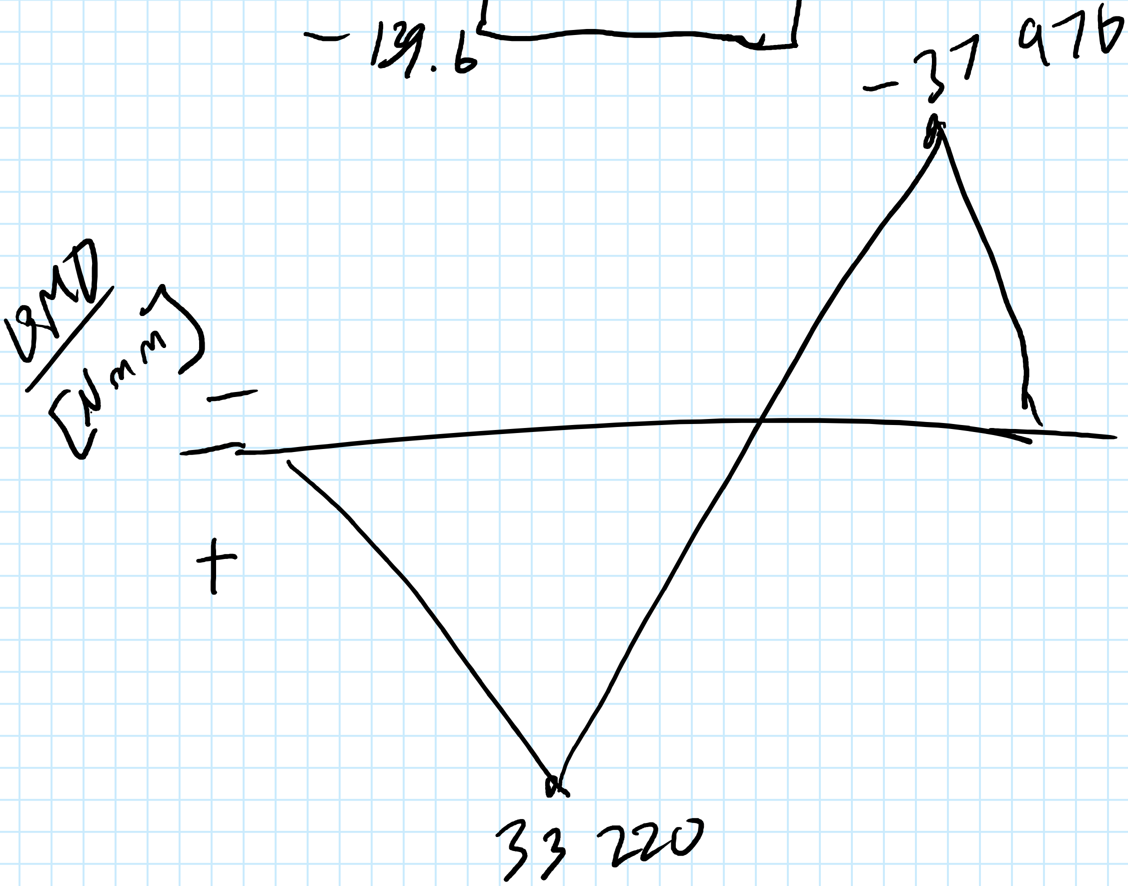
$1060 B_y = 550(200) + 1250(200)$

$B_y = 339.6 \text{ N}$

$\Sigma F_y = 0$

$A_y = 60.4 \text{ N}$





Tension Max

$\sigma = 30$ mpa

Comp Max

$\sigma = 6$ mpa

-ive Moment

$M(1 - \ldots)$

+ive Moment

$$30 = \frac{M\bar{y}}{I}$$

$M = 306\,371$

$$6 = \frac{M(h-\bar{y})}{I}$$

$M = 69\,043$

-ive Moment

$$30 = \frac{M(h-\bar{y})}{I}$$

$M = 345\,214$

$$6 = \frac{M\bar{y}}{I}$$

$M = 61\,274$

Max shear Force

$$\tau = 4\ MPa = \frac{VQ_{cent}}{I\ b}$$

$$V = 4I(1.27 \times 2) / Q_{cent}$$

$= 696.236\ N$

Max Glue Shear

$$\tau = 2\,MPa = \frac{V\,Q_{glue}}{I\,b}$$

$$V = 2I(10\times 2)/Q_{glue}$$
$$= 3688.54$$

Plate Buckling

$$\sigma = \frac{K\pi^2 E}{12(1-\mu^2)}\left(\frac{t}{b}\right)^2$$

$\boxed{\text{+ive } M}$

Mid Flange

$$\sigma = \frac{4\pi^2(4000)}{12(1-0.2^2)}\left(\frac{1.27}{80}\right)^2 = \frac{M(h-\bar{y})}{I}$$

$$M = \frac{\frac{4\pi^2(4000)}{12(1-0.2^2)}\left(\frac{1.27}{80}\right)^2 \cdot I}{h-\bar{y}}$$

$$\frac{\quad}{12(1-0.2^2)}$$
$$h-\bar{Y}$$

$$=39\ 752$$

Side Flange

$$\sigma=\frac{0.425\pi^2(4000)}{12(1-0.2^2)}\left(\frac{1.27}{80}\right)^2=\frac{M(h-\bar{Y})}{I}$$

$$M=\frac{\frac{0.425\pi^2(4000)}{12(1-0.2^2)}\left(\frac{1.27}{10}\right)^2\cdot I}{h-\bar{Y}}$$

$$=270\ 315.80$$

Web Compression

$$\sigma=\frac{6\pi^2(4000)}{12(1-0.2^2)}\left(\frac{1.27}{h-1.27-\bar{Y}}\right)^2=\frac{M(h-1.27-\bar{Y})}{I}$$

$$M = \frac{\frac{6\pi^2(4000)}{12(1-0.2^2)}\left(\frac{1.27}{h-1.27-\bar{y}}\right)^2 \cdot I}{h-1.27-\bar{y}}$$

$$= 319\,317.52$$

Bottom

Mid Flange

$$\sigma = \frac{4\pi^2(4000)}{12(1-0.2^2)}\left(\frac{1.27}{80}\right)^2 = \frac{M\bar{y}}{I}$$

$$M = \frac{\frac{4\pi^2(4000)}{12(1-0.2^2)}\left(\frac{1.27}{80}\right)^2 \cdot I}{\bar{y}}$$

$$= 35\,279.45$$

Web Compression

$$\frac{(\ \ \pi^2(4000))}{}\left(1.27\right)^2 = \frac{M(\bar{y}-1.27)}{}$$

$$\sigma = \frac{6\pi^2(4000)}{12(1-0.2^2)}\left(\frac{1.27}{\bar{y}-1.27}\right)^2 = \frac{M(\bar{y}-1.27)}{I}$$

$$M = \frac{\frac{6\pi^2(4000)}{12(1-0.2^2)}\left(\frac{1.27}{\bar{y}-1.27}\right)^2 \cdot I}{\bar{y}-1.27}$$

$$= 220\ 505.95$$

Shear Buckling

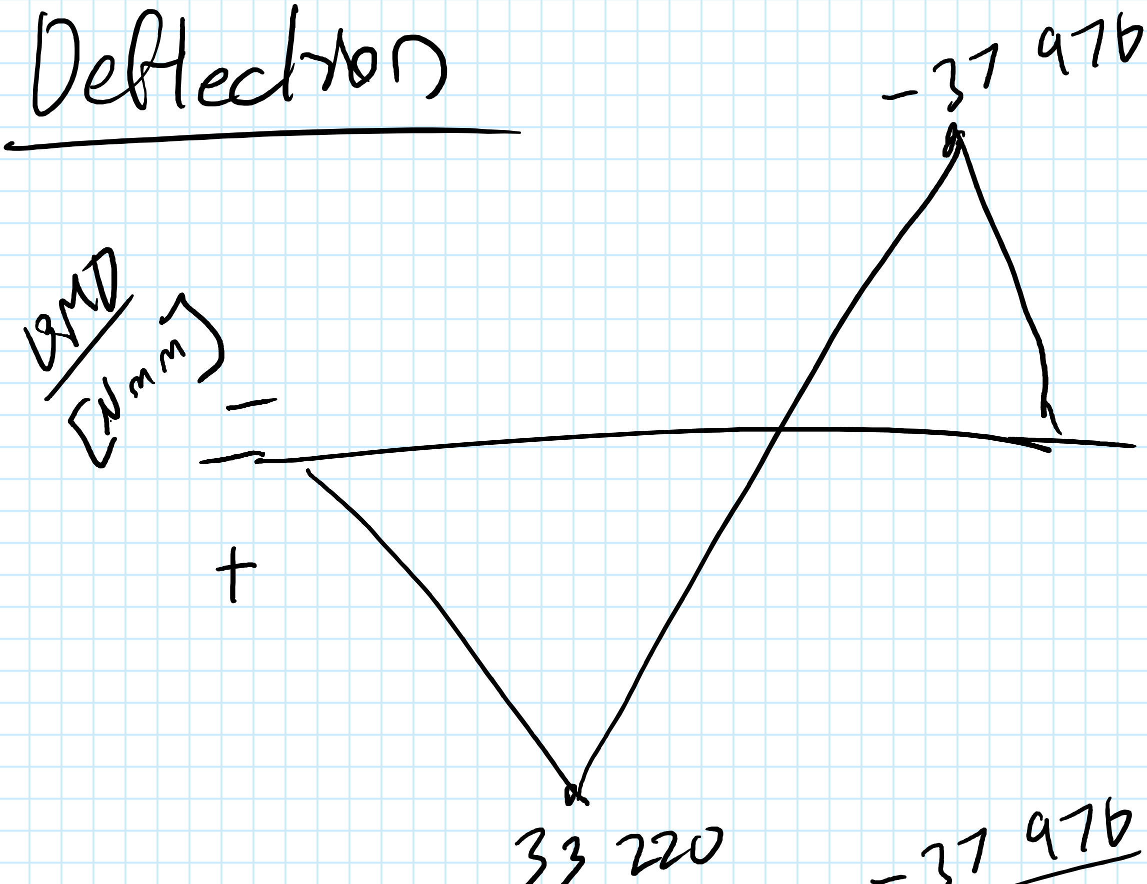
$$\tau = \frac{5\pi^2 E}{12(1-\mu^2)}\left(\left(\frac{t}{a}\right)^2 + \left(\frac{t}{h}\right)^2\right)$$

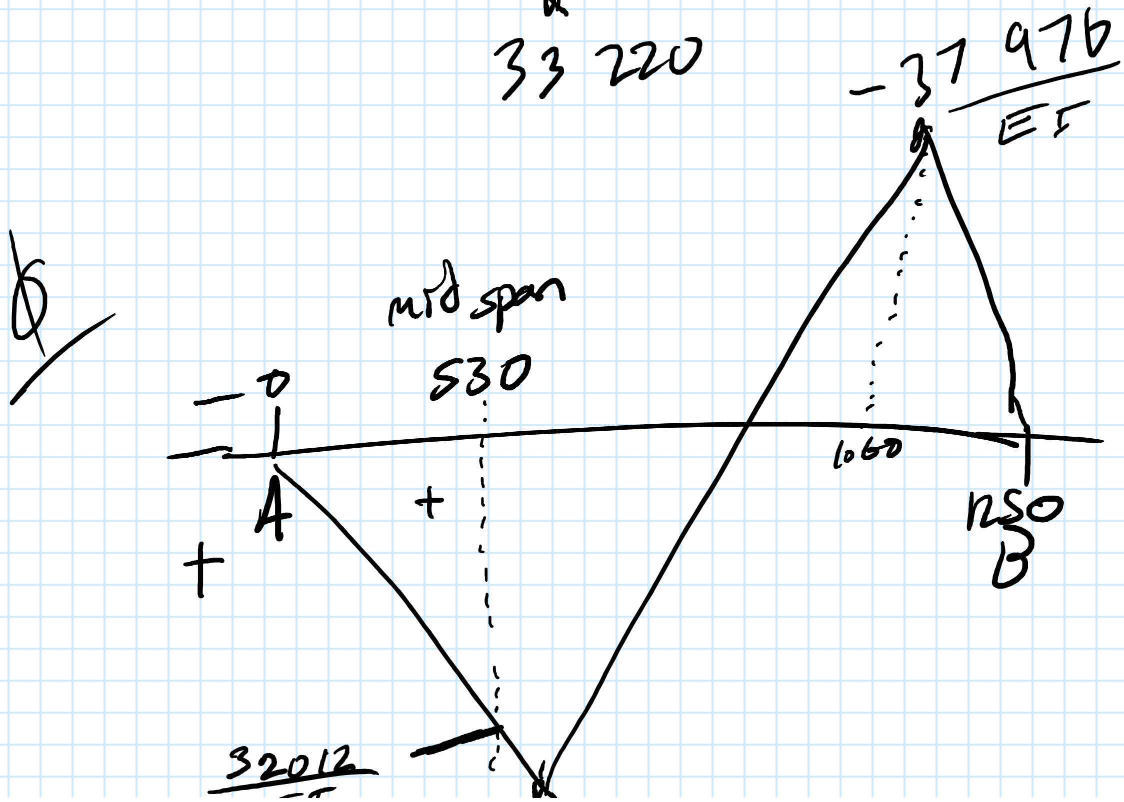
$$\tau = \frac{VQ}{IB}$$

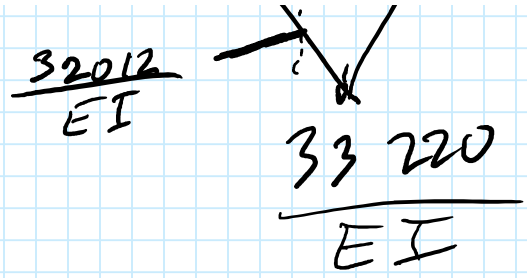
$$V = \frac{\frac{5\pi^2(4000)}{12(1-0.2^2)}\left(\left(\frac{1.27}{520}\right)^2 + \left(\frac{1.27}{75}\right)^2\right) \cdot I(1.27\times 2)}{Q_{cent}}$$

$= 872.97$

Deflection



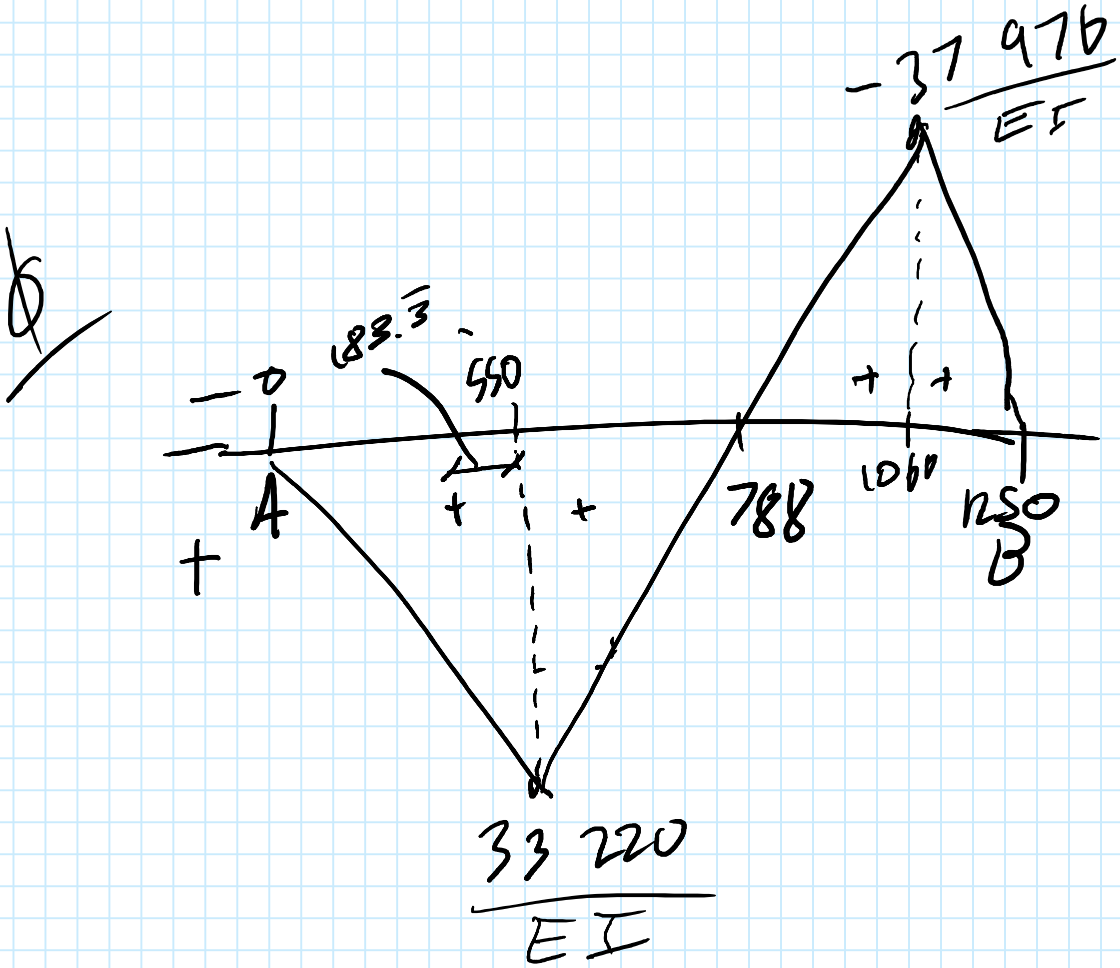




$$\delta_{midA} = \sum_i A_i d_i$$

$$= \frac{32012}{2EI} \times 530 \times \left(\frac{530}{3}\right)$$

$$= 0.893$$



$$\delta_{BA} = \sum_i A_i d_i$$

$$= \frac{33220}{2EI} \times 550 \times \left(\frac{550}{3} + 700\right)$$

$$+ \frac{33220}{2EI} \times 238 \times \left(\frac{2}{3} \times 238 + 462\right)$$

$$+ \frac{-37976}{2EI} \times 272 \times \left(\frac{1}{3} \times 272 + 190\right)$$

$$+ \frac{-37976}{2EI} \times 190 \times \left(\frac{2}{3} 190\right)$$

$$= 5.135$$

$$\frac{L_{midA}}{L_{BA}} = \frac{\delta_{mid} + \Delta_{mid}}{\delta_{BA}}$$

$$\frac{530}{1250} = \frac{0.893 + \Delta_{mid}}{5.135}$$

$$\frac{530}{1250}(5.135) - 0.893 = \Delta_{mid}$$

$\frac{\;}{1250}(5.155) - 0.8\ldots = \Delta\ldots$

$\Delta_{mid} = 1.284$ mm