Contents

PIPE SUPPORT STRUCTURAL DESIGN CALCULATIONS

Design per CSA S16-19 (Steel Structures) and CSA S6 standards Author: Structural Design Calculator Date: 2025-10-31

```
clear all;
clc;
format long;

fprintf('========================================\n');
fprintf('PIPE SUPPORT STRUCTURAL DESIGN\n');
fprintf('CSA Standards Compliance Check\n');
fprintf('========================================\n\n');
```

```
========================================
PIPE SUPPORT STRUCTURAL DESIGN
CSA Standards Compliance Check
========================================
```

MATERIAL PROPERTIES

Steel Grade: ASTM A500 Grade C (typical for hollow structural sections)

```
Fy = 345;           % Yield strength (MPa)
Fu = 448;           % Ultimate tensile strength (MPa)
E = 200000;         % Modulus of elasticity (MPa)
rho_steel = 7850;   % Density of steel (kg/m?)
rho_water = 1000;   % Density of water (kg/m?)
g = 9.81;           % Gravitational acceleration (m/s?)

% Safety factors per CSA S16-19
phi = 0.90;         % Resistance factor for steel (CSA S16 Cl. 13.5)
phi_b = 0.90;       % Resistance factor for bending
phi_w = 0.67;       % Resistance factor for welds (CSA W59)
phi_a = 0.75;       % Resistance factor for anchors (CSA A23.3)

fprintf('=== MATERIAL PROPERTIES ===\n');
fprintf('Steel Grade: ASTM A500 Grade C\n');
fprintf('Yield Strength (Fy): %.0f MPa\n', Fy);
```

```
fprintf('Ultimate Strength (Fu): %.0f MPa\n', Fu);
fprintf('Modulus of Elasticity (E): %.0f MPa\n\n', E);
```

```
=== MATERIAL PROPERTIES ===
Steel Grade: ASTM A500 Grade C
Yield Strength (Fy): 345 MPa
Ultimate Strength (Fu): 448 MPa
Modulus of Elasticity (E): 200000 MPa
```

GEOMETRIC PROPERTIES

```
% Square tube section: 3" x 3" x 0.25"
% Convert to mm
tube_outer = 3 * 25.4;        % Outer dimension (mm)
tube_thickness = 0.25 * 25.4; % Wall thickness (mm)
tube_inner = tube_outer - 2*tube_thickness;

% Section properties for square HSS
A_tube = tube_outer^2 - tube_inner^2;  % Cross-sectional area (mm?)
I_tube = (tube_outer^4 - tube_inner^4)/12;  % Moment of inertia (mm?)
S_tube = I_tube / (tube_outer/2);      % Section modulus (mm?)
Z_tube = (tube_outer^3 - tube_inner^3)/6;  % Plastic section modulus (mm?)
r_tube = sqrt(I_tube/A_tube);          % Radius of gyration (mm)

% Cantilever dimensions
L_cantilever = 200;           % Cantilever length (mm)
H_post = 885;                 % Post height (mm)

% Plate dimensions
plate_length = 230;           % Plate length (mm)
plate_width = 100;            % Plate width (mm)
plate_thickness = 6;          % Plate thickness (mm)

% Base plate dimensions
base_length = 8 * 25.4;       % Base plate length (mm)
base_width = 8 * 25.4;        % Base plate width (mm)
base_thickness = 0.25 * 25.4; % Base plate thickness (mm)

% Weld dimensions
weld_size = 6;                % Fillet weld size (mm)

% Anchor bolts
anchor_diameter = 0.5 * 25.4; % Anchor diameter (mm)
n_anchors = 4;                % Number of anchors
anchor_spacing = base_length - 25.4;  % Typical edge distance

fprintf('=== GEOMETRIC PROPERTIES ===\n');
fprintf('Square Tube (HSS): %.1f x %.1f x %.1f mm\n', tube_outer, tube_outer, tube_thickness);
fprintf('Cross-sectional area: %.2f mm?\n', A_tube);
fprintf('Moment of inertia: %.2f mm?\n', I_tube);
fprintf('Section modulus: %.2f mm?\n', S_tube);
fprintf('Plastic section modulus: %.2f mm?\n', Z_tube);
fprintf('Cantilever length: %.0f mm\n', L_cantilever);
fprintf('Post height: %.0f mm\n\n', H_post);
```

```
=== GEOMETRIC PROPERTIES ===
Square Tube (HSS): 76.2 x 76.2 x 6.3 mm
Cross-sectional area: 1774.19 mm?
Moment of inertia: 1454642.12 mm?
```

```
Section modulus: 38179.58 mm?
Plastic section modulus: 31067.14 mm?
Cantilever length: 200 mm
Post height: 885 mm
```

PIPE PROPERTIES AND LOADING

```
% 12" SCH 10 Stainless Steel 340L pipe properties
pipe_OD = 12.75 * 25.4;       % Outer diameter (mm) - 12" nominal
pipe_thickness = 0.25 * 25.4; % Wall thickness (mm) - SCH 10
pipe_ID = pipe_OD - 2*pipe_thickness;  % Inner diameter (mm)
pipe_length = 3000;           % Pipe length (mm)
rho_ss = 7900;                % Density of stainless steel 340L (kg/m?)

% Pipe cross-sectional area
A_pipe = pi/4 * (pipe_OD^2 - pipe_ID^2);  % mm?

% Volume calculations
V_steel_pipe = A_pipe * pipe_length / 1e9;  % m?
V_water = pi/4 * pipe_ID^2 * pipe_length / 1e9;  % m?

% Weight calculations
W_pipe = V_steel_pipe * rho_ss * g;      % Weight of pipe (N)
W_water = V_water * rho_water * g;       % Weight of water (N)
W_total = W_pipe + W_water;              % Total weight (N)

% Load factor for dead load per CSA S16 (factored load)
alpha_D = 1.25;                          % Dead load factor
W_factored = alpha_D * W_total;          % Factored load (N)

fprintf('=== PIPE LOADING ANALYSIS ===\n');
fprintf('Pipe: 12" SCH 10 Stainless Steel 340L\n');
fprintf('Pipe OD: %.2f mm\n', pipe_OD);
fprintf('Pipe ID: %.2f mm\n', pipe_ID);
fprintf('Pipe Length: %.0f mm (%.2f m)\n', pipe_length, pipe_length/1000);
fprintf('Pipe Weight: %.2f N (%.2f kg)\n', W_pipe, W_pipe/g);
fprintf('Water Weight: %.2f N (%.2f kg)\n', W_water, W_water/g);
fprintf('Total Unfactored Load: %.2f N (%.2f kg)\n', W_total, W_total/g);
fprintf('Total Factored Load: %.2f N (%.2f kg)\n\n', W_factored, W_factored/g);
```

```
=== PIPE LOADING ANALYSIS ===
Pipe: 12" SCH 10 Stainless Steel 340L
Pipe OD: 323.85 mm
Pipe ID: 311.15 mm
Pipe Length: 3000 mm (3.00 m)
Pipe Weight: 1472.60 N (150.11 kg)
Water Weight: 2237.79 N (228.11 kg)
Total Unfactored Load: 3710.39 N (378.23 kg)
Total Factored Load: 4637.99 N (472.78 kg)
```

CANTILEVER BENDING ANALYSIS

```
% Moment at the cantilever support (at tube connection)
M_cantilever = W_factored * L_cantilever / 1000;  % N?m
M_cantilever_Nmm = M_cantilever * 1000;           % N?mm

% Bending stress (elastic analysis)
f_b = M_cantilever_Nmm / S_tube;  % MPa
```

```
% Bending moment resistance (CSA S16 Cl. 13.5)
% For Class 1 or 2 sections, Mr = phi_b * Z * Fy
% For Class 3 sections, Mr = phi_b * S * Fy
% Assuming Class 1/2 section for square HSS
M_r = phi_b * Z_tube * Fy / 1000;  % kN?m

% Unity check for bending
UC_bending = M_cantilever / M_r;

fprintf('=== CANTILEVER BENDING ANALYSIS ===\n');
fprintf('Bending Moment: %.2f N?m (%.2f kN?m)\n', M_cantilever, M_cantilever/1000);
fprintf('Bending Stress: %.2f MPa\n', f_b);
fprintf('Moment Resistance (Mr): %.2f kN?m\n', M_r);
fprintf('Unity Check (M/Mr): %.3f ', UC_bending);
if UC_bending <= 1.0
    fprintf('? PASS\n\n');
else
    fprintf('? FAIL\n\n');
end
```

```
=== CANTILEVER BENDING ANALYSIS ===
Bending Moment: 927.60 N?m (0.93 kN?m)
Bending Stress: 24.30 MPa
Moment Resistance (Mr): 9646.35 kN?m
Unity Check (M/Mr): 0.096 ? PASS
```

SHEAR ANALYSIS IN CANTILEVER

```
% Shear force at support
V_cantilever = W_factored;  % N

% Shear resistance per CSA S16 Cl. 13.4.1
% For HSS sections, Vr = phi * 0.66 * Fy * Aw
% Aw = 2 * tube_outer * tube_thickness (for square HSS, two webs)
A_w = 2 * tube_outer * tube_thickness;  % mm?
V_r = phi * 0.66 * Fy * A_w / 1000;     % kN

UC_shear = (V_cantilever/1000) / V_r;

fprintf('=== SHEAR ANALYSIS ===\n');
fprintf('Shear Force: %.2f N (%.2f kN)\n', V_cantilever, V_cantilever/1000);
fprintf('Shear Resistance (Vr): %.2f kN\n', V_r);
fprintf('Unity Check (V/Vr): %.3f ', UC_shear);
if UC_shear <= 1.0
    fprintf('? PASS\n\n');
else
    fprintf('? FAIL\n\n');
end
```

```
=== SHEAR ANALYSIS ===
Shear Force: 4637.99 N (4.64 kN)
Shear Resistance (Vr): 198.32 kN
Unity Check (V/Vr): 0.023 ? PASS
```

WELD ANALYSIS (Plate to Cantilever)

```
% Fillet weld connecting plate to horizontal tube
% Weld is subjected to shear and moment

% Effective weld throat
a_w = weld_size / sqrt(2);  % Effective throat thickness (mm)

% Weld length - assuming weld around perimeter of plate contact
L_weld = 2 * plate_length + 2 * plate_width;  % mm (perimeter)

% Weld section properties
A_weld = a_w * L_weld;  % Effective area (mm?)

% For moment about weld group, calculate section modulus
% Treating weld as rectangular pattern
I_weld_x = (2 * a_w * plate_length^3 / 12) + (2 * a_w * plate_width * (plate_length/2)^2);
I_weld_y = (2 * a_w * plate_width^3 / 12) + (2 * a_w * plate_length * (plate_width/2)^2);
S_weld = I_weld_x / (plate_length/2);  % Section modulus about critical axis

% Shear stress in weld due to direct load
tau_direct = V_cantilever / A_weld;  % MPa

% Shear stress due to moment
tau_moment = M_cantilever_Nmm / S_weld;  % MPa

% Combined stress
tau_weld = sqrt(tau_direct^2 + tau_moment^2);  % MPa

% Weld resistance per CSA W59
% For E480XX electrodes, Xu = 480 MPa
Xu = 480;  % Electrode strength (MPa)
V_weld_r = phi_w * 0.67 * Xu * A_weld / 1000;  % kN

UC_weld = tau_weld / (phi_w * 0.67 * Xu);

fprintf('=== WELD STRESS ANALYSIS ===\n');
fprintf('Weld Size: %d mm fillet\n', weld_size);
fprintf('Effective Throat: %.2f mm\n', a_w);
fprintf('Weld Length: %.0f mm\n', L_weld);
fprintf('Direct Shear Stress: %.2f MPa\n', tau_direct);
fprintf('Moment Shear Stress: %.2f MPa\n', tau_moment);
fprintf('Combined Stress: %.2f MPa\n', tau_weld);
fprintf('Allowable Stress: %.2f MPa\n', phi_w * 0.67 * Xu);
fprintf('Unity Check: %.3f ', UC_weld);
if UC_weld <= 1.0
    fprintf('? PASS\n\n');
else
    fprintf('? FAIL\n\n');
end
```

```
=== WELD STRESS ANALYSIS ===
Weld Size: 6 mm fillet
Effective Throat: 4.24 mm
Weld Length: 660 mm
Direct Shear Stress: 1.66 MPa
Moment Shear Stress: 5.38 MPa
Combined Stress: 5.63 MPa
Allowable Stress: 215.47 MPa
Unity Check: 0.026 ? PASS
```

POST ANALYSIS (Axial + Bending)

```
% The vertical post experiences:
% 1. Axial compression from the load
% 2. Bending moment at the base from cantilever

% Axial compression
P_f = W_factored;  % N

% Compressive resistance per CSA S16
% Assuming pinned-pinned condition (conservative)
K = 1.0;           % Effective length factor
L_e = K * H_post;  % Effective length (mm)
lambda = L_e / r_tube;  % Slenderness ratio

% Column strength per CSA S16 Cl. 13.3.1
% Use proper CSA S16 column curve formula
Fe = pi^2 * E / lambda^2;  % Elastic buckling stress (MPa)

% Calculate non-dimensional slenderness parameter
lambda_normalized = sqrt(Fy / Fe);

% CSA S16 Column curve (Class C for HSS)
if lambda_normalized <= 1.34
    % Inelastic buckling range
    n = 1.34;  % Column curve parameter for Class C
    Cr = phi * A_tube * Fy * (1 + lambda_normalized^(2*n))^(-1/n) / 1000;  % kN
else
    % Elastic buckling range
    Cr = phi * A_tube * Fe / 1000;  % kN
end

UC_compression = (P_f/1000) / Cr;

% Bending moment at post base
M_base = M_cantilever + W_factored * (tube_outer/2)/1000;  % N?m (approx)
M_base_Nmm = M_base * 1000;

f_b_post = M_base_Nmm / S_tube;  % MPa

% Combined stress check per CSA S16 Cl. 13.8
% Interaction equation: P/Pr + 0.85*M/Mr <= 1.0
UC_combined = (P_f/1000)/Cr + 0.85*(M_base)/M_r;

fprintf('=== VERTICAL POST ANALYSIS ===\n');
fprintf('Post Height: %.0f mm\n', H_post);
fprintf('Slenderness Ratio: %.2f\n', lambda);
fprintf('Non-dimensional Slenderness: %.3f\n', lambda_normalized);
fprintf('Elastic Buckling Stress (Fe): %.2f MPa\n', Fe);
fprintf('Axial Compression: %.2f kN\n', P_f/1000);
fprintf('Compressive Resistance (Cr): %.2f kN\n', Cr);
fprintf('Compression Unity Check: %.3f ', UC_compression);
if UC_compression <= 1.0
    fprintf('? PASS\n');
else
    fprintf('? FAIL\n');
end
fprintf('Moment at Base: %.2f N?m\n', M_base);
fprintf('Combined Unity Check: %.3f ', UC_combined);
if UC_combined <= 1.0
    fprintf('? PASS\n\n');
else
    fprintf('? FAIL\n\n');
end
```

```
=== VERTICAL POST ANALYSIS ===
Post Height: 885 mm
Slenderness Ratio: 30.91
Non-dimensional Slenderness: 0.409
Elastic Buckling Stress (Fe): 2066.33 MPa
Axial Compression: 4.64 kN
Compressive Resistance (Cr): 516.27 kN
Compression Unity Check: 0.009 ? PASS
Moment at Base: 1104.31 N?m
Combined Unity Check: 0.106 ? PASS
```

ANCHOR BOLT ANALYSIS

```
% Base plate subjected to:
% 1. Axial load (tension/compression)
% 2. Moment from cantilever

% Assuming moment creates tension on one side
% Bolt spacing and geometry
bolt_circle = anchor_spacing;  % Distance between bolt centers

% Tension per bolt due to moment (using elastic analysis)
% T_bolt = M * c / (n * A_bolt * d)
% where c is distance to extreme bolt, n is number of bolts in tension

% Conservative: assume 2 bolts in tension
n_tension = 2;
y_bolt = bolt_circle / 2;  % Distance from center to bolt

% Moment at base plate
M_bp = M_base + P_f * (tube_outer/2 + base_thickness) / 1000;  % N?m

% For bolt group under moment: T = M * y / sum(y^2)
% For 2 bolts at distance y: sum(y^2) = 2*y^2
sum_y_squared = n_tension * y_bolt^2;  % mm^2
% Tension per bolt
T_bolt = (M_bp * 1000 * y_bolt) / sum_y_squared;  % N

% Add compression load distributed over all bolts
P_bolt = P_f / n_anchors;  % N per bolt

% Net tension (if applicable)
T_net = max(T_bolt - P_bolt, 0);  % N

% Bolt tensile area (for 1/2" bolt)
A_bolt = pi/4 * anchor_diameter^2;  % mm?

% Tensile stress in bolt
f_t_bolt = T_net / A_bolt;  % MPa

% Bolt capacity for Hilti drop-in anchors (typical)
% For 1/2" drop-in in 3000 psi concrete
T_bolt_capacity = 8.5 * 1000;  % N (typical value, consult Hilti specs)

% Resistance factor applied
T_bolt_r = phi_a * T_bolt_capacity;  % N

UC_bolt = T_net / T_bolt_r;

fprintf('=== ANCHOR BOLT ANALYSIS ===\n');
fprintf('Anchor Type: Hilti 1/2" Drop-in Anchors\n');
```

```
fprintf('Number of Anchors: %d\n', n_anchors);
fprintf('Moment at Base Plate: %.2f N?m\n', M_bp);
fprintf('Bolt Distance from Center: %.1f mm\n', y_bolt);
fprintf('Sum of y-squared: %.0f mm^2\n', sum_y_squared);
fprintf('Tension per Bolt (from moment): %.2f N\n', T_bolt);
fprintf('Compression per Bolt: %.2f N\n', P_bolt);
fprintf('Net Tension per Bolt: %.2f N\n', T_net);
fprintf('Bolt Tensile Stress: %.2f MPa\n', f_t_bolt);
fprintf('Bolt Tension Capacity: %.2f N (factored: %.2f N)\n', T_bolt_capacity, T_bolt_r);
fprintf('Unity Check: %.3f ', UC_bolt);
if UC_bolt <= 1.0
    fprintf('? PASS\n\n');
else
    fprintf('? FAIL\n\n');
end
```

```
=== ANCHOR BOLT ANALYSIS ===
Anchor Type: Hilti 1/2" Drop-in Anchors
Number of Anchors: 4
Moment at Base Plate: 1310.46 N?m
Bolt Distance from Center: 88.9 mm
Sum of y-squared: 15806 mm^2
Tension per Bolt (from moment): 7370.44 N
Compression per Bolt: 1159.50 N
Net Tension per Bolt: 6210.94 N
Bolt Tensile Stress: 49.03 MPa
Bolt Tension Capacity: 8500.00 N (factored: 6375.00 N)
Unity Check: 0.974 ? PASS
```

BASE PLATE BENDING ANALYSIS

```
% Base plate bending between anchor bolts
% Using yield line analysis or simplified approach

% Maximum moment in base plate (conservative)
% Assuming cantilever from tube edge to bolt
overhang = (base_length - tube_outer) / 2;  % mm

% Bearing stress under tube
sigma_bearing = P_f / A_tube;  % MPa

% Plate bending moment per unit width
m_plate = sigma_bearing * A_tube / (base_length * base_width) * overhang^2 / 2;  % N?mm/mm

% Plate section modulus per unit width
S_plate = base_thickness^2 / 6;  % mm?/mm

% Bending stress in plate
f_plate = m_plate / S_plate;  % MPa

% Allowable stress
f_allow_plate = phi * Fy;  % MPa

UC_base_plate = f_plate / f_allow_plate;

fprintf('=== BASE PLATE ANALYSIS ===\n');
fprintf('Base Plate: %.0f x %.0f x %.1f mm\n', base_length, base_width, base_thickness);
fprintf('Plate Bending Stress: %.2f MPa\n', f_plate);
fprintf('Allowable Stress: %.2f MPa\n', f_allow_plate);
fprintf('Unity Check: %.3f ', UC_base_plate);
if UC_base_plate <= 1.0
```

```
    fprintf('? PASS\n\n');
else
    fprintf('? FAIL\n\n');
end
```

```
=== BASE PLATE ANALYSIS ===
Base Plate: 203 x 203 x 6.3 mm
Plate Bending Stress: 33.70 MPa
Allowable Stress: 310.50 MPa
Unity Check: 0.109 ? PASS
```

DEFLECTION CHECK

```
% Cantilever deflection at free end
% delta = (W * L^3) / (3 * E * I)
delta = (W_factored * L_cantilever^3) / (3 * E * I_tube);  % mm

% Allowable deflection (typical: L/360 for dead load)
delta_allow = L_cantilever / 360;  % mm

UC_deflection = delta / delta_allow;

fprintf('=== DEFLECTION ANALYSIS ===\n');
fprintf('Cantilever Deflection: %.3f mm\n', delta);
fprintf('Allowable Deflection (L/360): %.3f mm\n', delta_allow);
fprintf('Unity Check: %.3f ', UC_deflection);
if UC_deflection <= 1.0
    fprintf('? PASS\n\n');
else
    fprintf('? FAIL\n\n');
end
```

```
=== DEFLECTION ANALYSIS ===
Cantilever Deflection: 0.043 mm
Allowable Deflection (L/360): 0.556 mm
Unity Check: 0.077 ? PASS
```

SUMMARY OF RESULTS

```
fprintf('========================================\n');
fprintf('DESIGN SUMMARY - CSA COMPLIANCE\n');
fprintf('========================================\n\n');

components = {
    'Cantilever Bending', UC_bending;
    'Cantilever Shear', UC_shear;
    'Weld Connection', UC_weld;
    'Post Compression', UC_compression;
    'Post Combined Stress', UC_combined;
    'Anchor Bolts', UC_bolt;
    'Base Plate', UC_base_plate;
    'Deflection', UC_deflection;
};

fprintf('Component                    Unity Check   Status\n');
fprintf('-------------------------------------------------\n');
for i = 1:size(components, 1)
```

```
    status = '? PASS';
    if components{i, 2} > 1.0
        status = '? FAIL';
    end
    fprintf('%-25s    %.3f      %s\n', components{i, 1}, components{i, 2}, status);
end

fprintf('\n========================================\n');
fprintf('DESIGN RECOMMENDATIONS\n');
fprintf('========================================\n\n');

all_pass = true;
for i = 1:size(components, 1)
    if components{i, 2} > 1.0
        all_pass = false;
        break;
    end
end

if all_pass
    fprintf('? All components meet CSA design requirements.\n');
    fprintf('? The pipe support system is adequate for the specified loading.\n');
else
    fprintf('? Some components exceed allowable limits.\n');
    fprintf('  Recommendations:\n');
    if UC_bending > 1.0 || UC_shear > 1.0
        fprintf('  - Increase cantilever tube size or reduce cantilever length\n');
    end
    if UC_weld > 1.0
        fprintf('  - Increase weld size or use full penetration weld\n');
    end
    if UC_compression > 1.0 || UC_combined > 1.0
        fprintf('  - Increase post tube size or reduce post height\n');
    end
    if UC_bolt > 1.0
        fprintf('  - Use larger diameter anchors or increase number of anchors\n');
    end
    if UC_base_plate > 1.0
        fprintf('  - Increase base plate thickness\n');
    end
    if UC_deflection > 1.0
        fprintf('  - Increase cantilever tube size to reduce deflection\n');
    end
end

fprintf('\n========================================\n');
fprintf('NOTES:\n');
fprintf('========================================\n');
fprintf('1. Calculations performed per CSA S16-19\n');
fprintf('2. Load factors per CSA S16 (Dead Load: 1.25)\n');
fprintf('3. Material: ASTM A500 Grade C structural steel\n');
fprintf('4. Weld design per CSA W59\n');
fprintf('5. Anchor design assumes 3000 psi concrete minimum\n');
fprintf('6. Verify actual anchor capacity with Hilti specifications\n');
fprintf('7. All dimensions and loads should be verified on site\n');
fprintf('8. Professional engineer review required for final design\n');
fprintf('========================================\n\n');
```

```
========================================
DESIGN SUMMARY - CSA COMPLIANCE
========================================

Component                    Unity Check    Status
```

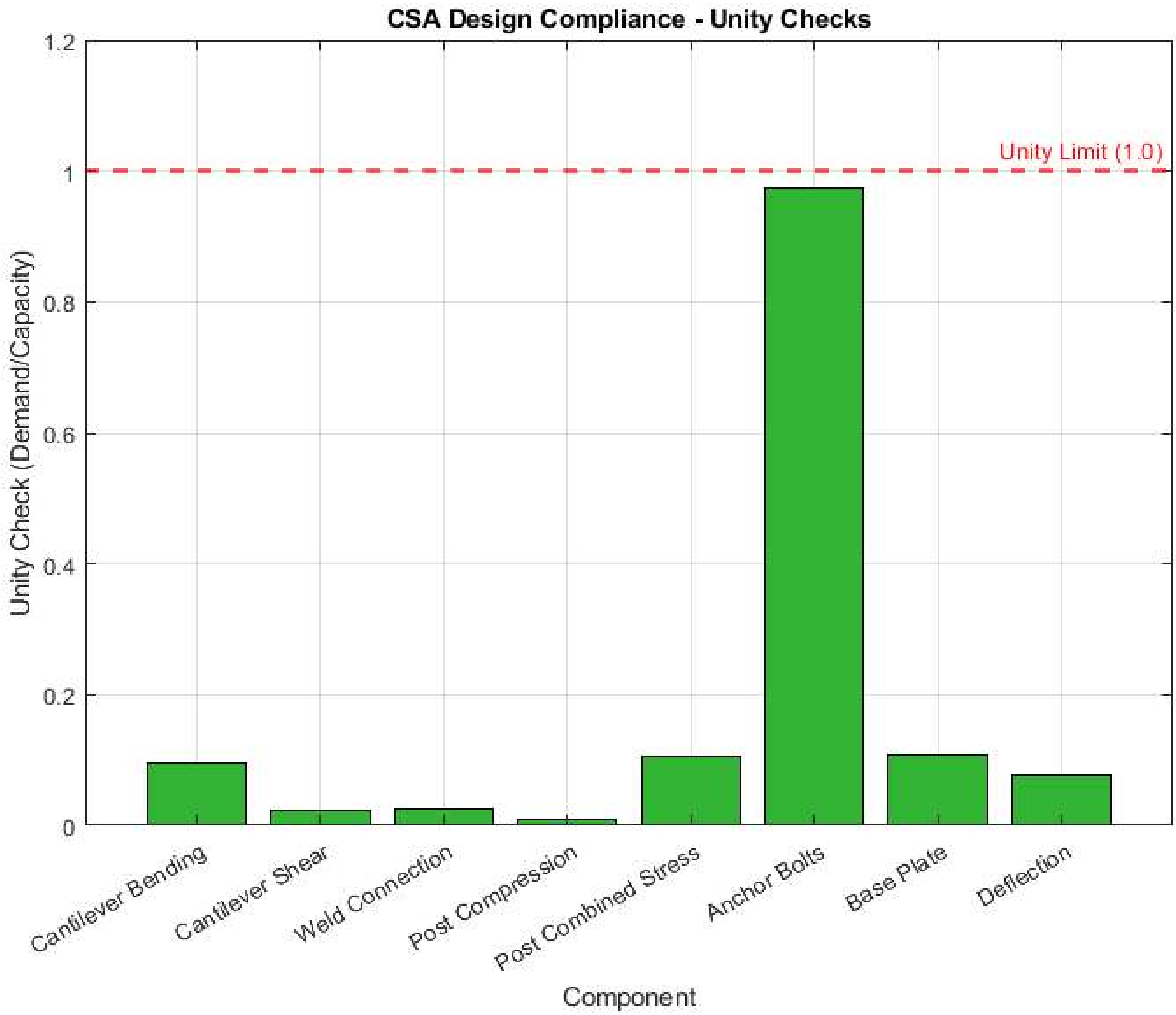
```
----------------------------------------------------
Cantilever Bending           0.096      ? PASS
Cantilever Shear             0.023      ? PASS
Weld Connection              0.026      ? PASS
Post Compression             0.009      ? PASS
Post Combined Stress         0.106      ? PASS
Anchor Bolts                 0.974      ? PASS
Base Plate                   0.109      ? PASS
Deflection                   0.077      ? PASS

========================================
DESIGN RECOMMENDATIONS
========================================

? All components meet CSA design requirements.
? The pipe support system is adequate for the specified loading.

========================================
NOTES:
========================================
1. Calculations performed per CSA S16-19
2. Load factors per CSA S16 (Dead Load: 1.25)
3. Material: ASTM A500 Grade C structural steel
4. Weld design per CSA W59
5. Anchor design assumes 3000 psi concrete minimum
6. Verify actual anchor capacity with Hilti specifications
7. All dimensions and loads should be verified on site
8. Professional engineer review required for final design
========================================
```

PLOT RESULTS (Optional Visualization)

```matlab
% Create a summary bar chart of unity checks
figure('Name', 'Structural Design Unity Checks', 'Position', [100 100 800 600]);
component_names = categorical(components(:,1));
component_names = reordercats(component_names, components(:,1));
unity_checks = cell2mat(components(:,2));

bar(component_names, unity_checks);
hold on;
yline(1.0, 'r--', 'LineWidth', 2, 'Label', 'Unity Limit (1.0)');
ylabel('Unity Check (Demand/Capacity)');
xlabel('Component');
title('CSA Design Compliance - Unity Checks');
grid on;
ylim([0 max(1.2, max(unity_checks)*1.1)]);

% Color code the bars
colors = repmat([0.2 0.7 0.2], length(unity_checks), 1);  % Green
for i = 1:length(unity_checks)
    if unity_checks(i) > 1.0
        colors(i,:) = [0.8 0.2 0.2];  % Red for failures
    end
end

b = bar(component_names, unity_checks);
b.FaceColor = 'flat';
b.CData = colors;

hold off;
```

```
fprintf('Program completed successfully.\n');
fprintf('Review results above for design adequacy.\n');
```

```
Program completed successfully.
Review results above for design adequacy.
```



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