Příloha 5 – numerická aproximace křivky pomocí interpolace

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clear
close all
clc

%% ANALYTICKÁ ROVNICE
kappa = 10;
c0 = 0.01;
p = 0.13;
lambda = 0.01;

xspan = linspace(0,10,5000);

funkce = @(x,phi) [phi(2), 0.5*phi(2)^2*sin(phi(1))/cos(phi(1)) +
sin(phi(1))/(2*(cos(phi(1)))^3)*(c0^2 + p/kappa*2*x*sin(phi(1)) +
2*lambda/kappa) + x*p/kappa/cos(phi(1))];

okrpodm = @(phi1a,phi1b) [phi1a(1), phi1b(1) - pi/2];

odhad = bvpinit(xspan, [0.001 0.001]);

sol = bvp5c(funkce,okrpodm,odhad);

%% ANALYTICKÁ KØIVKA
psi_an = sol.y(1,:);
dpsi_an = sol.y(2,:);

d_x = diff(xspan);
d_z = d_x .* tan(psi_an(1:end-1));
zspan = [0, -cumsum(d_z)];
zspan_0 = zspan;
zspan = zspan - zspan(end);

L = trapz(xspan, 1./cos(psi_an));
A = trapz(xspan, xspan.*tan(psi_an));

%% ANALYTICKÁ ENERGIE U
c2 = dpsi_an .* cos(psi_an);
U = kappa/2 * trapz(xspan,(dpsi_an .* cos(psi_an) - c0).^2 ./ cos(psi_an));
U = 4*U;

%% INTERPOLACE ELEMENTY STEJNÉ DÉLKY
Na = length(xspan) - 1;
points = [xspan; zspan];
dxy = (diff(points'))';
dl = zeros(1,Na);
for i = 1:Na
    dl(i) = norm(dxy(:,i));
end
l = [0, cumsum(dl)];
L = sum(dl);
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N = 10; % POCET ELEMENTU

l_step = L/N;
lq = 0:l_step:L;

xq = interp1(l,xspan,lq,'spline');
zq = interp1(l,zspan,lq,'spline');

body_int = [xq;zq];
d_elem = [diff(body_int(1,:)); diff(body_int(2,:))];

elementy = zeros(1,N);
for i = 1:N
    elementy(i) = norm(d_elem(:,i));
end

psi = -asin(diff(zq)./elementy);

dx = elementy .* cos(psi);
dz = -elementy .* sin(psi);

x0 = 0;
z0 = zspan(1);
x_0 = [x0, x0 + cumsum(dx)];
z_0 = [z0, z0 + cumsum(dz)];

%% VÝPOČET KŘIVOSTI - FITOVÁNÍ KRUŽNICE
body = [x_0;z_0];
body_0 = [-body(1,2);body(2,2)];
body_end = [body(1,end-1);-body(2,end-1)];

body1 = [body_0, body, body_end];

body1 = body1';

threes = zeros(3,2*(N+1));

for n = 1:2:2*(N+1)
    threes(:,n:n+1) = body1((n/2+0.5):(n/2+2.5),:);
end

R = fit_circle_through_3_points(threes);
c2_fit = 1./R;

%% DALŠÍ NUMERICKÉ VÝPOČTY KŘIVOSTI
elementy1 = [elementy(1), elementy];
dpsi = diff(psi);
dpsi = [2*psi(1),dpsi,2*(pi/2-psi(end))];

c2_avg = zeros(1,N);
c2_wind = zeros(1,N);
c2_darc = zeros(1,N);
c2_dain = zeros(1,N);
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```
for i = 1:N
    c2_avg(i) = 0.5 * ((dpsi(i)/elementy1(i)) + (dpsi(i+1)/elementy1(i+1)));
% VÝPOČET KŘIVOSTI - PRŮMĚRNÁ KŘIVOST
    c2_wind(i) = 2*dpsi(i)/(elementy1(i) + elementy1(i+1));
% VÝPOČET KŘIVOSTI - WINDING NUMBER THEOREM
    c2_darc(i) = 4*sin(dpsi(i)/2)/(elementy1(i) + elementy1(i+1));
% VÝPOČET KŘIVOSTI - DISCRETE GRADIENT OF ARC LENGTH
    c2_dain(i) = 4*tan(dpsi(i)/2)/(elementy1(i) + elementy1(i+1));
% VÝPOČET KŘIVOSTI - DISCRETE AREA INFLATION
end
c2_avg = [0.5 * ((dpsi(1)/elementy1(1)) + (dpsi(2)/elementy1(2))), c2_avg];
c2_wind = [2*dpsi(1)/(elementy1(1) + elementy1(2)), c2_wind];
c2_darc = [4*sin(dpsi(1)/2)/(elementy1(1) + elementy1(2)), c2_darc];
c2_dain = [4*tan(dpsi(1)/2)/(elementy1(1) + elementy1(2)), c2_dain];

dL = cumsum(elementy);
dL = [0,dL];

%% NUMERICKÉ HODNOTY DEFORMAČNÍ ENERGIE
U_avg = 2 * kappa * trapz(dL,(c2_avg - c0).^2);
U_wind = 2 * kappa * trapz(dL,(c2_wind - c0).^2);
U_darc = 2 * kappa * trapz(dL,(c2_darc - c0).^2);
U_dain = 2 * kappa * trapz(dL,(c2_dain - c0).^2);
U_fit = 2 * kappa * trapz(dL,(c2_fit - c0).^2);

U_komp = [U U_avg U_wind U_darc U_dain U_fit]
U_komp = [U U/L]
L_A = [L A]
osa_x = [-11 11; 0 0];
osa_y = [0 0; -2.5 2.5];


%% GRAF POROVNÁNÍ ANALYTICKÉHO A NUMERICKÉHO TVARU
hold on
axis equal
pbaspect([10 3 1]);
set(gca,'FontSize', 30, 'fontname', 'Cambria Math')
xlim([0 10]);
ylim([0 3]);
plot(xspan, zspan, '-k', 'lineWidth', 2);
plot(x_0, z_0, '--ok', 'markerSize', 10, 'MarkerFaceColor', 'k', 'lineWidth',
2);
legend('analytická køivka','numerická aproximace', 'fontSize', 25);
xlabel('{\itx} [\mum]', 'fontSize', 30, 'fontname', 'Times')
ylabel('{\itz} [\mum]', 'fontSize', 30, 'fontname', 'Times')
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