

post_processing_code.m

```
1 %% Post-processing code
2
3 % This code takes computed nodal displacements as input from pre-processing
4 % code and then calculates disp field, strain field and stress field.
5
6 %% Displacement field of the plate
7
8 u_field_plate=sym('A%d%d', [11 nel_x*nel_y]);
9
10 % There are 06 types of elements in our square plate which is SS on all
11 % sides. Disp field of all six types of elements is calculated one by one
12 % and then a matrix containing disp field of whole plate is constructed.
13
14 % 1) "corner elements" of the plate i.e. 04 corners
15
16 for ii=1:4
17     u_elem=zeros(68,1);
18     if ii==1 % lower left corner
19         u_elem_1=zeros(17,1);
20         u_elem_2=y_edge(u(1:6));
21         aa=6*(nel_x-1)+6+1;
22         u_elem_3=u(aa:(aa+16));
23         u_elem_4=x_edge(u(aa-6:aa-1));
24         u_elem=[u_elem_1; u_elem_2; u_elem_3; u_elem_4];
25
26     elseif ii==2 % lower right corner
27         aa=6*(nel_x-2)+1;
28         u_elem_1=y_edge(u(aa:aa+5));
29         u_elem_2=zeros(17,1);
30         aa=6*(nel_x-1)+6+17*(nel_x-1)+1;
31         u_elem_3=x_edge(u(aa:aa+5));
32         u_elem_4=u(aa-17:aa-1);
33         u_elem=[u_elem_1; u_elem_2; u_elem_3; u_elem_4];
34
35     elseif ii==3 % upper left corner
36         aa=6*(nel_x-1)+(nel_y-2)*(6+17*(nel_x-1)+6)+1;
37         u_elem_1=x_edge(u(aa:aa+5));
38         u_elem_2=u(aa+6:aa+22);
39         aa=6*(nel_x-1)+(nel_y-1)*(6+17*(nel_x-1)+6)+1;
40         u_elem_3=y_edge(u(aa:aa+5));
41         u_elem_4=zeros(17,1);
42         u_elem=[u_elem_1; u_elem_2; u_elem_3; u_elem_4];
43
44     elseif ii==4 % upper right corner
45         aa=6*(nel_x-1)+(nel_y-2)*(6+17*(nel_x-1)+6)+6+17*(nel_x-2)+1;
46         u_elem_1=u(aa:aa+16);
47         u_elem_2=x_edge(u(aa+17:aa+22));
48         u_elem_3=zeros(17,1);
49         u_elem_4=y_edge(u(end-5:end));
50         u_elem=[u_elem_1; u_elem_2; u_elem_3; u_elem_4];
51     end
52     u_field_elem=N*u_elem;
53     aa=1;
54     for jj=1:11
55         if ii==2
56             aa=nel_x;
57         elseif ii==3
58             aa=nel_x+(nel_y-2)*(nel_x)+1;
59         elseif ii==4
60             aa=nel_x*nel_y;
61         end
62         u_field_plate(jj,aa)=u_field_elem(jj);
63     end
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64 end
65
66 % 2) Elements on the "lower" edge of the plate except corners
67
68 aa=1; bb=6*(nel_x-1)+6+17+1; cc=2;
69 for ii=1:nel_x-2
70     u_elem_1=y_edge(u(aa:aa+5));
71     u_elem_2=y_edge(u(aa+6:aa+11));
72     u_elem_3=u(bb:bb+16);
73     u_elem_4=u(bb-17:bb-1);
74     u_elem=[u_elem_1; u_elem_2; u_elem_3; u_elem_4];
75     u_field_elem=N*u_elem;
76     aa=aa+6; bb=bb+17;
77
78     for jj=1:11
79         u_field_plate(jj,cc)=u_field_elem(jj);
80     end
81     cc=cc+1;
82 end
83
84 % 3) Elements on the "left" edge of the plate except corners
85
86 aa=6*(nel_x-1)+1; bb=6*(nel_x-1)+6+17*(nel_x-1)+6+6+1; cc=nel_x+1;
87 for ii=1:nel_y-2
88     u_elem_1=x_edge(u(aa:aa+5));
89     u_elem_2=u(aa+6:aa+22);
90     u_elem_3=u(bb:bb+16);
91     u_elem_4=x_edge(u(aa-6:aa-1));
92     u_elem=[u_elem_1; u_elem_2; u_elem_3; u_elem_4];
93     u_field_elem=N*u_elem;
94     aa=aa+6+17*(nel_x-1)+6; bb=bb+17*(nel_x-1)+6+6;
95
96     for jj=1:11
97         u_field_plate(jj,cc)=u_field_elem(jj);
98     end
99     cc=cc+nel_x;
100 end
101
102 % 4) Elements on the "right" edge of the plate except corners
103
104 aa=6*(nel_x-1)+6+17*(nel_x-1)-16; cc=2*nel_x;
105 for ii=1:nel_y-2
106     bb=aa+17+6+6+17*(nel_x-1);
107     u_elem_1=u(aa:aa+16);
108     u_elem_2=x_edge(u(aa+17:aa+22));
109     u_elem_3=x_edge(u(bb:bb+5));
110     u_elem_4=u(bb-17:bb-1);
111     u_elem=[u_elem_1; u_elem_2; u_elem_3; u_elem_4];
112     u_field_elem=N*u_elem;
113     aa=aa+17+6+6+17*(nel_x-1)-17;
114
115     for jj=1:11
116         u_field_plate(jj,cc)=u_field_elem(jj);
117     end
118     cc=cc+nel_x;
119 end
120
121 % 5) Elements on the "top" edge of the plate except corners
122
123 aa=6*(nel_x-1)+(nel_y-2)*(6+17*(nel_x-1)+6)+6+1;
124 bb=6*(nel_x-1)+(nel_y-1)*(6+17*(nel_x-1)+6)+6+1;
125 cc=nel_x*(nel_y-1)+2;
126 for ii=1:nel_x-2
127     u_elem_1=u(aa:aa+16);
128     u_elem_2=u(aa+17:aa+33);

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129     u_elem_3=y_edge(u(bb:bb+5));
130     u_elem_4=y_edge(u(bb-6:bb-1));
131     u_elem=[u_elem_1; u_elem_2; u_elem_3; u_elem_4];
132     u_field_elem=N*u_elem;
133     aa=aa+17; bb=bb+6;
134
135     for jj=1:11
136         u_field_plate(jj,cc)=u_field_elem(jj);
137     end
138     cc=cc+1;
139 end
140
141 % 6) Elements which are in-between the edges and have 17-DOF at each
142 %     node of the element
143
144 aa=6*(nel_x-1)+6+1;  bb=6*(nel_x-1)+6+17*(nel_x-1)+6+6+17+1;
145 cc=nel_x+2;
146 for ii=1:nel_y-2
147     for jj=1:nel_x-2
148         u_elem_1=u(aa:aa+16);
149         u_elem_2=u(aa+17:aa+33);
150         u_elem_3=u(bb:bb+16);
151         u_elem_4=u(bb-17:bb-1);
152         u_elem=[u_elem_1; u_elem_2; u_elem_3; u_elem_4];
153         u_field_elem=N*u_elem;
154         aa=aa+17; bb=bb+17;
155
156         for kk=1:11
157             u_field_plate(kk,cc)=u_field_elem(kk);
158         end
159         cc=cc+1;
160     end
161     aa=aa+17+6+6; bb=bb+6+6+17;
162     cc=cc+2;
163 end
164
165 %% Strain field of the face-sheets
166
167 % There are 03 types of strains in the face-sheets which are
168 % E_xx, E_yy and E_xy. Therefore, for our case there'll be a
169 % total of 06 strains in the face-sheets (03 in each).
170
171 U=u_field_plate;
172 zeta_t=z-(c+(ft/2));
173 zeta_b=z+(c+(fb/2));
174
175 % Top face-sheet
176 strain_field_plate_top=sym('A%d%d', [3 nel_x*nel_y]);
177 for ii=1:nel_x*nel_y
178     strain_field_plate_top(1,ii)=diff(U(1,ii),x) - zeta_t*(diff(U(3,ii),x,2));
179     strain_field_plate_top(2,ii)=diff(U(2,ii),y) - zeta_t*(diff(U(3,ii),y,2));
180     strain_field_plate_top(3,ii)=diff(U(1,ii),y) + diff(U(2,ii),x)...
181         - 2*zeta_t*(diff(diff(U(3,ii),y),x));
182 end
183
184 % Bottom face-sheet
185 strain_field_plate_bottom=sym('A%d%d', [3 nel_x*nel_y]);
186 for ii=1:nel_x*nel_y
187     strain_field_plate_bottom(1,ii)=diff(U(4,ii),x) - zeta_t*(diff(U(6,ii),x,2));
188     strain_field_plate_bottom(2,ii)=diff(U(5,ii),y) - zeta_t*(diff(U(6,ii),y,2));
189     strain_field_plate_bottom(3,ii)=diff(U(4,ii),y) + diff(U(5,ii),x)...
190         - 2*zeta_t*(diff(diff(U(6,ii),y),x));
191 end
192
193 %% Strain field of the core

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194
195 % There are 06 strains in the core whcih are E_xx, E_yy, E_zz, E_xy, E_yz
196 % and E_xz.
197
198 strain_field_plate_core=sym('A%d%d', [6 nel_x*nel_y]);
199 for ii=1:nel_x*nel_y
200     strain_field_plate_core(1,ii)=diff(U(7,ii),x) + z*(diff(U(10,ii),x)) - ...
201         (z^3/(4*c^3))*(2*diff(U(4,ii),x)-2*diff(U(1,ii),x)+4*c*diff(U(10,ii),x)-
fb*diff(U(6,ii),x,2)-ft*diff(U(3,ii),x,2))-...
202         (z^2/(4*c^2))*(-2*diff(U(4,ii),x)+4*diff(U(7,ii),x)-2*
(diff(U(1,ii),x))+fb*diff(U(6,ii),x,2)-ft*diff(U(3,ii),x,2)));
203
204     strain_field_plate_core(2,ii)=diff(U(8,ii),y) - z*(diff(U(11,ii),y)) - ...
205         (z^3/(4*c^3))*(2*diff(U(5,ii),y)-2*diff(U(2,ii),y)-4*c*diff(U(11,ii),y)-
fb*diff(U(6,ii),y,2)-ft*diff(U(3,ii),y,2))-...
206         (z^2/(4*c^2))*(-2*diff(U(5,ii),y)+4*diff(U(8,ii),y)-2*
(diff(U(2,ii),y))+fb*diff(U(6,ii),y,2)-ft*diff(U(3,ii),y,2)));
207
208     strain_field_plate_core(3,ii)=-(z/(c^2))*(2*U(9,ii)-U(6,ii)-U(3,ii))-(1/(2*c)*(U(6,ii)-
U(3,ii)));
209
210     strain_field_plate_core(4,ii)=-U(11,ii)+diff(U(9,ii),y)-(z^2/(2*c^2))*(2*diff(U(9,ii),y)-
diff(U(6,ii),y)-diff(U(3,ii),y))-...
211         (z/(2*c))*(diff(U(6,ii),y)-diff(U(3,ii),y))-(3*z^2/(4*c^3))*
(2*U(5,ii)-2*U(2,ii)-4*c*U(11,ii)-fb*diff(U(6,ii),y)-ft*diff(U(3,ii),y))-...
212         (z/(2*c^2))*(-2*U(5,ii)+4*U(8,ii)-2*U(2,ii)+fb*diff(U(6,ii),y)-
ft*diff(U(3,ii),y)));
213
214     strain_field_plate_core(5,ii)=U(10,ii)+diff(U(9,ii),x)-(z^2/(2*c^2))*(2*diff(U(9,ii),x))-
diff(U(6,ii),x)-diff(U(3,ii),x))-...
215         (z/(2*c))*(diff(U(6,ii),x)-diff(U(3,ii),x))-(3*z^2/(4*c^3))*
(2*U(4,ii)-2*U(1,ii)+4*c*U(10,ii)-fb*diff(U(6,ii),x)-ft*diff(U(3,ii),x))-...
216         (z/(2*c^2))*(-2*U(4,ii)+4*U(7,ii)-2*U(1,ii)+fb*diff(U(6,ii),x)-
ft*diff(U(3,ii),x)));
217
218     strain_field_plate_core(6,ii)=diff(U(7,ii),y)+z*diff(U(10,ii),y)+diff(U(8,ii),x)-
z*diff(U(11,ii),x))-...
219         (z^3/(4*c^3))*(2*diff(U(4,ii),y)-2*diff(U(1,ii),y)+4*c*diff(U(10,ii),y)-
fb*diff(diff(U(6,ii),y),x)-ft*diff(diff(U(3,ii),y),x))-...
220         (z^3/(4*c^3))*(2*diff(U(5,ii),x)-2*diff(U(2,ii),x)-4*c*diff(U(11,ii),x)-
fb*diff(diff(U(6,ii),y),x)-ft*diff(diff(U(3,ii),y),x))-...
221         (z^2/(4*c^2))*
(-2*diff(U(4,ii),y)+4*diff(U(7,ii),y)-2*diff(U(1,ii),y)+fb*diff(diff(U(6,ii),y),x)-
ft*diff(diff(U(3,ii),y),x))-...
222         (z^2/(4*c^2))*
(-2*diff(U(5,ii),x)+4*diff(U(8,ii),x)-2*diff(U(2,ii),x)+fb*diff(diff(U(6,ii),y),x)-
ft*diff(diff(U(3,ii),y),x)));
223 end
224
225 %% Stress field
226
227 % There are 03 types of stresses in the face-sheets which are
228 % sig_xx, sig_yy and sig_xy. Therefore, for our case there'll be a
229 % total of 06 stresses in the face-sheets (03 in each).
230 % Whereas, in core there are all 06 stresses present which are
231 % sig_xx, sig_yy, sig_zz, sig_xz, sig_yz and sig_xy.
232
233 % Top face-sheet
234 stress_field_plate_top=C_t*strain_field_plate_top;
235
236 % Bottom face-sheet
237 stress_field_plate_bottom=C_b*strain_field_plate_bottom;
238
239 % Core
240 stress_field_plate_core=C_c*strain_field_plate_core;

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