
Travail de Fin d'Etudes : Développement d'un modèle novateur de caractérisation du comportement précis d'assemblages de construction métallique et mixte acier-béton

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Data processing

```
1  % Generation of mechanical spring model for FINELG treatment, including
2  % group effects and components ductility
3
4  % Conducted as part of master thesis relating to the development of an
5  % innovative model for the precise characterization of steel and
6  % joints
7
8  % MATHIEU Julien
9
10 close all
11 clear
12 clc
13
14 %% General data
15 % Lines and columns of data_all must be verified if excel file is
16 %   changed
17
18 % Name of FINELG input file
19 Name = 'Input_Finelg';
20 Ext = '.dat';
21
22 % Extraction of data from excel file
23 data_all = xlsread('Data.xlsx');
24
25 % Name of .txt file usefull for results processing
26 Name_txt = 'Loads_Dep';
27 Ext_txt = '.txt';
28
29 % Number of rows in tension
30 n_rows_t = data_all(10,1);
31
32 % Number of rows in compression
33 n_rows_c = data_all(11,1);
34
35 % Total number of rows
36 n_rows_tot = n_rows_t + n_rows_c;
37
38 % Total number of groups
39 n_gr_tot = n_rows_t*(n_rows_t-1)/2;
40
41 % Total number of demultiplication of the rows
42 n_demult = n_gr_tot-(n_rows_t-1)-(n_rows_t-2)+1;
43
44 % Location of the point of application of the axial load
45 CG_beam = data_all(12,1);
46
47 % Bending moment
48 M = data_all(1,1)*10^6;
49
50 % Axial force
51 N = data_all(2,1)*10^3;
52
53 % Transversal load
```

```

48 V = data_all(3,1)*10^3;
49
50 % Initial increment
51 incr_ini = data_all(4,1);
52 % Initial small axial force (sequences 1 and 3)
53 N1 = data_all(5,1)*10^3;
54 % Initial small bending moment (sequence 2)
55 M1 = data_all(6,1)*10^6;
56
57 % First line of table 'Components data' in 'data_all'
58 first_line_comp = 2;
59 % First column of table 'Components data' in 'data_all'
60 first_column_comp = 3;
61 % Last line of table 'Components data' in 'data_all'
62 last_line_comp = size(data_all,1);
63
64 % First line of table 'Groups data' in 'data_all'
65 first_line_gr = 2;
66 % First column of table 'Groups data' in 'data_all'
67 first_column_gr = 11;
68 % Last line of table 'Groups data'
69 last_line_gr = first_line_gr+n_gr_tot-1;
70
71 %% Rows general data
72
73 % Column 1 : Row number
74 % Column 2 : Distance between the bottom row and row i
75 % Column 3 : Row in tension(1)/compression(0)
76 % Column 4 : Number of groups in row i
77 % Column 5 : Number of groups seperating the row i (number of "cuts")
78 % Column 6 : Total number of elements in row i
79 % Column 7 : First element in row i
80 % Column 8 : Last element in row i
81 % Column 9 : Total number of nodes in row i
82 % Column 10 : First node in row i
83 % Column 11 : Last node in row i
84
85 data_rows = zeros(n_rows_tot,4);
86 nt = 0;
87 for i = 1:n_rows_tot
88
89     data_rows(i,1) = i;
90
91     for j = first_line_comp:last_line_comp
92         if data_all(j,first_column_comp) == i
93
94             data_rows(i,2) = data_all(j,first_column_comp+1);
95             data_rows(i,3) = data_all(j,first_column_comp+2);
96
97         end
98     end

```

```

99
100 if data_rows(i,3) == 1
101     nt = nt+1;
102     if nt == 1
103
104         data_rows(i,4) = n_rows_t-1;
105
106     elseif nt <= n_demult+1
107
108         n = 1;
109         while data_rows(i-n,3) == 0
110             n = n+1;
111         end
112         data_rows(i,4) = data_rows(i-n,4)-1;
113
114     else
115
116         n = 1;
117         while data_rows(i-n,3) == 0
118             n = n+1;
119         end
120         data_rows(i,4) = data_rows(i-n,4)-1;
121
122     end
123 end
124 end
125
126 % Number of groups considering row i in each zone
127 % Each zone j is composed of all equivalent springs next to groups j to
128 i
129 % Number of zones = total number of rows in tension - 3 (only one
130 equivalent spring in the two first rows and no group in last row)
131 for i = 1:n_rows_t
132     for j = 1:n_rows_t-2-1
133
134         if i <= 2+(j-1)
135
136             nb_groups_zone(i,j) = 0;
137
138         elseif i == 2+(j-1)+1
139
140             nb_groups_zone (i,j) = n_rows_t-i;
141
142         elseif i == 2+(j-1)+2
143
144             nb_groups_zone (i,j) = nb_groups_zone(i-1,j);
145
146         else
147
148             nb_groups_zone (i,j) = nb_groups_zone(i-1,j)-1;

```

```

149     end
150   end
151 end
152
153 % Total number of groups considering row i
154 n = 0;
155 for i = 1:n_rows_tot
156   if data_rows(i,3) == 1
157     n = n+1;
158     data_rows(i,5) = sum(nb_groups_zone(n,:));
159   end
160 end
161
162 n = 0;
163 for i = 1:n_rows_tot
164   if data_rows(i,3) == 1
165     n = n+1;
166
167     if n <= 2
168       data_rows(i,6) = data_rows(i,4)+1;
169       data_rows(i,9) = data_rows(i,6)+1;
170     else
171       data_rows(i,6) = data_rows(i,4)+n_demult;
172       data_rows(i,9) = data_rows(i,5)+n_demult+1;
173     end
174
175     else
176       data_rows(i,6) = 1;
177       data_rows(i,9) = 2;
178     end
179
180     data_rows(i,7) = sum(data_rows(1:i,6))-data_rows(i,6)+1;
181     data_rows(i,8) = sum(data_rows(1:i,6));
182     data_rows(i,10) = sum(data_rows(1:i,9))-data_rows(i,9)+1;
183     data_rows(i,11) = sum(data_rows(1:i,9));
184
185 end
186
187 % Additional node if the last row is in tension
188 if data_rows(end,3) ~= 0
189   data_rows(end,9) = data_rows(end,9)+1;
190   data_rows(i,11) = data_rows(i,11)+1;
191 end
192
193 % Separation between rows in tension and rows in compression
194 nt = 0;
195 nc = 0;
196 for i = 1:n_rows_tot
197   if data_rows(i,3) == 1
198
199     nt = nt+1;

```

```

200     data_rows_t(nt,:) = data_rows(i,:);
201
202     else
203
204         nc = nc+1;
205         data_rows_c(nc,:) = data_rows(i,:);
206
207     end
208 end
209
210 % Number of nodes
211 n_nodes = data_rows(end,11)+1;
212
213 % Number of linear constrains in rows in tension 3 to n_rows_t
214 n = 0;
215 for i = 3:n_rows_t
216
217     n = n+1;
218     lin_const_int(n,1) = sum(1:1:data_rows_t(i,4));
219
220 end
221
222 % Total number of linear constrains
223 if data_rows(end,3) == 0
224     n_lin_const = sum(lin_const_int)+sum(data_rows_t(1:2,4))+(n_demult-1)*(n_rows_t
225         -2)+n_rows_c+1;
226 else
227     n_lin_const = sum(lin_const_int)+sum(data_rows_t(1:2,4))+(n_demult-1)*(n_rows_t
228         -2)+n_rows_c+2;
229 end
230
231 % Number of fictional nodes
232 n_fict_nodes = ceil(n_lin_const/3);
233
234 % Total number of nodes
235 n_nodes_tot = n_nodes + n_fict_nodes;
236
237 %% Nodes coordinates
238 coord = zeros(n_nodes_tot,5);
239
240 % FINELG input
241 % Nodes numbering
242 for i = 1:n_nodes_tot
243
244     coord(i,1) = i;
245
246 end
247
248 for i = 1:n_nodes

```

```

249
250     coord(i,2) = 0;
251     coord(i,3) = 0;
252     coord(i,5) = 0;
253
254 end
255
256 % Distance from the bottom row to the node
257 for i = 1:n_rows_tot
258     for j = data_rows(i,10):data_rows(i,11)
259
260         coord(j,4) = data_rows(i,2);
261
262     end
263 end
264
265 % Coordinates of the point of application of the axial load
266 coord(end-n_fict_nodes,4) = CG_beam;
267
268
269 %% Constitutive laws
270
271 % Constitutive laws of the components
272 for i = 1:n_rows_tot
273     n = 0;
274     for j = 1:last_line_comp-first_line_comp+1
275         if data_all(first_line_comp-1+j,first_column_comp) == i
276             n = n+1;
277
278             % Bi-linear law
279             if data_all(first_line_comp-1+j,first_column_comp+3) == 1
280
281                 Resistance(n,1,i) = data_all(first_line_comp-1+j,first_column_comp+5)
282                 ;
283                 Rigidity(n,1,i) = min(data_all(first_line_comp-1+j,first_column_comp
284                 +4),500000000);
285                 Delta(n,i) = data_all(first_line_comp-1+j,first_column_comp+6);
286
287                 % Tri-linear law
288                 elseif data_all(first_line_comp-1+j,first_column_comp+3) == 2
289
290                     Resistance(n,2,i) = data_all(first_line_comp-1+j,first_column_comp+5)
291                     ;
292                     Resistance(n,1,i) = Resistance(n,2,i)*2/3;
293                     Rigidity(n,1,i) = min(data_all(first_line_comp-1+j,first_column_comp
294                     +4),500000000);
295                     Rigidity(n,2,i) = (Resistance(n,2,i)-Resistance(n,1,i))/(Resistance(n,2,i)
296                     /(Rigidity(n,1,i)/3)-Resistance(n,1,i)/Rigidity(n,1,i));
297                     Delta(n,i) = data_all(first_line_comp-1+j,first_column_comp+6);
298
299                     % Multi-linear law

```

```

295     elseif data_all(first_line_comp-1+j,first_column_comp+3) == 3
296
297         Resistance(n,4,i) = data_all(first_line_comp-1+j,first_column_comp+5)
298             ;
299         Resistance(n,1,i) = Resistance(n,4,i)*6/9;
300         Resistance(n,2,i) = Resistance(n,4,i)*7/9;
301         Resistance(n,3,i) = Resistance(n,4,i)*8/9;
302         Rigidity(n,1,i) = min(data_all(first_line_comp-1+j,first_column_comp
303             +4),500000000);
304         Rigidity(n,2,i) = (Resistance(n,2,i)-Resistance(n,1,i))/(Resistance(n,2,i)
305             /(Rigidity(n,1,i)/1.5)-Resistance(n,1,i)/Rigidity(n,1,i));
306         Rigidity(n,3,i) = (Resistance(n,3,i)-Resistance(n,2,i))/(Resistance(n,3,i)
307             /(Rigidity(n,1,i)/2.2)-Resistance(n,1,i)/(Rigidity(n,1,i))/1.5);
308         Rigidity(n,4,i) = (Resistance(n,4,i)-Resistance(n,3,i))/(Resistance(n,4,i)
309             /(Rigidity(n,1,i)/3)-Resistance(n,1,i)/(Rigidity(n,1,i))/2.2);
310         Delta(n,i) = data_all(first_line_comp-1+j,first_column_comp+6);
311
312     end
313 end
314
315 % Constitutive laws of the groups
316 data_laws_gr(:,1) = data_all(first_line_gr:last_line_gr,first_column_gr);
317 data_laws_gr(:,2) = data_all(first_line_gr:last_line_gr,first_column_gr+1);
318 data_laws_gr(:,3) = data_all(first_line_gr:last_line_gr,first_column_gr+2);
319 data_laws_gr(:,4) = data_all(first_line_gr:last_line_gr,first_column_gr+3);
320
321 % Constitutive laws of the equivalent springs
322 n = 0;
323 for i = 1:n_rows_tot
324     clear temp
325     for j = 1:nnz(any(Resistance(:,i),1))
326         temp(size(Resistance,1)*(j-1)+1:size(Resistance,1)*j,1) = Resistance(:,j,i);
327     end
328     temp = sort(temp(temp>0));
329
330     K_i(:,1,i) = Rigidity(:,1,i);
331
332     for j = 1:size(temp)
333         [r,c] = find(Resistance(:,i)==temp(j,1));
334         if c ~= nnz(any(Resistance(:,i),1))
335             data_laws_spring(i,j*2) = temp(j,1);
336             K_i(:,j+1,i) = K_i(:,j,i);
337             K_i(r,j+1,i) = Rigidity(r,c+1,i);
338         else
339             data_laws_spring(i,j*2) = temp(j,1);
340

```



```

341         break
342     end
343 end
344
345 K_i(K_i==0)=NaN;
346 inv_K_i = 1./K_i;
347
348 for j = 1:nnz(any(inv_K_i(:,i),1))
349     data_laws_spring(i,j*2-1) = 1/nansum(inv_K_i(:,j,i));
350 end
351
352 if data_rows(i,3) == 1
353     n = n+1;
354     if n > 2
355         for j = 1:2:nnz(any(data_laws_spring(i,:),1))
356             data_laws_spring(i,j) = data_laws_spring(i,j)*n_demult;
357         end
358     end
359 end
360
361 end
362
363 % Maximum displacement of the equivalent spring
364 [r_d,c_d] = find(Resistance(:,nnz(any(Resistance(:,i),1)),i)==data_laws_spring(i,nnz
    (any(data_laws_spring(i,:),1))));
365 n_r = 1;
366 Delta_spring(i,n_r) = data_laws_spring(i,2)/data_laws_spring(i,1);
367 for j = 3:2:nnz(any(data_laws_spring(i,:),1))-1
368     n_r = n_r+1;
369     Delta_spring(i,n_r) = Delta_spring(i,n_r-1)+(data_laws_spring(i,j+1)-
        data_laws_spring(i,j-1))/data_laws_spring(i,j);
370 end
371
372 Delta_max(i,1) = Delta_spring(i,nnz(any(Delta_spring(i,:),1)))+Delta(r_d,i);
373
374 end
375
376 % Maximum displacement of the groups
377 for i = 1:n_gr_tot
378
379     Delta_max(n_rows_tot+i,1) = data_laws_gr(i,3)/500000000 + data_laws_gr(i,4);
380
381 end
382
383 % Conversion to FINELG laws parameters
384 % Column 1 : Constitutive law number
385 % Column 2 : law type
386 % Column 3 to ... : law parameters
387
388 for i = 1:size(data_laws_spring,1)
389

```

```

390     meca(i,1) = i;
391     meca(i,2) = 11;
392     meca(i,3) = data_laws_spring(i,1);
393     meca(i,4) = 0;
394
395     for j = 2:2:nnz(any(data_laws_spring(i,:),1))
396         meca(i,j+3) = data_laws_spring(i,j);
397     end
398
399     if nnz(any(data_laws_spring(i,:),1)) > 2
400
401         meca(i,6) = data_laws_spring(i,2)/data_laws_spring(i,1)+(data_laws_spring(i,4)
402             -data_laws_spring(i,2))/(data_laws_spring(i,3));
403
404         for j = 5:2:nnz(any(data_laws_spring(i,:),1))
405             meca(i,j+3) = meca(i,j-2+3) + (data_laws_spring(i,j+1)-data_laws_spring(i
406                 ,j-1))/(data_laws_spring(i,j));
407         end
408     end
409
410     end
411     meca(i,nnz(any(meca(i,:),1))+2) = 1;
412 end
413
414 if size(meca,2) > 20
415     error('Equivalent spring constitutive law too nonlinear, please choose another component
416         constitutive law type')
417 end
418
419 % Groups laws
420 for i = 1:size(data_laws_gr,1)
421
422     meca(end+1,1) = meca(end,1)+1;
423     meca(end,2) = 2;
424     meca(end,3) = 500000000;
425     meca(end,4) = 0;
426     meca(end,5) = data_laws_gr(i,3);
427     meca(end,6) = 1;
428
429 end
430
431 % Rigid material law
432 meca(end+1,1) = meca(end,1)+1;
433 meca(end,2) = 0;
434 meca(end,3) = 200000;
435 meca(end,4) = 3.0000E-01;
436
437 % "Constitutive laws" for linear constrains

```

```

438 % Column 1 : law number
439 % Column 3 to ... : linear constrain parameters
440
441 % Linear constrains for groups 1 to i
442 meca(end+1,1) = meca(end,1)+1;
443 meca(end,2) = 0;
444 meca(end,3) = 1;
445 meca(end,4) = -1;
446
447 % Linear constrains for groups 3 => n_rows_t-1 to i
448 meca(end+1,1) = meca(end,1)+1;
449 meca(end,2) = 0;
450 meca(end,3) = 1;
451 meca(end,4) = -1;
452 meca(end,5) = -1;
453 meca(end,6) = 1;
454
455 % Linear constrains for groups 2 to i
456 for i = 2 : (n_rows_t-1)
457
458     meca(end+1,1) = meca(end,1)+1;
459     meca(end,2) = 0;
460     meca(end,3) = data_rows_t(1,2);
461     meca(end,4) = -data_rows_t(1,2);
462     meca(end,5) = -(data_rows_t(2,2)-data_rows_t(2+(i-1),2));
463     meca(end,6) = data_rows_t(2,2)-data_rows_t(2+(i-1),2);
464
465 end
466
467 % Linear constrains for the "Bernouilli element"
468 x = 0;
469 nt = 0;
470 if data_rows(end,3) == 1
471     for i = 1:n_rows_tot
472         if x < n_rows_c+1
473             if data_rows(i,3) == 1
474                 nt = nt+1;
475             end
476             if nt < 2
477
478                 x = x+1;
479                 meca(end+1,1) = meca(end,1)+1;
480                 meca(end,2) = 0;
481                 meca(end,3) = data_rows(i+1,2);
482                 meca(end,4) = data_rows(1,2)-data_rows(i+1,2);
483                 meca(end,5) = -data_rows(1,2);
484
485             else
486                 if data_rows(i+1,3)==1
487                     continue
488                 else

```

```

489
490         x = x+1;
491         meca(end+1,1) = meca(end,1)+1;
492         meca(end,2) = 0;
493         meca(end,3) = data_rows(i+1,2);
494         meca(end,4) = data_rows(1,2)-data_rows(i+1,2);
495         meca(end,5) = -data_rows(1,2);
496
497     end
498 end
499 end
500 end
501 else
502     for i = 1:n_rows_tot
503         if x < n_rows_c
504             if data_rows(i,3) == 1
505                 nt = nt+1;
506             end
507             if nt < 2
508
509                 x = x+1;
510                 meca(end+1,1) = meca(end,1)+1;
511                 meca(end,2) = 0;
512                 meca(end,3) = data_rows(i+1,2);
513                 meca(end,4) = data_rows(1,2)-data_rows(i+1,2);
514                 meca(end,5) = -data_rows(1,2);
515
516             else
517                 if data_rows(i+1,3)==1
518                     continue
519                 else
520
521                     x = x+1;
522                     meca(end+1,1) = meca(end,1)+1;
523                     meca(end,2) = 0;
524                     meca(end,3) = data_rows(i+1,2);
525                     meca(end,4) = data_rows(1,2)-data_rows(i+1,2);
526                     meca(end,5) = -data_rows(1,2);
527
528                 end
529             end
530         else
531             break
532         end
533     end
534 end
535
536 % Linear constrains for the "Bernouilli element" – Point of application
537 % the axial load
538 meca(end+1,1) = meca(end,1)+1;

```

```

539 meca(end,2) = 0;
540 meca(end,3) = CG_beam;
541 meca(end,4) = data_rows(1,2)-CG_beam;
542 meca(end,5) = -data_rows(1,2);
543
544
545 %% Elements
546
547 % Column 1 : Element number
548 % Column 2 : Element identification number (FINELG)
549 % Column 3 : Constitutive law linked to the element
550 % Column 4 : Geometrical parameter
551 % Column 5 : First node of the element
552 % Column 6 : Last node of the element
553 % Column 18 : row active in tension (1), compression (2) or both (0)
554 % Column 19 : identification of groups elements
555
556 % Groups and components
557 nt = 0;
558 n_delta = 0;
559 for i = 1:n_rows_tot
560     if data_rows(i,3) == 0
561         % Rows in compression
562         % Equivalent spring
563         for j = data_rows(i,7) : data_rows(i,8)
564
565             elements(j,1) = j;
566             elements(j,2) = 201;
567             elements(j,3) = i;
568             if j == 1
569                 elements(j,4) = 1;
570             else
571                 elements(j,4) = 0;
572             end
573             if i == 1
574                 elements(j,5) = j;
575             else
576                 if j == data_rows(i,7)
577                     elements(j,5) = data_rows(i,10);
578                 else
579                     elements(j,5) = elements(j-1,6);
580                 end
581             end
582             elements(j,6) = elements(j,5)+1;
583             elements(j,18) = 2;
584         end
585
586         % Identification of the node which will be usefull for the
587         % displacement verification
588         Delta_max(i,2) = elements(j,6);
589         % Negative displacement for equivalent spring in compression

```

```

590     Delta_max(i,1) = -Delta_max(i,1);
591
592     else
593         % Rows in tension
594         nt = nt+1;
595         if nt == 1
596             % First row in tension
597             % Groups
598             n = 0;
599             for j = data_rows(i,7) : data_rows(i,4)
600
601                 n = n+1;
602                 elements(j,1) = j;
603                 elements(j,2) = 201;
604                 elements(j,3) = n_rows_tot+(n_rows_t-1)-(j-data_rows(i,7));
605                 if j == 1
606                     elements(j,4) = 1;
607                 else
608                     elements(j,4) = 0;
609                 end
610                 if i == 1
611                     elements(j,5) = j;
612                 else
613                     if j == data_rows(i,7)
614                         elements(j,5) = data_rows(i,10);
615                     else
616                         elements(j,5) = elements(j-1,6);
617                     end
618                 end
619
620                 elements(j,6) = elements(j,5)+1;
621
622                 % Identification of group element
623                 elements(j,19) = 1;
624
625                 % Identification of the node which will be usefull for the
626                 % displacement verification
627                 Delta_max(n_rows_tot+(n_rows_t-1)-(n-1),2) = elements(j,6);
628
629             end
630             % Equivalent spring
631             for j = data_rows(i,7)+data_rows(i,4) : data_rows(i,8)
632
633                 elements(j,1) = j;
634                 elements(j,2) = 201;
635                 elements(j,3) = i;
636                 if j == 1
637                     elements(j,4) = 1;
638                 else
639                     elements(j,4) = 0;
640                 end

```

```

641     if i == 1
642         elements(j,5) = j;
643     else
644         if j == data_rows(i,7)
645             elements(j,5) = data_rows(i,10);
646         else
647             elements(j,5) = elements(j-1,6);
648         end
649     end
650     elements(j,6) = elements(j,5)+1;
651     elements(j,18) = 1;
652
653     % Identification of the node which will be usefull for the
654     % displacement verification
655     Delta_max(i,2) = elements(j,6);
656
657 end
658 elseif nt == 2
659     % Second row in tension
660     % Equivalent spring
661     for j = data_rows(i,7) : data_rows(i,8)-data_rows(i,4)
662
663         elements(j,1) = j;
664         elements(j,2) = 201;
665         elements(j,3) = i;
666         elements(j,4) = 0;
667         if j == data_rows(i,7)
668             elements(j,5) = data_rows(i,10);
669         else
670             elements(j,5) = elements(j-1,6);
671         end
672         elements(j,6) = elements(j,5)+1;
673         elements(j,18) = 1;
674
675         % Identification of the node which will be usefull for the
676         % displacement verification
677         Delta_max(i,2) = elements(j,6);
678
679     end
680     % Groups
681     n = 0;
682     for j = data_rows(i,8)-data_rows(i,4)+1 : data_rows(i,8)
683
684         n = n+1;
685         elements(j,1) = j;
686         elements(j,2) = 201;
687         elements(j,3) = n_rows_tot+(n_rows_t-1)+(j-(data_rows(i,8)-data_rows(
688             i,4)));
689         elements(j,4) = 0;
690         if j == data_rows(i,7)

```

```

691     else
692         elements(j,5) = elements(j-1,6);
693     end
694     elements(j,6) = elements(j,5)+1;
695
696     % Identification of group element
697     elements(j,19) = 1;
698
699     % Identification of the node which will be usefull for the
700     % displacement verification
701     Delta_max(n_rows_tot+(n_rows_t-1)+n,2) = elements(j,6);
702
703     end
704 else
705     % Other rows
706     for j = 1:size(nb_groups_zone,2)
707         if nt > j+2
708             % Equivalent springs in rows i > j+2 in each zone
709             for k = data_rows(i,7) : data_rows(i,7)
710
711                 elements(k,1) = k;
712                 elements(k,2) = 201;
713                 elements(k,3) = i;
714                 elements(k,4) = 0;
715                 elements(k,5) = data_rows(i,10);
716                 elements(k,6) = elements(k,5)+1;
717                 elements(k,18) = 1;
718
719             end
720             for k = data_rows(i,7)+sum(data_rows_t(3:2+(j-1),4))+1 : data_rows(i,7)+sum(data_rows_t(3:2+(j-1),4))+nb_groups_zone(nt,j)
721
722                 elements(k,1) = k;
723                 elements(k,2) = 201;
724                 elements(k,3) = i;
725                 elements(k,4) = 0;
726                 if k == data_rows(i,7)
727                     elements(k,5) = data_rows(i,10);
728                 else
729                     elements(k,5) = elements(k-1,6)+1;
730                 end
731                 elements(k,6) = elements(k,5)+1;
732                 elements(k,18) = 1;
733
734             end
735             if nt > j+3
736                 for k = data_rows(i,7)+sum(data_rows_t(3:2+(j-1),4))+
737                     nb_groups_zone(nt,j)+1 : data_rows(i,7)+sum(data_rows_t(3:2+(j-1),4))+data_rows_t(j+2,4)
738
739                     elements(k,1) = k;

```



```

739         elements(k,2) = 201;
740         elements(k,3) = i;
741         elements(k,4) = 0;
742         elements(k,5) = elements(k-1,6);
743         elements(k,6) = elements(k,5)+1;
744         elements(k,18) = 1;
745
746     end
747 end
748 elseif nt == j+2
749     % Rows and zones including groups j+2 to i
750     % Equivalent springs
751     for k = data_rows(i,7)+sum(data_rows_t(3:nt,4))-data_rows(i,4) : 2 :
752         data_rows(i,7)+sum(data_rows_t(3:nt,4))-data_rows(i,4)+2*
753         data_rows(i,4)
754
755         elements(k,1) = k;
756         elements(k,2) = 201;
757         elements(k,3) = i;
758         elements(k,4) = 0;
759
760         if k == data_rows(i,7)
761             elements(k,5) = data_rows(i,10);
762         elseif k ~= data_rows(i,7) && k == data_rows(i,7)+sum(
763             data_rows_t(3:nt,4))-data_rows(i,4)
764             elements(k,5) = elements(k-1,6)+1;
765         else
766             elements(k,5) = elements(k-2,6)+1;
767         end
768         elements(k,6) = elements(k,5)+1;
769         elements(k,18) = 1;
770
771     end
772     % Groups
773     n = 0;
774     for k = data_rows(i,7)+sum(data_rows_t(3:nt,4))-data_rows(i,4)+1 : 2
775         : data_rows(i,7)+sum(data_rows_t(3:nt,4))-data_rows(i,4)+2*
776         data_rows(i,4)-1
777
778         elements(k,1) = k;
779         elements(k,2) = 201;
780         elements(k,3) = n_rows_tot+sum(data_rows(1:i,4))-(k-(k-n));
781         elements(k,4) = 0;
782         elements(k,5) = elements(k-1,6);
783         elements(k,6) = elements(k,5)+1;
784         n = n+1;
785         % Identification of group element
786         elements(k,19) = 1;
787
788         % Identification of the node which will be usefull
789         for the

```

```

784         % displacement verification
785         n_delta = n_delta+1;
786         Delta_max(n_rows_tot+(n_rows_t-1)+(n_rows_t-2)+n_delta,2) =
            elements(k,6);
787
788     end
789 else
790     % Springs after the groups (j+2) to i
791     % Equivalent springs
792     for k = data_rows(i,7)+sum(data_rows_t(3:nt,4))+data_rows(i,4) :
        data_rows(i,8)
793
794         elements(k,1) = k;
795         elements(k,2) = 201;
796         elements(k,3) = i;
797         elements(k,4) = 0;
798         elements(k,5) = elements(k-1,6);
799         elements(k,6) = elements(k,5)+1;
800         elements(k,18) = 1;
801
802     end
803 end
804 end
805 end
806
807 % Identification of the node which will be usefull for the
808 % displacement verification
809 if nt > 2 && nt < n_rows_t
810     Delta_max(i,2) = data_rows_t(nt,11);
811 elseif nt == n_rows_t
812     if data_rows(end,3)==0
813         Delta_max(i,2) = data_rows_t(nt,11);
814     else
815         Delta_max(i,2) = data_rows_t(nt,11)-1;
816     end
817 end
818
819 end
820 end
821
822 % Elements connecting embedded supports
823 nt = 0;
824 n = 0;
825 for i = 1:n_rows_tot
826     if n < n_rows_c
827         if data_rows(i,3) == 1
828             nt = nt+1;
829             if nt == 1
830
831                 n=n+1;
832                 elements(end+1,1) = elements(end,1)+1;

```

```

833     elements(end,2) = 33;
834     elements(end,3) = n_rows_tot+n_gr_tot+1;
835     if i == 1
836         elements(end,4) = 1;
837     else
838         elements(end,4) = 0;
839     end
840     elements(end,5) = data_rows(i,10);
841     for j = i+1:n_rows_tot
842         if data_rows(j,3) == 0
843             elements(end,6) = data_rows(j,10);
844             break
845         end
846     end
847
848     else
849         continue
850     end
851 else
852
853     n=n+1;
854     elements(end+1,1) = elements(end,1)+1;
855     elements(end,2) = 33;
856     elements(end,3) = n_rows_tot+n_gr_tot+1;
857     if i == 1
858         elements(end,4) = 1;
859     else
860         elements(end,4) = 0;
861     end
862     elements(end,5) = data_rows(i,10);
863     for j = i+1:n_rows_tot
864         if nt >= 1
865             if data_rows(j,3) == 0
866
867                 elements(end,6) = data_rows(j,10);
868                 break
869
870             end
871         else
872
873             elements(end,6) = data_rows(j,10);
874             break
875
876         end
877     end
878 end
879 end
880 end
881
882 % Linear constrains elements
883 % Column 1 : element number

```

```

884 % Column 2 : element indentification number
885 % Column 3 : "constitutive law" of the linear constrain
886 % Column 5 : node linked to the linear constrain
887 % Column 6 to ... : linear constrain parameters
888
889 % Linear constrains for groups 1 to i
890 n = 0;
891 for i = 1:data_rows_t(1,4)
892
893     elements(end+1,1) = elements(end,1)+1;
894     elements(end,2) = 221;
895     elements(end,3) = n_rows_tot+n_gr_tot+2;
896     if i == 1
897         elements(end,4) = 1;
898     else
899         elements(end,4) = 0;
900     end
901     if n < 3
902         elements(end,5) = coord(data_rows_t(end,11),1)+1+ceil(i/3);
903     else
904         elements(end,5) = elements(end-1,5)+1;
905     end
906     elements(end,6) = data_rows_t(1,10)+i;
907     elements(end,7) = data_rows_t(end-(i-1),10);
908     elements(end,8) = 0;
909     elements(end,9) = 0;
910     elements(end,10) = 0;
911     n = n+1;
912     if n == 4
913         n = 1;
914     end
915     elements(end,11) = n;
916     elements(end,12) = 1;
917     elements(end,13) = 1;
918
919 end
920
921 % Linear constrains of groups 3 => n_rows_t to i
922 for i = 3:n_rows_t-1
923     for j = 1:nnz(any(nb_groups_zone(i,:),1))
924         n_lc = 0;
925         if i == j+2
926             for k = sum(data_rows_t(3:2+(j-1),4)) : 2 : sum(data_rows_t(3:2+(j-1),4))+
                data_rows_t(i,4)-1)*2
927
928                 elements(end+1,1) = elements(end,1)+1;
929                 elements(end,2) = 221;
930                 elements(end,3) = n_rows_tot+n_gr_tot+3;
931                 elements(end,4) = 0;
932                 if n < 3
933                     elements(end,5) = elements(end-1,5);

```

```

934     else
935         elements(end,5) = elements(end-1,5)+1;
936     end
937     elements(end,6) = elements(k+data_rows_t(i,7),6);
938     elements(end,7) = elements((k-n_lc)+data_rows_t(i+1,7),6);
939     elements(end,8) = elements(end,6)+1;
940     elements(end,9) = elements(end,7)+1;
941     elements(end,10) = 0;
942     elements(end,11) = 0;
943     elements(end,12) = 0;
944     n = n+1;
945     if n == 4
946         n = 1;
947     end
948     elements(end,13) = n;
949     elements(end,14) = 1;
950     elements(end,15) = 1;
951     elements(end,16) = 1;
952     elements(end,17) = 1;
953     n_lc = n_lc+1;
954
955 end
956 else
957     for k = sum(data_rows_t(3:2+(j-1),4)) : sum(data_rows_t(3:2+(j-1),4))+
958         data_rows_t(i,4)-1
959
960         elements(end+1,1) = elements(end,1)+1;
961         elements(end,2) = 221;
962         elements(end,3) = n_rows_tot+n_gr_tot+3;
963         elements(end,4) = 0;
964         if n < 3
965             elements(end,5) = elements(end-1,5);
966         else
967             elements(end,5) = elements(end-1,5)+1;
968         end
969         elements(end,6) = elements(k+data_rows_t(i,7),6);
970         elements(end,7) = elements(k+data_rows_t(i+1,7),6);
971         elements(end,8) = elements(end,6)+1;
972         elements(end,9) = elements(end,7)+1;
973         elements(end,10) = 0;
974         elements(end,11) = 0;
975         elements(end,12) = 0;
976         n = n+1;
977         if n == 4
978             n = 1;
979         end
980         elements(end,13) = n;
981         elements(end,14) = 1;
982         elements(end,15) = 1;
983         elements(end,16) = 1;
984         elements(end,17) = 1;

```

```

984         end
985     end
986 end
987 end
988
989 % Linear constrains for groups 2 to i
990 for i = 1:data_rows_t(2,4)
991
992     elements(end+1,1) = elements(end,1)+1;
993     elements(end,2) = 221;
994     elements(end,3) = elements(end-1,3)+1;
995     elements(end,4) = 0;
996     if n < 3
997         elements(end,5) = elements(end-1,5);
998     else
999         elements(end,5) = elements(end-1,5)+1;
1000    end
1001    elements(end,6) = data_rows_t(2,10)+i;
1002    elements(end,7) = data_rows_t(2+i,11);
1003    elements(end,8) = data_rows(1,11);
1004    elements(end,9) = data_rows(end,11);
1005    elements(end,10) = 0;
1006    elements(end,11) = 0;
1007    elements(end,12) = 0;
1008    n = n+1;
1009    if n == 4
1010        n = 1;
1011    end
1012    elements(end,13) = n;
1013    elements(end,14) = 1;
1014    elements(end,15) = 1;
1015    elements(end,16) = 1;
1016    elements(end,17) = 1;
1017
1018 end
1019
1020 if data_rows(end,3) == 1
1021     elements(end,7) = data_rows_t(end,11)-1;
1022 end
1023
1024 % Linear constrains of the "Bernouilli element"
1025 nt = 0;
1026 x = 0;
1027 if data_rows(end,3) == 1
1028     for i = 1:n_rows_tot
1029         if x < n_rows_c+1
1030             if data_rows(i,3) == 1
1031                 nt = nt+1;
1032             end
1033             if nt < 2

```

```

1035     elements(end+1,1) = elements(end,1)+1;
1036     elements(end,2) = 221;
1037     elements(end,3) = elements(end-1,3)+1;
1038     elements(end,4) = 0;
1039     if n < 3
1040         elements(end,5) = elements(end-1,5);
1041     else
1042         elements(end,5) = elements(end-1,5)+1;
1043     end
1044     elements(end,6) = data_rows(1,11);
1045     elements(end,7) = data_rows(end,11);
1046     elements(end,8) = data_rows(i+1,11);
1047     elements(end,9) = 0;
1048     elements(end,10) = 0;
1049     elements(end,11) = 0;
1050     n = n+1;
1051     if n == 4
1052         n = 1;
1053     end
1054     elements(end,12) = n;
1055     elements(end,13) = 1;
1056     elements(end,14) = 1;
1057     elements(end,15) = 1;
1058     x=x+1;
1059
1060 else
1061     if data_rows(i+1,3)==1
1062         continue
1063     else
1064         elements(end+1,1) = elements(end,1)+1;
1065         elements(end,2) = 221;
1066         elements(end,3) = elements(end-1,3)+1;
1067         elements(end,4) = 0;
1068         if n < 3
1069             elements(end,5) = elements(end-1,5);
1070         else
1071             elements(end,5) = elements(end-1,5)+1;
1072         end
1073         elements(end,6) = data_rows(1,11);
1074         elements(end,7) = data_rows(end,11);
1075         elements(end,8) = data_rows(i+1,11);
1076         elements(end,9) = 0;
1077         elements(end,10) = 0;
1078         elements(end,11) = 0;
1079         n = n+1;
1080         if n == 4
1081             n = 1;
1082         end
1083         elements(end,12) = n;
1084         elements(end,13) = 1;
1085         elements(end,14) = 1;

```

```

1086         elements(end,15) = 1;
1087         x = x+1;
1088
1089         end
1090     end
1091 end
1092 end
1093 else
1094     for i = 1:n_rows_tot
1095         if x < n_rows_c
1096             if data_rows(i,3) == 1
1097                 nt = nt+1;
1098             end
1099             if nt < 2
1100
1101                 elements(end+1,1) = elements(end,1)+1;
1102                 elements(end,2) = 221;
1103                 elements(end,3) = elements(end-1,3)+1;
1104                 elements(end,4) = 0;
1105                 if n < 3
1106                     elements(end,5) = elements(end-1,5);
1107                 else
1108                     elements(end,5) = elements(end-1,5)+1;
1109                 end
1110                 elements(end,6) = data_rows(1,11);
1111                 elements(end,7) = data_rows(end,11);
1112                 elements(end,8) = data_rows(i+1,11);
1113                 elements(end,9) = 0;
1114                 elements(end,10) = 0;
1115                 elements(end,11) = 0;
1116                 n = n+1;
1117                 if n == 4
1118                     n = 1;
1119                 end
1120                 elements(end,12) = n;
1121                 elements(end,13) = 1;
1122                 elements(end,14) = 1;
1123                 elements(end,15) = 1;
1124                 x=x+1;
1125
1126             else
1127                 if data_rows(i+1,3)==1
1128                     continue
1129                 else
1130                     elements(end+1,1) = elements(end,1)+1;
1131                     elements(end,2) = 221;
1132                     elements(end,3) = elements(end-1,3)+1;
1133                     elements(end,4) = 0;
1134                     if n < 3
1135                         elements(end,5) = elements(end-1,5);
1136                     else

```



```

1137         elements(end,5) = elements(end-1,5)+1;
1138     end
1139     elements(end,6) = data_rows(1,11);
1140     elements(end,7) = data_rows(end,11);
1141     elements(end,8) = data_rows(i+1,11);
1142     elements(end,9) = 0;
1143     elements(end,10) = 0;
1144     elements(end,11) = 0;
1145     n = n+1;
1146     if n == 4
1147         n = 1;
1148     end
1149     elements(end,12) = n;
1150     elements(end,13) = 1;
1151     elements(end,14) = 1;
1152     elements(end,15) = 1;
1153     x = x+1;
1154
1155     end
1156 end
1157 end
1158 end
1159 end
1160
1161 % Linear constrain for "Bernouilli element" - Axial force application
1162     node
1163     elements(end+1,1) = elements(end,1)+1;
1164     elements(end,2) = 221;
1165     elements(end,3) = elements(end-1,3)+1;
1166     elements(end,4) = 0;
1167     if n < 3
1168         elements(end,5) = elements(end-1,5);
1169     else
1170         elements(end,5) = elements(end-1,5)+1;
1171     end
1172     elements(end,6) = data_rows(1,11);
1173     elements(end,7) = data_rows(end,11);
1174     elements(end,8) = coord(data_rows(end,11)+1,1);
1175     elements(end,9) = 0;
1176     elements(end,10) = 0;
1177     elements(end,11) = 0;
1178     n = n+1;
1179     if n == 4
1180         n = 1;
1181     end
1182     elements(end,12) = n;
1183     elements(end,13) = 1;
1184     elements(end,14) = 1;
1185     elements(end,15) = 1;

```

```

1186 % Linear constrains for equalization of the displacements of all
      % aquivalent
1187 % springs of row i
1188 for i = 3:n_rows_t
1189     for j = data_rows_t(i,7) : data_rows_t(i,8)-1
1190         if elements(j,19) == 0
1191
1192             elements(end+1,1) = elements(end,1)+1;
1193             elements(end,2) = 221;
1194             elements(end,3) = n_rows_tot+n_gr_tot+3;
1195             elements(end,4) = 0;
1196             if n < 3
1197                 elements(end,5) = elements(end-1,5);
1198             else
1199                 elements(end,5) = elements(end-1,5)+1;
1200             end
1201             elements(end,6) = elements(j,6);
1202             elements(end,7) = elements(j,5);
1203             elements(end,8) = elements(data_rows_t(i,8),6);
1204             elements(end,9) = elements(data_rows_t(i,8),6)-1;
1205             elements(end,10) = 0;
1206             elements(end,11) = 0;
1207             elements(end,12) = 0;
1208             n = n+1;
1209             if n == 4
1210                 n = 1;
1211             end
1212             elements(end,13) = n;
1213             elements(end,14) = 1;
1214             elements(end,15) = 1;
1215             elements(end,16) = 1;
1216             elements(end,17) = 1;
1217
1218         end
1219     end
1220 end
1221
1222 %% Supports
1223
1224 nt = 0;
1225 n = 0;
1226 nb_col = 0;
1227 nb_row = 1;
1228
1229 % Embedded supports
1230 for i = 1:n_gr_tot
1231     if n <= n_rows_c
1232         if data_rows(i,3) == 1
1233             nt = nt+1;
1234             if nt == 1
1235

```

```

1236         n=n+1;
1237         if nb_col == 16
1238             nb_row = nb_row+1;
1239             nb_col = 1;
1240         else
1241             nb_col = nb_col+1;
1242         end
1243         supports(nb_row,1) = 1110000;
1244         supports(nb_row,2) = 0;
1245         supports(nb_row,3) = 0;
1246         supports(nb_row,3+nb_col) = data_rows(i,10);
1247
1248     else
1249         continue
1250     end
1251 else
1252
1253     n=n+1;
1254     if nb_col == 16
1255         nb_row = nb_row+1;
1256         nb_col = 1;
1257     else
1258         nb_col = nb_col+1;
1259     end
1260     supports(nb_row,1) = 1110000;
1261     supports(nb_row,2) = 0;
1262     supports(nb_row,3) = 0;
1263     supports(nb_row,3+nb_col) = data_rows(i,10);
1264
1265     end
1266 end
1267 end
1268
1269 nb_col = 0;
1270 nb_row = nb_row+1;
1271
1272 % Springs internal supports (not part of a group or an embedded support
1273 )
1274 for i = 3:n_rows_t
1275     if i < n_rows_t
1276         for j = data_rows_t(i,7)+sum(data_rows_t(3:i-1,4))+data_rows_t(i,4)*2 :
1277             data_rows_t(i,8)-1
1278
1279             if nb_col == 16
1280                 nb_row = nb_row+1;
1281                 nb_col = 1;
1282             else
1283                 nb_col = nb_col+1;
1284             end
1285             supports(nb_row,1) = 0110000;
1286             supports(nb_row,2) = 0;

```

```

1285     supports(nb_row,3) = 0;
1286     supports(nb_row,3+nb_col) = elements(j,6);
1287
1288     end
1289 end
1290     for j = 1 : i-4
1291         if i >= j+4
1292             for k = data_rows_t(i,7)+sum(data_rows_t(3:2+(j-1)))+nb_groups_zone(i,j) :
1293                 data_rows_t(i,7)+sum(data_rows_t(3:2+j,4))-1
1294
1295                 if nb_col == 16
1296                     nb_row = nb_row+1;
1297                     nb_col = 1;
1298                 else
1299                     nb_col = nb_col+1;
1300                 end
1301                 supports(nb_row,1) = 0110000;
1302                 supports(nb_row,2) = 0;
1303                 supports(nb_row,3) = 0;
1304                 supports(nb_row,3+nb_col) = elements(k,6);
1305             end
1306         end
1307     end
1308 end
1309
1310 % Groups supports
1311 a = 0;
1312 for i = 1:size(supports,1)
1313     for j = 4:size(supports,2)
1314         if supports(i,j) ~= 0
1315             a = a+1;
1316             nodes(a,1) = supports(i,j);
1317             nodes = sort(nodes);
1318         end
1319     end
1320 end
1321
1322 nb_col = 0;
1323 if nnz(any(supports,2)) == nb_row
1324     nb_row = nb_row+1;
1325 end
1326
1327 for i = 1:size(nodes,1)-1
1328     if nodes(i+1,1) ~= nodes(i,1)+1
1329         n = nodes(i,1)+1;
1330         while n ~= nodes(i+1,1)
1331
1332             if nb_col == 16
1333                 nb_row = nb_row+1;
1334                 nb_col = 1;

```

```
1335     else
1336         nb_col = nb_col+1;
1337     end
1338     supports(nb_row,1) = 0100000;
1339     supports(nb_row,2) = 0;
1340     supports(nb_row,3) = 0;
1341     supports(nb_row,3+nb_col) = n;
1342     n = n+1;
1343
1344     end
1345 end
1346 end
1347
1348 if nodes(end,1)+1 ~= data_rows(end,11)
1349
1350     if nb_col == 16
1351         nb_row = nb_row+1;
1352         nb_col = 1;
1353     else
1354         nb_col = nb_col+1;
1355     end
1356     supports(nb_row,1) = 0100000;
1357     supports(nb_row,2) = 0;
1358     supports(nb_row,3) = 0;
1359     supports(nb_row,3+nb_col) = data_rows(end,11)-1;
1360
1361     if nb_col == 16
1362         nb_row = nb_row+1;
1363         nb_col = 1;
1364     else
1365         nb_col = nb_col+1;
1366     end
1367     supports(nb_row,1) = 0100000;
1368     supports(nb_row,2) = 0;
1369     supports(nb_row,3) = 0;
1370     supports(nb_row,3+nb_col) = data_rows(end,11);
1371
1372 else
1373
1374     if nb_col == 16
1375         nb_row = nb_row+1;
1376         nb_col = 1;
1377     else
1378         nb_col = nb_col+1;
1379     end
1380     supports(nb_row,1) = 0100000;
1381     supports(nb_row,2) = 0;
1382     supports(nb_row,3) = 0;
1383     supports(nb_row,3+nb_col) = data_rows(end,11);
1384
1385 end
```

```
1386
1387 % Point of application of the axial load
1388 if nb_col == 16
1389     nb_row = nb_row+1;
1390     nb_col = 1;
1391 else
1392     nb_col = nb_col+1;
1393 end
1394 supports(nb_row,1) = 0100000;
1395 supports(nb_row,2) = 0;
1396 supports(nb_row,3) = 0;
1397 supports(nb_row,3+nb_col) = data_rows(end,11)+1;
1398
1399
1400 %% Sequences
1401
1402 % Number of sequences
1403 if M == 0
1404     % N only
1405     nb_seq = 1;
1406 else
1407     % M only and other MN
1408     nb_seq = 4;
1409 end
1410
1411 % FINELG input
1412 for i = 1:nb_seq
1413     sequences(i,1) = 1;
1414     sequences(i,2) = 1;
1415     for j = 3:6
1416         if j-2 == i
1417             sequences(i,j) = 1;
1418         else
1419             sequences(i,j) = 0;
1420         end
1421     end
1422 end
1423
1424
1425 %% Loading
1426
1427 % Number of loads
1428 if M == 0
1429     % N only
1430     nb_loads = 1;
1431 else
1432     % M only and other MN
1433     nb_loads = 7;
1434 end
1435
1436 % FINELG input
```

```
1437 for i = 1:nb_loads
1438
1439     loading(i,1) = i;
1440     loading(i,2) = 0;
1441     loading(i,4) = 0;
1442
1443 end
1444 for i = nb_loads+1:nb_loads*2
1445
1446     loading(i,2) = 1;
1447     loading(i,3) = i-nb_loads;
1448     loading(i,4) = 0;
1449
1450 end
1451 if M == 0
1452
1453     loading(nb_loads,3) = N;
1454     loading(nb_loads*2,1) = 1;
1455     loading(nb_loads*2,5) = data_rows(end,11)+1;
1456
1457 else
1458     loading(1,3) = N1;
1459     if M < 0
1460         loading(2,3) = M1/data_rows(1,2);
1461         loading(3,3) = -M1/data_rows(1,2);
1462     elseif M > 0
1463         loading(2,3) = -M1/data_rows(1,2);
1464         loading(3,3) = M1/data_rows(1,2);
1465     end
1466     loading(4,3) = -N1;
1467     loading(5,3) = -M/data_rows(1,2);
1468     loading(6,3) = M/data_rows(1,2);
1469     loading(7,3) = N;
1470
1471     loading(8,1) = 1;
1472     loading(9,1) = 2;
1473     loading(10,1) = 2;
1474     loading(11,1) = 3;
1475     loading(12,1) = 4;
1476     loading(13,1) = 4;
1477     loading(14,1) = 4;
1478
1479     loading(8,5) = data_rows(end,11)+1;
1480     loading(9,5) = data_rows(1,11);
1481     loading(10,5) = data_rows(end,11);
1482     loading(11,5) = data_rows(end,11)+1;
1483     loading(12,5) = data_rows(1,11);
1484     loading(13,5) = data_rows(end,11);
1485     loading(14,5) = data_rows(end,11)+1;
1486
1487 end
```

```
1488
1489
1490 %% Control
1491
1492 control(1,1) = 0;
1493 control(1,2) = 0;
1494 control(1,3) = 0;
1495 control(1,4) = 23;
1496 control(1,5) = 1200060;
1497 control(1,6) = 0;
1498 control(1,7) = 1;
1499 control(1,8) = 0;
1500 control(1,9) = 0;
1501 control(1,10) = 0;
1502 control(1,11) = 0;
1503
1504 for i = 2:1+nb_seq
1505
1506     control(i,1) = 0;
1507     control(i,2) = 0;
1508     control(i,3) = 500;
1509     control(i,4) = 1;
1510     control(i,5) = 99999999;
1511
1512 end
1513
1514 control(end,1) = 1;
1515
1516 %% Data writing
1517
1518 FileName = (fullfile([Name, Ext]));
1519 nb_files = 0;
1520
1521 if exist(FileName,'file')
1522
1523     Dir = dir(fullfile([Name, '*', Ext]));
1524     nb_files = size(Dir,1);
1525     FileName = fullfile([Name, sprintf('%d', nb_files), Ext]);
1526
1527 end
1528
1529 fid = fopen(FileName,'w');
1530
1531 % Version FINELG
1532 fprintf(fid,'%s%6s%8s\n','FINELG','103','12');
1533
1534 % Control
1535 fprintf(fid,'%s\n','CTRL');
1536 fprintf(fid,'%4s%4s\n','N','MM');
1537 for i = 1:3
1538     fprintf(fid,'%4.0f',control(1,i));
```



```

1539 end
1540 for i = 4:5
1541     fprintf(fid,'%8.0f',control(1,i));
1542 end
1543 for i = 6:size(control,2)
1544     fprintf(fid,'%4.0f',control(1,i));
1545 end
1546 fprintf(fid,'\n%8s\n','NONL');
1547 for i = 2:size(control,1)
1548     fprintf(fid,'%8s%4.0f\n','SEQP',i-1);
1549     fprintf(fid,'%4.0f%4.0f%4.0f%24.0f%12.0f\n\n',control(i,1:5));
1550 end
1551 fprintf(fid,'%s\n','CTRL_END');
1552
1553 % Loading sequences
1554 for i = 1:size(sequences,1)-1
1555     fprintf(fid,'%s%8.0f\n','SEQP',i);
1556     fprintf(fid,'%8s\n%4.0f%12.3f%8.3f%8.3f%8.3f%8.3f\n','COMB',sequences(i,1:6));
1557     fprintf(fid,'%8s\n%4.0f%4.0f\n','INCR',110,-4);
1558     fprintf(fid,'%8s\n%8.3f\n','CREM',0.1);
1559     fprintf(fid,'%8s\n%4.0f%4.0f%4.0f\n','MOPA',1,60,-4);
1560     fprintf(fid,'%8s\n%4.0f\n%4.0f\n','NODC',data_rows(end,11)+1,1);
1561     fprintf(fid,'%s%4.0f\n','SEQP_END',i);
1562 end
1563 fprintf(fid,'%s%8.0f\n','SEQP',nb_seq);
1564 fprintf(fid,'%8s\n%4.0f%12.3f%8.3f%8.3f%8.3f%8.3f\n','COMB',sequences(end,1:6));
1565 fprintf(fid,'%8s\n%4.0f%4.0f%4.0f\n','INCR',-4,139,4);
1566 fprintf(fid,'%8s\n%8.3f\n','CREM',incr_ini);
1567 fprintf(fid,'%8s\n%4.0f%4.0f%4.0f\n','MOPA',1,60,-4);
1568 fprintf(fid,'%8s\n%4.0f\n%4.0f\n','NODC',data_rows(end,11)+1,1);
1569 fprintf(fid,'%s%4.0f\n','SEQP_END',nb_seq);
1570
1571 % Meca
1572 fprintf(fid,'%s','MECA');
1573 for i = 1:n_rows_tot+n_gr_tot
1574
1575     nb_lines = ceil((nnz(any(meca(i,3:end),1))+1)/6);
1576     nb_terms = -((nb_lines-1)*8-nnz(any(meca(i,:),1))+1);
1577
1578     if nnz(any(meca(i,:),1))+1 <= 8
1579         fprintf(fid,'\n%4.0f%4.0f%12.2f%12.8f%12.2f%12.8f%12.2f%12.8f',meca(i,1:nnz(any(
1580             meca(i,:),1))+1));
1581     else
1582         fprintf(fid,'\n%4.0f%4.0f%12.2f%12.8f%12.2f%12.8f%12.2f%12.8f',meca(i,1:8));
1583         for j = 2:nb_lines-1
1584             fprintf(fid,'\n%4.0f%16.2f%12.8f%12.2f%12.8f%12.2f%12.8f',-meca(i,1),meca(i
1585                 ,(8+(j-2)*6+1):(8+(j-1)*6)));
1586         end
1587         fprintf(fid,'\n%4.0f%16.2f%12.8f%12.2f%12.8f%12.2f%12.8f',-meca(i,1),meca(i,(8+(
1588             nb_lines-2)*6+1):nnz(any(meca(i,:),1))+1));
1589     end
1590 end

```

```

1587 end
1588 for i = n_rows_tot+n_gr_tot+1:size(meca,1)
1589     fprintf(fid,'\n%4.0f%4.0f%12.3f%12.3f%12.3f%12.3f',meca(i,1:nz(any(meca(i,:),1))+1));
1590 end
1591 fprintf(fid,'\n%s\n','MECA_END');
1592
1593 % Geometry
1594 fprintf(fid,'%s\n','GEOM');
1595 fprintf(fid,'%4.0f%4.0f%12.2f%12.0f\n',1,31,90,67500);
1596 fprintf(fid,'%s\n','GEOM_END');
1597
1598 % Coordinates
1599 fprintf(fid,'%s\n','COOR');
1600 for i = 1:data_rows(end,11)+1
1601     fprintf(fid,'%4.0f%4.0f%12.3f%12.3f%12.3f\n',coord(i,1:5));
1602 end
1603 for i = data_rows(end,11)+2:size(coord,1)
1604     fprintf(fid,'%4.0f\n',coord(i,1));
1605 end
1606
1607 % Elements
1608 fprintf(fid,'%s\n','ELEM');
1609 for i = 1:data_rows(end,8)+n_rows_c
1610     if i == 1 && elements(i,18) ~= 0
1611         fprintf(fid,'%4.0f%4.0f%4.0f%4.0f%4.0f%4.0f%44s%5.0f\n',elements(i,1:6),'S',
1612             elements(i,18));
1613     elseif i == 1 && elements(i,18) == 0
1614         fprintf(fid,'%4.0f%4.0f%4.0f%4.0f%4.0f%4.0f%44s\n',elements(i,1:6),'S');
1615     elseif elements(i,18) == 0
1616         fprintf(fid,'%4.0f%4.0f%4.0f%4.0f%4.0f%4.0f\n',elements(i,1:6));
1617     else
1618         fprintf(fid,'%4.0f%4.0f%4.0f%4.0f%4.0f%4.0f%49.0f\n',elements(i,1:6),elements(i,18)
1619             );
1620     end
1621 end
1622 for i = data_rows(end,8)+n_rows_c+1:data_rows(end,8)+n_rows_c+data_rows_t(1,4)
1623     for j = 1:12
1624         fprintf(fid,'%4.0f',elements(i,j));
1625     end
1626     fprintf(fid,'%4.0f\n',elements(i,13));
1627 end
1628 for i = data_rows(end,8)+n_rows_c+data_rows_t(1,4)+1:data_rows(end,8)+n_rows_c+
1629     data_rows_t(1,4)+data_rows_t(2,4)+sum(lin_const_int)
1630     for j = 1:16
1631         fprintf(fid,'%4.0f',elements(i,j));
1632     end
1633     fprintf(fid,'%3.0f\n%20.0f\n',elements(i,17),1);
1634 end
1635 if data_rows(end,3) == 0
1636 for i = data_rows(end,8)+n_rows_c+data_rows_t(1,4)+data_rows_t(2,4)+sum(
1637     lin_const_int)+1:data_rows(end,8)+n_rows_c+data_rows_t(1,4)+data_rows_t(2,4)+

```

```

sum(lin_const_int)+n_rows_c+1
1634 for j = 1:14
1635     fprintf(fid,'%4.0f',elements(i,j));
1636 end
1637 fprintf(fid,'%4.0f\n',elements(i,15));
1638 end
1639 for i = data_rows(end,8)+n_rows_c+data_rows_t(1,4)+data_rows_t(2,4)+sum(
lin_const_int)+n_rows_c+2:size(elements,1)
1640 for j = 1:16
1641     fprintf(fid,'%4.0f',elements(i,j));
1642 end
1643 fprintf(fid,'%3.0f\n%20.0f\n',elements(i,17),1);
1644 end
1645 else
1646 for i = data_rows(end,8)+n_rows_c+data_rows_t(1,4)+data_rows_t(2,4)+sum(
lin_const_int)+1:data_rows(end,8)+n_rows_c+data_rows_t(1,4)+data_rows_t(2,4)+
sum(lin_const_int)+n_rows_c+2
1647 for j = 1:14
1648     fprintf(fid,'%4.0f',elements(i,j));
1649 end
1650 fprintf(fid,'%4.0f\n',elements(i,15));
1651 end
1652 for i = data_rows(end,8)+n_rows_c+data_rows_t(1,4)+data_rows_t(2,4)+sum(
lin_const_int)+n_rows_c+3:size(elements,1)
1653 for j = 1:16
1654     fprintf(fid,'%4.0f',elements(i,j));
1655 end
1656 fprintf(fid,'%3.0f\n%20.0f\n',elements(i,17),1);
1657 end
1658 end
1659
1660 fprintf(fid,'%s\n','RENU');
1661 fprintf(fid,'%s\n','ELEM_END');
1662
1663 % Loading
1664 fprintf(fid,'%s\n','CHAR');
1665 for i = 1:nb_loads
1666     fprintf(fid,'%4.0f%4.0f%12.0f%12.0f\n',loading(i,1:4));
1667 end
1668 fprintf(fid,'%7s\n','CAS');
1669 for i = nb_loads+1:size(loading,1)
1670     for j = 1:size(loading,2)-1
1671         fprintf(fid,'%4.0f',loading(i,j));
1672     end
1673     fprintf(fid,'%4.0f\n',loading(i,5));
1674 end
1675 fprintf(fid,'%s\n','CHAR_END');
1676
1677 % Supports
1678 fprintf(fid,'%8s\n','APPU');
1679 for i = 1:size(supports,1)

```

```
1680     fprintf(fid,'%8.0f',supports(i,1));
1681     for j = 2:size(supports,2)-1
1682         fprintf(fid,'%4.0f',supports(i,j));
1683     end
1684     fprintf(fid,'%4.0f\n',supports(i,size(supports,2)));
1685 end
1686 fprintf(fid,'%s\n','END');
1687
1688 fclose(fid);
1689
1690
1691 if nb_files > 0
1692
1693     FileName_txt = fullfile([Name_txt, sprintf('%d', nb_files), Ext_txt]);
1694
1695 else
1696
1697     FileName_txt = (fullfile([Name_txt, Ext_txt]));
1698
1699 end
1700
1701 % Text file for the verification of the displacement + loads in results
1702 % processing
1703 fid = fopen(FileName_txt,'w');
1704
1705 fprintf(fid,'%20.3f%20.3f%20.3f\n',M,N,V);
1706 for i = 1:size(Delta_max,1)
1707     fprintf(fid,'%20.6f%20.0f\n',Delta_max(i,1),Delta_max(i,2));
1708 end
1709
1710 fclose(fid);
```

Results processing

```

1  % Post treatment of FINELG output data – Ductility considered
2
3  % Conducted as part of master thesis relating to the development of an
4  % innovative model for the precise characterization of steel and
   % composite
5  % joints
6
7  % MATHIEU Julien
8
9  close all
10 clear
11 clc
12
13 %% Results extraction
14
15 % Extraction of shear resistance data from excel file
16 data_all = xlsread('Data.xlsx');
17
18 % First line/column of shear resistance table
19 First_line_table = 2;
20 First_column_table = 16;
21
22 % Number of rows in tension/compression
23 n_rows_t = data_all(10,1);
24 n_rows_c = data_all(11,1);
25 n_rows_tot = n_rows_t+n_rows_c;
26
27 % Shear resistance data
28 for i = First_line_table : First_line_table+n_rows_t-1
29
30     shear_resistance(i-(First_line_table-1),1) = data_all(i,First_column_table
   +1);
31     shear_resistance(i-(First_line_table-1),2) = data_all(i,First_column_table
   +2);
32     shear_resistance(i-(First_line_table-1),3) = data_all(i,First_column_table
   +4);
33
34 end
35
36 % Name of .TPS file
37 Name = 'Input_Finelg';
38 Ext = '.TPS';
39 FileName = (fullfile([Name, Ext]));
40
41 % Name of loads/max displacment file
42 Name_txt = 'Loads_Dep';
43 Ext_txt = '.txt';
44 FileName_txt = (fullfile([Name_txt, Ext_txt]));
45

```

```
46 % Name of displacements file
47 Name_Delta = 'Input_Finelg';
48 Ext_Delta = '.DE3';
49 FileName_Delta = (fullfile([Name_Delta, Ext_Delta]));
50
51
52 %% MN diagram
53
54 % Number of .TPS/loads files
55 if exist(FileName,'file')
56
57     Dir = dir(fullfile([Name, '*', Ext]));
58     nb_files = size(Dir,1);
59
60 else
61
62     nb_files = 1;
63
64 end
65
66 % Values of final load multipliers
67 for i = 1:nb_files
68
69     % Name of output files
70     if i > 1
71
72         FileName = fullfile([Name, sprintf('%d', i-1), Ext]);
73         FileName_txt = fullfile([Name_txt, sprintf('%d', i-1), Ext_txt]);
74         FileName_Delta = fullfile([Name, sprintf('%d', i-1), Ext_Delta]);
75
76     end
77
78     % Extraction of results
79     % TPS
80     fid = fopen(FileName,'r');
81
82     Results = textscan(fid, repmat('%s',[1,25]),'Delimiter','*');
83
84     fclose(fid);
85
86     % Loads and displacement
87     fid = fopen(FileName_txt,'r');
88
89     Loads_Delta = textscan(fid,'%f%f%f');
90
91     fclose(fid);
92
93     % Conversion to numbers
94     Mult = Results{1,4};
95     Ajust = Results{1,3};
96     Step = Results{1,2};
```

```

97
98   Ajust(cellfun(@isempty,Ajust)) = [];
99   Mult(cellfun(@isempty,Mult)) = [];
100  Step(cellfun(@isempty,Step)) = [];
101
102  Ajust = str2double(Ajust(2:end,:));
103  Mult = cell2mat(Mult(2:end,:));
104  Increment = Mult(:,7:end-2);
105  Mult = Mult(:,1:end-9);
106  Step = str2double(Step(2:end,:));
107
108  for j = 1:size(Mult,1)
109
110      Mult_all(j,i) = str2double(sscanf(Mult(j,:), '%s'));
111
112  end
113
114  Loads_Delta = cell2mat(Loads_Delta);
115  % Imposed loads
116  Loads_all(i,1) = Loads_Delta(1,1);
117  Loads_all(i,2) = Loads_Delta(1,2);
118  Loads_all(i,3) = Loads_Delta(1,3);
119
120  % Maximum displacement
121  Delta_max = Loads_Delta(2:end,1:2);
122
123  % Extraction of displacement of all nodes at each step
124  [DEP,NENR,LIB,NOMAX,FREQ] = lect_DE3(FileName_Delta,'C:');
125
126  n = 1;
127  Delta_all = zeros(size(DEP,1)/3,size(DEP,2));
128
129  for j = 1:size(DEP,1)
130      if j == 3*(n-1)+1
131
132          Delta_all(n,:) = DEP(j,:);
133          n = n+1;
134
135      end
136  end
137
138  % Displacement of each component located in the last zone
139  Delta_spring = zeros(size(Delta_max,1),size(Delta_all,2));
140  for j = 1:size(Delta_max,1)
141      for k = 1:size(Delta_all,1)
142          if k == Delta_max(j,2)
143              Delta_spring(j,:) = Delta_all(k,:)-Delta_all(k-1,:);
144          end
145      end
146  end
147

```

```

148 % Negative displacement in components in tension = 0
149 % Positive displacement in components in compression = 0
150 for j = 1:size(Delta_spring,1)
151     for k = 1:size(Delta_spring,2)
152         if Delta_max(j,1) < 0 && Delta_spring(j,k) > 0
153
154             Delta_spring(j,k) = 0;
155
156         end
157         if Delta_max(j,1) > 0 && Delta_spring(j,k) < 0
158
159             Delta_spring(j,k) = 0;
160
161         end
162     end
163 end
164
165 % Verification of the displacements
166 n_steps = nnz(any(Mult_all(:,i),2));
167 leave = 0;
168 for j = 1:size(Delta_spring,2)
169     for k = 1:size(Delta_spring,1)
170         if abs(Delta_spring(k,j)) > abs(Delta_max(k,1))
171
172             n_steps = nnz(any(Mult_all(:,i),2))-(size(Delta_all,2)-(j-1));
173             n_steps_delta = j-1;
174             leave = 1;
175
176         end
177         if leave == 1
178             break
179         end
180     end
181     if leave == 1
182         break
183     end
184 end
185
186 % Value of the load multiplier
187
188 Multip(i,1) = Mult_all(n_steps,i);
189
190 % Value of bending moment and axial force at failure
191 MN(i,1:2) = Loads_all(i,1:2)*Multip(i,1);
192
193 % Final step number
194
195 fprintf('%s %s %s %d %s\n',FileName,'=',Step(end,1),'(max = 40)')
196 fprintf('%s %s %s %s\n',FileName,'=',Increment(end,:))
197
198 % Shear resistance

```



```

199 n = 0;
200 if n_steps == nnz(any(Mult_all(:,i),2))
201     for j = 1:n_rows_tot
202         if Delta_max(j,1) < 0 && Delta_spring(j,end) <= 0
203             n = n+1;
204             elseif Delta_max(j,1) >= 0 && Delta_spring(j,end) == 0
205
206                 shear_resistance_bolts(j-n,1) = shear_resistance(j-n,1);
207
208             elseif Delta_max(j,1) >= 0 && Delta_spring(j,end) > 0
209
210                 shear_resistance_bolts(j-n,1) = shear_resistance(j-n,1)*0.29;
211
212         end
213     end
214 else
215     for j = 1:n_rows_tot
216         if Delta_max(j,1) < 0 && Delta_spring(j,n_steps_delta) <= 0
217             n = n+1;
218             continue
219             elseif Delta_max(j,1) >= 0 && Delta_spring(j,n_steps_delta) == 0
220
221                 shear_resistance_bolts(j-n,1) = shear_resistance(j-n,1);
222
223             elseif Delta_max(j,1) >= 0 && Delta_spring(j,n_steps_delta) > 0
224
225                 shear_resistance_bolts(j-n,1) = shear_resistance(j-n,1)*0.29;
226
227         end
228     end
229 end
230
231 for j = 1:n_rows_t
232     if shear_resistance_bolts(j,1) <= shear_resistance(j,2)
233         resistance_bolts(j,1) = shear_resistance_bolts(j,1);
234     else
235         resistance_bolts(j,1) = shear_resistance(j,2);
236     end
237 end
238
239 Total_resistance = sum(resistance_bolts);
240
241 for j = 1:sum(not(isnan(shear_resistance(:,3))))
242     if Total_resistance >= shear_resistance(j,3)
243
244         Total_resistance = shear_resistance(j,3);
245
246     else
247         continue
248     end
249 end

```

```

250
251     if Loads_Delta(1,3) <= Total_resistance
252
253         fprintf(' %s %d% s %s %d% s %s\n\n', 'Shear resistance :', Loads_Delta(1,3), 'N', '<=',
                Total_resistance, 'N', 'OK')
254
255     else
256
257         fprintf(' %s %d% s %s %d% s %s\n\n', 'Shear resistance :', Loads_Delta(1,3), 'N', '>',
                Total_resistance, 'N', '!NOT OK!')
258
259     end
260 end
261
262 % Values of the four peaks of the MN diagram
263 [Mpos_max,loc(1,1)] = max(MN(:,1));
264 [Npos_max,loc(2,1)] = max(MN(:,2));
265 [Mneg_max,loc(3,1)] = min(MN(:,1));
266 [Nneg_max,loc(4,1)] = min(MN(:,2));
267
268 MN1_max = MN(loc(1,1),:);
269 MN2_max = MN(loc(2,1),:);
270 MN3_max = MN(loc(3,1),:);
271 MN4_max = MN(loc(4,1),:);
272
273
274 % Division of the MN diagram in four zones
275 n1 = 0;
276 n2 = 0;
277 n3 = 0;
278 n4 = 0;
279 for i = 1:size(MN,1)
280     if MN(i,1) <= MN1_max(1,1) && MN(i,2) >= MN1_max(1,2) && MN(i,1) > MN2_max(1,1) &&
        MN(i,2) < MN2_max(1,2)
281
282         n1 = n1+1;
283         M1(n1,1) = MN(i,1)/10^6;
284         N1(n1,1) = MN(i,2)/10^3;
285
286     elseif MN(i,1) <= MN2_max(1,1) && MN(i,2) <= MN2_max(1,2) && MN(i,1) > MN3_max(1,1)
        && MN(i,2) > MN3_max(1,2)
287
288         n2 = n2+1;
289         M2(n2,1) = MN(i,1)/10^6;
290         N2(n2,1) = MN(i,2)/10^3;
291
292     elseif MN(i,1) >= MN3_max(1,1) && MN(i,2) <= MN3_max(1,2) && MN(i,1) < MN4_max(1,1)
        && MN(i,2) > MN4_max(1,2)
293
294         n3 = n3+1;
295         M3(n3,1) = MN(i,1)/10^6;

```

```
296     N3(n3,1) = MN(i,2)/10^3;
297
298     elseif MN(i,1) >= MN4_max(1,1) && MN(i,2) >= MN4_max(1,2) && MN(i,1) < MN1_max(1,1)
299         && MN(i,2) < MN1_max(1,2)
300
301         n4 = n4+1;
302         M4(n4,1) = MN(i,1)/10^6;
303         N4(n4,1) = MN(i,2)/10^3;
304     end
305 end
306
307 % Sorting of the MN values in the considered zone
308 M1 = sort(M1,'descend');
309 N1 = sort(N1,'ascend');
310 M2 = sort(M2,'descend');
311 N2 = sort(N2,'descend');
312 M3 = sort(M3,'ascend');
313 N3 = sort(N3,'descend');
314 M4 = sort(M4,'ascend');
315 N4 = sort(N4,'ascend');
316
317 % Plot
318 M = [M1' M2' M3' M4' M1(1,1)'];
319 N = [N1' N2' N3' N4' N1(1,1)'];
320
321 plot(M,N,'red')
322 hold on
323 Analytique;
324 grid on
```

To not consider ductility, lines 167 to 184 must be deleted.