Appendix B: Scripts

Evaluation and assessment of wind effects on Banafjäl
bridge (Västernorrland, Sweden) during its construction.

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Appendix B

Scripts

B.1 Mesh generation

B.1.1 With ground

```
1
2  ################################ INPUTS ################################
3
4  # Save mesh (1) or not (0)
5  set save_mesh 0
6
7  # Bridge geometry
8  set h 3
9  set b 0.9
10 set d 0
11 set H 10
12
13 set t1 0.02
14 set t2 0.04
15 set t3 0.04
16
17 #Model size
18 set height 120
19 set pre_dist 120
20 set pos_dist 150
21
22 # Working directory
23 set work_direc "C:/Master_Thesis/3_Ansys_files/190404_Parametric_study"
24
25
26
27
28 ######################### PRELIMINARY CALCULATIONS #########################
29
30 set case_name 2D_[expr {$h}]_[expr {$d}]_[expr {$b}]_[expr {$H}]
```

```
31
32  if {$d != 0} {
33  set case_type "Two_beams"
34  } else {
35  if {$t1 > 1} {
36  set distance [expr {$t1-0.02}]
37  set case_type "Two_beams_closed"
38  if {$distance == [floor $distance]} {
39  set case_name 2D_[expr {$h}]_[expr {int($t1-0.02)}]_[expr {$b-$t1+0.02}]_[expr
        {$H}]
40  } else {
41  set case_name 2D_[expr {$h}]_[expr {$t1-0.02}]_[expr {$b-$t1+0.02}]_[expr {$H}]
42  }
43  } else {
44  set case_type "One_beam"
45  }}
46
47
48  ########################## GEOMETRY CONSTRUCTION ##########################
49
50  # Reset previous geometry
51  ic_delete_geometry point all 0
52  ic_delete_geometry curve all 0
53  ic_delete_geometry surface all 0
54  ic_delete_geometry density all 0
55  ic_delete_geometry material all 0
56  ic_delete_geometry loop all 0
57
58  # Boundary construction
59  ic_point {} VALLEY pnt.01 0,0,0
60  ic_point {} VALLEY pnt.02 [expr {$pre_dist+$pos_dist}],0,0
61  ic_point {} LIMIT pnt.03 0,[expr {$height+$h+$H}],0
62  ic_point {} LIMIT pnt.04 [expr {$pre_dist+$pos_dist}],[expr {$height+$h+$H}],0
63  ic_curve point VALLEY crv.01 {pnt.01 pnt.02}
64  ic_curve point LIMIT crv.02 {pnt.03 pnt.04}
65  ic_curve point INLET crv.03 {pnt.01 pnt.03}
66  ic_curve point OUTLET crv.04 {pnt.02 pnt.04}
67
68  # Beam A construction
69  ic_point {} BEAM_A pnt.05 [expr {$pre_dist-$b/2.0}],$H,0
70  ic_point {} BEAM_A pnt.06 [expr {$pre_dist-$b/2.0}],[expr {$H+$t3}],0
71  ic_point {} BEAM_A pnt.07 [expr {$pre_dist-$t1/2}],[expr {$H+$t3}],0
72  ic_point {} BEAM_A pnt.08 [expr {$pre_dist-$t1/2}],[expr {$H+$h-$t2}],0
73  ic_point {} BEAM_A pnt.09 [expr {$pre_dist-$b/2.0}],[expr {$H+$h-$t2}],0
74  ic_point {} BEAM_A pnt.10 [expr {$pre_dist-$b/2.0}],[expr {$H+$h}],0
75  ic_point {} BEAM_A pnt.11 [expr {$pre_dist+$b/2.0}],[expr {$H+$h}],0
76  ic_point {} BEAM_A pnt.12 [expr {$pre_dist+$b/2.0}],[expr {$H+$h-$t2}],0
77  ic_point {} BEAM_A pnt.13 [expr {$pre_dist+$t1/2}],[expr {$H+$h-$t2}],0
78  ic_point {} BEAM_A pnt.14 [expr {$pre_dist+$t1/2}],[expr {$H+$t3}],0
79  ic_point {} BEAM_A pnt.15 [expr {$pre_dist+$b/2.0}],[expr {$H+$t3}],0
80  ic_point {} BEAM_A pnt.16 [expr {$pre_dist+$b/2.0}],$H,0
```

100

```
81  ic_curve point BEAM_A crv.05 {pnt.05 pnt.06}
82  ic_curve point BEAM_A crv.06 {pnt.06 pnt.07}
83  ic_curve point BEAM_A crv.07 {pnt.07 pnt.08}
84  ic_curve point BEAM_A crv.08 {pnt.08 pnt.09}
85  ic_curve point BEAM_A crv.09 {pnt.09 pnt.10}
86  ic_curve point BEAM_A crv.10 {pnt.10 pnt.11}
87  ic_curve point BEAM_A crv.11 {pnt.11 pnt.12}
88  ic_curve point BEAM_A crv.12 {pnt.12 pnt.13}
89  ic_curve point BEAM_A crv.13 {pnt.13 pnt.14}
90  ic_curve point BEAM_A crv.14 {pnt.14 pnt.15}
91  ic_curve point BEAM_A crv.15 {pnt.15 pnt.16}
92  ic_curve point BEAM_A crv.16 {pnt.16 pnt.05}
93
94  # Beam B construction
95  ic_point {} BEAM_B pnt.17 [expr {$pre_dist-$b/2.0+$d}],$H,0
96  ic_point {} BEAM_B pnt.18 [expr {$pre_dist-$b/2.0+$d}],[expr {$H+$t3}],0
97  ic_point {} BEAM_B pnt.19 [expr {$pre_dist-$t1/2+$d}],[expr {$H+$t3}],0
98  ic_point {} BEAM_B pnt.20 [expr {$pre_dist-$t1/2+$d}],[expr {$H+$h-$t2}],0
99  ic_point {} BEAM_B pnt.21 [expr {$pre_dist-$b/2.0+$d}],[expr {$H+$h-$t2}],0
100 ic_point {} BEAM_B pnt.22 [expr {$pre_dist-$b/2.0+$d}],[expr {$H+$h}],0
101 ic_point {} BEAM_B pnt.23 [expr {$pre_dist+$b/2.0+$d}],[expr {$H+$h}],0
102 ic_point {} BEAM_B pnt.24 [expr {$pre_dist+$b/2.0+$d}],[expr {$H+$h-$t2}],0
103 ic_point {} BEAM_B pnt.25 [expr {$pre_dist+$t1/2+$d}],[expr {$H+$h-$t2}],0
104 ic_point {} BEAM_B pnt.26 [expr {$pre_dist+$t1/2+$d}],[expr {$H+$t3}],0
105 ic_point {} BEAM_B pnt.27 [expr {$pre_dist+$b/2.0+$d}],[expr {$H+$t3}],0
106 ic_point {} BEAM_B pnt.28 [expr {$pre_dist+$b/2.0+$d}],$H,0
107 ic_curve point BEAM_B crv.17 {pnt.17 pnt.18}
108 ic_curve point BEAM_B crv.18 {pnt.18 pnt.19}
109 ic_curve point BEAM_B crv.19 {pnt.19 pnt.20}
110 ic_curve point BEAM_B crv.20 {pnt.20 pnt.21}
111 ic_curve point BEAM_B crv.21 {pnt.21 pnt.22}
112 ic_curve point BEAM_B crv.22 {pnt.22 pnt.23}
113 ic_curve point BEAM_B crv.23 {pnt.23 pnt.24}
114 ic_curve point BEAM_B crv.24 {pnt.24 pnt.25}
115 ic_curve point BEAM_B crv.25 {pnt.25 pnt.26}
116 ic_curve point BEAM_B crv.26 {pnt.26 pnt.27}
117 ic_curve point BEAM_B crv.27 {pnt.27 pnt.28}
118 ic_curve point BEAM_B crv.28 {pnt.28 pnt.17}
119
120 # Air surface contruction
121 ic_surface 2-4crvs AIR srf.01 {0.01 {crv.03 crv.01 crv.04 crv.02}}
122 ic_geo_trim_surface srf.01 {crv.15 crv.14 crv.13 crv.12 crv.11 crv.10 crv.09
       crv.08 crv.07 crv.06 crv.05 crv.16} 1
123 ic_delete_geometry surface names srf.01.cut.0 0
124 ic_geo_trim_surface srf.01 {crv.27 crv.26 crv.25 crv.24 crv.23 crv.22 crv.21
       crv.20 crv.19 crv.18 crv.17 crv.28} 1
125 ic_delete_geometry surface names srf.01.cut.0 0
126
127
128
129 ######################### MESH GENERATION #########################
```

```
130
131  ############### INITIALIZING
132
133  ic_hex_unload_blocking
134  ic_hex_initialize_mesh 2d new_numbering new_blocking AIR
135  ic_hex_unblank_blocks
136  ic_hex_multi_grid_level 0
137  ic_hex_projection_limit 0
138  ic_hex_default_bunching_law default 2
139  ic_hex_floating_grid off
140  ic_hex_transfinite_degree 1
141  ic_hex_unstruct_face_type one_tri
142  ic_hex_set_unstruct_face_method uniform_quad
143  ic_hex_set_n_tetra_smoothing_steps 20
144  ic_hex_error_messages off_minor
145
146  # Boundary association
147  ic_hex_set_edge_projection 11 19 0 1 crv.01
148  ic_hex_set_edge_projection 13 21 0 1 crv.02
149  ic_hex_set_edge_projection 11 13 0 1 crv.03
150  ic_hex_set_edge_projection 19 21 0 1 crv.04
151
152  # Cutting beam A section
153  ic_hex_split_grid 11 19 pnt.05 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
154  ic_hex_split_grid 33 34 pnt.16 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
155  ic_hex_split_grid 38 39 pnt.11 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
156  ic_hex_split_grid 38 34 pnt.11 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
157  ic_hex_split_grid 38 48 pnt.09 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
158  ic_hex_split_grid 38 54 pnt.06 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
159  ic_hex_split_grid 38 43 pnt.07 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
160  ic_hex_split_grid 66 43 pnt.14 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
161
162
163  ############# CREATION AND SIZING
164
165  # Creation (zone 1, inside)
166  ic_point {} AUX pnt.51 pnt.05+vector(-0.6,-0.6,0)
167  ic_point {} AUX pnt.52 pnt.11+vector([expr {$d+0.6}],0.6,0)
168  ic_point {} AUX pnt.53 pnt.52+vector(3,0,0)
169  ic_hex_split_grid 37 38 pnt.51 m VALLEY LIMIT INLET OUTLET BEAM_A AIR AUX VORFN
170  ic_hex_split_grid 33 38 pnt.51 m VALLEY LIMIT INLET OUTLET BEAM_A AIR AUX VORFN
171  ic_hex_split_grid 49 50 pnt.52 m VALLEY LIMIT INLET OUTLET BEAM_A AIR AUX VORFN
172  ic_hex_split_grid 49 44 pnt.52 m VALLEY LIMIT INLET OUTLET BEAM_A AIR AUX VORFN
173  ic_hex_split_grid 103 50 pnt.53 m VALLEY LIMIT INLET OUTLET BEAM_A AIR AUX
        VORFN
174  ic_hex_mark_blocks unmark
175  ic_hex_mark_blocks superblock 14
176  ic_hex_mark_blocks superblock 18
177  ic_hex_mark_blocks superblock 22
178  ic_hex_mark_blocks superblock 23
179  ic_hex_mark_blocks superblock 27
```

```
180  ic_hex_mark_blocks superblock 28
181  ic_hex_mark_blocks superblock 32
182  ic_hex_mark_blocks superblock 33
183  ic_hex_mark_blocks superblock 37
184  ic_hex_mark_blocks superblock 38
185  ic_hex_mark_blocks superblock 39
186  ic_hex_mark_blocks superblock 40
187  ic_hex_mark_blocks superblock 44
188  ic_hex_mark_blocks superblock 45
189  ic_hex_mark_blocks superblock 46
190  ic_hex_mark_blocks superblock 47
191  ic_hex_mark_blocks superblock 51
192  ic_hex_mark_blocks superblock 52
193  ic_hex_mark_blocks superblock 53
194  ic_hex_mark_blocks superblock 54
195  ic_hex_mark_blocks superblock 58
196  ic_hex_mark_blocks superblock 59
197  ic_hex_mark_blocks superblock 60
198  ic_hex_mark_blocks superblock 61
199  ic_hex_mark_blocks superblock 62
200  ic_hex_mark_blocks superblock 66
201  ic_hex_mark_blocks superblock 67
202  ic_hex_mark_blocks superblock 68
203  ic_hex_mark_blocks superblock 69
204  ic_hex_mark_blocks superblock 70
205  ic_hex_ogrid 1 not_marked m VALLEY LIMIT INLET OUTLET BEAM_A AIR AUX -version
        50
206
207
208  # Sizing (zone 1, inside)
209  set n0 28
210  set n00 22
211  set n1 [expr {($h-$t2-$t3)/0.05+40}]
212  set n2 [expr {-32.6*($b/2.0-$t1/2.0)*($b/2.0-$t1/2.0)+58.9*($b/2.0-$t1/2.0)
        +15}] ;#+21}]
213  set n3 [expr {167*$t2+5.8}]
214  set n4 2 ;#[expr {100*$t1+1}]
215  set n5 [expr {167*$t3+5.8}]
216  set n6 [expr {3/0.075}]
217  set n10 [expr {($d-$b)/0.075+28}]
218
219  ic_hex_place_node 108 [expr {$pre_dist-$b/2.0-0.45}] [expr {$H+$h+0.45}] 0
220  ic_hex_place_node 90 [expr {$pre_dist-$b/2.0-0.45}] [expr {$H-0.45}] 0
221  ic_hex_place_node 123 [expr {$pre_dist+$d+$b/2.0+0.45+3}] [expr {$H+$h+0.45}] 0
222  ic_hex_place_node 118 [expr {$pre_dist+$d+$b/2.0+0.45+3}] [expr {$H-0.45}] 0
223
224  ic_hex_place_node 84 [expr {$pre_dist-$b/2.0-0.6}] [expr {$H+$h-$t2-0.1}] 0
225  ic_hex_place_node 83 [expr {$pre_dist-$b/2.0-0.6}] [expr {$H+$t3+0.1}] 0
226
227  set inc_s1 [expr {($h+0.9)/(2*$n0+$n3+$n1+$n5)}]
228  ic_hex_place_node 121 [expr {$pre_dist+$d+$b/2.0+0.6+3}] [expr {$H+$h+0.45-($n0
```

```
        +$n3)*$inc_s1}] 0
229  ic_hex_place_node 120 [expr {$pre_dist+$d+$b/2.0+0.6+3}] [expr {$H-0.45+($n0+
        $n5)*$inc_s1}] 0
230  ic_hex_place_node 122 [expr {$pre_dist+$d+$b/2.0+0.6+3}] [expr {$H+$h+0
        .45-$n0*$inc_s1}] 0
231  ic_hex_place_node 119 [expr {$pre_dist+$d+$b/2.0+0.6+3}] [expr {$H-0.45+
        $n0*$inc_s1}] 0
232
233
234  # Pre-mesh web trick
235  set inc_s2 [expr {$b/(2*$n2+1)}]
236  ic_hex_place_node 110 [expr {$pre_dist-$b/2.0+$n2*$inc_s2}] [expr {$H+$h+0.6}]
        0
237  ic_hex_place_node 69 curve:crv.10 [expr {$n2*$inc_s2/$b}]
238  ic_hex_place_node 74 curve:crv.16 [expr {$n2*$inc_s2/$b}]
239  ic_hex_place_node 92 [expr {$pre_dist-$b/2.0+$n2*$inc_s2}] [expr {$H-0.6}] 0
240  ic_hex_place_node 111 [expr {$pre_dist-$b/2.0+($n2+1)*$inc_s2}] [expr {$H+$h+0
        .6}] 0
241  ic_hex_place_node 77 curve:crv.10 [expr {($n2+1)*$inc_s2/$b}]
242  ic_hex_place_node 66 curve:crv.16 [expr {($n2+1)*$inc_s2/$b}]
243  ic_hex_place_node 93 [expr {$pre_dist-$b/2.0+($n2+1)*$inc_s2}] [expr {$H-0.6}]
        0
244
245
246  # Sizing (zone 1, outside)
247  set inc_s1 [expr {(2*$h+0.9)/(2*$n0+$n3+$n1+$n5)}]
248  ic_hex_place_node 131 [expr {$pre_dist-$b/2.0-$h/2.0-0.45}] [expr {$H+1.5*$h+0
        .45}] 0
249  ic_hex_place_node 130 [expr {$pre_dist-$b/2.0-$h/2.0-0.9}] [expr {$H+1.5*$h+0
        .45-$n0*$inc_s1}] 0
250  ic_hex_place_node 129 [expr {$pre_dist-$b/2.0-$h/2.0-0.9}] [expr {$H+1.5*$h+0
        .45-($n0+$n3)*$inc_s1}] 0
251  ic_hex_place_node 128 [expr {$pre_dist-$b/2.0-$h/2.0-0.9}] [expr {$H-$h/2
        .0-0.45+($n0+$n3)*$inc_s1}] 0
252  ic_hex_place_node 127 [expr {$pre_dist-$b/2.0-$h/2.0-0.9}] [expr {$H-$h/2
        .0-0.45+$n0*$inc_s1}] 0
253  ic_hex_place_node 126 [expr {$pre_dist-$b/2.0-$h/2.0-0.9}] [expr {$H-$h/2
        .0-0.45}] 0
254
255  ic_hex_place_node 147 [expr {$pre_dist+$b/2.0+$d+3+$h/2.0+0.3}] [expr {$H+1
        .5*$h+0.45}] 0
256  ic_hex_place_node 146 [expr {$pre_dist+$b/2.0+$d+3+$h/2.0+0.9}] [expr {$H+1
        .5*$h+0.45-$n0*$inc_s1}] 0
257  ic_hex_place_node 145 [expr {$pre_dist+$b/2.0+$d+3+$h/2.0+0.9}] [expr {$H+1
        .5*$h+0.45-($n0+$n3)*$inc_s1}] 0
258  ic_hex_place_node 144 [expr {$pre_dist+$b/2.0+$d+3+$h/2.0+0.9}] [expr {$H-$h/2
        .0-0.45+($n0+$n3)*$inc_s1}] 0
259  ic_hex_place_node 143 [expr {$pre_dist+$b/2.0+$d+3+$h/2.0+0.9}] [expr {$H-$h/2
        .0-0.45+$n0*$inc_s1}] 0
260  ic_hex_place_node 142 [expr {$pre_dist+$b/2.0+$d+3+$h/2.0+0.3}] [expr {$H-$h/2
        .0-0.45}] 0
```

```
261
262  set inc_s2 [expr {(1.8+$b+$d+$h)/(2*$n00+4*$n2+$n10+2)}]
263  if {$d == 0} {set inc_s2 [expr {(1.8+$b+$d+$h)/(2*$n00+2*$n2+1)}]}
264  ic_hex_place_node 133 [expr {$pre_dist-$b/2.0-$h/2.0-0.6+$n00*$inc_s2}] [expr {
         $H+1.5*$h+0.9}] 0
265  ic_hex_place_node 135 [expr {$pre_dist-$b/2.0-$h/2.0-0.9+($n00+$n2)*$inc_s2}] [
         expr {$H+1.5*$h+0.9}] 0
266  ic_hex_place_node 137 [expr {$pre_dist-$b/2.0-$h/2.0-0.9+($n00+$n2+1)*$inc_s2}]
          [expr {$H+1.5*$h+0.9}] 0
267  ic_hex_place_node 139 [expr {$pre_dist-$b/2.0-$h/2.0-1.2+($n00+2*$n2+1)*$inc_s2
         }] [expr {$H+1.5*$h+0.9}] 0
268  ic_hex_place_node 141 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d}] [expr {$H+1.5*$h
         +0.9}] 0
269
270  set aux 0.45
271  if {[expr {$H-$h/2.0-0.9}] > 0.6} {set aux 0.9}
272  ic_hex_place_node 132 [expr {$pre_dist-$b/2.0-$h/2.0-0.6+$n00*$inc_s2}] [expr {
         $H-$h/2.0-$aux}] 0
273  ic_hex_place_node 134 [expr {$pre_dist-$b/2.0-$h/2.0-0.9+($n00+$n2)*$inc_s2}] [
         expr {$H-$h/2.0-$aux}] 0
274  ic_hex_place_node 136 [expr {$pre_dist-$b/2.0-$h/2.0-0.9+($n00+$n2+1)*$inc_s2}]
          [expr {$H-$h/2.0-$aux}] 0
275  ic_hex_place_node 138 [expr {$pre_dist-$b/2.0-$h/2.0-1.2+($n00+2*$n2+1)*$inc_s2
         }] [expr {$H-$h/2.0-$aux}] 0
276  ic_hex_place_node 140 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d}] [expr {$H-$h/2
         .0-$aux}] 0
277
278
279  # Creation (zone 2, inside)
280  ic_point {} AUX pnt.54 pnt.53+vector([expr {$h/2.0+5.3}],0,0)
281  ic_hex_split_grid 145 56 pnt.54 m VALLEY LIMIT INLET OUTLET BEAM_A AIR AUX
         VORFN
282
283
284  # Sizing (zone 2, inside)
285  set n8 [expr {5/0.15}]
286  set n7 [expr {($H-$h/2.0-0.9)/0.2+30}]
287
288  ic_hex_place_node 150 [expr {$pre_dist+$b/2.0+$d+3+$h/2.0+5.9}] [expr {$H-$h/2
         .0-0.45}] 0
289  set aux [expr {0.5*($H-$h/2.0-0.45)}]
290  ic_hex_place_node 81 curve:crv.01 [expr {($pre_dist-$b/2.0-$h/2.0-0.9-$aux)/(
         $pre_dist+$pos_dist)}]
291  ic_hex_place_node 117 curve:crv.01 [expr {($pre_dist+$b/2.0+$d+3+$h/2.0+0.3+1
         .1*$aux)/($pre_dist+$pos_dist)}]
292  ic_hex_place_node 149 curve:crv.01 [expr {($pre_dist+$b/2.0+$d+3+$h/2.0+5.9+1
         .1*$aux)/($pre_dist+$pos_dist)}]
293  if {[expr {$H-$h/2.0-0.9}] > 0.6} {set aux [expr {0.5*($H-$h/2.0-0.9)}]}
294  ic_hex_place_node 33 curve:crv.01 [expr {($pre_dist-$b/2.0-$h/2.0-0.6+
         $n00*$inc_s2-0.7*$aux)/($pre_dist+$pos_dist)}]
295  ic_hex_place_node 65 curve:crv.01 [expr {($pre_dist-$b/2.0-$h/2.0-0.9+($n00+$n2
```

105

```
                    )*$inc_s2)/($pre_dist+$pos_dist)}]
296  ic_hex_place_node 73 curve:crv.01 [expr {($pre_dist-$b/2.0-$h/2.0-0.9+($n00+$n2
         +1)*$inc_s2)/($pre_dist+$pos_dist)}]
297  ic_hex_place_node 42 curve:crv.01 [expr {($pre_dist-$b/2.0-$h/2.0-1.2+($n00+2
         *$n2+1)*$inc_s2+0.7*$aux)/($pre_dist+$pos_dist)}]
298  ic_hex_place_node 98 curve:crv.01 [expr {($pre_dist+$b/2.0+$h/2.0+$d+0.6+1
         .1*$aux)/($pre_dist+$pos_dist)}]
299
300
301  # Creation (zone 2, outside)
302  ic_hex_mark_blocks unmark
303  ic_hex_mark_blocks superblock 10
304  ic_hex_mark_blocks superblock 100
305  ic_hex_mark_blocks superblock 101
306  ic_hex_mark_blocks superblock 102
307  ic_hex_mark_blocks superblock 103
308  ic_hex_mark_blocks superblock 104
309  ic_hex_mark_blocks superblock 105
310  ic_hex_mark_blocks superblock 106
311  ic_hex_mark_blocks superblock 107
312  ic_hex_mark_blocks superblock 108
313  ic_hex_mark_blocks superblock 109
314  ic_hex_mark_blocks superblock 110
315  ic_hex_mark_blocks superblock 111
316  ic_hex_mark_blocks superblock 14
317  ic_hex_mark_blocks superblock 17
318  ic_hex_mark_blocks superblock 18
319  ic_hex_mark_blocks superblock 22
320  ic_hex_mark_blocks superblock 23
321  ic_hex_mark_blocks superblock 27
322  ic_hex_mark_blocks superblock 28
323  ic_hex_mark_blocks superblock 32
324  ic_hex_mark_blocks superblock 33
325  ic_hex_mark_blocks superblock 36
326  ic_hex_mark_blocks superblock 37
327  ic_hex_mark_blocks superblock 38
328  ic_hex_mark_blocks superblock 39
329  ic_hex_mark_blocks superblock 40
330  ic_hex_mark_blocks superblock 43
331  ic_hex_mark_blocks superblock 44
332  ic_hex_mark_blocks superblock 45
333  ic_hex_mark_blocks superblock 46
334  ic_hex_mark_blocks superblock 47
335  ic_hex_mark_blocks superblock 50
336  ic_hex_mark_blocks superblock 51
337  ic_hex_mark_blocks superblock 52
338  ic_hex_mark_blocks superblock 53
339  ic_hex_mark_blocks superblock 54
340  ic_hex_mark_blocks superblock 58
341  ic_hex_mark_blocks superblock 59
342  ic_hex_mark_blocks superblock 60
```

```
343  ic_hex_mark_blocks superblock 61
344  ic_hex_mark_blocks superblock 62
345  ic_hex_mark_blocks superblock 65
346  ic_hex_mark_blocks superblock 66
347  ic_hex_mark_blocks superblock 67
348  ic_hex_mark_blocks superblock 68
349  ic_hex_mark_blocks superblock 69
350  ic_hex_mark_blocks superblock 70
351  ic_hex_mark_blocks superblock 82
352  ic_hex_mark_blocks superblock 83
353  ic_hex_mark_blocks superblock 84
354  ic_hex_mark_blocks superblock 85
355  ic_hex_mark_blocks superblock 86
356  ic_hex_mark_blocks superblock 87
357  ic_hex_mark_blocks superblock 90
358  ic_hex_mark_blocks superblock 91
359  ic_hex_mark_blocks superblock 92
360  ic_hex_mark_blocks superblock 93
361  ic_hex_mark_blocks superblock 94
362  ic_hex_mark_blocks superblock 95
363  ic_hex_mark_blocks superblock 96
364  ic_hex_mark_blocks superblock 97
365  ic_hex_mark_blocks superblock 98
366  ic_hex_mark_blocks superblock 99
367  ic_hex_ogrid distance 80 fix_dist not_marked m VALLEY LIMIT INLET OUTLET BEAM_A
         AIR AUX -version 50
368  ic_hex_mark_blocks unmark
369
370
371  # Sizing (zone 2, outside)
372  set n9 [expr {0.85*$pre_dist/1.5+35}]
373  if {$H < 4} {
374  set n7 [expr {$n7-29}]
375  } else {
376  set n7 [expr {$n7-32}]
377  }
378  set inc_s1 [expr {($H+$h+0.7*$pre_dist)/(2*$n0+$n3+$n1+$n5+$n7)}]
379  ic_hex_place_node 164 [expr {0.3*$pre_dist}] [expr {$H+$h+0.7*$pre_dist}] 0
380  ic_hex_place_node 163 [expr {0.15*$pre_dist}] [expr {($n7+$n0+$n5+$n1+$n3)
         *$inc_s1}] 0
381  ic_hex_place_node 162 [expr {0.15*$pre_dist}] [expr {($n7+$n0+$n5+$n1)*$inc_s1
         }] 0
382  ic_hex_place_node 161 [expr {0.15*$pre_dist}] [expr {($n7+$n0+$n5)*$inc_s1}] 0
383  ic_hex_place_node 160 [expr {0.15*$pre_dist}] [expr {($n7+$n0)*$inc_s1}] 0
384  ic_hex_place_node 159 [expr {0.15*$pre_dist}] [expr {$n7*$inc_s1}] 0
385  ic_hex_place_node 158 curve:crv.01 [expr {(0.15*$pre_dist)/($pre_dist+$pos_dist
         )}]
386  ic_hex_align_vertices2 159 164 -nodes 160 161 162 163
387  ic_hex_place_node 107 curve:crv.03 [expr {1.08*($H+$h+0.7*$pre_dist)/($H+$h+
         $height)}]
388  ic_hex_place_node 47 curve:crv.03 [expr {1.05*(($n7+$n0+$n5+$n1+$n3)*$inc_s1)/(
```

```
      $H+$h+$height)}]
389 ic_hex_place_node 53 curve:crv.03 [expr {1.05*(($n7+$n0+$n5+$n1)*$inc_s1)/($H+
      $h+$height)}]
390 ic_hex_place_node 59 curve:crv.03 [expr {1.05*(($n7+$n0+$n5)*$inc_s1)/($H+$h+
      $height)}]
391 ic_hex_place_node 37 curve:crv.03 [expr {1.05*(($n7+$n0)*$inc_s1)/($H+$h+
      $height)}]
392 ic_hex_place_node 89 curve:crv.03 [expr {1.05*($n7*$inc_s1)/($H+$h+$height)}]
393
394 ic_hex_place_node 183 [expr {1.7*$pre_dist}] [expr {$H+$h+0.7*$pre_dist}] 0
395 ic_hex_place_node 182 [expr {1.85*$pre_dist}] [expr {($n7+$n0+$n5+$n1+$n3)
      *$inc_s1}] 0
396 ic_hex_place_node 181 [expr {1.85*$pre_dist}] [expr {($n7+$n0+$n5+$n1)*$inc_s1
      }] 0
397 ic_hex_place_node 180 [expr {1.85*$pre_dist}] [expr {($n7+$n0+$n5)*$inc_s1}] 0
398 ic_hex_place_node 179 [expr {1.85*$pre_dist}] [expr {($n7+$n0)*$inc_s1}] 0
399 ic_hex_place_node 178 [expr {1.85*$pre_dist}] [expr {$n7*$inc_s1}] 0
400 ic_hex_place_node 177 curve:crv.01 [expr {(1.85*$pre_dist)/($pre_dist+$pos_dist
      )}]
401 ic_hex_align_vertices2 178 183 -nodes 179 180 181 182
402 ic_hex_place_node 114 curve:crv.04 [expr {1.15*($H+$h+0.7*$pre_dist)/($H+$h+
      $height)}]
403 ic_hex_place_node 50 curve:crv.04 [expr {1.1*(($n7+$n0+$n5+$n1+$n3)*$inc_s1)/(
      $H+$h+$height)}]
404 ic_hex_place_node 56 curve:crv.04 [expr {1.1*(($n7+$n0+$n5+$n1)*$inc_s1)/($H+$h
      +$height)}]
405 ic_hex_place_node 62 curve:crv.04 [expr {1.1*(($n7+$n0+$n5)*$inc_s1)/($H+$h+
      $height)}]
406 ic_hex_place_node 39 curve:crv.04 [expr {1.1*(($n7+$n0)*$inc_s1)/($H+$h+$height
      )}]
407 ic_hex_place_node 95 curve:crv.04 [expr {1.1*($n7*$inc_s1)/($H+$h+$height)}]
408
409 set inc_s2 [expr {(1.4*$pre_dist)/(2*$n00+4*$n2+$n10+2+$n6+$n8)}]
410 if {$d == 0} {set inc_s2 [expr {(1.4*$pre_dist)/(2*$n00+2*$n2+1+$n6+$n8)}]}]
411 ic_hex_place_node 166 [expr {0.3*$pre_dist+$n00*$inc_s2}] [expr {$H+$h+0
      .85*$pre_dist}] 0
412 ic_hex_place_node 168 [expr {0.3*$pre_dist+($n00+$n2)*$inc_s2}] [expr {$H+$h+0
      .85*$pre_dist}] 0
413 ic_hex_place_node 170 [expr {0.3*$pre_dist+($n00+$n2+1)*$inc_s2}] [expr {$H+$h
      +0.85*$pre_dist}] 0
414 ic_hex_place_node 172 [expr {0.3*$pre_dist+($n00+2*$n2+1)*$inc_s2}] [expr {$H+
      $h+0.85*$pre_dist}] 0
415 ic_hex_place_node 174 [expr {1.7*$pre_dist-($n6+$n8)*$inc_s2}] [expr {$H+$h+0
      .85*$pre_dist}] 0
416 ic_hex_place_node 176 [expr {1.7*$pre_dist-($n8)*$inc_s2}] [expr {$H+$h+0
      .85*$pre_dist}] 0
417 ic_hex_align_vertices2 164 168 -nodes 166
418 ic_hex_align_vertices2 174 183 -nodes 176
419 ic_hex_place_node 86 curve:crv.02 [expr {(0.3*$pre_dist)/($pre_dist+$pos_dist)
      }]
420 ic_hex_place_node 34 curve:crv.02 [expr {(0.3*$pre_dist+$n00*$inc_s2)/(
```

```
            $pre_dist+$pos_dist)}]
421  ic_hex_place_node 70 curve:crv.02 [expr {(0.3*$pre_dist+($n00+$n2)*$inc_s2)/(
            $pre_dist+$pos_dist)}]
422  ic_hex_place_node 78 curve:crv.02 [expr {(0.3*$pre_dist+($n00+$n2+1)*$inc_s2)/(
            $pre_dist+$pos_dist)}]
423  ic_hex_place_node 44 curve:crv.02 [expr {(0.3*$pre_dist+($n00+2*$n2+1)*$inc_s2)
            /($pre_dist+$pos_dist)}]
424  ic_hex_place_node 104 curve:crv.02 [expr {(1.7*$pre_dist-($n6+$n8)*$inc_s2)/(
            $pre_dist+$pos_dist)}]
425  ic_hex_place_node 124 curve:crv.02 [expr {(1.7*$pre_dist-($n8)*$inc_s2)/(
            $pre_dist+$pos_dist)}]
426  ic_hex_place_node 156 curve:crv.02 [expr {(1.7*$pre_dist)/($pre_dist+$pos_dist)
            }]
427
428  ic_hex_place_node 164 [expr {0.33*$pre_dist}] [expr {$H+$h+0.67*$pre_dist}] 0
429  ic_hex_place_node 183 [expr {1.67*$pre_dist}] [expr {$H+$h+0.67*$pre_dist}] 0
430
431
432  ############## 2 BEAM ADAPTATION
433
434  if {$d != 0} {
435
436  # Cutting beam B section
437  ic_point {} AUX pnt.55 pnt.11+vector([expr {($d-$b)/2}],0,0)
438  ic_hex_split_grid 112 113 pnt.17 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
439  ic_hex_split_grid 193 113 pnt.28 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
440  ic_hex_split_grid 193 207 pnt.19 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
441  ic_hex_split_grid 221 207 pnt.26 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
442  ic_hex_split_grid 112 193 pnt.55 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
443
444  # Position of internal nodes
445  ic_hex_place_node 248 [expr {$pre_dist+$d/2.0}] [expr {$H+$h+0.05}] 0
446  ic_hex_place_node 247 [expr {$pre_dist+$d/2.0}] [expr {$H+$h-$t2-$h*0.05}] 0
447  ic_hex_place_node 246 [expr {$pre_dist+$d/2.0}] [expr {$H+$t3+$h*0.05}] 0
448  ic_hex_place_node 245 [expr {$pre_dist+$d/2.0}] [expr {$H-0.05}] 0
449
450
451  # Position of the nodes in the zone 1 boundary
452  set inc_s2 [expr {(1.2+$b+$d+$h)/(2*$n00+4*$n2+$n10+2)}]
453
454  ic_hex_place_node 133 [expr {$pre_dist-$b/2.0-$h/2.0-0.6+$n00*$inc_s2}] [expr {
            $H+1.5*$h+0.9}] 0
455  ic_hex_place_node 135 [expr {$pre_dist-$b/2.0-$h/2.0-0.6+($n00+$n2)*$inc_s2}] [
            expr {$H+1.5*$h+0.9}] 0
456  ic_hex_place_node 137 [expr {$pre_dist-$b/2.0-$h/2.0-0.6+($n00+$n2+1)*$inc_s2}]
             [expr {$H+1.5*$h+0.9}] 0
457  ic_hex_place_node 139 [expr {$pre_dist-$b/2.0-$h/2.0-0.6+($n00+2*$n2+1)*$inc_s2
            }] [expr {$H+1.5*$h+0.9}] 0
458  ic_hex_place_node 141 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d}] [expr {$H+1.5*$h
            +0.9}] 0
459  ic_hex_place_node 250 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d-($n00+2*$n2+1+$n10
```

```
        /2.0)*$inc_s2}] [expr {$H+1.5*$h+0.9}] 0
460 ic_hex_place_node 194 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d-($n00+2*$n2+1)
        *$inc_s2}] [expr {$H+1.5*$h+0.9}] 0
461 ic_hex_place_node 222 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d-($n00+$n2+1)
        *$inc_s2}] [expr {$H+1.5*$h+0.9}] 0
462 ic_hex_place_node 236 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d-($n00+$n2)*$inc_s2
        }] [expr {$H+1.5*$h+0.9}] 0
463 ic_hex_place_node 208 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d-$n00*$inc_s2}] [
        expr {$H+1.5*$h+0.9}] 0
464 set aux 0.45
465 if {[expr {$H-$h/2.0-0.9}] > 0.6} {set aux 0.9}
466 ic_hex_place_node 132 [expr {$pre_dist-$b/2.0-$h/2.0-0.6+$n00*$inc_s2}] [expr {
        $H-$h/2.0-$aux}] 0
467 ic_hex_place_node 134 [expr {$pre_dist-$b/2.0-$h/2.0-0.6+($n00+$n2)*$inc_s2}] [
        expr {$H-$h/2.0-$aux}] 0
468 ic_hex_place_node 136 [expr {$pre_dist-$b/2.0-$h/2.0-0.6+($n00+$n2+1)*$inc_s2}]
         [expr {$H-$h/2.0-$aux}] 0
469 ic_hex_place_node 138 [expr {$pre_dist-$b/2.0-$h/2.0-0.6+($n00+2*$n2+1)*$inc_s2
        }] [expr {$H-$h/2.0-$aux}] 0
470 ic_hex_place_node 140 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d}] [expr {$H-$h/2
        .0-$aux}] 0
471 ic_hex_place_node 244 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d-($n00+2*$n2+1+$n10
        /2.0)*$inc_s2}] [expr {$H-$h/2.0-$aux}] 0
472 ic_hex_place_node 188 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d-($n00+2*$n2+1)
        *$inc_s2}] [expr {$H-$h/2.0-$aux}] 0
473 ic_hex_place_node 216 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d-($n00+$n2+1)
        *$inc_s2}] [expr {$H-$h/2.0-$aux}] 0
474 ic_hex_place_node 230 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d-($n00+$n2)*$inc_s2
        }] [expr {$H-$h/2.0-$aux}] 0
475 ic_hex_place_node 202 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d-$n00*$inc_s2}] [
        expr {$H-$h/2.0-$aux}] 0
476
477
478 # Position of the nodes in the floor
479 set inc_s2 [expr {(1.2+$b+$d+$h)/(2*$n00+4*$n2+$n10+2)}]
480 set aux [expr {0.5*($H-$h/2.0-0.45)}]
481 ic_hex_place_node 81 curve:crv.01 [expr {($pre_dist-$b/2.0-$h/2.0-0.9-$aux)/(
        $pre_dist+$pos_dist)}]
482 ic_hex_place_node 117 curve:crv.01 [expr {($pre_dist+$b/2.0+$d+3+$h/2.0+0.3+1
        .1*$aux)/($pre_dist+$pos_dist)}]
483 ic_hex_place_node 149 curve:crv.01 [expr {($pre_dist+$b/2.0+$d+3+$h/2.0+5.9+1
        .1*$aux)/($pre_dist+$pos_dist)}]
484 if {[expr {$H-$h/2.0-0.9}] > 0.6} {set aux [expr {0.5*($H-$h/2.0-0.9)}]}
485 ic_hex_place_node 33 curve:crv.01 [expr {($pre_dist-$b/2.0-$h/2.0-0.6+
        $n00*$inc_s2-0.8*$aux)/($pre_dist+$pos_dist)}]
486 ic_hex_place_node 65 curve:crv.01 [expr {($pre_dist-$b/2.0-$h/2.0-0.6+($n00+$n2
        )*$inc_s2-0.4*$aux)/($pre_dist+$pos_dist)}]
487 ic_hex_place_node 73 curve:crv.01 [expr {($pre_dist-$b/2.0-$h/2.0-0.6+($n00+$n2
        +1)*$inc_s2-0.4*$aux)/($pre_dist+$pos_dist)}]
488 ic_hex_place_node 42 curve:crv.01 [expr {($pre_dist-$b/2.0-$h/2.0-0.6+($n00+2
        *$n2+1)*$inc_s2-0.1*$aux)/($pre_dist+$pos_dist)}]
```

110

```
489  ic_hex_place_node 241 curve:crv.01 [expr {($pre_dist+$b/2.0+$h/2.0+$d+0.6-($n00
         +2*$n2+1+$n10/2.0)*$inc_s2)/($pre_dist+$pos_dist)}]
490  ic_hex_place_node 185 curve:crv.01 [expr {($pre_dist+$b/2.0+$h/2.0+$d+0.6-($n00
         +2*$n2+1)*$inc_s2+0.1*$aux)/($pre_dist+$pos_dist)}]
491  ic_hex_place_node 213 curve:crv.01 [expr {($pre_dist+$b/2.0+$h/2.0+$d+0.6-($n00
         +$n2+1)*$inc_s2+0.4*$aux)/($pre_dist+$pos_dist)}]
492  ic_hex_place_node 227 curve:crv.01 [expr {($pre_dist+$b/2.0+$h/2.0+$d+0.6-($n00
         +$n2)*$inc_s2+0.4*$aux)/($pre_dist+$pos_dist)}]
493  ic_hex_place_node 199 curve:crv.01 [expr {($pre_dist+$b/2.0+$h/2.0+$d+0
         .6-$n00*$inc_s2+0.8*$aux)/($pre_dist+$pos_dist)}]
494
495
496  # Position of the upper nodes
497  set inc_s2 [expr {(1.4*$pre_dist)/(2*$n00+4*$n2+$n10+2+$n6+$n8)}]
498  ic_hex_place_node 251 [expr {1.7*$pre_dist-($n6+$n8+$n00+2*$n2+1+$n10/2.0)
         *$inc_s2}] [expr {$H+$h+0.85*$pre_dist}] 0
499  ic_hex_place_node 195 [expr {1.7*$pre_dist-($n6+$n8+$n00+2*$n2+1)*$inc_s2}] [
         expr {$H+$h+0.85*$pre_dist}] 0
500  ic_hex_place_node 223 [expr {1.7*$pre_dist-($n6+$n8+$n00+$n2+1)*$inc_s2}] [expr
          {$H+$h+0.85*$pre_dist}] 0
501  ic_hex_place_node 237 [expr {1.7*$pre_dist-($n6+$n8+$n00+$n2)*$inc_s2}] [expr {
         $H+$h+0.85*$pre_dist}] 0
502  ic_hex_place_node 209 [expr {1.7*$pre_dist-($n6+$n8+$n00)*$inc_s2}] [expr {$H+
         $h+0.85*$pre_dist}] 0
503  ic_hex_place_node 252 curve:crv.02 [expr {(1.7*$pre_dist-($n6+$n8+$n00+2*$n2+1+
         $n10/2.0)*$inc_s2)/($pre_dist+$pos_dist)}]
504  ic_hex_place_node 196 curve:crv.02 [expr {(1.7*$pre_dist-($n6+$n8+$n00+2*$n2+1)
         *$inc_s2)/($pre_dist+$pos_dist)}]
505  ic_hex_place_node 224 curve:crv.02 [expr {(1.7*$pre_dist-($n6+$n8+$n00+$n2+1)
         *$inc_s2)/($pre_dist+$pos_dist)}]
506  ic_hex_place_node 238 curve:crv.02 [expr {(1.7*$pre_dist-($n6+$n8+$n00+$n2)
         *$inc_s2)/($pre_dist+$pos_dist)}]
507  ic_hex_place_node 210 curve:crv.02 [expr {(1.7*$pre_dist-($n6+$n8+$n00)*$inc_s2
         )/($pre_dist+$pos_dist)}]
508
509  ic_hex_align_vertices2 164 172 -nodes 166 168 170
510  ic_hex_align_vertices2 209 183 -nodes 174 176
511
512
513  # Pre-mesh web trick
514  set inc_s2 [expr {$b/(2*$n2+1)}]
515  ic_hex_place_node 221 [expr {$pre_dist-$b/2.0+$n2*$inc_s2+$d}] [expr {$H+$h+0.6
         }] 0
516  ic_hex_place_node 220 curve:crv.22 [expr {$n2*$inc_s2/$b}]
517  ic_hex_place_node 217 curve:crv.28 [expr {($n2+1)*$inc_s2/$b}]
518  ic_hex_place_node 215 [expr {$pre_dist-$b/2.0+$n2*$inc_s2+$d}] [expr {$H-0.6}]
         0
519  ic_hex_place_node 235 [expr {$pre_dist-$b/2.0+($n2+1)*$inc_s2+$d}] [expr {$H+$h
         +0.6}] 0
520  ic_hex_place_node 234 curve:crv.22 [expr {($n2+1)*$inc_s2/$b}]
521  ic_hex_place_node 231 curve:crv.28 [expr {$n2*$inc_s2/$b}]
```

111

```
522  ic_hex_place_node 229 [expr {$pre_dist-$b/2.0+($n2+1)*$inc_s2+$d}] [expr {
         $H-0.6}] 0
523  }
524
525  ic_hex_place_node 102 [expr {$pre_dist+$b/2.0+0.6+$d}] [expr {$H+$h-$t2-0.1}] 0
526  ic_hex_place_node 101 [expr {$pre_dist+$b/2.0+0.6+$d}] [expr {$H+$t3+0.1}] 0
527
528
529  ################# BEAM CONTOUR
530
531  # Erasing beam internal blocks
532  ic_hex_mark_blocks unmark
533  ic_hex_mark_blocks superblock 27
534  ic_hex_mark_blocks superblock 39
535  ic_hex_mark_blocks superblock 46
536  ic_hex_mark_blocks superblock 38
537  ic_hex_mark_blocks superblock 14
538  ic_hex_mark_blocks superblock 37
539  ic_hex_mark_blocks superblock 44
540  ic_hex_change_element_id VORFN
541  ic_delete_empty_parts
542  if {$d!=0} {
543  ic_hex_mark_blocks unmark
544  ic_hex_mark_blocks superblock 154
545  ic_hex_mark_blocks superblock 180
546  ic_hex_mark_blocks superblock 193
547  ic_hex_mark_blocks superblock 179
548  ic_hex_mark_blocks superblock 152
549  ic_hex_mark_blocks superblock 178
550  ic_hex_mark_blocks superblock 191
551  ic_hex_change_element_id VORFN
552  ic_delete_empty_parts
553  }
554
555  # Beam association
556  ic_hex_set_edge_projection 48 69 0 1 crv.10
557  ic_hex_set_edge_projection 69 77 0 1 crv.10
558  ic_hex_set_edge_projection 77 49 0 1 crv.10
559  ic_hex_set_edge_projection 54 48 0 1 crv.09
560  ic_hex_set_edge_projection 55 49 0 1 crv.11
561  ic_hex_set_edge_projection 54 68 0 1 crv.08
562  ic_hex_set_edge_projection 76 55 0 1 crv.12
563  ic_hex_set_edge_projection 67 68 0 1 crv.07
564  ic_hex_set_edge_projection 75 76 0 1 crv.13
565  ic_hex_set_edge_projection 60 67 0 1 crv.06
566  ic_hex_set_edge_projection 75 61 0 1 crv.14
567  ic_hex_set_edge_projection 38 60 0 1 crv.05
568  ic_hex_set_edge_projection 43 61 0 1 crv.15
569  ic_hex_set_edge_projection 74 43 0 1 crv.16
570  ic_hex_set_edge_projection 66 74 0 1 crv.16
571  ic_hex_set_edge_projection 38 66 0 1 crv.16
```

```
572  if {$d!=0} {
573  ic_hex_set_edge_projection 192 220 0 1 crv.22
574  ic_hex_set_edge_projection 220 234 0 1 crv.22
575  ic_hex_set_edge_projection 234 206 0 1 crv.22
576  ic_hex_set_edge_projection 191 192 0 1 crv.21
577  ic_hex_set_edge_projection 205 206 0 1 crv.23
578  ic_hex_set_edge_projection 191 219 0 1 crv.20
579  ic_hex_set_edge_projection 233 205 0 1 crv.24
580  ic_hex_set_edge_projection 218 219 0 1 crv.19
581  ic_hex_set_edge_projection 232 233 0 1 crv.25
582  ic_hex_set_edge_projection 190 218 0 1 crv.18
583  ic_hex_set_edge_projection 232 204 0 1 crv.26
584  ic_hex_set_edge_projection 189 190 0 1 crv.17
585  ic_hex_set_edge_projection 203 204 0 1 crv.27
586  ic_hex_set_edge_projection 189 217 0 1 crv.28
587  ic_hex_set_edge_projection 217 231 0 1 crv.28
588  ic_hex_set_edge_projection 231 203 0 1 crv.28
589  }
590
591
592
593  ############# CUT TRICK
594
595  ic_hex_split_grid 83 84 0.5 m VALLEY LIMIT INLET OUTLET BEAM_A AIR AUX VORFN
596
597
598  ############## PRE-MESH
599
600  # Pre-mesh (zone 1, inside)
601  #set n7 [expr {($H-$h/2.0-0.9)/0.2+30}]
602
603  ic_hex_set_mesh 82 38 n $n00 h1 0.0 h2 0.003 r1 2 r2 1.2 lmax 0 default
         unlocked
604  ic_hex_set_mesh 84 54 n $n00 h1 0.0 h2 0.003 r1 2 r2 1.2 lmax 0 default
         unlocked
605  ic_hex_set_mesh 85 48 n $n00 h1 0.0 h2 0.003 r1 2 r2 1.2 lmax 0 default
         unlocked
606  ic_hex_set_mesh 83 60 n $n00 h1 0.0 h2 0.003 r1 2 r2 1.2 lmax 0 default
         unlocked
607  if {$d!=0} {
608  ic_hex_set_mesh 206 103 n $n00 h1 0.003 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
609  ic_hex_set_mesh 205 102 n $n00 h1 0.003 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
610  ic_hex_set_mesh 204 101 n $n00 h1 0.003 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
611  ic_hex_set_mesh 203 100 n $n00 h1 0.003 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
612  } else {
613  ic_hex_set_mesh 49 103 n $n00 h1 0.003 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
```

```
614  ic_hex_set_mesh 55 102 n $n00 h1 0.003 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
615  ic_hex_set_mesh 61 101 n $n00 h1 0.003 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
616  ic_hex_set_mesh 43 100 n $n00 h1 0.003 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
617  }
618
619  ic_hex_set_mesh 91 38 n $n0 h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0 default unlocked
620  ic_hex_set_mesh 92 66 n $n0 h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0 default unlocked
621  ic_hex_set_mesh 93 74 n $n0 h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0 default unlocked
622  ic_hex_set_mesh 94 43 n $n0 h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0 default unlocked
623  ic_hex_set_mesh 48 109 n $n0 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
624  ic_hex_set_mesh 69 110 n $n0 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
625  ic_hex_set_mesh 77 111 n $n0 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
626  ic_hex_set_mesh 49 112 n $n0 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
627  if {$d!=0} {
628  ic_hex_set_mesh 187 189 n $n0 h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0 default
         unlocked
629  ic_hex_set_mesh 215 217 n $n0 h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0 default
         unlocked
630  ic_hex_set_mesh 229 231 n $n0 h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0 default
         unlocked
631  ic_hex_set_mesh 201 203 n $n0 h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0 default
         unlocked
632  ic_hex_set_mesh 192 193 n $n0 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
633  ic_hex_set_mesh 220 221 n $n0 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
634  ic_hex_set_mesh 234 235 n $n0 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
635  ic_hex_set_mesh 206 207 n $n0 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
636  }
637
638  if {$d!=0} {
639  ic_hex_set_mesh 60 259 n [expr {$n1/2}] h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0
         default unlocked
640  ic_hex_set_mesh 259 54 n [expr {$n1/2}] h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0
         default unlocked
641  ic_hex_set_mesh 67 260 n [expr {$n1/2}] h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0
         default unlocked
642  ic_hex_set_mesh 260 68 n [expr {$n1/2}] h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0
         default unlocked
643  ic_hex_set_mesh 75 261 n [expr {$n1/2}] h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0
         default unlocked
644  ic_hex_set_mesh 261 76 n [expr {$n1/2}] h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0
```

```
        default unlocked
645 ic_hex_set_mesh 61 262 n [expr {$n1/2}] h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0
        default unlocked
646 ic_hex_set_mesh 262 55 n [expr {$n1/2}] h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0
        default unlocked
647 ic_hex_set_mesh 190 264 n [expr {$n1/2}] h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0
        default unlocked
648 ic_hex_set_mesh 264 191 n [expr {$n1/2}] h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0
        default unlocked
649 ic_hex_set_mesh 218 265 n [expr {$n1/2}] h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0
        default unlocked
650 ic_hex_set_mesh 265 219 n [expr {$n1/2}] h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0
        default unlocked
651 ic_hex_set_mesh 232 266 n [expr {$n1/2}] h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0
        default unlocked
652 ic_hex_set_mesh 266 233 n [expr {$n1/2}] h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0
        default unlocked
653 ic_hex_set_mesh 204 267 n [expr {$n1/2}] h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0
        default unlocked
654 ic_hex_set_mesh 267 205 n [expr {$n1/2}] h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0
        default unlocked
655 ic_hex_set_mesh 83 256 n [expr {$n1/2}] h1 0.008 h2 0.0 r1 1.12 r2 2 lmax 0
        default unlocked
656 ic_hex_set_mesh 256 84 n [expr {$n1/2}] h1 0.0 h2 0.008 r1 2 r2 1.12 lmax 0
        default unlocked
657 ic_hex_set_mesh 246 263 n [expr {$n1/2}] h1 [expr {0.0125*($d-$b)}] h2 0.0 r1 1
        .1 r2 2 lmax 0 default unlocked
658 ic_hex_set_mesh 263 247 n [expr {$n1/2}] h1 0.0 h2 [expr {0.0125*($d-$b)}] r1 2
         r2 1.1 lmax 0 default unlocked
659 ic_hex_set_mesh 101 268 n [expr {$n1/2}] h1 0.008 h2 0.0 r1 1.12 r2 2 lmax 0
        default unlocked
660 ic_hex_set_mesh 268 102 n [expr {$n1/2}] h1 0.0 h2 0.008 r1 2 r2 1.12 lmax 0
        default unlocked
661 } else {
662 ic_hex_set_mesh 60 189 n [expr {$n1/2}] h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0
        default unlocked
663 ic_hex_set_mesh 189 54 n [expr {$n1/2}] h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0
        default unlocked
664 ic_hex_set_mesh 67 190 n [expr {$n1/2}] h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0
        default unlocked
665 ic_hex_set_mesh 190 68 n [expr {$n1/2}] h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0
        default unlocked
666 ic_hex_set_mesh 75 191 n [expr {$n1/2}] h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0
        default unlocked
667 ic_hex_set_mesh 191 76 n [expr {$n1/2}] h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0
        default unlocked
668 ic_hex_set_mesh 61 192 n [expr {$n1/2}] h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0
        default unlocked
669 ic_hex_set_mesh 192 55 n [expr {$n1/2}] h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0
        default unlocked
670 ic_hex_set_mesh 83 186 n [expr {$n1/2}] h1 0.008 h2 0.0 r1 1.12 r2 2 lmax 0
```

115

```
        default unlocked
671 ic_hex_set_mesh 186 84 n [expr {$n1/2}] h1 0.0 h2 0.008 r1 2 r2 1.12 lmax 0
        default unlocked
672 ic_hex_set_mesh 101 193 n [expr {$n1/2}] h1 0.008 h2 0.0 r1 1.12 r2 2 lmax 0
        default unlocked
673 ic_hex_set_mesh 193 102 n [expr {$n1/2}] h1 0.0 h2 0.008 r1 2 r2 1.12 lmax 0
        default unlocked
674 }
675
676 ic_hex_set_mesh 54 68 n $n2 h1 0.004 h2 0.001 r1 1.2 r2 1.2 lmax 0 default
        unlocked
677 ic_hex_set_mesh 60 67 n $n2 h1 0.004 h2 0.001 r1 1.2 r2 1.2 lmax 0 default
        unlocked
678 ic_hex_set_mesh 76 55 n $n2 h1 0.001 h2 0.004 r1 1.2 r2 1.2 lmax 0 default
        unlocked
679 ic_hex_set_mesh 75 61 n $n2 h1 0.001 h2 0.004 r1 1.2 r2 1.2 lmax 0 default
        unlocked
680 ic_hex_set_mesh 48 69 n $n2 h1 0.004 h2 0.0 r1 1.2 r2 2 lmax 0 default unlocked
681 ic_hex_set_mesh 38 66 n $n2 h1 0.004 h2 0.0 r1 1.2 r2 2 lmax 0 default unlocked
682 ic_hex_set_mesh 77 49 n $n2 h1 0.0 h2 0.004 r1 2 r2 1.2 lmax 0 default unlocked
683 ic_hex_set_mesh 74 43 n $n2 h1 0.0 h2 0.004 r1 2 r2 1.2 lmax 0 default unlocked
684 ic_hex_set_mesh 109 110 n $n2 h1 0.008 h2 0.0 r1 1.1 r2 2 lmax 0 default
        unlocked
685 ic_hex_set_mesh 91 92 n $n2 h1 0.008 h2 0.0 r1 1.1 r2 2 lmax 0 default unlocked
686 ic_hex_set_mesh 111 112 n $n2 h1 0.0 h2 0.008 r1 2 r2 1.1 lmax 0 default
        unlocked
687 ic_hex_set_mesh 93 94 n $n2 h1 0.0 h2 0.008 r1 2 r2 1.1 lmax 0 default unlocked
688 if {$d!=0} {
689 ic_hex_set_mesh 191 219 n $n2 h1 0.004 h2 0.001 r1 1.2 r2 1.2 lmax 0 default
        unlocked
690 ic_hex_set_mesh 190 218 n $n2 h1 0.004 h2 0.001 r1 1.2 r2 1.2 lmax 0 default
        unlocked
691 ic_hex_set_mesh 233 205 n $n2 h1 0.001 h2 0.004 r1 1.2 r2 1.2 lmax 0 default
        unlocked
692 ic_hex_set_mesh 232 204 n $n2 h1 0.001 h2 0.004 r1 1.2 r2 1.2 lmax 0 default
        unlocked
693 ic_hex_set_mesh 192 220 n $n2 h1 0.004 h2 0.0 r1 1.2 r2 2 lmax 0 default
        unlocked
694 ic_hex_set_mesh 189 217 n $n2 h1 0.004 h2 0.0 r1 1.2 r2 2 lmax 0 default
        unlocked
695 ic_hex_set_mesh 234 206 n $n2 h1 0.0 h2 0.004 r1 2 r2 1.2 lmax 0 default
        unlocked
696 ic_hex_set_mesh 231 203 n $n2 h1 0.0 h2 0.004 r1 2 r2 1.2 lmax 0 default
        unlocked
697 ic_hex_set_mesh 193 221 n $n2 h1 0.008 h2 0.0 r1 1.1 r2 2 lmax 0 default
        unlocked
698 ic_hex_set_mesh 187 215 n $n2 h1 0.008 h2 0.0 r1 1.1 r2 2 lmax 0 default
        unlocked
699 ic_hex_set_mesh 235 207 n $n2 h1 0.0 h2 0.008 r1 2 r2 1.1 lmax 0 default
        unlocked
700 ic_hex_set_mesh 231 203 n $n2 h1 0.0 h2 0.008 r1 2 r2 1.1 lmax 0 default
```

```
            unlocked
701     }
702
703     ic_hex_set_mesh 54 48 n $n3 h1 0.002 h2 0.002 r1 1.2 r2 1.2 lmax 0 default
            unlocked
704     ic_hex_set_mesh 55 49 n $n3 h1 0.002 h2 0.002 r1 1.2 r2 1.2 lmax 0 default
            unlocked
705     if {$d!=0} {
706     ic_hex_set_mesh 191 192 n $n3 h1 0.002 h2 0.002 r1 1.2 r2 1.2 lmax 0 default
            unlocked
707     ic_hex_set_mesh 205 206 n $n3 h1 0.002 h2 0.002 r1 1.2 r2 1.2 lmax 0 default
            unlocked
708     }
709
710     ic_hex_set_mesh 38 60 n $n5 h1 0.002 h2 0.002 r1 1.2 r2 1.2 lmax 0 default
            unlocked
711     ic_hex_set_mesh 43 61 n $n5 h1 0.002 h2 0.002 r1 1.2 r2 1.2 lmax 0 default
            unlocked
712     if {$d!=0} {
713     ic_hex_set_mesh 189 190 n $n5 h1 0.002 h2 0.002 r1 1.2 r2 1.2 lmax 0 default
            unlocked
714     ic_hex_set_mesh 203 204 n $n5 h1 0.002 h2 0.002 r1 1.2 r2 1.2 lmax 0 default
            unlocked
715     }
716
717     ic_hex_set_mesh 100 119 n $n6 h1 0.0 h2 0.0 r1 2 r2 2 lmax 0 default unlocked
718
719     if {$d!=0} {
720     ic_hex_set_mesh 49 248 n [expr {$n10/2.0}] h1 0.003 h2 0.0 r1 1.2 r2 2 lmax 0
            default unlocked
721     ic_hex_set_mesh 55 247 n [expr {$n10/2.0}] h1 0.003 h2 0.0 r1 1.2 r2 2 lmax 0
            default unlocked
722     ic_hex_set_mesh 61 246 n [expr {$n10/2.0}] h1 0.003 h2 0.0 r1 1.2 r2 2 lmax 0
            default unlocked
723     ic_hex_set_mesh 43 245 n [expr {$n10/2.0}] h1 0.003 h2 0.0 r1 1.2 r2 2 lmax 0
            default unlocked
724     ic_hex_set_mesh 248 192 n [expr {$n10/2.0}] h1 0.0 h2 0.003 r1 2 r2 1.2 lmax 0
            default unlocked
725     ic_hex_set_mesh 247 191 n [expr {$n10/2.0}] h1 0.0 h2 0.003 r1 2 r2 1.2 lmax 0
            default unlocked
726     ic_hex_set_mesh 246 190 n [expr {$n10/2.0}] h1 0.0 h2 0.003 r1 2 r2 1.2 lmax 0
            default unlocked
727     ic_hex_set_mesh 245 189 n [expr {$n10/2.0}] h1 0.0 h2 0.003 r1 2 r2 1.2 lmax 0
            default unlocked
728     }
729
730
731     # Pre-mesh (zone 1, outside)
732     ic_hex_set_mesh 129 84 n 16 h1 0.0 h2 0.04 r1 2 r2 1.2 lmax 0 default
            copy_to_parallel unlocked
733
```

```
734
735  # Pre-mesh (zone 2, inside)
736  set n8 [expr {5/0.15}]
737  set n7 [expr {($H-$h/2.0-0.9)/0.2+30}]
738  ic_hex_set_mesh 144 152 n $n8 h1 0.0 h2 0.0 r1 2 r2 2 lmax 0 default unlocked
739  ic_hex_set_mesh 81 126 n $n7 h1 0.001 h2 0.16 r1 1.2 r2 1.2 lmax 0 default
         copy_to_parallel unlocked
740
741
742  # Pre-mesh (zone 2, outside)
743  set n9 [expr {0.85*$pre_dist/1.5+35}]
744  ic_hex_set_mesh 164 131 n $n9 h1 1.5 h2 0.15 r1 2 r2 1.02 lmax 0 default
         copy_to_parallel unlocked
745  ic_hex_set_mesh 11 89 n $n7 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default unlocked
746  ic_hex_set_mesh 158 159 n $n7 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
747  ic_hex_set_mesh 177 178 n $n7 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
748  ic_hex_set_mesh 19 95 n $n7 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default unlocked
749
750
751  # Pre-mesh (zone 3)
752  if {$d!=0} {
753  ic_hex_set_mesh 107 164 n [expr {0.2*$pre_dist}] h1rel 0.0 h2rel 0.0 r1 2 r2 2
         lmax 0 default copy_to_parallel unlocked
754  ic_hex_set_mesh 164 86 n [expr {($H+$h+$height-0.85*$pre_dist)}] h1rel 0.0
         h2rel 0.0 r1 2 r2 2 lmax 0 default copy_to_parallel unlocked
755  ic_hex_set_mesh 183 114 n [expr {($pos_dist-0.85*$pre_dist)}] h1rel 0.0 h2rel 0
         .0 r1 2 r2 2 lmax 0 default copy_to_parallel unlocked
756  } else {
757  ic_hex_set_mesh 107 164 n [expr {0.16*$pre_dist}] h1rel 0.0 h2rel 0.0 r1 2 r2 2
         lmax 0 default copy_to_parallel unlocked
758  ic_hex_set_mesh 164 86 n [expr {0.55*($H+$h+$height-0.85*$pre_dist)}] h1rel 0.0
         h2rel 0.0 r1 2 r2 2 lmax 0 default copy_to_parallel unlocked
759  ic_hex_set_mesh 183 114 n [expr {0.55*($pos_dist-0.85*$pre_dist)}] h1rel 0.0
         h2rel 0.0 r1 2 r2 2 lmax 0 default copy_to_parallel unlocked
760  }
761
762
763  # Cut trick pre-mesh
764  if {$d!=0} {
765  ic_hex_set_mesh 259 260 n $n2 h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0 default
         unlocked
766  ic_hex_set_mesh 261 262 n $n2 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
767  ic_hex_set_mesh 264 265 n $n2 h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0 default
         unlocked
768  ic_hex_set_mesh 266 267 n $n2 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
769  } else {
770  ic_hex_set_mesh 189 190 n $n2 h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0 default
```

118

```
            unlocked
771  ic_hex_set_mesh 191 192 n $n2 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default
            unlocked
772  }
773
774
775  ########## FINAL PROCEDURES
776
777
778  # Computing pre-mesh
779  ic_hex_create_mesh VALLEY LIMIT INLET OUTLET BEAM_A AIR AUX proj 2 dim_to_mesh
            3
780
781
782  # Converting to unstructured mesh
783  ic_chdir $work_direc/$case_type/$case_name
784  ic_hex_write_file hex.uns VALLEY LIMIT INLET OUTLET BEAM_A AIR AUX proj 2
            dim_to_mesh 2 no_boco
785  ic_unload_mesh
786  ic_delete_empty_parts
787  ic_uns_load hex.uns 3 0 {} 1
788
789
790
791  ########################### SAVING FILES ###########################
792
793
794  ic_solver_mesh_info {ANSYS Fluent}
795  ic_solution_set_solver {ANSYS Fluent} 1
796  ic_boco_save $case_name.fbc
797  ic_boco_save_atr $case_name.atr
798  ic_save_tetin $case_name.tin 0 0 {} {} 0 0 1
799  ic_save_unstruct $case_name.uns 1 {} {} {}
800  ic_hex_save_blocking $case_name.blk
```

B.1.2 With free flow conditions

```
1
2  #
       ########################################################################
3  ################################# INPUTS
       #####################################
4  #
       ########################################################################
5
6  # Save mesh (1) or not (0)
7  set save_mesh 0
8
9  # Bridge geometry
```

```
10  set h 3
11  set b 4.4
12  set d 0
13
14  set t1 3.52
15  set t2 0.04
16  set t3 0.04
17
18  #Model size
19  set height 120
20  set pre_dist 120
21  set pos_dist 150
22
23  # Working directory
24  set work_direc "C:/Master_Thesis/3_Ansys_files/190404_Parametric_study"
25
26
27  ##################### PRELIMINARY CALCULATIONS #####################
28
29
30  set H $height
31  set case_name 2D_[expr {$h}]_[expr {$d}]_[expr {$b}]_[expr {$H}]
32
33  if {$d != 0} {
34  set case_type "Two_beams"
35  } else {
36  if {$t1 > 1} {
37  set distance [expr {$t1-0.02}]
38  set case_type "Two_beams_closed"
39  if {$distance == [floor $distance]} {
40  set case_name 2D_[expr {$h}]_[expr {int($t1-0.02)}]_[expr {$b-$t1+0.02}]_[expr
        {$H}]
41  } else {
42  set case_name 2D_[expr {$h}]_[expr {$t1-0.02}]_[expr {$b-$t1+0.02}]_[expr {$H}]
43  }
44  } else {
45  set case_type "One_beam"
46  }}
47
48
49  ###################### GEOMETRY CONSTRUCTION ######################
50
51
52  # Reset previous geometry
53  ic_delete_geometry point all 0
54  ic_delete_geometry curve all 0
55  ic_delete_geometry surface all 0
56  ic_delete_geometry density all 0
57  ic_delete_geometry material all 0
58  ic_delete_geometry loop all 0
59
```

```
60  # Boundary construction
61  ic_point {} VALLEY pnt.01 0,0,0
62  ic_point {} VALLEY pnt.02 [expr {$pre_dist+$pos_dist}],0,0
63  ic_point {} LIMIT pnt.03 0,[expr {$height+$h+$H}],0
64  ic_point {} LIMIT pnt.04 [expr {$pre_dist+$pos_dist}],[expr {$height+$h+$H}],0
65  ic_curve point VALLEY crv.01 {pnt.01 pnt.02}
66  ic_curve point LIMIT crv.02 {pnt.03 pnt.04}
67  ic_curve point INLET crv.03 {pnt.01 pnt.03}
68  ic_curve point OUTLET crv.04 {pnt.02 pnt.04}
69
70  # Beam A construction
71  ic_point {} BEAM_A pnt.05 [expr {$pre_dist-$b/2.0}],$H,0
72  ic_point {} BEAM_A pnt.06 [expr {$pre_dist-$b/2.0}],[expr {$H+$t3}],0
73  ic_point {} BEAM_A pnt.07 [expr {$pre_dist-$t1/2}],[expr {$H+$t3}],0
74  ic_point {} BEAM_A pnt.08 [expr {$pre_dist-$t1/2}],[expr {$H+$h-$t2}],0
75  ic_point {} BEAM_A pnt.09 [expr {$pre_dist-$b/2.0}],[expr {$H+$h-$t2}],0
76  ic_point {} BEAM_A pnt.10 [expr {$pre_dist-$b/2.0}],[expr {$H+$h}],0
77  ic_point {} BEAM_A pnt.11 [expr {$pre_dist+$b/2.0}],[expr {$H+$h}],0
78  ic_point {} BEAM_A pnt.12 [expr {$pre_dist+$b/2.0}],[expr {$H+$h-$t2}],0
79  ic_point {} BEAM_A pnt.13 [expr {$pre_dist+$t1/2}],[expr {$H+$h-$t2}],0
80  ic_point {} BEAM_A pnt.14 [expr {$pre_dist+$t1/2}],[expr {$H+$t3}],0
81  ic_point {} BEAM_A pnt.15 [expr {$pre_dist+$b/2.0}],[expr {$H+$t3}],0
82  ic_point {} BEAM_A pnt.16 [expr {$pre_dist+$b/2.0}],$H,0
83  ic_curve point BEAM_A crv.05 {pnt.05 pnt.06}
84  ic_curve point BEAM_A crv.06 {pnt.06 pnt.07}
85  ic_curve point BEAM_A crv.07 {pnt.07 pnt.08}
86  ic_curve point BEAM_A crv.08 {pnt.08 pnt.09}
87  ic_curve point BEAM_A crv.09 {pnt.09 pnt.10}
88  ic_curve point BEAM_A crv.10 {pnt.10 pnt.11}
89  ic_curve point BEAM_A crv.11 {pnt.11 pnt.12}
90  ic_curve point BEAM_A crv.12 {pnt.12 pnt.13}
91  ic_curve point BEAM_A crv.13 {pnt.13 pnt.14}
92  ic_curve point BEAM_A crv.14 {pnt.14 pnt.15}
93  ic_curve point BEAM_A crv.15 {pnt.15 pnt.16}
94  ic_curve point BEAM_A crv.16 {pnt.16 pnt.05}
95
96  # Beam B construction
97  ic_point {} BEAM_B pnt.17 [expr {$pre_dist-$b/2.0+$d}],$H,0
98  ic_point {} BEAM_B pnt.18 [expr {$pre_dist-$b/2.0+$d}],[expr {$H+$t3}],0
99  ic_point {} BEAM_B pnt.19 [expr {$pre_dist-$t1/2+$d}],[expr {$H+$t3}],0
100 ic_point {} BEAM_B pnt.20 [expr {$pre_dist-$t1/2+$d}],[expr {$H+$h-$t2}],0
101 ic_point {} BEAM_B pnt.21 [expr {$pre_dist-$b/2.0+$d}],[expr {$H+$h-$t2}],0
102 ic_point {} BEAM_B pnt.22 [expr {$pre_dist-$b/2.0+$d}],[expr {$H+$h}],0
103 ic_point {} BEAM_B pnt.23 [expr {$pre_dist+$b/2.0+$d}],[expr {$H+$h}],0
104 ic_point {} BEAM_B pnt.24 [expr {$pre_dist+$b/2.0+$d}],[expr {$H+$h-$t2}],0
105 ic_point {} BEAM_B pnt.25 [expr {$pre_dist+$t1/2+$d}],[expr {$H+$h-$t2}],0
106 ic_point {} BEAM_B pnt.26 [expr {$pre_dist+$t1/2+$d}],[expr {$H+$t3}],0
107 ic_point {} BEAM_B pnt.27 [expr {$pre_dist+$b/2.0+$d}],[expr {$H+$t3}],0
108 ic_point {} BEAM_B pnt.28 [expr {$pre_dist+$b/2.0+$d}],$H,0
109 ic_curve point BEAM_B crv.17 {pnt.17 pnt.18}
110 ic_curve point BEAM_B crv.18 {pnt.18 pnt.19}
```

```
111  ic_curve point BEAM_B crv.19 {pnt.19 pnt.20}
112  ic_curve point BEAM_B crv.20 {pnt.20 pnt.21}
113  ic_curve point BEAM_B crv.21 {pnt.21 pnt.22}
114  ic_curve point BEAM_B crv.22 {pnt.22 pnt.23}
115  ic_curve point BEAM_B crv.23 {pnt.23 pnt.24}
116  ic_curve point BEAM_B crv.24 {pnt.24 pnt.25}
117  ic_curve point BEAM_B crv.25 {pnt.25 pnt.26}
118  ic_curve point BEAM_B crv.26 {pnt.26 pnt.27}
119  ic_curve point BEAM_B crv.27 {pnt.27 pnt.28}
120  ic_curve point BEAM_B crv.28 {pnt.28 pnt.17}
121
122  # Air surface contruction
123  ic_surface 2-4crvs AIR srf.01 {0.01 {crv.03 crv.01 crv.04 crv.02}}
124  ic_geo_trim_surface srf.01 {crv.15 crv.14 crv.13 crv.12 crv.11 crv.10 crv.09
        crv.08 crv.07 crv.06 crv.05 crv.16} 1
125  ic_delete_geometry surface names srf.01.cut.0 0
126  ic_geo_trim_surface srf.01 {crv.27 crv.26 crv.25 crv.24 crv.23 crv.22 crv.21
        crv.20 crv.19 crv.18 crv.17 crv.28} 1
127  ic_delete_geometry surface names srf.01.cut.0 0
128
129
130  ########################### MESH GENERATION ###########################
131
132
133  ############## INITIALIZING
134
135  ic_hex_unload_blocking
136  ic_hex_initialize_mesh 2d new_numbering new_blocking AIR
137  ic_hex_unblank_blocks
138  ic_hex_multi_grid_level 0
139  ic_hex_projection_limit 0
140  ic_hex_default_bunching_law default 2
141  ic_hex_floating_grid off
142  ic_hex_transfinite_degree 1
143  ic_hex_unstruct_face_type one_tri
144  ic_hex_set_unstruct_face_method uniform_quad
145  ic_hex_set_n_tetra_smoothing_steps 20
146  ic_hex_error_messages off_minor
147
148  # Boundary association
149  ic_hex_set_edge_projection 11 19 0 1 crv.01
150  ic_hex_set_edge_projection 13 21 0 1 crv.02
151  ic_hex_set_edge_projection 11 13 0 1 crv.03
152  ic_hex_set_edge_projection 19 21 0 1 crv.04
153
154  # Cutting beam A section
155  ic_hex_split_grid 11 19 pnt.05 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
156  ic_hex_split_grid 33 34 pnt.16 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
157  ic_hex_split_grid 38 39 pnt.11 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
158  ic_hex_split_grid 38 34 pnt.11 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
159  ic_hex_split_grid 38 48 pnt.09 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
```

```
160  ic_hex_split_grid 38 54 pnt.06 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
161  ic_hex_split_grid 38 43 pnt.07 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
162  ic_hex_split_grid 66 43 pnt.14 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
163
164
165  ############# CREATION AND SIZING
166
167  # Creation (zone 1, inside)
168  ic_point {} AUX pnt.51 pnt.05+vector(-0.6,-0.6,0)
169  ic_point {} AUX pnt.52 pnt.11+vector([expr {$d+0.6}],0.6,0)
170  ic_point {} AUX pnt.53 pnt.52+vector(3,0,0)
171  ic_hex_split_grid 37 38 pnt.51 m VALLEY LIMIT INLET OUTLET BEAM_A AIR AUX VORFN
172  ic_hex_split_grid 33 38 pnt.51 m VALLEY LIMIT INLET OUTLET BEAM_A AIR AUX VORFN
173  ic_hex_split_grid 49 50 pnt.52 m VALLEY LIMIT INLET OUTLET BEAM_A AIR AUX VORFN
174  ic_hex_split_grid 49 44 pnt.52 m VALLEY LIMIT INLET OUTLET BEAM_A AIR AUX VORFN
175  ic_hex_split_grid 103 50 pnt.53 m VALLEY LIMIT INLET OUTLET BEAM_A AIR AUX
         VORFN
176  ic_hex_mark_blocks unmark
177  ic_hex_mark_blocks superblock 14
178  ic_hex_mark_blocks superblock 18
179  ic_hex_mark_blocks superblock 22
180  ic_hex_mark_blocks superblock 23
181  ic_hex_mark_blocks superblock 27
182  ic_hex_mark_blocks superblock 28
183  ic_hex_mark_blocks superblock 32
184  ic_hex_mark_blocks superblock 33
185  ic_hex_mark_blocks superblock 37
186  ic_hex_mark_blocks superblock 38
187  ic_hex_mark_blocks superblock 39
188  ic_hex_mark_blocks superblock 40
189  ic_hex_mark_blocks superblock 44
190  ic_hex_mark_blocks superblock 45
191  ic_hex_mark_blocks superblock 46
192  ic_hex_mark_blocks superblock 47
193  ic_hex_mark_blocks superblock 51
194  ic_hex_mark_blocks superblock 52
195  ic_hex_mark_blocks superblock 53
196  ic_hex_mark_blocks superblock 54
197  ic_hex_mark_blocks superblock 58
198  ic_hex_mark_blocks superblock 59
199  ic_hex_mark_blocks superblock 60
200  ic_hex_mark_blocks superblock 61
201  ic_hex_mark_blocks superblock 62
202  ic_hex_mark_blocks superblock 66
203  ic_hex_mark_blocks superblock 67
204  ic_hex_mark_blocks superblock 68
205  ic_hex_mark_blocks superblock 69
206  ic_hex_mark_blocks superblock 70
207  ic_hex_ogrid 1 not_marked m VALLEY LIMIT INLET OUTLET BEAM_A AIR AUX -version
         50
208
```

```
209
210  # Sizing (zone 1, inside)
211  set n0 28
212  set n00 22
213  set n1 [expr {($h-$t2-$t3)/0.05+40}]
214  set n2 [expr {-32.6*($b/2.0-$t1/2.0)*($b/2.0-$t1/2.0)+58.9*($b/2.0-$t1/2.0)
         +15}] ;#+21}]
215  set n3 [expr {167*$t2+5.8}]
216  set n4 2 ;#[expr {100*$t1+1}]
217  set n5 [expr {167*$t3+5.8}]
218  set n6 [expr {3/0.075}]
219  set n8 [expr {5/0.15}]
220  set n9 [expr {0.85*$pre_dist/1.5+35}]
221  set n10 [expr {($d-$b)/0.075+28}]
222
223  ic_hex_place_node 108 [expr {$pre_dist-$b/2.0-0.45}] [expr {$H+$h+0.45}] 0
224  ic_hex_place_node 90 [expr {$pre_dist-$b/2.0-0.45}] [expr {$H-0.45}] 0
225  ic_hex_place_node 123 [expr {$pre_dist+$d+$b/2.0+0.45+3}] [expr {$H+$h+0.45}] 0
226  ic_hex_place_node 118 [expr {$pre_dist+$d+$b/2.0+0.45+3}] [expr {$H-0.45}] 0
227
228  ic_hex_place_node 84 [expr {$pre_dist-$b/2.0-0.6}] [expr {$H+$h-$t2-0.1}] 0
229  ic_hex_place_node 83 [expr {$pre_dist-$b/2.0-0.6}] [expr {$H+$t3+0.1}] 0
230
231  set inc_s1 [expr {($h+0.9)/(2*$n0+$n3+$n1+$n5)}]
232  ic_hex_place_node 121 [expr {$pre_dist+$d+$b/2.0+0.6+3}] [expr {$H+$h+0.45-($n0
         +$n3)*$inc_s1}] 0
233  ic_hex_place_node 120 [expr {$pre_dist+$d+$b/2.0+0.6+3}] [expr {$H-0.45+($n0+
         $n5)*$inc_s1}] 0
234  ic_hex_place_node 122 [expr {$pre_dist+$d+$b/2.0+0.6+3}] [expr {$H+$h+0
         .45-$n0*$inc_s1}] 0
235  ic_hex_place_node 119 [expr {$pre_dist+$d+$b/2.0+0.6+3}] [expr {$H-0.45+
         $n0*$inc_s1}] 0
236
237
238  # Pre-mesh web trick
239  set inc_s2 [expr {$b/(2*$n2+1)}]
240  ic_hex_place_node 110 [expr {$pre_dist-$b/2.0+$n2*$inc_s2}] [expr {$H+$h+0.6}]
         0
241  ic_hex_place_node 69 curve:crv.10 [expr {$n2*$inc_s2/$b}]
242  ic_hex_place_node 74 curve:crv.16 [expr {$n2*$inc_s2/$b}]
243  ic_hex_place_node 92 [expr {$pre_dist-$b/2.0+$n2*$inc_s2}] [expr {$H-0.6}] 0
244  ic_hex_place_node 111 [expr {$pre_dist-$b/2.0+($n2+1)*$inc_s2}] [expr {$H+$h+0
         .6}] 0
245  ic_hex_place_node 77 curve:crv.10 [expr {($n2+1)*$inc_s2/$b}]
246  ic_hex_place_node 66 curve:crv.16 [expr {($n2+1)*$inc_s2/$b}]
247  ic_hex_place_node 93 [expr {$pre_dist-$b/2.0+($n2+1)*$inc_s2}] [expr {$H-0.6}]
         0
248
249
250  # Sizing (zone 1, outside)
251  set inc_s1 [expr {(2*$h+0.9)/(2*$n0+$n3+$n1+$n5)}]
```

124

```
252  ic_hex_place_node 131 [expr {$pre_dist-$b/2.0-$h/2.0-0.45}] [expr {$H+1.5*$h+0
         .45}] 0
253  ic_hex_place_node 130 [expr {$pre_dist-$b/2.0-$h/2.0-0.9}] [expr {$H+1.5*$h+0
         .45-$n0*$inc_s1}] 0
254  ic_hex_place_node 129 [expr {$pre_dist-$b/2.0-$h/2.0-0.9}] [expr {$H+1.5*$h+0
         .45-($n0+$n3)*$inc_s1}] 0
255  ic_hex_place_node 128 [expr {$pre_dist-$b/2.0-$h/2.0-0.9}] [expr {$H-$h/2
         .0-0.45+($n0+$n3)*$inc_s1}] 0
256  ic_hex_place_node 127 [expr {$pre_dist-$b/2.0-$h/2.0-0.9}] [expr {$H-$h/2
         .0-0.45+$n0*$inc_s1}] 0
257  ic_hex_place_node 126 [expr {$pre_dist-$b/2.0-$h/2.0-0.9}] [expr {$H-$h/2
         .0-0.45}] 0
258
259  ic_hex_place_node 147 [expr {$pre_dist+$b/2.0+$d+3+$h/2.0+0.3}] [expr {$H+1
         .5*$h+0.45}] 0
260  ic_hex_place_node 146 [expr {$pre_dist+$b/2.0+$d+3+$h/2.0+0.9}] [expr {$H+1
         .5*$h+0.45-$n0*$inc_s1}] 0
261  ic_hex_place_node 145 [expr {$pre_dist+$b/2.0+$d+3+$h/2.0+0.9}] [expr {$H+1
         .5*$h+0.45-($n0+$n3)*$inc_s1}] 0
262  ic_hex_place_node 144 [expr {$pre_dist+$b/2.0+$d+3+$h/2.0+0.9}] [expr {$H-$h/2
         .0-0.45+($n0+$n3)*$inc_s1}] 0
263  ic_hex_place_node 143 [expr {$pre_dist+$b/2.0+$d+3+$h/2.0+0.9}] [expr {$H-$h/2
         .0-0.45+$n0*$inc_s1}] 0
264  ic_hex_place_node 142 [expr {$pre_dist+$b/2.0+$d+3+$h/2.0+0.3}] [expr {$H-$h/2
         .0-0.45}] 0
265
266  set inc_s2 [expr {(1.8+$b+$d+$h)/(2*$n00+4*$n2+$n10+2)}]
267  if {$d == 0} {set inc_s2 [expr {(1.8+$b+$d+$h)/(2*$n00+2*$n2+1)}]}
268  ic_hex_place_node 133 [expr {$pre_dist-$b/2.0-$h/2.0-0.6+$n00*$inc_s2}] [expr {
         $H+1.5*$h+0.9}] 0
269  ic_hex_place_node 135 [expr {$pre_dist-$b/2.0-$h/2.0-0.9+($n00+$n2)*$inc_s2}] [
         expr {$H+1.5*$h+0.9}] 0
270  ic_hex_place_node 137 [expr {$pre_dist-$b/2.0-$h/2.0-0.9+($n00+$n2+1)*$inc_s2}]
          [expr {$H+1.5*$h+0.9}] 0
271  ic_hex_place_node 139 [expr {$pre_dist-$b/2.0-$h/2.0-1.2+($n00+2*$n2+1)*$inc_s2
         }] [expr {$H+1.5*$h+0.9}] 0
272  ic_hex_place_node 141 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d}] [expr {$H+1.5*$h
         +0.9}] 0
273
274  set aux 0.9
275  ic_hex_place_node 132 [expr {$pre_dist-$b/2.0-$h/2.0-0.6+$n00*$inc_s2}] [expr {
         $H-$h/2.0-$aux}] 0
276  ic_hex_place_node 134 [expr {$pre_dist-$b/2.0-$h/2.0-0.9+($n00+$n2)*$inc_s2}] [
         expr {$H-$h/2.0-$aux}] 0
277  ic_hex_place_node 136 [expr {$pre_dist-$b/2.0-$h/2.0-0.9+($n00+$n2+1)*$inc_s2}]
          [expr {$H-$h/2.0-$aux}] 0
278  ic_hex_place_node 138 [expr {$pre_dist-$b/2.0-$h/2.0-1.2+($n00+2*$n2+1)*$inc_s2
         }] [expr {$H-$h/2.0-$aux}] 0
279  ic_hex_place_node 140 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d}] [expr {$H-$h/2
         .0-$aux}] 0
280
```

```
281
282 # Creation (zone 2, inside)
283 ic_point {} AUX pnt.54 pnt.53+vector([expr {$h/2.0+5.3}],0,0)
284 ic_hex_split_grid 145 56 pnt.54 m VALLEY LIMIT INLET OUTLET BEAM_A AIR AUX
        VORFN
285
286
287 # Creation (zone 2, outside)
288 ic_hex_mark_blocks unmark
289 ic_hex_mark_blocks superblock 100
290 ic_hex_mark_blocks superblock 101
291 ic_hex_mark_blocks superblock 102
292 ic_hex_mark_blocks superblock 103
293 ic_hex_mark_blocks superblock 104
294 ic_hex_mark_blocks superblock 105
295 ic_hex_mark_blocks superblock 106
296 ic_hex_mark_blocks superblock 107
297 ic_hex_mark_blocks superblock 108
298 ic_hex_mark_blocks superblock 109
299 ic_hex_mark_blocks superblock 110
300 ic_hex_mark_blocks superblock 111
301 ic_hex_mark_blocks superblock 14
302 ic_hex_mark_blocks superblock 18
303 ic_hex_mark_blocks superblock 22
304 ic_hex_mark_blocks superblock 23
305 ic_hex_mark_blocks superblock 27
306 ic_hex_mark_blocks superblock 28
307 ic_hex_mark_blocks superblock 32
308 ic_hex_mark_blocks superblock 33
309 ic_hex_mark_blocks superblock 37
310 ic_hex_mark_blocks superblock 38
311 ic_hex_mark_blocks superblock 39
312 ic_hex_mark_blocks superblock 40
313 ic_hex_mark_blocks superblock 44
314 ic_hex_mark_blocks superblock 45
315 ic_hex_mark_blocks superblock 46
316 ic_hex_mark_blocks superblock 47
317 ic_hex_mark_blocks superblock 51
318 ic_hex_mark_blocks superblock 52
319 ic_hex_mark_blocks superblock 53
320 ic_hex_mark_blocks superblock 54
321 ic_hex_mark_blocks superblock 58
322 ic_hex_mark_blocks superblock 59
323 ic_hex_mark_blocks superblock 60
324 ic_hex_mark_blocks superblock 61
325 ic_hex_mark_blocks superblock 62
326 ic_hex_mark_blocks superblock 66
327 ic_hex_mark_blocks superblock 67
328 ic_hex_mark_blocks superblock 68
329 ic_hex_mark_blocks superblock 69
330 ic_hex_mark_blocks superblock 70
```

```
331  ic_hex_mark_blocks superblock 83
332  ic_hex_mark_blocks superblock 84
333  ic_hex_mark_blocks superblock 85
334  ic_hex_mark_blocks superblock 86
335  ic_hex_mark_blocks superblock 87
336  ic_hex_mark_blocks superblock 90
337  ic_hex_mark_blocks superblock 91
338  ic_hex_mark_blocks superblock 92
339  ic_hex_mark_blocks superblock 93
340  ic_hex_mark_blocks superblock 94
341  ic_hex_mark_blocks superblock 95
342  ic_hex_mark_blocks superblock 96
343  ic_hex_mark_blocks superblock 97
344  ic_hex_mark_blocks superblock 98
345  ic_hex_mark_blocks superblock 99
346  ic_hex_ogrid distance 80 fix_dist not_marked m VALLEY LIMIT INLET OUTLET BEAM_A
         AIR AUX -version 50
347  ic_hex_mark_blocks unmark
348
349
350  # Sizing (zone 2, outside)
351  set inc_s1 [expr {(1.4*$pre_dist)/(2*$n0+$n3+$n1+$n5)}]
352  ic_hex_place_node 163 [expr {0.3*$pre_dist}] [expr {$height+$h/2.0+0
         .7*$pre_dist}] 0
353  ic_hex_place_node 162 [expr {0.15*$pre_dist}] [expr {$height+$h/2.0+0
         .7*$pre_dist-$n0*$inc_s1}] 0
354  ic_hex_place_node 161 [expr {0.15*$pre_dist}] [expr {$height+$h/2.0+0
         .7*$pre_dist-($n0+$n3)*$inc_s1}] 0
355  ic_hex_place_node 160 [expr {0.15*$pre_dist}] [expr {$height+$h/2
         .0-0.7*$pre_dist+($n0+$n3)*$inc_s1}] 0
356  ic_hex_place_node 159 [expr {0.15*$pre_dist}] [expr {$height+$h/2
         .0-0.7*$pre_dist+$n0*$inc_s1}] 0
357  ic_hex_place_node 158 [expr {0.3*$pre_dist}] [expr {$height+$h/2
         .0-0.7*$pre_dist}] 0
358  ic_hex_align_vertices2 161 163 -nodes 162
359  ic_hex_align_vertices2 158 160 -nodes 159
360  ic_hex_place_node 107 curve:crv.03 [expr {($height+$h/2.0+1.05*(0.7*$pre_dist))
         /($h+2*$height)}]
361  ic_hex_place_node 47 curve:crv.03 [expr {($height+$h/2.0+1.05*(0
         .7*$pre_dist-$n0*$inc_s1))/($h+2*$height)}]
362  ic_hex_place_node 53 curve:crv.03 [expr {($height+$h/2.0+1.05*(0.7*$pre_dist-(
         $n0+$n3)*$inc_s1))/($h+2*$height)}]
363  ic_hex_place_node 59 curve:crv.03 [expr {($height+$h/2.0-1.05*(0.7*$pre_dist-(
         $n0+$n3)*$inc_s1))/($h+2*$height)}]
364  ic_hex_place_node 37 curve:crv.03 [expr {($height+$h/2.0-1.05*(0
         .7*$pre_dist-$n0*$inc_s1))/($h+2*$height)}]
365  ic_hex_place_node 89 curve:crv.03 [expr {($height+$h/2.0-1.05*(0.7*$pre_dist))
         /($h+2*$height)}]
366
367  ic_hex_place_node 181 [expr {1.7*$pre_dist}] [expr {$height+$h/2.0+0
         .7*$pre_dist}] 0
```

127

```
368  ic_hex_place_node 180 [expr {1.85*$pre_dist}] [expr {$height+$h/2.0+0
         .7*$pre_dist-$n0*$inc_s1}] 0
369  ic_hex_place_node 179 [expr {1.85*$pre_dist}] [expr {$height+$h/2.0+0
         .7*$pre_dist-($n0+$n3)*$inc_s1}] 0
370  ic_hex_place_node 178 [expr {1.85*$pre_dist}] [expr {$height+$h/2
         .0-0.7*$pre_dist+($n0+$n3)*$inc_s1}] 0
371  ic_hex_place_node 177 [expr {1.85*$pre_dist}] [expr {$height+$h/2
         .0-0.7*$pre_dist+$n0*$inc_s1}] 0
372  ic_hex_place_node 176 [expr {1.7*$pre_dist}] [expr {$height+$h/2
         .0-0.7*$pre_dist}] 0
373  ic_hex_align_vertices2 179 181 -nodes 180
374  ic_hex_align_vertices2 176 178 -nodes 177
375  ic_hex_place_node 114 curve:crv.04 [expr {($height+$h/2.0+1.1*(0.7*$pre_dist))
         /($h+2*$height)}]
376  ic_hex_place_node 50 curve:crv.04 [expr {($height+$h/2.0+1.1*(0
         .7*$pre_dist-$n0*$inc_s1))/($h+2*$height)}]
377  ic_hex_place_node 56 curve:crv.04 [expr {($height+$h/2.0+1.1*(0.7*$pre_dist-(
         $n0+$n3)*$inc_s1))/($h+2*$height)}]
378  ic_hex_place_node 62 curve:crv.04 [expr {($height+$h/2.0-1.1*(0.7*$pre_dist-(
         $n0+$n3)*$inc_s1))/($h+2*$height)}]
379  ic_hex_place_node 39 curve:crv.04 [expr {($height+$h/2.0-1.1*(0
         .7*$pre_dist-$n0*$inc_s1))/($h+2*$height)}]
380  ic_hex_place_node 95 curve:crv.04 [expr {($height+$h/2.0-1.1*(0.7*$pre_dist))/(
         $h+2*$height)}]
381
382  set inc_s2 [expr {(1.4*$pre_dist)/(2*$n00+4*$n2+$n10+2+$n6+$n8)}]
383  if {$d == 0} {set inc_s2 [expr {(1.4*$pre_dist)/(2*$n00+2*$n2+1+$n6+$n8)}]}
384  ic_hex_place_node 165 [expr {0.3*$pre_dist+$n00*$inc_s2}] [expr {$height+$h+0
         .85*$pre_dist}] 0
385  ic_hex_place_node 167 [expr {0.3*$pre_dist+($n00+$n2)*$inc_s2}] [expr {$height+
         $h+0.85*$pre_dist}] 0
386  ic_hex_place_node 169 [expr {0.3*$pre_dist+($n00+$n2+1)*$inc_s2}] [expr {
         $height+$h+0.85*$pre_dist}] 0
387  ic_hex_place_node 171 [expr {0.3*$pre_dist+($n00+2*$n2+1)*$inc_s2}] [expr {
         $height+$h+0.85*$pre_dist}] 0
388  ic_hex_place_node 173 [expr {1.7*$pre_dist-($n6+$n8)*$inc_s2}] [expr {$height+
         $h+0.85*$pre_dist}] 0
389  ic_hex_place_node 175 [expr {1.7*$pre_dist-($n8)*$inc_s2}] [expr {$height+$h+0
         .85*$pre_dist}] 0
390  ic_hex_align_vertices2 163 167 -nodes 165
391  ic_hex_align_vertices2 173 181 -nodes 175
392  ic_hex_place_node 86 curve:crv.02 [expr {($pre_dist-1.05*(0.7*$pre_dist))/(
         $pre_dist+$pos_dist)}]
393  ic_hex_place_node 34 curve:crv.02 [expr {($pre_dist-1.05*(0
         .7*$pre_dist-$n00*$inc_s2))/($pre_dist+$pos_dist)}]
394  ic_hex_place_node 70 curve:crv.02 [expr {($pre_dist-1.05*(0.7*$pre_dist-($n00+
         $n2)*$inc_s2))/($pre_dist+$pos_dist)}]
395  ic_hex_place_node 78 curve:crv.02 [expr {($pre_dist-1.05*(0.7*$pre_dist-($n00+
         $n2+1)*$inc_s2))/($pre_dist+$pos_dist)}]
396  ic_hex_place_node 44 curve:crv.02 [expr {($pre_dist-1.05*(0.7*$pre_dist-($n00+2
         *$n2+1)*$inc_s2))/($pre_dist+$pos_dist)}]
```

```
397 ic_hex_place_node 104 curve:crv.02 [expr {($pre_dist+1.05*(0.7*$pre_dist-($n6+
        $n8)*$inc_s2))/($pre_dist+$pos_dist)}]
398 ic_hex_place_node 124 curve:crv.02 [expr {($pre_dist+1.05*(0.7*$pre_dist-($n8)
        *$inc_s2))/($pre_dist+$pos_dist)}]
399 ic_hex_place_node 156 curve:crv.02 [expr {($pre_dist+1.05*(0.7*$pre_dist))/(
        $pre_dist+$pos_dist)}]
400
401 ic_hex_place_node 164 [expr {0.3*$pre_dist+$n00*$inc_s2}] [expr {
        $height-0.85*$pre_dist}] 0
402 ic_hex_place_node 166 [expr {0.3*$pre_dist+($n00+$n2)*$inc_s2}] [expr {
        $height-0.85*$pre_dist}] 0
403 ic_hex_place_node 168 [expr {0.3*$pre_dist+($n00+$n2+1)*$inc_s2}] [expr {
        $height-0.85*$pre_dist}] 0
404 ic_hex_place_node 170 [expr {0.3*$pre_dist+($n00+2*$n2+1)*$inc_s2}] [expr {
        $height-0.85*$pre_dist}] 0
405 ic_hex_place_node 172 [expr {1.7*$pre_dist-($n6+$n8)*$inc_s2}] [expr {
        $height-0.85*$pre_dist}] 0
406 ic_hex_place_node 174 [expr {1.7*$pre_dist-($n8)*$inc_s2}] [expr {
        $height-0.85*$pre_dist}] 0
407 ic_hex_align_vertices2 158 166 -nodes 164
408 ic_hex_align_vertices2 172 176 -nodes 174
409 ic_hex_place_node 81 curve:crv.01 [expr {($pre_dist-1.05*(0.7*$pre_dist))/(
        $pre_dist+$pos_dist)}]
410 ic_hex_place_node 33 curve:crv.01 [expr {($pre_dist-1.05*(0
        .7*$pre_dist-$n00*$inc_s2))/($pre_dist+$pos_dist)}]
411 ic_hex_place_node 65 curve:crv.01 [expr {($pre_dist-1.05*(0.7*$pre_dist-($n00+
        $n2)*$inc_s2))/($pre_dist+$pos_dist)}]
412 ic_hex_place_node 73 curve:crv.01 [expr {($pre_dist-1.05*(0.7*$pre_dist-($n00+
        $n2+1)*$inc_s2))/($pre_dist+$pos_dist)}]
413 ic_hex_place_node 42 curve:crv.01 [expr {($pre_dist-1.05*(0.7*$pre_dist-($n00+2
        *$n2+1)*$inc_s2))/($pre_dist+$pos_dist)}]
414 ic_hex_place_node 98 curve:crv.01 [expr {($pre_dist+1.05*(0.7*$pre_dist-($n6+
        $n8)*$inc_s2))/($pre_dist+$pos_dist)}]
415 ic_hex_place_node 117 curve:crv.01 [expr {($pre_dist+1.05*(0.7*$pre_dist-($n8)
        *$inc_s2))/($pre_dist+$pos_dist)}]
416 ic_hex_place_node 149 curve:crv.01 [expr {($pre_dist+1.05*(0.7*$pre_dist))/(
        $pre_dist+$pos_dist)}]
417
418 ic_hex_place_node 163 [expr {0.33*$pre_dist}] [expr {$height+$h+0.67*$pre_dist
        }] 0
419 ic_hex_place_node 158 [expr {0.33*$pre_dist}] [expr {$height-0.67*$pre_dist}] 0
420 ic_hex_place_node 181 [expr {1.67*$pre_dist}] [expr {$height+$h+0.67*$pre_dist
        }] 0
421 ic_hex_place_node 176 [expr {1.67*$pre_dist}] [expr {$height-0.67*$pre_dist}] 0
422
423
424
425 ######### 2 BEAM ADAPTATION
426
427 if {$d != 0} {
428
```

```
429  # Cutting beam B section
430  ic_point {} AUX pnt.55 pnt.11+vector([expr {($d-$b)/2}],0,0)
431  ic_hex_split_grid 112 113 pnt.17 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
432  ic_hex_split_grid 191 113 pnt.28 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
433  ic_hex_split_grid 191 205 pnt.19 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
434  ic_hex_split_grid 219 205 pnt.26 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
435  ic_hex_split_grid 112 191 pnt.55 m VALLEY LIMIT INLET OUTLET BEAM_A AIR VORFN
436
437
438  # Position of internal nodes
439  ic_hex_place_node 246 [expr {$pre_dist+$d/2.0}] [expr {$H+$h+0.05}] 0
440  ic_hex_place_node 245 [expr {$pre_dist+$d/2.0}] [expr {$H+$h-$t2-$h*0.05}] 0
441  ic_hex_place_node 244 [expr {$pre_dist+$d/2.0}] [expr {$H+$t3+$h*0.05}] 0
442  ic_hex_place_node 243 [expr {$pre_dist+$d/2.0}] [expr {$H-0.05}] 0
443
444
445  # Position of the nodes in the zone 1 boundary
446  set inc_s2 [expr {(1.2+$b+$d+$h)/(2*$n00+4*$n2+$n10+2)}]
447
448  ic_hex_place_node 133 [expr {$pre_dist-$b/2.0-$h/2.0-0.6+$n00*$inc_s2}] [expr {
         $H+1.5*$h+0.9}] 0
449  ic_hex_place_node 135 [expr {$pre_dist-$b/2.0-$h/2.0-0.6+($n00+$n2)*$inc_s2}] [
         expr {$H+1.5*$h+0.9}] 0
450  ic_hex_place_node 137 [expr {$pre_dist-$b/2.0-$h/2.0-0.6+($n00+$n2+1)*$inc_s2}]
          [expr {$H+1.5*$h+0.9}] 0
451  ic_hex_place_node 139 [expr {$pre_dist-$b/2.0-$h/2.0-0.6+($n00+2*$n2+1)*$inc_s2
         }] [expr {$H+1.5*$h+0.9}] 0
452  ic_hex_place_node 141 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d}] [expr {$H+1.5*$h
         +0.9}] 0
453  ic_hex_place_node 248 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d-($n00+2*$n2+1+$n10
         /2.0)*$inc_s2}] [expr {$H+1.5*$h+0.9}] 0
454  ic_hex_place_node 192 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d-($n00+2*$n2+1)
         *$inc_s2}] [expr {$H+1.5*$h+0.9}] 0
455  ic_hex_place_node 220 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d-($n00+$n2+1)
         *$inc_s2}] [expr {$H+1.5*$h+0.9}] 0
456  ic_hex_place_node 234 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d-($n00+$n2)*$inc_s2
         }] [expr {$H+1.5*$h+0.9}] 0
457  ic_hex_place_node 206 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d-$n00*$inc_s2}] [
         expr {$H+1.5*$h+0.9}] 0
458  set aux 0.45
459  if {[expr {$H-$h/2.0-0.9}] > 0.6} {set aux 0.9}
460  ic_hex_place_node 132 [expr {$pre_dist-$b/2.0-$h/2.0-0.6+$n00*$inc_s2}] [expr {
         $H-$h/2.0-$aux}] 0
461  ic_hex_place_node 134 [expr {$pre_dist-$b/2.0-$h/2.0-0.6+($n00+$n2)*$inc_s2}] [
         expr {$H-$h/2.0-$aux}] 0
462  ic_hex_place_node 136 [expr {$pre_dist-$b/2.0-$h/2.0-0.6+($n00+$n2+1)*$inc_s2}]
          [expr {$H-$h/2.0-$aux}] 0
463  ic_hex_place_node 138 [expr {$pre_dist-$b/2.0-$h/2.0-0.6+($n00+2*$n2+1)*$inc_s2
         }] [expr {$H-$h/2.0-$aux}] 0
464  ic_hex_place_node 140 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d}] [expr {$H-$h/2
         .0-$aux}] 0
```

130

```
465  ic_hex_place_node 241 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d-($n00+2*$n2+1+$n10
     /2.0)*$inc_s2}] [expr {$H-$h/2.0-$aux}] 0
466  ic_hex_place_node 185 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d-($n00+2*$n2+1)
     *$inc_s2}] [expr {$H-$h/2.0-$aux}] 0
467  ic_hex_place_node 213 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d-($n00+$n2+1)
     *$inc_s2}] [expr {$H-$h/2.0-$aux}] 0
468  ic_hex_place_node 227 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d-($n00+$n2)*$inc_s2
     }] [expr {$H-$h/2.0-$aux}] 0
469  ic_hex_place_node 199 [expr {$pre_dist+$b/2.0+$h/2.0+0.6+$d-$n00*$inc_s2}] [
     expr {$H-$h/2.0-$aux}] 0
470
471
472  # Position of the nodes in the zone 2 boundary
473  set inc_s2 [expr {(1.4*$pre_dist)/(2*$n00+4*$n2+$n10+2+$n6+$n8)}]
474  ic_hex_place_node 249 [expr {1.7*$pre_dist-($n6+$n8+$n00+2*$n2+1+$n10/2.0)
     *$inc_s2}] [expr {$H+$h+0.85*$pre_dist}] 0
475  ic_hex_place_node 193 [expr {1.7*$pre_dist-($n6+$n8+$n00+2*$n2+1)*$inc_s2}] [
     expr {$H+$h+0.85*$pre_dist}] 0
476  ic_hex_place_node 221 [expr {1.7*$pre_dist-($n6+$n8+$n00+$n2+1)*$inc_s2}] [expr
      {$H+$h+0.85*$pre_dist}] 0
477  ic_hex_place_node 235 [expr {1.7*$pre_dist-($n6+$n8+$n00+$n2)*$inc_s2}] [expr {
     $H+$h+0.85*$pre_dist}] 0
478  ic_hex_place_node 207 [expr {1.7*$pre_dist-($n6+$n8+$n00)*$inc_s2}] [expr {$H+
     $h+0.85*$pre_dist}] 0
479  ic_hex_place_node 250 curve:crv.02 [expr {($pre_dist+1.05*(0.7*$pre_dist-($n6+
     $n8+$n00+2*$n2+1+$n10/2.0)*$inc_s2))/($pre_dist+$pos_dist)}]
480  ic_hex_place_node 194 curve:crv.02 [expr {($pre_dist+1.05*(0.7*$pre_dist-($n6+
     $n8+$n00+2*$n2+1)*$inc_s2))/($pre_dist+$pos_dist)}]
481  ic_hex_place_node 222 curve:crv.02 [expr {($pre_dist+1.05*(0.7*$pre_dist-($n6+
     $n8+$n00+$n2+1)*$inc_s2))/($pre_dist+$pos_dist)}]
482  ic_hex_place_node 236 curve:crv.02 [expr {($pre_dist+1.05*(0.7*$pre_dist-($n6+
     $n8+$n00+$n2)*$inc_s2))/($pre_dist+$pos_dist)}]
483  ic_hex_place_node 208 curve:crv.02 [expr {($pre_dist+1.05*(0.7*$pre_dist-($n6+
     $n8+$n00)*$inc_s2))/($pre_dist+$pos_dist)}]
484  ic_hex_align_vertices2 163 171 -nodes 165 167 169
485  ic_hex_align_vertices2 207 181 -nodes 173 175
486
487  ic_hex_place_node 242 [expr {1.7*$pre_dist-($n6+$n8+$n00+2*$n2+1+$n10/2.0)
     *$inc_s2}] [expr {$H-0.85*$pre_dist}] 0
488  ic_hex_place_node 186 [expr {1.7*$pre_dist-($n6+$n8+$n00+2*$n2+1)*$inc_s2}] [
     expr {$H-0.85*$pre_dist}] 0
489  ic_hex_place_node 214 [expr {1.7*$pre_dist-($n6+$n8+$n00+$n2+1)*$inc_s2}] [expr
      {$H-0.85*$pre_dist}] 0
490  ic_hex_place_node 228 [expr {1.7*$pre_dist-($n6+$n8+$n00+$n2)*$inc_s2}] [expr {
     $H-0.85*$pre_dist}] 0
491  ic_hex_place_node 200 [expr {1.7*$pre_dist-($n6+$n8+$n00)*$inc_s2}] [expr {
     $H-0.85*$pre_dist}] 0
492  ic_hex_place_node 239 curve:crv.01 [expr {(1.7*$pre_dist-($n6+$n8+$n00+2*$n2+1+
     $n10/2.0)*$inc_s2)/($pre_dist+$pos_dist)}]
493  ic_hex_place_node 183 curve:crv.01 [expr {(1.7*$pre_dist-($n6+$n8+$n00+2*$n2+1)
     *$inc_s2)/($pre_dist+$pos_dist)}]
```

131

```
494  ic_hex_place_node 211 curve:crv.01 [expr {(1.7*$pre_dist-($n6+$n8+$n00+$n2+1)
         *$inc_s2)/($pre_dist+$pos_dist)}]
495  ic_hex_place_node 225 curve:crv.01 [expr {(1.7*$pre_dist-($n6+$n8+$n00+$n2)
         *$inc_s2)/($pre_dist+$pos_dist)}]
496  ic_hex_place_node 197 curve:crv.01 [expr {(1.7*$pre_dist-($n6+$n8+$n00)*$inc_s2
         )/($pre_dist+$pos_dist)}]
497  ic_hex_align_vertices2 158 170 -nodes 164 166 168
498  ic_hex_align_vertices2 200 176 -nodes 172 174
499
500
501  # Pre-mesh web trick
502  set inc_s2 [expr {$b/(2*$n2+1)}]
503  ic_hex_place_node 219 [expr {$pre_dist-$b/2.0+$n2*$inc_s2+$d}] [expr {$H+$h+0.6
         }] 0
504  ic_hex_place_node 218 curve:crv.22 [expr {$n2*$inc_s2/$b}]
505  ic_hex_place_node 215 curve:crv.28 [expr {($n2+1)*$inc_s2/$b}]
506  ic_hex_place_node 212 [expr {$pre_dist-$b/2.0+$n2*$inc_s2+$d}] [expr {$H-0.6}]
         0
507  ic_hex_place_node 233 [expr {$pre_dist-$b/2.0+($n2+1)*$inc_s2+$d}] [expr {$H+$h
         +0.6}] 0
508  ic_hex_place_node 232 curve:crv.22 [expr {($n2+1)*$inc_s2/$b}]
509  ic_hex_place_node 229 curve:crv.28 [expr {$n2*$inc_s2/$b}]
510  ic_hex_place_node 226 [expr {$pre_dist-$b/2.0+($n2+1)*$inc_s2+$d}] [expr {
         $H-0.6}] 0
511  }
512
513  ic_hex_place_node 102 [expr {$pre_dist+$b/2.0+0.6+$d}] [expr {$H+$h-$t2-0.1}] 0
514  ic_hex_place_node 101 [expr {$pre_dist+$b/2.0+0.6+$d}] [expr {$H+$t3+0.1}] 0
515
516
517  ############ BEAM CONTOUR
518
519  # Erasing beam internal blocks
520  ic_hex_mark_blocks unmark
521  ic_hex_mark_blocks superblock 27
522  ic_hex_mark_blocks superblock 39
523  ic_hex_mark_blocks superblock 46
524  ic_hex_mark_blocks superblock 38
525  ic_hex_mark_blocks superblock 14
526  ic_hex_mark_blocks superblock 37
527  ic_hex_mark_blocks superblock 44
528  ic_hex_change_element_id VORFN
529  ic_delete_empty_parts
530  if {$d!=0} {
531  ic_hex_mark_blocks unmark
532  ic_hex_mark_blocks superblock 152
533  ic_hex_mark_blocks superblock 178
534  ic_hex_mark_blocks superblock 191
535  ic_hex_mark_blocks superblock 177
536  ic_hex_mark_blocks superblock 150
537  ic_hex_mark_blocks superblock 176
```

```
538  ic_hex_mark_blocks superblock 189
539  ic_hex_change_element_id VORFN
540  ic_delete_empty_parts
541  }
542
543  # Beam association
544  ic_hex_set_edge_projection 48 69 0 1 crv.10
545  ic_hex_set_edge_projection 69 77 0 1 crv.10
546  ic_hex_set_edge_projection 77 49 0 1 crv.10
547  ic_hex_set_edge_projection 54 48 0 1 crv.09
548  ic_hex_set_edge_projection 55 49 0 1 crv.11
549  ic_hex_set_edge_projection 54 68 0 1 crv.08
550  ic_hex_set_edge_projection 76 55 0 1 crv.12
551  ic_hex_set_edge_projection 67 68 0 1 crv.07
552  ic_hex_set_edge_projection 75 76 0 1 crv.13
553  ic_hex_set_edge_projection 60 67 0 1 crv.06
554  ic_hex_set_edge_projection 75 61 0 1 crv.14
555  ic_hex_set_edge_projection 38 60 0 1 crv.05
556  ic_hex_set_edge_projection 43 61 0 1 crv.15
557  ic_hex_set_edge_projection 74 43 0 1 crv.16
558  ic_hex_set_edge_projection 66 74 0 1 crv.16
559  ic_hex_set_edge_projection 38 66 0 1 crv.16
560  if {$d!=0} {
561  ic_hex_set_edge_projection 190 218 0 1 crv.22
562  ic_hex_set_edge_projection 218 232 0 1 crv.22
563  ic_hex_set_edge_projection 232 204 0 1 crv.22
564  ic_hex_set_edge_projection 189 190 0 1 crv.21
565  ic_hex_set_edge_projection 203 204 0 1 crv.23
566  ic_hex_set_edge_projection 189 217 0 1 crv.20
567  ic_hex_set_edge_projection 231 203 0 1 crv.24
568  ic_hex_set_edge_projection 216 217 0 1 crv.19
569  ic_hex_set_edge_projection 230 231 0 1 crv.25
570  ic_hex_set_edge_projection 188 216 0 1 crv.18
571  ic_hex_set_edge_projection 230 202 0 1 crv.26
572  ic_hex_set_edge_projection 187 188 0 1 crv.17
573  ic_hex_set_edge_projection 201 202 0 1 crv.27
574  ic_hex_set_edge_projection 187 215 0 1 crv.28
575  ic_hex_set_edge_projection 215 229 0 1 crv.28
576  ic_hex_set_edge_projection 229 201 0 1 crv.28
577  }
578
579
580
581  ########### CUT TRICK
582
583  ic_hex_split_grid 83 84 0.5 m VALLEY LIMIT INLET OUTLET BEAM_A AIR AUX VORFN
584
585
586  ########### PRE-MESH
587
588  # Pre-mesh (zone 1, inside)
```

```
543  # Beam association
```

```
589  ic_hex_set_mesh 82 38 n $n00 h1 0.0 h2 0.003 r1 2 r2 1.2 lmax 0 default
         unlocked
590  ic_hex_set_mesh 84 54 n $n00 h1 0.0 h2 0.003 r1 2 r2 1.2 lmax 0 default
         unlocked
591  ic_hex_set_mesh 85 48 n $n00 h1 0.0 h2 0.003 r1 2 r2 1.2 lmax 0 default
         unlocked
592  ic_hex_set_mesh 83 60 n $n00 h1 0.0 h2 0.003 r1 2 r2 1.2 lmax 0 default
         unlocked
593  if {$d!=0} {
594  ic_hex_set_mesh 204 103 n $n00 h1 0.003 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
595  ic_hex_set_mesh 203 102 n $n00 h1 0.003 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
596  ic_hex_set_mesh 202 101 n $n00 h1 0.003 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
597  ic_hex_set_mesh 201 100 n $n00 h1 0.003 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
598  } else {
599  ic_hex_set_mesh 49 103 n $n00 h1 0.003 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
600  ic_hex_set_mesh 55 102 n $n00 h1 0.003 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
601  ic_hex_set_mesh 61 101 n $n00 h1 0.003 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
602  ic_hex_set_mesh 43 100 n $n00 h1 0.003 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
603  }
604
605  ic_hex_set_mesh 91 38 n $n0 h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0 default unlocked
606  ic_hex_set_mesh 92 66 n $n0 h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0 default unlocked
607  ic_hex_set_mesh 93 74 n $n0 h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0 default unlocked
608  ic_hex_set_mesh 94 43 n $n0 h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0 default unlocked
609  ic_hex_set_mesh 48 109 n $n0 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
610  ic_hex_set_mesh 69 110 n $n0 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
611  ic_hex_set_mesh 77 111 n $n0 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
612  ic_hex_set_mesh 49 112 n $n0 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
613  if {$d!=0} {
614  ic_hex_set_mesh 184 187 n $n0 h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0 default
         unlocked
615  ic_hex_set_mesh 212 215 n $n0 h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0 default
         unlocked
616  ic_hex_set_mesh 226 229 n $n0 h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0 default
         unlocked
617  ic_hex_set_mesh 198 201 n $n0 h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0 default
         unlocked
618  ic_hex_set_mesh 190 191 n $n0 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
```

```
619  ic_hex_set_mesh 218 219 n $n0 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
620  ic_hex_set_mesh 232 233 n $n0 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
621  ic_hex_set_mesh 204 205 n $n0 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
622  }
623
624  if {$d!=0} {
625  ic_hex_set_mesh 60 257 n [expr {$n1/2}] h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0
         default unlocked
626  ic_hex_set_mesh 257 54 n [expr {$n1/2}] h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0
         default unlocked
627  ic_hex_set_mesh 67 258 n [expr {$n1/2}] h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0
         default unlocked
628  ic_hex_set_mesh 258 68 n [expr {$n1/2}] h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0
         default unlocked
629  ic_hex_set_mesh 75 259 n [expr {$n1/2}] h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0
         default unlocked
630  ic_hex_set_mesh 259 76 n [expr {$n1/2}] h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0
         default unlocked
631  ic_hex_set_mesh 61 260 n [expr {$n1/2}] h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0
         default unlocked
632  ic_hex_set_mesh 260 55 n [expr {$n1/2}] h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0
         default unlocked
633  ic_hex_set_mesh 188 262 n [expr {$n1/2}] h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0
         default unlocked
634  ic_hex_set_mesh 262 189 n [expr {$n1/2}] h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0
         default unlocked
635  ic_hex_set_mesh 216 263 n [expr {$n1/2}] h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0
         default unlocked
636  ic_hex_set_mesh 263 217 n [expr {$n1/2}] h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0
         default unlocked
637  ic_hex_set_mesh 230 264 n [expr {$n1/2}] h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0
         default unlocked
638  ic_hex_set_mesh 264 231 n [expr {$n1/2}] h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0
         default unlocked
639  ic_hex_set_mesh 202 265 n [expr {$n1/2}] h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0
         default unlocked
640  ic_hex_set_mesh 265 203 n [expr {$n1/2}] h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0
         default unlocked
641  ic_hex_set_mesh 83 254 n [expr {$n1/2}] h1 0.008 h2 0.0 r1 1.12 r2 2 lmax 0
         default unlocked
642  ic_hex_set_mesh 254 84 n [expr {$n1/2}] h1 0.0 h2 0.008 r1 2 r2 1.12 lmax 0
         default unlocked
643  ic_hex_set_mesh 244 261 n [expr {$n1/2}] h1 [expr {0.0125*($d-$b)}] h2 0.0 r1 1
         .1 r2 2 lmax 0 default unlocked
644  ic_hex_set_mesh 261 245 n [expr {$n1/2}] h1 0.0 h2 [expr {0.0125*($d-$b)}] r1 2
          r2 1.1 lmax 0 default unlocked
645  ic_hex_set_mesh 101 266 n [expr {$n1/2}] h1 0.008 h2 0.0 r1 1.12 r2 2 lmax 0
         default unlocked
```

```
646  ic_hex_set_mesh 266 102 n [expr {$n1/2}] h1 0.0 h2 0.008 r1 2 r2 1.12 lmax 0
         default unlocked
647  } else {
648  ic_hex_set_mesh 60 187 n [expr {$n1/2}] h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0
         default unlocked
649  ic_hex_set_mesh 187 54 n [expr {$n1/2}] h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0
         default unlocked
650  ic_hex_set_mesh 67 188 n [expr {$n1/2}] h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0
         default unlocked
651  ic_hex_set_mesh 188 68 n [expr {$n1/2}] h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0
         default unlocked
652  ic_hex_set_mesh 75 189 n [expr {$n1/2}] h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0
         default unlocked
653  ic_hex_set_mesh 189 76 n [expr {$n1/2}] h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0
         default unlocked
654  ic_hex_set_mesh 61 190 n [expr {$n1/2}] h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0
         default unlocked
655  ic_hex_set_mesh 190 55 n [expr {$n1/2}] h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0
         default unlocked
656  ic_hex_set_mesh 83 184 n [expr {$n1/2}] h1 0.008 h2 0.0 r1 1.12 r2 2 lmax 0
         default unlocked
657  ic_hex_set_mesh 184 84 n [expr {$n1/2}] h1 0.0 h2 0.008 r1 2 r2 1.12 lmax 0
         default unlocked
658  ic_hex_set_mesh 101 191 n [expr {$n1/2}] h1 0.008 h2 0.0 r1 1.12 r2 2 lmax 0
         default unlocked
659  ic_hex_set_mesh 191 102 n [expr {$n1/2}] h1 0.0 h2 0.008 r1 2 r2 1.12 lmax 0
         default unlocked
660  }
661
662  ic_hex_set_mesh 54 68 n $n2 h1 0.004 h2 0.001 r1 1.2 r2 1.2 lmax 0 default
         unlocked
663  ic_hex_set_mesh 60 67 n $n2 h1 0.004 h2 0.001 r1 1.2 r2 1.2 lmax 0 default
         unlocked
664  ic_hex_set_mesh 76 55 n $n2 h1 0.001 h2 0.004 r1 1.2 r2 1.2 lmax 0 default
         unlocked
665  ic_hex_set_mesh 75 61 n $n2 h1 0.001 h2 0.004 r1 1.2 r2 1.2 lmax 0 default
         unlocked
666  ic_hex_set_mesh 48 69 n $n2 h1 0.004 h2 0.0 r1 1.2 r2 2 lmax 0 default unlocked
667  ic_hex_set_mesh 38 66 n $n2 h1 0.004 h2 0.0 r1 1.2 r2 2 lmax 0 default unlocked
668  ic_hex_set_mesh 77 49 n $n2 h1 0.0 h2 0.004 r1 2 r2 1.2 lmax 0 default unlocked
669  ic_hex_set_mesh 74 43 n $n2 h1 0.0 h2 0.004 r1 2 r2 1.2 lmax 0 default unlocked
670  ic_hex_set_mesh 109 110 n $n2 h1 0.008 h2 0.0 r1 1.1 r2 2 lmax 0 default
         unlocked
671  ic_hex_set_mesh 91 92 n $n2 h1 0.008 h2 0.0 r1 1.1 r2 2 lmax 0 default unlocked
672  ic_hex_set_mesh 111 112 n $n2 h1 0.0 h2 0.008 r1 2 r2 1.1 lmax 0 default
         unlocked
673  ic_hex_set_mesh 93 94 n $n2 h1 0.0 h2 0.008 r1 2 r2 1.1 lmax 0 default unlocked
674  if {$d!=0} {
675  ic_hex_set_mesh 189 217 n $n2 h1 0.004 h2 0.001 r1 1.2 r2 1.2 lmax 0 default
         unlocked
676  ic_hex_set_mesh 188 216 n $n2 h1 0.004 h2 0.001 r1 1.2 r2 1.2 lmax 0 default
```

```
            unlocked
677  ic_hex_set_mesh 231 203 n $n2 h1 0.001 h2 0.004 r1 1.2 r2 1.2 lmax 0 default
            unlocked
678  ic_hex_set_mesh 230 202 n $n2 h1 0.001 h2 0.004 r1 1.2 r2 1.2 lmax 0 default
            unlocked
679  ic_hex_set_mesh 190 218 n $n2 h1 0.004 h2 0.0 r1 1.2 r2 2 lmax 0 default
            unlocked
680  ic_hex_set_mesh 187 215 n $n2 h1 0.004 h2 0.0 r1 1.2 r2 2 lmax 0 default
            unlocked
681  ic_hex_set_mesh 232 204 n $n2 h1 0.0 h2 0.004 r1 2 r2 1.2 lmax 0 default
            unlocked
682  ic_hex_set_mesh 229 201 n $n2 h1 0.0 h2 0.004 r1 2 r2 1.2 lmax 0 default
            unlocked
683  ic_hex_set_mesh 191 219 n $n2 h1 0.008 h2 0.0 r1 1.1 r2 2 lmax 0 default
            unlocked
684  ic_hex_set_mesh 184 212 n $n2 h1 0.008 h2 0.0 r1 1.1 r2 2 lmax 0 default
            unlocked
685  ic_hex_set_mesh 233 205 n $n2 h1 0.0 h2 0.008 r1 2 r2 1.1 lmax 0 default
            unlocked
686  ic_hex_set_mesh 226 198 n $n2 h1 0.0 h2 0.008 r1 2 r2 1.1 lmax 0 default
            unlocked
687  }
688
689  ic_hex_set_mesh 54 48 n $n3 h1 0.002 h2 0.002 r1 1.2 r2 1.2 lmax 0 default
            unlocked
690  ic_hex_set_mesh 55 49 n $n3 h1 0.002 h2 0.002 r1 1.2 r2 1.2 lmax 0 default
            unlocked
691  if {$d!=0} {
692  ic_hex_set_mesh 189 190 n $n3 h1 0.002 h2 0.002 r1 1.2 r2 1.2 lmax 0 default
            unlocked
693  ic_hex_set_mesh 203 204 n $n3 h1 0.002 h2 0.002 r1 1.2 r2 1.2 lmax 0 default
            unlocked
694  }
695
696  ic_hex_set_mesh 38 60 n $n5 h1 0.002 h2 0.002 r1 1.2 r2 1.2 lmax 0 default
            unlocked
697  ic_hex_set_mesh 43 61 n $n5 h1 0.002 h2 0.002 r1 1.2 r2 1.2 lmax 0 default
            unlocked
698  if {$d!=0} {
699  ic_hex_set_mesh 187 188 n $n5 h1 0.002 h2 0.002 r1 1.2 r2 1.2 lmax 0 default
            unlocked
700  ic_hex_set_mesh 201 202 n $n5 h1 0.002 h2 0.002 r1 1.2 r2 1.2 lmax 0 default
            unlocked
701  }
702
703  ic_hex_set_mesh 100 119 n $n6 h1 0.0 h2 0.0 r1 2 r2 2 lmax 0 default unlocked
704
705  if {$d!=0} {
706  ic_hex_set_mesh 49 246 n [expr {$n10/2.0}] h1 0.003 h2 0.0 r1 1.2 r2 2 lmax 0
            default unlocked
707  ic_hex_set_mesh 55 245 n [expr {$n10/2.0}] h1 0.003 h2 0.0 r1 1.2 r2 2 lmax 0
```

```
        default unlocked
708  ic_hex_set_mesh 61 244 n [expr {$n10/2.0}] h1 0.003 h2 0.0 r1 1.2 r2 2 lmax 0
        default unlocked
709  ic_hex_set_mesh 43 243 n [expr {$n10/2.0}] h1 0.003 h2 0.0 r1 1.2 r2 2 lmax 0
        default unlocked
710  ic_hex_set_mesh 246 190 n [expr {$n10/2.0}] h1 0.0 h2 0.003 r1 2 r2 1.2 lmax 0
        default unlocked
711  ic_hex_set_mesh 245 189 n [expr {$n10/2.0}] h1 0.0 h2 0.003 r1 2 r2 1.2 lmax 0
        default unlocked
712  ic_hex_set_mesh 244 188 n [expr {$n10/2.0}] h1 0.0 h2 0.003 r1 2 r2 1.2 lmax 0
        default unlocked
713  ic_hex_set_mesh 243 187 n [expr {$n10/2.0}] h1 0.0 h2 0.003 r1 2 r2 1.2 lmax 0
        default unlocked
714  }
715
716
717  # Pre-mesh (zone 1, outside)
718  ic_hex_set_mesh 129 84 n 16 h1 0.0 h2 0.04 r1 2 r2 1.2 lmax 0 default
        copy_to_parallel unlocked
719
720
721  # Pre-mesh (zone 2, inside)
722  set n8 [expr {5/0.15}]
723  ic_hex_set_mesh 144 152 n $n8 h1 0.0 h2 0.0 r1 2 r2 2 lmax 0 default unlocked
724
725
726  # Pre-mesh (zone 2, outside)
727  set n9 [expr {0.85*$pre_dist/1.5+35}]
728  ic_hex_set_mesh 163 131 n $n9 h1 1.5 h2 0.15 r1 2 r2 1.02 lmax 0 default
        copy_to_parallel unlocked
729
730
731  # Pre-mesh (zone 3)
732  if {$d!=0} {
733  ic_hex_set_mesh 107 163 n [expr {0.2*$pre_dist}] h1rel 0.0 h2rel 0.0 r1 2 r2 2
        lmax 0 default copy_to_parallel unlocked
734  ic_hex_set_mesh 163 86 n [expr {($height-0.85*$pre_dist)}] h1rel 0.0 h2rel 0.0
        r1 2 r2 2 lmax 0 default copy_to_parallel unlocked
735  ic_hex_set_mesh 181 114 n [expr {($pos_dist-0.85*$pre_dist)}] h1rel 0.0 h2rel 0
        .0 r1 2 r2 2 lmax 0 default copy_to_parallel unlocked
736  ic_hex_set_mesh 81 158 n [expr {($height-0.85*$pre_dist)}] h1rel 0.0 h2rel 0.0
        r1 2 r2 2 lmax 0 default copy_to_parallel unlocked
737  } else {
738  ic_hex_set_mesh 107 163 n [expr {0.16*$pre_dist}] h1rel 0.0 h2rel 0.0 r1 2 r2 2
         lmax 0 default copy_to_parallel unlocked
739  ic_hex_set_mesh 163 86 n [expr {0.6*($height-0.85*$pre_dist)}] h1rel 0.0 h2rel
        0.0 r1 2 r2 2 lmax 0 default copy_to_parallel unlocked
740  ic_hex_set_mesh 181 114 n [expr {0.55*($pos_dist-0.85*$pre_dist)}] h1rel 0.0
        h2rel 0.0 r1 2 r2 2 lmax 0 default copy_to_parallel unlocked
741  ic_hex_set_mesh 81 158 n [expr {0.6*($height-0.85*$pre_dist)}] h1rel 0.0 h2rel
        0.0 r1 2 r2 2 lmax 0 default copy_to_parallel unlocked
```

```
742  }
743
744
745  # Cut trick pre-mesh
746  if {$d!=0} {
747  ic_hex_set_mesh 257 258 n $n2 h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0 default
         unlocked
748  ic_hex_set_mesh 259 260 n $n2 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
749  ic_hex_set_mesh 262 263 n $n2 h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0 default
         unlocked
750  ic_hex_set_mesh 264 265 n $n2 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
751  } else {
752  ic_hex_set_mesh 187 188 n $n2 h1 0.0 h2 0.001 r1 2 r2 1.2 lmax 0 default
         unlocked
753  ic_hex_set_mesh 189 190 n $n2 h1 0.001 h2 0.0 r1 1.2 r2 2 lmax 0 default
         unlocked
754  }
755
756
757
758  ########## FINAL PROCEDURES
759
760
761  # Computing pre-mesh
762  ic_hex_create_mesh VALLEY LIMIT INLET OUTLET BEAM_A AIR AUX proj 2 dim_to_mesh
         3
763
764
765  # Converting to unstructured mesh
766  ic_chdir $work_direc/$case_type/$case_name
767  ic_hex_write_file hex.uns VALLEY LIMIT INLET OUTLET BEAM_A AIR AUX proj 2
         dim_to_mesh 2 no_boco
768  ic_unload_mesh
769  ic_delete_empty_parts
770  ic_uns_load hex.uns 3 0 {} 1
771
772
773
774  ########################### SAVING FILES ###########################
775
776
777  ic_solver_mesh_info {ANSYS Fluent}
778  ic_solution_set_solver {ANSYS Fluent} 1
779  ic_boco_save $case_name.fbc
780  ic_boco_save_atr $case_name.atr
781  ic_save_tetin $case_name.tin 0 0 {} {} 0 0 1
782  ic_save_unstruct $case_name.uns 1 {} {} {}
783  ic_hex_save_blocking $case_name.blk
```

B.2 Job submission in Tegner

```python
import os,shutil,math

############################### INPUT ###############################

job_n=2
job_time='24:00:00'
allocation='2019-3-124'
submit_job=0

base_dir='/cfs/klemming/nobackup/g/gml/Master_Thesis/Simulations'
case_dir='Models/Parametric_study'
results_dir='Results/Fluent/Parametric_study'
job_files_dir='Job_files'

height_beams=[2,2,2,2,3,3,3,3]
distance_beams=[0,0,0,0,0,0,0,0,0]
width_beams=[0.9,0.9,0.9,0.9,0.9,0.9,0.9,0.9]
height_bridge=[120,120,120,120,120,120,120,120]

wind_speeds=[5,7.5,10,12.5,15]

steady_iterations=10000
time_step_n=6000
results_freq=2


############ GENERATING JOURNAL FILES & RESULT FOLDERS  ##############

# Building time step vector
time_step_length=[]
for v in range(0,len(wind_speeds)):
    if wind_speeds[v]==5:
        time_step_length.append(0.02)
    elif wind_speeds[v]==7.5:
        time_step_length.append(0.012)
    elif wind_speeds[v]==10:
        time_step_length.append(0.01)
    elif wind_speeds[v]==12.5:
        time_step_length.append(0.008)
    elif wind_speeds[v]==15:
        time_step_length.append(0.006)
    else:
        print('Specified speed out of the predetermined ones. Could not assign
            time step')
        print('Canceling job...')
        exit()

for c in range(0,len(height_beams)):

```

```python
49        # Paths
50        case_name='2D_'+str(height_beams[c])+'_'+str(distance_beams[c])+'_'+str(
              width_beams[c])+'_'+str(height_bridge[c])+'.cas'
51
52        if distance_beams[c]!=0:
53            case_type='Two_beams'
54        else:
55            case_type='One_beam'
56
57        # Results folders
58        for v in range(0,len(wind_speeds)):
59            results_folder=case_type+'/Results_2D_'+str(height_beams[c])+'_'+str(
                  distance_beams[c])+'_'+str(width_beams[c])+'_'+str(height_bridge[c
                  ])+'_'+str(wind_speeds[v]))
60            if os.path.isdir(base_dir+'/'+results_dir+'/'+results_folder):
61                n_files=len(os.listdir(base_dir+'/'+results_dir+'/'+results_folder)
                      )
62                print(results_folder+' already exists and has '+n_files+' files. Do
                       you want to overwrite it?')
63                answer=input(results_folder+' already exists and has '+n_files+'
                      files. Do you want to overwrite it?')
64                if answer=='yes':
65                    print('Overwriting...')
66                    shutil.rmtree(base_dir+'/'+results_dir+'/'+results_folder)
67                else:
68                    print('Canceling job...')
69                    exit()
70            os.makedirs(base_dir+'/'+results_dir+'/'+results_folder)
71
72        # Journal file
73        journal_file=open(base_dir+'/'+job_files_dir+'/Job_'+str(job_n)+'/journal_'
              +str(height_beams[c])+'_'+str(distance_beams[c])+'_'+str(width_beams[c
              ])+'_'+str(height_bridge[c])+'.jou','w')
74        journal_file.write('/file/set-tui-version "18.2" \n'+
75                           'chdir "'+base_dir+'" \n')
76        for v in range(0,len(wind_speeds)):
77            journal_file.write('/file/read-case "'+base_dir+'/'+case_dir+'/'+
                  case_name+'" \n'+
78                               '/define/models/steady? \n'+
79                               '/define/boundary-conditions/velocity-inlet inlet no
                                   no yes yes no '+str(wind_speeds[v])+
80                               ' no 0. no no no yes 10 28 \n'+
81                               '/solve/initialize/hyb-initialization \n'+
82                               '/solve/iterate 10000 \n'+
83                               '/define/models/unsteady-2nd-order? yes \n'+
84                               '/file/transient-export/ascii "'+base_dir+'/'+
                                   results_dir+'/'+results_folder+'/
                                   beam_a_pressure_cell" '+
85                               'beam_a () pressure face-area-magnitude x-face-
                                   area y-face-area dynamic-pressure total-
                                   pressure '+
```

```
86                                    'quit yes yes "export-1" '+str(results_freq)+'
                                          time-step \n')
87          if distance_beams[c]!=0:
88              journal_file.write('/file/transient-export/ascii "'+base_dir+'/'+
                   results_dir+'/'+results_folder+'/beam_b_pressure_cell" '+
89                                    'beam_b () pressure face-area-magnitude x-
                                          face-area y-face-area dynamic-pressure
                                          total-pressure '+
90                                    'quit yes yes "export-2" '+str(results_freq)
                                          +' time-step \n')
91          journal_file.write('/solve/set/time-step '+str(time_step_length[v])+' \
                n'+
92                              '/solve/dual-time-iterate '+str(time_step_n)+' 200 \
                                  n')
93      journal_file.write('exit yes')
94      journal_file.close()
95
96  #################### GENERATING BATCH FILE #######################
97
98  nodes_per_sim=int(math.floor(24/len(wind_speeds)))
99  print('Creating batch file... '+str(nodes_per_sim)+' nodes per simulation')
100
101 if height_beams[1]<1:
102     h='0'+str(int(10*height_beams[1]))
103 else:
104     h=str(int(10*height_beams[1]))
105
106 if distance_beams[1]<1:
107     d='0'+str(int(10*distance_beams[1]))
108 else:
109     d=str(int(10*distance_beams[1]))
110
111 if height_bridge[1]<1:
112     H='0'+str(int(10*height_bridge[1]))
113 else:
114     H=str(int(10*height_bridge[1]))
115
116
117 batch_file=open(base_dir+'/'+job_files_dir+'/Job_'+str(job_n)+'/run_fluent.sh',
        'w')
118 batch_file.write('#!/bin/bash \n\n'+
119                  '# Name of the job\n'+
120                  '#SBATCH -J '+str(job_n)+'_'+h+d+H+'\n\n'+
121                  '# Job estimated time\n'+
122                  '#SBATCH -t '+job_time+'\n\n'+
123                  '# Scania time allocation\n'+
124                  '#SBATCH -A '+allocation+'\n\n'+
125                  '# Number of nodes\n'+
126                  '#SBATCH -N -1\n\n'+
127                  '# Number of MPI processes per node\n'+
128                  '###SBATCH --ntasks-per-node=24\n\n'+
```

```
129                         '#SBATCH -e error_file.e\n'+
130                         '#SBATCH -o output_file.o\n\n'+
131                         '# load module fluent v19.2\n'+
132                         'module add fluent/19.2\n\n')
133
134  for c in range(0,len(wind_speeds)):
135       batch_file.write('fluent 2ddp -g -t '+str(nodes_per_sim)+' -i journal_'+str
                (height_beams[c])+'_'+str(distance_beams[c])+'_'+str(width_beams[c])+'_
                '+str(height_bridge[c])+'.jou > '+
136                         'sim_'+str(height_beams[c])+'_'+str(distance_beams[c])
                            +'_'+str(width_beams[c])+'_'+str(height_bridge[c])
                            +'.log &\n')
137
138  batch_file.write('wait')
139
140  batch_file.close()
141
142  ####################### SUBMITTING JOB ###########################
143
144  if submit_job==1:
145       os.chdir(base_dir+'/'+job_files_dir+'/Job_'+str(job_n))
146       batch_file=base_dir+'/'+job_files_dir+'/Job_'+str(job_n)+'/run_fluent.sh'
147       os.system('sbatch %s' % batch_file)
```

B.3   Read of Fluent outputs

```
1
2  clear, clf
3
4  %%%%%%%%%%%%%%%%%%%%%%%%%%%%% INPUTS %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
5
6  results_path="/cfs/klemming/nobackup/g/gml/Master_Thesis/Simulations/Results/
        Fluent/Parametric_study/Two_beams";
7  output_path="/cfs/klemming/nobackup/g/gml/Master_Thesis/Simulations/Results/
        Matlab/Parametric_study/Two_beams";
8
9  % Time and frequency domain characteristics
10 results_freq=2;
11
12 % Organization of Fluent files
13 cellID_column=1;
14 x_column=2;
15 y_column=3;
16 static_pressure_column=9;
17 face_area_column=8;
18 x_area_column=7;
19 y_area_column=6;
20
21
22 %%%%%%%%%%%%%%%%%%%%%%%%%%% STARTING OPERATIONS %%%%%%%%%%%%%%%%%%%%%%%%%%
```

```matlab
23
24  % Initializing variables
25  height_beams=[];
26  distance_beams=[];
27  width_beams=[];
28  height_bridge=[];
29  wind_speed=[];
30  time_step_length=[];
31
32  %parpool(24)
33
34
35  %%%%%%%%%%%%%%%%%%%%%%%%%%% GENERATING CASE VECTORS %%%%%%%%%%%%%%%%%%%%%%%%%%
36
37  t_0 = tic;
38
39  % Counting archives
40  files=dir(results_path);
41  disp(length(files)+" cases detected")
42
43  for c=3:length(files)
44      file_name=files(c).name;
45      fields=strfind(file_name,"_");
46      height_beams=[height_beams,str2num(char( ...
47          extractBetween(file_name,fields(2)+1,fields(3)-1)))];
48      distance_beams=[distance_beams,str2num(char( ...
49          extractBetween(file_name,fields(3)+1,fields(4)-1)))];
50      width_beams=[width_beams,str2num(char( ...
51          extractBetween(file_name,fields(4)+1,fields(5)-1)))];
52      height_bridge=[height_bridge,str2num(char( ...
53          extractBetween(file_name,fields(5)+1,fields(6)-1)))];
54      wind_speed=[wind_speed,str2num(char( ...
55          extractAfter(file_name,fields(6)+1)))];
56      if wind_speed(length(wind_speed))==2.5
57          time_step_length=[time_step_length,0.04];
58      elseif wind_speed(length(wind_speed))==5
59          time_step_length=[time_step_length,0.02];
60      elseif wind_speed(length(wind_speed))==7.5
61          time_step_length=[time_step_length,0.012];
62      elseif wind_speed(length(wind_speed))==10
63          time_step_length=[time_step_length,0.01];
64      elseif wind_speed(length(wind_speed))==12.5
65          time_step_length=[time_step_length,0.008];
66      elseif wind_speed(length(wind_speed))==15
67          time_step_length=[time_step_length,0.006];
68      elseif wind_speed(length(wind_speed))==20
69          time_step_length=[time_step_length,0.005];
70      elseif wind_speed(length(wind_speed))==30
71          time_step_length=[time_step_length,0.0032];
72      end
73  end
```

144

```
74
75  % Detecting 1 or 2 beam case
76  if distance_beams(1)==0
77      n_beams=1;
78  else
79      n_beams=2;
80  end
81
82
83  %%%%%%%%%%%%%%%% DRAG AND LIFT TIME SERIES CONSTRUCTION %%%%%%%%%%%%%%%%%
84
85  for c=1:length(wind_speed)
86
87      % Setting path to the corresponding Fluent files
88      case_path=results_path+"/Results_2D_"+height_beams(c)+"_" ...
89          +distance_beams(c)+"_"+width_beams(c)+"_"+height_bridge(c) ...
90          +"_"+wind_speed(c);
91      %if turbulence(c)~=0
92      %    case_path=case_path+"_"+turbulence(c);
93      %end
94      disp("Case "+c+" --> h = "+height_beams(c)+", d = " ...
95          +distance_beams(c)+", b = "+width_beams(c)+", H = " ...
96          +height_bridge(c)+", v = "+wind_speed(c))
97
98      % Counting number of files
99      n_files=numel(dir(case_path+"/*"));
100     n_data=round((n_files-2)/n_beams-0.25);
101     sim_time=n_data*results_freq*time_step_length(c);
102     disp(n_files+" archives, "+n_data+" time steps, "+sim_time ...
103         +" s of simulation");
104
105     % Initializing variables
106     drag=zeros(n_beams,n_data);
107     lift=zeros(n_beams,n_data);
108     tors=zeros(n_beams,n_data);
109
110     for b=1:n_beams % 1=beam_A, 2=beam_B
111
112         % Selecting beam A or B
113         if b==1
114             file_name="beam_a_pressure_cell";
115         else
116             file_name="beam_b_pressure_cell";
117         end
118
119         % Reading and treating data for each time step
120         parfor d=1:n_data %parfor
121
122             ts=d*results_freq;
123
124             % Reading fluent file
```

```matlab
125            n_numb=4;
126            name_num="";
127            for i=1:n_numb
128                if ts<10^(i-1)
129                    name_num=name_num+"0";
130                end
131            end
132            name_num=name_num+num2str(ts);
133            fluent_data=dlmread(case_path+"/"+file_name+"-"+name_num,",",1,0);
134
135            % Coordinates of the centroid
136            centroid_x=(max(fluent_data(:,x_column)) ...
137                +min(fluent_data(:,x_column)))/2;
138            centroid_y=(max(fluent_data(:,y_column)) ...
139                +min(fluent_data(:,y_column)))/2;
140
141            % Calculating drag and lift from element pressures
142            f_1=fluent_data(:,static_pressure_column) ...
143                .*fluent_data(:,x_area_column);
144            f_2=fluent_data(:,static_pressure_column) ...
145                .*fluent_data(:,y_area_column);
146            dist_centroid=[fluent_data(:,x_column)-centroid_x
147                           fluent_data(:,y_column)-centroid_y];
148            f_3=f_2*dist_centroid(1)-f_1*dist_centroid(2);
149            drag(b,d)=sum(f_1);
150            lift(b,d)=sum(f_2);
151            tors(b,d)=sum(f_3);
152        end
153    end
154
155    time_step_data=time_step_length(c)*results_freq;
156    save_file="Fluent2Matlab_2D_"+height_beams(c)+"_"+distance_beams(c) ...
157        +"_"+width_beams(c)+"_"+height_bridge(c)+"_"+wind_speed(c)+".mat";
158    %if turbulence~=0
159    %    save_file=save_file+"_"+turbulence(c)+".mat";
160    %else
161    %    save_file=save_file+".mat";
162    %end
163    save(output_path+"/"+save_file,"drag","lift","tors","time_step_data")
164 end
165
166 toc(t_0)
```

B.4 Parameter calculation and plots

B.4.1 One beam

```matlab
1 clear, clf
2
3 %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% INPUTS %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
4
5   % Folder where the matlab files are stored
6   results_folder="C:\Master_Thesis\4_PDC\Results\Matlab\Parametric_study\One_beam
        ";
7
8   % Time and frequency domain characteristics
9   steady_state_start=1001;
10
11  % Parameters of the model
12  density=1.225;
13  kin_visc=0.000017894/density;
14
15  % Precision of the frequency obtained
16  st_resolution=0.001;
17
18  % Plot configuration
19  avg_speeds=[2 3 4 5 6];
20  x_axis=1;
21  mean_speeds=1;
22  all_speeds=1;
23  draw_speeds=[2 3 4 5 6];
24
25
26  %%%%%%%%%%%%%%%%%%%%%%%%%% PRELIMINARY TASKS %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
27
28  files=dir(results_folder);
29  data=zeros(12,8,14);
30  data(:,:,3)=0.9;
31  data(:,:,1)=[2 2 2 2 2 2 2 2;
32              2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5;
33              3 3 3 3 3 3 3 3;
34              2 2 2 2 2 2 2 2;
35              2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5;
36              3 3 3 3 3 3 3 3;
37              2 2 2 2 2 2 2 2;
38              2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5;
39              3 3 3 3 3 3 3 3;
40              2 2 2 2 2 2 2 2;
41              2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5;
42              3 3 3 3 3 3 3 3];
43  data(:,:,4)=[120 120 120 120 120 120 120 120;
44              120 120 120 120 120 120 120 120;
45              120 120 120 120 120 120 120 120;
46              10 10 10 10 10 10 10 10;
47              10 10 10 10 10 10 10 10;
48              10 10 10 10 10 10 10 10;
49              5 5 5 5 5 5 5 5;
50              5 5 5 5 5 5 5 5;
51              5 5 5 5 5 5 5 5;
52              3 3 3 3 3 3 3 3;
53              3 3 3 3 3 3 3 3;
```

```
54                 3 3 3 3 3 3 3 3];
55  data(:,:,5)=[2.5 5 7.5 10 12.5 15 20 30;
56                 2.5 5 7.5 10 12.5 15 20 30;
57                 2.5 5 7.5 10 12.5 15 20 30;
58                 2.5 5 7.5 10 12.5 15 20 30;
59                 2.5 5 7.5 10 12.5 15 20 30;
60                 2.5 5 7.5 10 12.5 15 20 30;
61                 2.5 5 7.5 10 12.5 15 20 30;
62                 2.5 5 7.5 10 12.5 15 20 30;
63                 2.5 5 7.5 10 12.5 15 20 30;
64                 2.5 5 7.5 10 12.5 15 20 30;
65                 2.5 5 7.5 10 12.5 15 20 30;
66                 2.5 5 7.5 10 12.5 15 20 30];
67
68  if x_axis==1
69      x_axis_text="Beam height (m)";
70  elseif x_axis==4
71      x_axis_text="Bridge height (m)";
72  elseif x_axis==6
73      x_axis_text="h/H";
74  elseif x_axis==5
75      x_axis_text="Wind speed (m/s)";
76  else
77      x_axis_text="?";
78  end
79
80  if x_axis==4
81      org=[1 4 7 10;2 5 8 11;3 6 9 12];
82      leg={"h = 2 m","h = 2.5 m","h = 3 m"};
83  else
84      org=[10 11 12;7 8 9;4 5 6;1 2 3];
85      leg={"H = 3 m","H = 5 m","H = 10 m","Free flow"};
86  end
87
88
89  %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% LOADING DATA %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
90
91  for c=3:length(files)
92
93      % Reading parameters from file name
94      file_name=files(c).name;
95      fields=strfind(file_name,"_");
96      dots=strfind(file_name,".");
97      final=dots(length(dots));
98      h=str2num(char(extractBetween(file_name,fields(2)+1,fields(3)-1)));
99      d=str2num(char(extractBetween(file_name,fields(3)+1,fields(4)-1)));
100     b=str2num(char(extractBetween(file_name,fields(4)+1,fields(5)-1)));
101     H=str2num(char(extractBetween(file_name,fields(5)+1,fields(6)-1)));
102     v=str2num(char(extractBetween(file_name,fields(6)+1,final-1)));
103     param=[h d b H v];
104
```

```matlab
105     % Calculating position in data matrix
106     geom=1;
107     while geom<=size(data,1)
108         if squeeze(data(geom,1,1:4))==transpose(param(1:4))
109             break
110         end
111         geom=geom+1;
112     end
113
114     speed=1;
115     while speed<=size(data,2)
116         if data(1,speed,5)==param(5)
117             break
118         end
119         speed=speed+1;
120     end
121
122     data(geom,speed,1:5)=param;
123
124     % Loading data
125     load(results_folder+"\"+file_name)
126
127     %Recovering time step
128     time_steps_n=size(drag,2);
129
130     % Time and frequency domains construction
131     time_domain=time_step_data:time_step_data:time_steps_n*time_step_data;
132     time_domain_steady=time_domain(1,steady_state_start:time_steps_n);
133     steady_state_time=(time_steps_n-steady_state_start+1)*time_step_data;
134     freq_domain=0:1/steady_state_time:1/time_step_data-1/steady_state_time;
135
136     freq_resolution=st_resolution*v/h;
137     freq_domain_zp=0:freq_resolution:1/time_step_data-freq_resolution;
138
139     if d~=0
140         freq_lift=zeros(2,1);
141     else
142         freq_lift=zeros(1,1);
143     end
144
145     % Finding steady-state interval
146     drag_steady=drag(:,steady_state_start:time_steps_n);
147     lift_steady=lift(:,steady_state_start:time_steps_n);
148     tors_steady=tors(:,steady_state_start:time_steps_n);
149
150     % Mean values
151     mean_drag=mean(drag_steady,2);
152     mean_lift=mean(lift_steady,2);
153     mean_tors=mean(tors_steady,2);
154     drag_coeff=mean_drag*2/(h*v^2*density);
155     lift_coeff=mean_lift*2/(h*v^2*density);
```

```matlab
156     tors_coeff=mean_tors*2/(h^2*v^2*density);
157
158     rms_drag=sqrt(mean((drag_steady-mean_drag).^2,2));
159     rms_lift=sqrt(mean((lift_steady-mean_lift).^2,2));
160     rms_tors=sqrt(mean((tors_steady-mean_tors).^2,2));
161     rms_drag_coeff=rms_drag*2/(h*v^2*density);
162     rms_lift_coeff=rms_lift*2/(h*v^2*density);
163     rms_tors_coeff=rms_tors*2/(h^2*v^2*density);
164
165     % Calculating main frequency with zero padding for more accuracy
166     lift_norm=lift_steady-mean_lift;
167     zp=1/(freq_resolution*time_step_data);
168     spec_lift_zp=2*freq_resolution*time_step_data*abs(fft(lift_norm,zp,2));
169     pos=find(spec_lift_zp(1,:)==max(spec_lift_zp(1,:)));
170     freq_lift(1)=freq_domain_zp(pos(1));
171     if d~=0
172         pos=find(spec_lift_zp(2,:)==max(spec_lift_zp(2,:)));
173         freq_lift(2)=freq_domain_zp(pos(1));
174     end
175
176     % Strouhal number
177     St=freq_lift*h/v;
178     Strouhal=mean(St);
179
180     %Reynolds number
181     Reynolds=v*h/kin_visc;
182
183     data(geom,speed,6:9)=[h/b d/b H/b h/H];
184     data(geom,speed,11:18)=[Strouhal Reynolds drag_coeff rms_drag_coeff ...
185                     lift_coeff rms_lift_coeff tors_coeff rms_tors_coeff];
186
187 end
188
189
190
191 %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% PLOTS %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
192
193 if mean_speeds==1
194     var=11;
195     subplot(2,4,[1 5]), hold on
196     a1=plot(data(org(1,:),1,x_axis),mean(data(org(1,:),avg_speeds,var),2), ...
197         "Color",[0.8,0,0],"LineWidth",2);
198     a2=plot(data(org(2,:),1,x_axis),mean(data(org(2,:),avg_speeds,var),2), ...
199         "Color",[0,0.7,0],"LineWidth",2);
200     a3=plot(data(org(3,:),1,x_axis),mean(data(org(3,:),avg_speeds,var),2), ...
201         "Color",[0.2,0.2,0.8],"LineWidth",2);
202     a4=plot(data(org(4,:),1,x_axis),mean(data(org(4,:),avg_speeds,var),2), ...
203         "Color",[0.8,0.8,0],"LineWidth",2);
204     legend(leg)
205     title("Strouhal number"), xlabel(x_axis_text)
206     ylim([0.1 0.17])
```

150

```
207
208
209     var=13;
210     subplot(2,4,2), hold on
211     b1=plot(data(org(1,:),1,x_axis),mean(data(org(1,:),avg_speeds,var),2), ...
212         "Color",[0.8,0,0],"LineWidth",2);
213     b2=plot(data(org(2,:),1,x_axis),mean(data(org(2,:),avg_speeds,var),2), ...
214         "Color",[0,0.7,0],"LineWidth",2);
215     b3=plot(data(org(3,:),1,x_axis),mean(data(org(3,:),avg_speeds,var),2), ...
216         "Color",[0.2,0.2,0.8],"LineWidth",2);
217     b4=plot(data(org(4,:),1,x_axis),mean(data(org(4,:),avg_speeds,var),2), ...
218         "Color",[0.8,0.8,0],"LineWidth",2);
219     title("Drag coefficient"), xlabel(x_axis_text)
220
221     var=15;
222     subplot(2,4,3), hold on
223     c1=plot(data(org(1,:),1,x_axis),mean(data(org(1,:),avg_speeds,var),2), ...
224         "Color",[0.8,0,0],"LineWidth",2);
225     c2=plot(data(org(2,:),1,x_axis),mean(data(org(2,:),avg_speeds,var),2), ...
226         "Color",[0,0.7,0],"LineWidth",2);
227     c3=plot(data(org(3,:),1,x_axis),mean(data(org(3,:),avg_speeds,var),2), ...
228         "Color",[0.2,0.2,0.8],"LineWidth",2);
229     c4=plot(data(org(4,:),1,x_axis),mean(data(org(4,:),avg_speeds,var),2), ...
230         "Color",[0.8,0.8,0],"LineWidth",2);
231     title("Lift coefficient"), xlabel(x_axis_text)
232
233     var=17;
234     subplot(2,4,4), hold on
235     d1=plot(data(org(1,:),1,x_axis),mean(data(org(1,:),avg_speeds,var),2), ...
236         "Color",[0.8,0,0],"LineWidth",2);
237     d2=plot(data(org(2,:),1,x_axis),mean(data(org(2,:),avg_speeds,var),2), ...
238         "Color",[0,0.7,0],"LineWidth",2);
239     d3=plot(data(org(3,:),1,x_axis),mean(data(org(3,:),avg_speeds,var),2), ...
240         "Color",[0.2,0.2,0.8],"LineWidth",2);
241     d4=plot(data(org(4,:),1,x_axis),mean(data(org(4,:),avg_speeds,var),2), ...
242         "Color",[0.8,0.8,0],"LineWidth",2);
243     title("Torsional coefficient"), xlabel(x_axis_text)
244
245     var=14;
246     subplot(2,4,6), hold on
247     e1=plot(data(org(1,:),1,x_axis),mean(data(org(1,:),avg_speeds,var),2), ...
248         "Color",[0.8,0,0],"LineWidth",2);
249     e2=plot(data(org(2,:),1,x_axis),mean(data(org(2,:),avg_speeds,var),2), ...
250         "Color",[0,0.7,0],"LineWidth",2);
251     e3=plot(data(org(3,:),1,x_axis),mean(data(org(3,:),avg_speeds,var),2), ...
252         "Color",[0.2,0.2,0.8],"LineWidth",2);
253     e4=plot(data(org(4,:),1,x_axis),mean(data(org(4,:),avg_speeds,var),2), ...
254         "Color",[0.8,0.8,0],"LineWidth",2);
255     title("RMS drag coefficient"), xlabel(x_axis_text)
256
257     var=16;
```

```matlab
258     subplot(2,4,7), hold on
259     f1=plot(data(org(1,:),1,x_axis),mean(data(org(1,:),avg_speeds,var),2), ...
260         "Color",[0.8,0,0],"LineWidth",2);
261     f2=plot(data(org(2,:),1,x_axis),mean(data(org(2,:),avg_speeds,var),2), ...
262         "Color",[0,0.7,0],"LineWidth",2);
263     f3=plot(data(org(3,:),1,x_axis),mean(data(org(3,:),avg_speeds,var),2), ...
264         "Color",[0.2,0.2,0.8],"LineWidth",2);
265     f4=plot(data(org(4,:),1,x_axis),mean(data(org(4,:),avg_speeds,var),2), ...
266         "Color",[0.8,0.8,0],"LineWidth",2);
267     title("RMS lift coefficient"), xlabel(x_axis_text)
268
269     var=18;
270     subplot(2,4,8), hold on
271     g1=plot(data(org(1,:),1,x_axis),mean(data(org(1,:),avg_speeds,var),2), ...
272         "Color",[0.8,0,0],"LineWidth",2);
273     g2=plot(data(org(2,:),1,x_axis),mean(data(org(2,:),avg_speeds,var),2), ...
274         "Color",[0,0.7,0],"LineWidth",2);
275     g3=plot(data(org(3,:),1,x_axis),mean(data(org(3,:),avg_speeds,var),2), ...
276         "Color",[0.2,0.2,0.8],"LineWidth",2);
277     g4=plot(data(org(4,:),1,x_axis),mean(data(org(4,:),avg_speeds,var),2), ...
278         "Color",[0.8,0.8,0],"LineWidth",2);
279     title("RMS torsional coefficient"), xlabel(x_axis_text)
280 end
281
282 if all_speeds==1
283     var=11;
284     subplot(2,4,[1 5])
285     plot(data(org(1,:),1,x_axis),data(org(1,:),draw_speeds,var),":", ...
286         "Color",[0.8,0,0])
287     plot(data(org(2,:),1,x_axis),data(org(2,:),draw_speeds,var),":", ...
288         "Color",[0,0.8,0])
289     plot(data(org(3,:),1,x_axis),data(org(3,:),draw_speeds,var),":", ...
290         "Color",[0.2,0.2,0.8])
291     plot(data(org(4,:),1,x_axis),data(org(4,:),draw_speeds,var),":", ...
292         "Color",[0.8,0.8,0])
293     legend([a1 a2 a3 a4],leg)
294
295     var=13;
296     subplot(2,4,2)
297     plot(data(org(1,:),1,x_axis),data(org(1,:),draw_speeds,var),":", ...
298         "Color",[0.8,0,0])
299     plot(data(org(2,:),1,x_axis),data(org(2,:),draw_speeds,var),":", ...
300         "Color",[0,0.8,0])
301     plot(data(org(3,:),1,x_axis),data(org(3,:),draw_speeds,var),":", ...
302         "Color",[0.2,0.2,0.8])
303     plot(data(org(4,:),1,x_axis),data(org(4,:),draw_speeds,var),":", ...
304         "Color",[0.8,0.8,0])
305
306     var=15;
307     subplot(2,4,3)
308     plot(data(org(1,:),1,x_axis),data(org(1,:),draw_speeds,var),":", ...
```

```
309         "Color",[0.8,0,0])
310     plot(data(org(2,:),1,x_axis),data(org(2,:),draw_speeds,var),":", ...
311         "Color",[0,0.8,0])
312     plot(data(org(3,:),1,x_axis),data(org(3,:),draw_speeds,var),":", ...
313         "Color",[0.2,0.2,0.8])
314     plot(data(org(4,:),1,x_axis),data(org(4,:),draw_speeds,var),":", ...
315         "Color",[0.8,0.8,0])
316
317     var=17;
318     subplot(2,4,4)
319     plot(data(org(1,:),1,x_axis),data(org(1,:),draw_speeds,var),":", ...
320         "Color",[0.8,0,0])
321     plot(data(org(2,:),1,x_axis),data(org(2,:),draw_speeds,var),":", ...
322         "Color",[0,0.8,0])
323     plot(data(org(3,:),1,x_axis),data(org(3,:),draw_speeds,var),":", ...
324         "Color",[0.2,0.2,0.8])
325     plot(data(org(4,:),1,x_axis),data(org(4,:),draw_speeds,var),":", ...
326         "Color",[0.8,0.8,0])
327
328     var=14;
329     subplot(2,4,6)
330     plot(data(org(1,:),1,x_axis),data(org(1,:),draw_speeds,var),":", ...
331         "Color",[0.8,0,0])
332     plot(data(org(2,:),1,x_axis),data(org(2,:),draw_speeds,var),":", ...
333         "Color",[0,0.8,0])
334     plot(data(org(3,:),1,x_axis),data(org(3,:),draw_speeds,var),":", ...
335         "Color",[0.2,0.2,0.8])
336     plot(data(org(4,:),1,x_axis),data(org(4,:),draw_speeds,var),":", ...
337         "Color",[0.8,0.8,0])
338
339     var=16;
340     subplot(2,4,7)
341     plot(data(org(1,:),1,x_axis),data(org(1,:),draw_speeds,var),":", ...
342         "Color",[0.8,0,0])
343     plot(data(org(2,:),1,x_axis),data(org(2,:),draw_speeds,var),":", ...
344         "Color",[0,0.8,0])
345     plot(data(org(3,:),1,x_axis),data(org(3,:),draw_speeds,var),":", ...
346         "Color",[0.2,0.2,0.8])
347     plot(data(org(4,:),1,x_axis),data(org(4,:),draw_speeds,var),":", ...
348         "Color",[0.8,0.8,0])
349
350     var=18;
351     subplot(2,4,8)
352     plot(data(org(1,:),1,x_axis),data(org(1,:),draw_speeds,var),":", ...
353         "Color",[0.8,0,0])
354     plot(data(org(2,:),1,x_axis),data(org(2,:),draw_speeds,var),":", ...
355         "Color",[0,0.8,0])
356     plot(data(org(3,:),1,x_axis),data(org(3,:),draw_speeds,var),":", ...
357         "Color",[0.2,0.2,0.8])
358     plot(data(org(4,:),1,x_axis),data(org(4,:),draw_speeds,var),":", ...
359         "Color",[0.8,0.8,0])
```

```
360  end
361
362  sgtitle("One-beam simulations")
```

B.4.2   Two beams

```
1   clear, clf
2
3   %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% INPUTS %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
4
5   % Folder where the matlab files are stored
6   results_folder="C:\Master_Thesis\4_PDC\Results\Matlab\Parametric_study";
7   case_type="Two_beams_closed";
8
9   % Time and frequency domain characteristics
10  steady_state_start=1001;
11
12  % Parameters of the model
13  density=1.225;
14  kin_visc=0.000017894/density;
15
16  % Precision of the frequency obtained
17  st_resolution=0.001;
18
19  % Plot configuration
20  plot_beam=1; % 1=upwind, 2=downwind, 3=joined
21  plot_heights_bridge=[1 2 3 4];
22  avg_speeds=[1 2 3 4 5];
23  x_axis=1; % Parameter to put in the X axis
24  colors=[0.8 0 0;0 0.7 0;0.2 0.2 0.8;0.8,0.8,0];
25  lines=["-" "--" ":"];
26
27
28  %%%%%%%%%%%%%%%%%%%%%%%%%%%% PRELIMINARY TASKS %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
29
30  files=dir(results_folder+"\"+case_type);
31  data=zeros(36,5,18,3);
32  for beam=1:3
33      data(:,:,1,beam)=[2 2 2 2 2; 2 2 2 2 2; 2 2 2 2 2;
34                        2.5 2.5 2.5 2.5 2.5;
35                        2.5 2.5 2.5 2.5 2.5;
36                        2.5 2.5 2.5 2.5 2.5;
37                        3 3 3 3 3; 3 3 3 3 3; 3 3 3 3 3;
38                        2 2 2 2 2; 2 2 2 2 2; 2 2 2 2 2;
39                        2.5 2.5 2.5 2.5 2.5;
40                        2.5 2.5 2.5 2.5 2.5;
41                        2.5 2.5 2.5 2.5 2.5;
42                        3 3 3 3 3; 3 3 3 3 3; 3 3 3 3 3;
43                        2 2 2 2 2; 2 2 2 2 2; 2 2 2 2 2;
44                        2.5 2.5 2.5 2.5 2.5;
45                        2.5 2.5 2.5 2.5 2.5;
```

```
46                       2.5 2.5 2.5 2.5 2.5;
47                       3 3 3 3 3; 3 3 3 3 3; 3 3 3 3 3;
48                       2 2 2 2 2; 2 2 2 2 2; 2 2 2 2 2;
49                       2.5 2.5 2.5 2.5 2.5;
50                       2.5 2.5 2.5 2.5 2.5;
51                       2.5 2.5 2.5 2.5 2.5;
52                       3 3 3 3 3; 3 3 3 3 3; 3 3 3 3 3];
53     data(:,:,2,beam)=[2 2 2 2 2; 2.5 2.5 2.5 2.5 2.5; 3 3 3 3 3;
54                       2.5 2.5 2.5 2.5 2.5; 3 3 3 3 3; 3.5 3.5 3.5 3.5 3.5;
55                       3 3 3 3 3; 3.5 3.5 3.5 3.5 3.5; 4 4 4 4 4;
56                       2 2 2 2 2; 2.5 2.5 2.5 2.5 2.5; 3 3 3 3 3;
57                       2.5 2.5 2.5 2.5 2.5; 3 3 3 3 3; 3.5 3.5 3.5 3.5 3.5;
58                       3 3 3 3 3; 3.5 3.5 3.5 3.5 3.5; 4 4 4 4 4;
59                       2 2 2 2 2; 2.5 2.5 2.5 2.5 2.5; 3 3 3 3 3;
60                       2.5 2.5 2.5 2.5 2.5; 3 3 3 3 3; 3.5 3.5 3.5 3.5 3.5;
61                       3 3 3 3 3; 3.5 3.5 3.5 3.5 3.5; 4 4 4 4 4;
62                       2 2 2 2 2; 2.5 2.5 2.5 2.5 2.5; 3 3 3 3 3;
63                       2.5 2.5 2.5 2.5 2.5; 3 3 3 3 3; 3.5 3.5 3.5 3.5 3.5;
64                       3 3 3 3 3; 3.5 3.5 3.5 3.5 3.5; 4 4 4 4 4];
65     data(:,:,3,beam)=0.9;
66     data(:,:,4,beam)=[120 120 120 120 120; 120 120 120 120 120;
67                       120 120 120 120 120; 120 120 120 120 120;
68                       120 120 120 120 120; 120 120 120 120 120;
69                       120 120 120 120 120; 120 120 120 120 120;
70                       120 120 120 120 120;
71                       10 10 10 10 10; 10 10 10 10 10; 10 10 10 10 10;
72                       10 10 10 10 10; 10 10 10 10 10; 10 10 10 10 10;
73                       10 10 10 10 10; 10 10 10 10 10; 10 10 10 10 10;
74                       5 5 5 5 5; 5 5 5 5 5; 5 5 5 5 5;
75                       5 5 5 5 5; 5 5 5 5 5; 5 5 5 5 5;
76                       5 5 5 5 5; 5 5 5 5 5; 5 5 5 5 5;
77                       3 3 3 3 3; 3 3 3 3 3; 3 3 3 3 3;
78                       3 3 3 3 3; 3 3 3 3 3; 3 3 3 3 3;
79                       3 3 3 3 3; 3 3 3 3 3; 3 3 3 3 3];
80     data(:,:,5,beam)=[5 7.5 10 12.5 15; 5 7.5 10 12.5 15; 5 7.5 10 12.5 15;
81                       5 7.5 10 12.5 15; 5 7.5 10 12.5 15; 5 7.5 10 12.5 15;
82                       5 7.5 10 12.5 15; 5 7.5 10 12.5 15; 5 7.5 10 12.5 15;
83                       5 7.5 10 12.5 15; 5 7.5 10 12.5 15; 5 7.5 10 12.5 15;
84                       5 7.5 10 12.5 15; 5 7.5 10 12.5 15; 5 7.5 10 12.5 15;
85                       5 7.5 10 12.5 15; 5 7.5 10 12.5 15; 5 7.5 10 12.5 15;
86                       5 7.5 10 12.5 15; 5 7.5 10 12.5 15; 5 7.5 10 12.5 15;
87                       5 7.5 10 12.5 15; 5 7.5 10 12.5 15; 5 7.5 10 12.5 15;
88                       5 7.5 10 12.5 15; 5 7.5 10 12.5 15; 5 7.5 10 12.5 15;
89                       5 7.5 10 12.5 15; 5 7.5 10 12.5 15; 5 7.5 10 12.5 15;
90                       5 7.5 10 12.5 15; 5 7.5 10 12.5 15; 5 7.5 10 12.5 15;
91                       5 7.5 10 12.5 15; 5 7.5 10 12.5 15; 5 7.5 10 12.5 15];
92 end
93
94 if x_axis==1
95     x_axis_text="Beam height (m)";
96 elseif x_axis==2
```

```
97        x_axis_text="Distance between beams (m)";
98   elseif x_axis==4
99        x_axis_text="Bridge height (m)";
100  elseif x_axis==5
101        x_axis_text="Wind speed (m/s)";
102  elseif x_axis==6
103        x_axis_text="h/H";
104  else
105        x_axis_text="?";
106  end
107
108  if x_axis==2
109      org(1,:,:)=[28 29 30;31 32 33;34 35 36];
110      org(2,:,:)=[19 20 21;22 23 24;25 26 27];
111      org(3,:,:)=[10 11 12;13 14 15;16 17 18];
112      org(4,:,:)=[1 2 3;4 5 6;7 8 9];
113      leg_1={"H = 3 m","H = 5 m","H = 10 m","Free flow"};
114      leg_2={"h = 2 m","h = 2.5 m","h = 3 m"};
115  %elseif x_axis==10
116
117  else
118      org(1,:,:)=[28 31 34;29 32 35;30 33 36];
119      org(2,:,:)=[19 22 25;20 23 26;21 24 27];
120      org(3,:,:)=[10 13 16;11 14 17;12 15 18];
121      org(4,:,:)=[1 4 7;2 5 8;3 6 9];
122      leg_1={"H = 3 m","H = 5 m","H = 10 m","Free flow"};
123      leg_2={"d = h","d = h+0.5","d = h+1"};
124  end
125
126
127  %%%%%%%%%%%%%%%%%%%%%%%%%%%% LOADING DATA %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
128
129  for c=3:length(files)
130
131      % Reading parameters from file name
132      file_name=files(c).name;
133      fields=strfind(file_name,"_");
134      dots=strfind(file_name,".");
135      final=dots(length(dots));
136      h=str2num(char(extractBetween(file_name,fields(2)+1,fields(3)-1)));
137      d=str2num(char(extractBetween(file_name,fields(3)+1,fields(4)-1)));
138      b=str2num(char(extractBetween(file_name,fields(4)+1,fields(5)-1)));
139      H=str2num(char(extractBetween(file_name,fields(5)+1,fields(6)-1)));
140      v=str2num(char(extractBetween(file_name,fields(6)+1,final-1)));
141      param=[h d b H v];
142
143      % Calculating position in data matrix
144      geom=1;
145      while geom<=size(data,1)
146          if squeeze(data(geom,1,1:4))==transpose(param(1:4))
147              break
```

156

```matlab
148            end
149            geom=geom+1;
150        end
151
152        speed=1;
153        while speed<=size(data,2)
154            if data(1,speed,5)==param(5)
155                break
156            end
157            speed=speed+1;
158        end
159
160        data(geom,speed,1:5)=param;
161
162        % Loading data
163        load(results_folder+"\"+case_type+"\"+file_name)
164
165        %Recovering time step
166        time_steps_n=size(drag,2);
167
168        % Time and frequency domains construction
169        time_domain=time_step_data:time_step_data:time_steps_n*time_step_data;
170        time_domain_steady=time_domain(1,steady_state_start:time_steps_n);
171        steady_state_time=(time_steps_n-steady_state_start+1)*time_step_data;
172        freq_domain=0:1/steady_state_time:1/time_step_data-1/steady_state_time;
173
174        freq_resolution=st_resolution*v/h;
175        freq_domain_zp=0:freq_resolution:1/time_step_data-freq_resolution;
176
177        if d~=0
178            freq_lift=zeros(2,1);
179        else
180            freq_lift=zeros(1,1);
181        end
182
183        % Calculating time series with both beams joined
184        if case_type=="Two_beams"
185            drag(3,:)=drag(1,:)+drag(2,:);
186            lift(3,:)=lift(1,:)+lift(2,:);
187            tors(3,:)=tors(1,:)+tors(2,:)+(lift(2,:)-lift(1,:))*d/2;
188        end
189
190        % Finding steady-state interval
191        drag_steady=drag(:,steady_state_start:time_steps_n);
192        lift_steady=lift(:,steady_state_start:time_steps_n);
193        tors_steady=tors(:,steady_state_start:time_steps_n);
194        drag_coeff_steady=drag_steady*2/(h*v^2*density);
195        lift_coeff_steady=lift_steady*2/(h*v^2*density);
196        tors_coeff_steady=tors_steady*2/(h^2*v^2*density);
197
198        % Mean values
```

```
199        mean_drag=mean(drag_steady,2);
200        mean_lift=mean(lift_steady,2);
201        mean_tors=mean(tors_steady,2);
202        drag_coeff=mean(drag_coeff_steady,2);
203        lift_coeff=mean(lift_coeff_steady,2);
204        tors_coeff=mean(tors_coeff_steady,2);
205
206        rms_drag=sqrt(mean((drag_steady-mean_drag).^2,2));
207        rms_lift=sqrt(mean((lift_steady-mean_lift).^2,2));
208        rms_tors=sqrt(mean((tors_steady-mean_tors).^2,2));
209        rms_drag_coeff=sqrt(mean((drag_coeff_steady-drag_coeff).^2,2));
210        rms_lift_coeff=sqrt(mean((lift_coeff_steady-lift_coeff).^2,2));
211        rms_tors_coeff=sqrt(mean((tors_coeff_steady-tors_coeff).^2,2));
212
213        % Calculating main frequency with zero padding for more accuracy
214        lift_norm=lift_steady-mean_lift;
215        zp=1/(freq_resolution*time_step_data);
216        spec_lift_zp=2*freq_resolution*time_step_data*abs(fft(lift_norm,zp,2));
217        pos=find(spec_lift_zp(1,:)==max(spec_lift_zp(1,:)));
218        freq_lift(1)=freq_domain_zp(pos(1));
219        if d~=0 & case_type=="Two_beams"
220            pos=find(spec_lift_zp(2,:)==max(spec_lift_zp(2,:)));
221            freq_lift(2)=freq_domain_zp(pos(1));
222        end
223
224        % Strouhal number
225        St=freq_lift*h/v;
226        if case_type=="Two_beams"
227            Strouhal=mean(St);
228        else
229            Strouhal=St(1);
230        end
231
232        %Reynolds number
233        Reynolds=v*h/kin_visc;
234
235        if case_type=="Two_beams_closed"
236            beams=1;
237        else
238            beams=3;
239        end
240        for beam=1:beams
241            data(geom,speed,6:9,beam)=[h/b d/b H/b h/H];
242            data(geom,speed,11:18,beam)=[Strouhal Reynolds drag_coeff(beam) ...
243                rms_drag_coeff(beam) lift_coeff(beam) rms_lift_coeff(beam) ...
244                tors_coeff(beam) rms_tors_coeff(beam)];
245        end
246  end
247
248
249  %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% PLOTS %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

158

```matlab
250
251  var=11;
252  subplot(2,4,[1 5]), hold on
253  for x=1:3
254      plot(nan,nan,lines(x),"Color",[0.2,0.2,0.2],"LineWidth",2)
255  end
256  for x=1:3
257      for HH=plot_heights_bridge
258          plot(data(org(HH,x,:),1,x_axis,1),mean(data(org(HH,x,:),avg_speeds, ...
259              var,plot_beam),2),lines(x),"Color",colors(HH,:),"LineWidth",2);
260      end
261  end
262  title("Strouhal number"), xlabel(x_axis_text)
263  if case_type=="Two_beams_closed"
264      ylim([0.06 0.12])
265  else
266      ylim([0.12 0.18])
267  end
268
269  leg=legend([leg_2 leg_1(plot_heights_bridge)]);
270
271  var=13;
272  subplot(2,4,2), hold on
273  for x=1:3
274      for HH=plot_heights_bridge
275          plot(data(org(HH,x,:),1,x_axis,1),mean(data(org(HH,x,:),avg_speeds, ...
276              var,plot_beam),2),lines(x),"Color",colors(HH,:),"LineWidth",2);
277      end
278  end
279  title("Drag coefficient"), xlabel(x_axis_text)
280
281  var=15;
282  subplot(2,4,3), hold on
283  for x=1:3
284      for HH=plot_heights_bridge
285          plot(data(org(HH,x,:),1,x_axis,1),mean(data(org(HH,x,:),avg_speeds, ...
286              var,plot_beam),2),lines(x),"Color",colors(HH,:),"LineWidth",2);
287      end
288  end
289  title("Lift coefficient"), xlabel(x_axis_text)
290
291  var=17;
292  subplot(2,4,4), hold on
293  for x=1:3
294      for HH=plot_heights_bridge
295          plot(data(org(HH,x,:),1,x_axis,1),mean(data(org(HH,x,:),avg_speeds, ...
296              var,plot_beam),2),lines(x),"Color",colors(HH,:),"LineWidth",2);
297      end
298  end
299  title("Torsional coefficient"), xlabel(x_axis_text)
300
```

```matlab
301  var=14;
302  subplot(2,4,6), hold on
303  for x=1:3
304      for HH=plot_heights_bridge
305          plot(data(org(HH,x,:),1,x_axis,1),mean(data(org(HH,x,:),avg_speeds, ...
306              var,plot_beam),2),lines(x),"Color",colors(HH,:),"LineWidth",2);
307      end
308  end
309  title("RMS drag coefficient"), xlabel(x_axis_text)
310
311  var=16;
312  subplot(2,4,7), hold on
313  for x=1:3
314      for HH=plot_heights_bridge
315          plot(data(org(HH,x,:),1,x_axis,1),mean(data(org(HH,x,:),avg_speeds, ...
316              var,plot_beam),2),lines(x),"Color",colors(HH,:),"LineWidth",2);
317      end
318  end
319  title("RMS lift coefficient"), xlabel(x_axis_text)
320
321  var=18;
322  subplot(2,4,8), hold on
323  for x=1:3
324      for HH=plot_heights_bridge
325          plot(data(org(HH,x,:),1,x_axis,1),mean(data(org(HH,x,:),avg_speeds, ...
326              var,plot_beam),2),lines(x),"Color",colors(HH,:),"LineWidth",2);
327      end
328  end
329  title("RMS torsional coefficient"), xlabel(x_axis_text)
330
331  if case_type=="Two_beams_closed"
332      text_beam="closed beams";
333  elseif plot_beam==1
334      text_beam="beam A";
335  elseif plot_beam==2
336      text_beam="beam B";
337  elseif plot_beam==3
338      text_beam="joined beams";
339  end
340
341  sgtitle("Two-beam simulations ("+text_beam+")")
```

B.5   Eurocode application

B.5.1   Buffeting response

```matlab
1  clear, clf
2
3  %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% INPUTS %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
4
```

```matlab
5  % Each row is a situation (single beam, double beam...)
6  % Each column is an alternative design
7
8  % Geometrical parameters
9  h=[2.5 2.75 2.5 2.5 2.5; % Beam height
10     2.5 2.75 2.5 2.5 2.5;
11     2.5 2.75 2.5 2.5 2.5];
12 b=[0.9 0.9 1 0.9 0.9; % Beam width
13     0.9 0.9 1 0.9 0.9;
14     0.9 0.9 1 0.9 0.9];
15 d=[0 0 0 0 0; % Beam distance
16     0 0 0 0 0; % Structurally acts as a single beam, only changes the flow
17     2.5 2.5 2.5 2.75 2.5];
18 H=9.5-h; % Height of the bridge
19 L_b=42; % Bridge length
20
21 % Flow properties
22 dens=1.25; % Air density
23 Cd=[2.82 2.887 2.86 2.82 2.82; % Drag coefficient
24     2.5 2.546 2.524 2.461 2.5;
25     1.878 1.937 1.936 1.776 1.9];
26
27 % Eurocode parameters
28 z_o=0.3; % Terrain roughness
29 z_min=5; % Minimum height
30 c_o=1; % Orography factor
31 d_s=0.02; % Logarithmic decrement of damping
32
33 % Structure properties
34 n=[0.9076 0.8894 1.0286 0.9076 0.9076; % Natural frequency of the structure
35     0.9076 0.8894 1.0286 0.9076 0.9076;
36     0.9222 0.902 1.0385 0.9309 0.9222];
37 f_s=460000000; % Steel elastic limit
38
39 % Plotting configuration
40 colors=[0 0 0;0.8 0 0;0.2 0.2 0.8;0 0.7 0;0.8 0.6 0]; % For each alternative
41 lines=["-" "--" ":"]; % For each situation
42
43
44 %%%%%%%%%%%%%%%%%%%%%%%%%%%% CALCULATIONS %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
45
46 v_b=1:0.1:80; % Range of wind speeds tested
47 v_max=zeros(3,5);
48
49 % Initialization plots
50 subplot(3,2,[1 3]), plot([0 100],[460 460],"Color",[0.6 0.3 0.9]), hold on
51 subplot(3,2,[2 4]), plot([0 100],[460 460],"Color",[0.6 0.3 0.9]), hold on
52 for sit=1:3 % "ghost" lines to include in the legend afterwards
53     plot(nan,nan,lines(sit),"Color",[0.5,0.5,0.5],"LineWidth",1.5)
54 end
55
```

```matlab
56  for sit=1:3
57      for alt=1:5
58
59          % Reference height
60          z_ref=H(sit,alt)+h(sit,alt)/2;
61
62          if z_ref>z_min
63              v_m=v_b*0.19*(z_o/0.05)^0.07*log(z_ref/z_o);
64          else
65              v_m=v_b*0.19*(z_o/0.05)^0.07*log(z_min/z_o);
66          end
67
68          % Velocity pressure
69          I_v=1/(c_o*log(z_ref/z_o)); % Turbulence intensity
70          q_p=(1+7*I_v)/2*dens*v_m.^2; % Peak pressure
71
72          % Integral length scale
73          L_t=300;
74          z_t=200;
75          alpha=0.67+0.05*log(z_o);
76          if z_ref>z_min
77              L=L_t*(z_ref/z_t)^alpha;
78          else
79              L=L_t*(z_min/z_t)^alpha;
80          end
81
82          % Normalised power-spectral density function
83          f_L=n(sit,alt)*L./v_m; % Normalised frequency
84          S_L=6.8*f_L./(1+10.2*f_L).^(5/3);
85
86          % Background response factor "B2"
87          B2=1/(1+3/2*sqrt((L_b/L)^2+(h(sit,alt)/L)^2+(L_b*h(sit,alt)/L^2)^2));
88
89          % Resonance factor "R2"
90          G_y=4/pi^2; % Sinusoidal mode shape
91          G_z=1/2; % No variation in the vertical direction
92          c_y=11.5; % Decay constants
93          c_z=11.5;
94          Phi_y=c_y*L_b*n(sit,alt)./v_m;
95          Phi_z=c_z*h(sit,alt)*n(sit,alt)./v_m;
96          K_s=1./(1+sqrt((G_y*Phi_y).^2+(G_z*Phi_z).^2 ...
97              +(2/pi*G_y*Phi_y*G_z.*Phi_z).^2));
98          R2=pi^2/2/d_s*S_L.*K_s;
99
100         % Peak factor
101         T=600;
102         v=n(sit,alt)*sqrt(R2/(B2+R2));
103         k_p=max([sqrt(2*log(v*T))+0.6/sqrt(2*log(v*T)) 3]);
104
105         % Structural factor
106         c_s=(1+7*I_v*sqrt(B2))/(1+7*I_v);
```

```matlab
107            c_d=(1+2*k_p*I_v*sqrt(B2+R2))/(1+7*I_v*sqrt(B2));
108
109            % Force per unit length (N/m)
110            F_w=c_s*c_d*Cd(sit,alt).*q_p*h(sit,alt);
111
112            % Maximum stress in elastic behaviour
113            M_max=F_w*L_b^2/8;
114            if d(sit,alt)~=0    % If there are two beams each receives
115                M_max=M_max/2;  % half the moment because they deform
116            end                 % independently (see Section 5.4.1)
117            I_z=0.02^3*(h(sit,alt)-0.085)/12+(0.085)*b(sit,alt)^3/12;
118            max_stress=M_max/I_z*b(sit,alt)/2;
119
120            % Finding maximum wind speed without plastic effects in the material
121            for i=2:length(v_m)
122                if (max_stress(i-1)-f_s)*(max_stress(i)-f_s)<0
123                    v_max(sit,alt)=v_m(i-1);
124                end
125            end
126
127            % Plotting stress-wind speed lines
128            subplot(3,2,[1 3])
129            plot(v_m,max_stress/1000000,lines(sit),"Color",colors(alt,:), ...
130                "LineWidth",1.5)
131            subplot(3,2,[2 4])
132            plot(v_b,max_stress/1000000,lines(sit),"Color",colors(alt,:), ...
133                "LineWidth",1.5)
134        end
135 end
136
137 % Configuration of the plots
138 subplot(3,2,[1 3]), ylim([0 600]), xlim([0 max(v_m)])
139 ylabel("Maximum elastic stress (MPa)","FontSize",18)
140 xlabel("Mean wind speed at the reference height (m/s)","FontSize",18)
141 subplot(3,2,[2 4]), ylim([0 600]), xlim([0 max(v_b)])
142 ylabel("Maximum elastic stress (MPa)","FontSize",18)
143 xlabel("Basic wind speed at 10 meters height (m/s)","FontSize",18)
144 legend(["Elastic limit" "Single beam" "Two beams (free)" ...
145     "Two beams (joined)" "Banafjal" "Alt. 1" "Alt. 2" "Alt. 3" ...
146     "Alt. 4"],"Orientation","horizontal","FontSize",18)
```

B.5.2 Vortex shedding response

```matlab
1 clear
2
3 %%%%%%%%%%%%%%%%%%%%%%%%%%%%% INPUTS %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
4
5 % Each row is a situation (single beam, double beam...)
6 % Each column is an alternative design
7
8 % Geometrical parameters
```

```matlab
9   h=[2.5 2.75 2.5 2.5 2.5; % Beam height
10      2.5 2.75 2.5 2.5 2.5;
11      2.5 2.75 2.5 2.5 2.5];
12  b=[0.9 0.9 1 0.9 0.9; % Beam width
13      0.9 0.9 1 0.9 0.9;
14      0.9 0.9 1 0.9 0.9];
15  d=[0 0 0 0 0; % Beam distance
16      0 0 0 0 0; % Structurally acts as a single beam, only changes the flow
17      2.5 2.5 2.5 2.75 2.5];
18  H=9.5-h; % Height of the bridge
19  L_b=42; % Bridge length
20
21  % Physical characteristics
22  steel_dens=7850;
23  air_dens=1.25;
24
25  % Mode
26  n=[0.9076 0.8894 1.0286 0.9076 0.9076; % Natural frequency of the structure
27      0.9076 0.8894 1.0286 0.9076 0.9076;
28      0.9222 0.902 1.0385 0.9309 0.9222];
29  n=2*n;
30  mode_direction=["hor" "hor" "hor" "hor" "hor"; % "hor" or "vertical"
31                  "hor" "hor" "hor" "hor" "hor";
32                  "hor" "hor" "hor" "hor" "hor"];
33  shape=["simply" "simply" "simply" "simply" "simply"; %"simply" or "clamped"
34         "simply" "simply" "simply" "simply" "simply";
35         "simply" "simply" "simply" "simply" "simply"];
36
37  % Procedure parameters
38  d_s=0.02; % Damping logarithmic decrement provided by Eurocode
39  St=[0.1466 0.1446 0.1473 0.1466 0.1466; % Strouhal number
40      0.1642 0.1667 0.1626 0.1636 0.1642;
41      0.1642 0.1667 0.1626 0.1636 0.1118];
42  c_lat=[0.517 0.5218 0.473 0.517 0.517; % RMS in the ode shape direction
43         0.237 0.2599 0.2155 0.2376 0.237;
44         0.2712 0.2835 0.2561 0.2484 0.0355];
45
46  %%%%%%%%%%%%%%%%%%%%%%%%%%%%% CALCULATIONS %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
47
48  % Initialization of output variables
49  v_crit=zeros(3,5);
50  max_stress=zeros(3,5);
51  y_max=zeros(3,5);
52  a_max=zeros(3,5);
53
54  % Calculation of each case/situation
55  for sit=1:3
56      for alt=1:5
57
58          %%%%%%%%%%%%%%%%%%%%%%%% PRELIMINARY CALCULATIONS
59
```

```matlab
60          % Section properties
61          area=h(sit,alt)*b(sit,alt)-(h(sit,alt)-0.085)*(b(sit,alt)-0.02);
62          % Moment of inertia
63          if mode_direction=="hor"
64              I=0.02^3*(h(sit,alt)-0.085)/12+(0.085)*b(sit,alt)^3/12;
65          elseif mode_direction=="vertical"
66              I=h^3*b(sit,alt)/12-(h(sit,alt)-0.085)^3*(b(sit,alt)-0.02)/12;
67          else
68              disp('Error: mode_direction must be "hor" or "vertical".')
69              exit
70          end
71          if d~=0 % In the case there are two beams
72              if mode_direction=="hor"
73                  %I=2*(I+area*d/2); % Assuming integrated behaviour
74                  I=2*I; % Each beam deforms independently (see Section 5.4.1)
75              else
76                  I=2*I;
77              end
78              area=2*area;
79          end


82          %%%%%%%%%%%%%%%%%%%%%%%%%% EUROCODE APPLICATION

84          % Equivalent mass
85          m_e=area*steel_dens;

87          % Scruton number
88          Sc=2*d_s*m_e/air_dens/h(sit,alt)^2;

90          % Strouhal number
91          if mode_direction=="hor"
92              St(sit,alt)=St(sit,alt)*2;
93              % Simulates the double frequency in the along-wind direction
94          end

96          % Iterative process
97          y_max(sit,alt)=0.5*h(sit,alt); % Only initial value for iterations
98          crit=0; % Stop criterion will be 1 when convergence arrives
99          iterations=0; % Counter of iterations
100         while crit==0
101             iterations=iterations+1;

103             % Correlation length
104             if y_max(sit,alt)/h(sit,alt)<0.1
105                 L=6*b(sit,alt);
106             elseif y_max(sit,alt)>0.6
107                 L=12*b(sit,alt);
108             else
109                 L=4.8*b(sit,alt)+12*y_max(sit,alt);
110             end
```

```matlab
111
112            % Correlation length factor
113            if shape=="simply"
114                K_w=cos(pi/2*(1-L/L_b));
115                K=0.1;
116            elseif shape=="clamped"
117                K_w=L/L_b+sin(pi*(1-L/L_b))/pi;
118                K=0.11;
119            else
120                disp('Error: shape must be "simply" or "clamped".')
121                exit
122            end
123
124            % Maximum displacement
125            y_max_old=y_max(sit,alt);
126            y_max(sit,alt)=h(sit,alt)*K*K_w*c_lat(sit,alt)/St(sit,alt)^2/Sc;
127
128            % Convergence?
129            if abs(y_max(sit,alt)/y_max_old-1)<0.001
130                crit=1;
131            end
132        end
133
134        % Critical speed
135        v_crit(sit,alt)=h(sit,alt)*n(sit,alt)/St(sit,alt);
136
137
138        %%%%%%%%%%%%%%%%%%%%%%%%%%%%% MAXIMUM STRESS
139
140        % Moment at middle span
141        if shape=="simply"
142            M=m_e*(2*pi*n(sit,alt))^2*y_max(sit,alt)*(L_b/pi)^2;
143        else
144            M=m_e*(2*pi*n(sit,alt))^2*y_max(sit,alt)*((L_b/2/pi)^2+(L_b/4)^2);
145        end
146
147        % Maximum stress
148        if mode_direction=="hor"
149            max_stress(sit,alt)=M/I*b(sit,alt)/2;
150        else
151            max_stress(sit,alt)=M/I*h(sit,alt)/2;
152        end
153
154        a_max(sit,alt)=y_max(sit,alt)*(2*pi*n(sit,alt))^2;
155
156    end
157 end
```