بسم الله النور

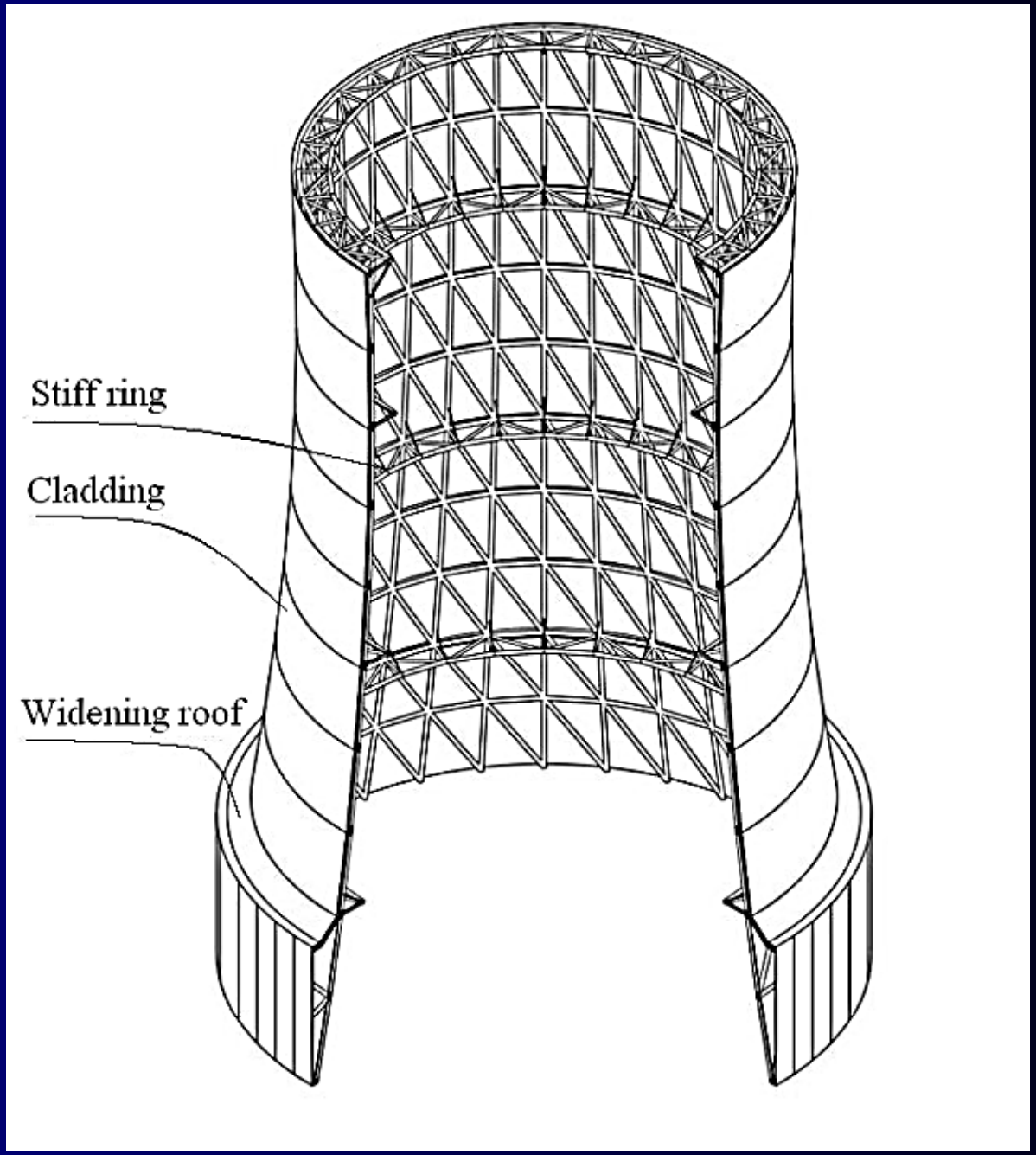
Lattice Steel Cooling Towers for Power Plants

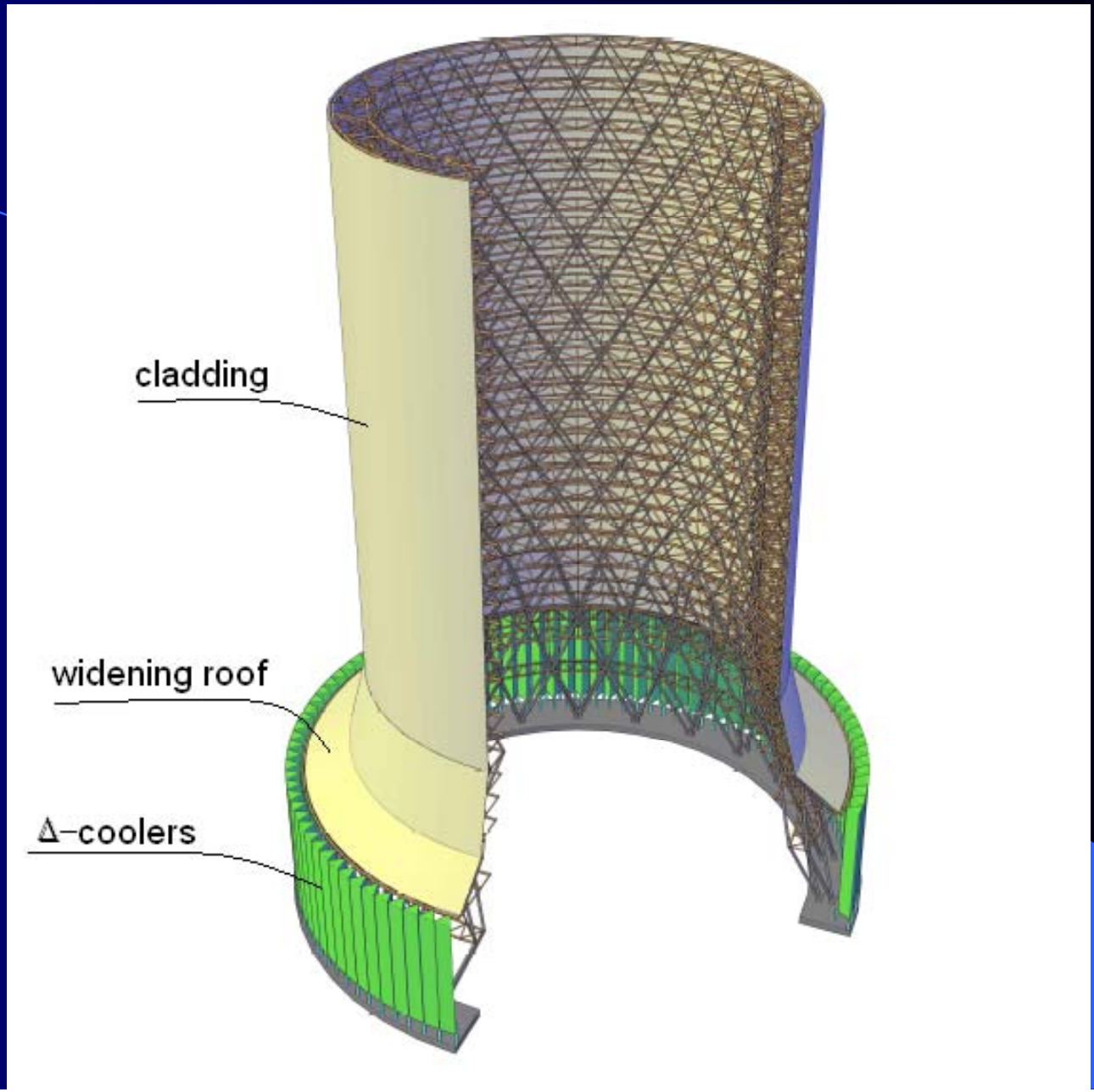
by
Dr Mahmoud Heristchian
heris@azad.ac.ir

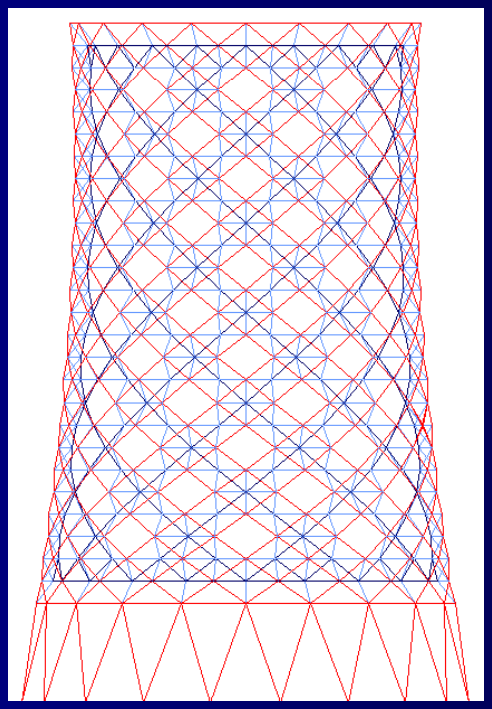
Concrete Towers vs Steel Towers

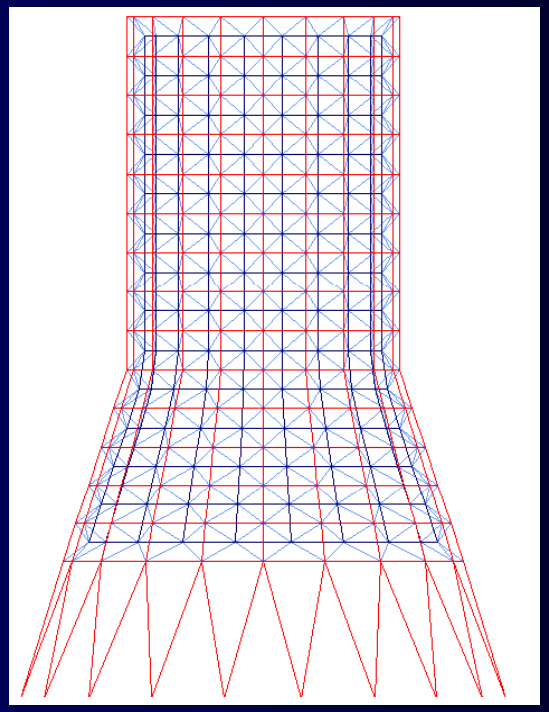
1) EQ
2) Wind
3) Steel Consumption
4) Foundations
5) Recycling

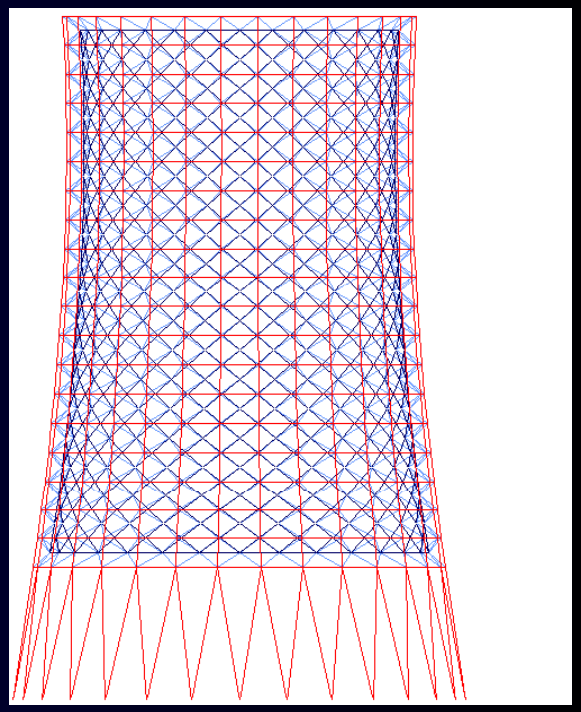
.....


Stiff ring
Cladding
Widening roof

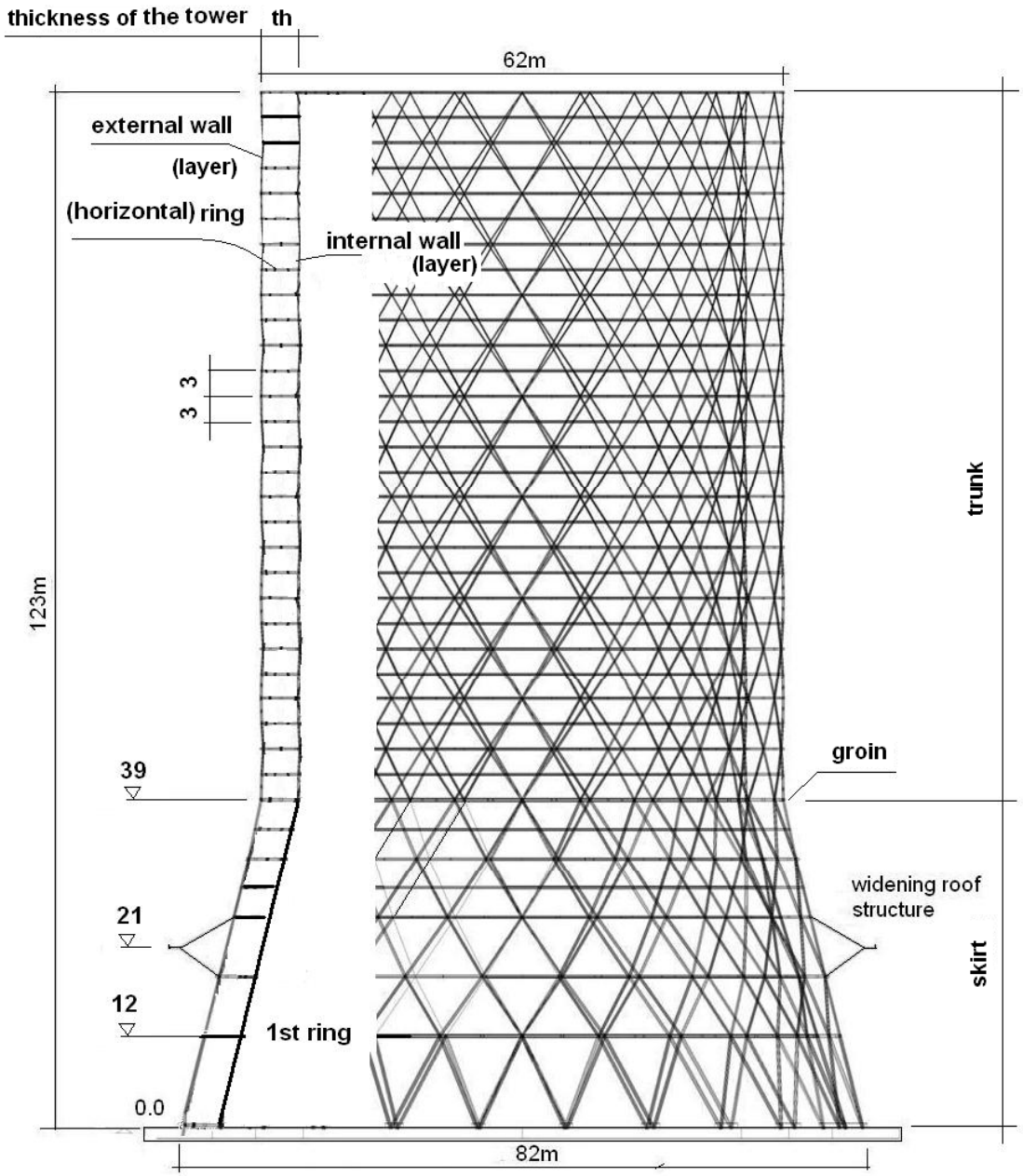

cladding
widening roof
Δ–coolers








2005
2005
2005


thickness of the tower
th
62m
external wall
(layer)
(horizontal) ring
internal wall
(layer)
3
3
123m
trunk
39
groin
widening roof
structure
21
skirt
12
1st ring
0.0
82m

The external pressure is

$$W_e(Z,\theta) = C_{pe}(\theta) \times \varphi \times F_1 \times q_b(Z)$$

Where,

F_1=1 is the interference factor

Θ is the angular distance in a horizontal cross section from the stagnation line,

Cpe is the external pressure coefficient determined according to 3.1.3.3(VGB)

q_b gust velocity pressure as defined $q_b = 1.06 \times \left(\frac{Z}{10}\right)^{0.22}$ kN/m^2

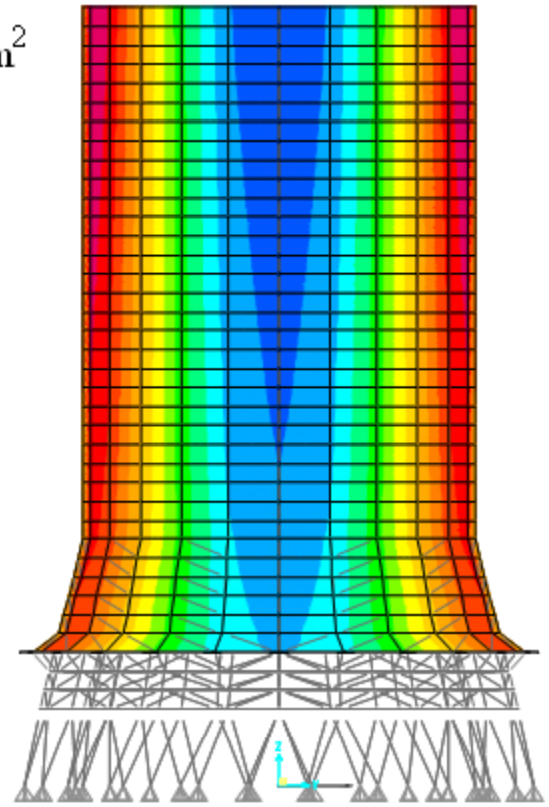
φ=1.15 is the dynamic amplification factor.

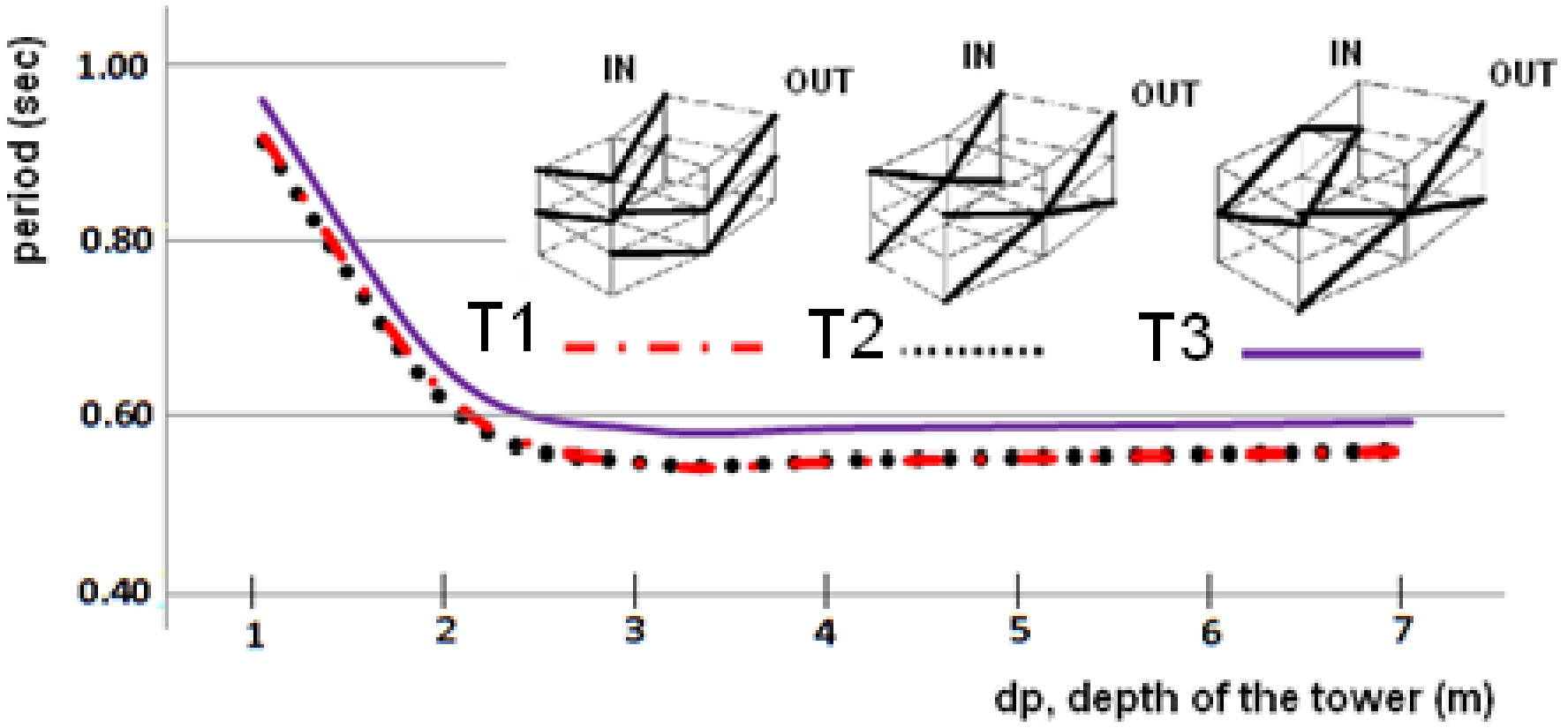
(According to the surface condition of the cladding)

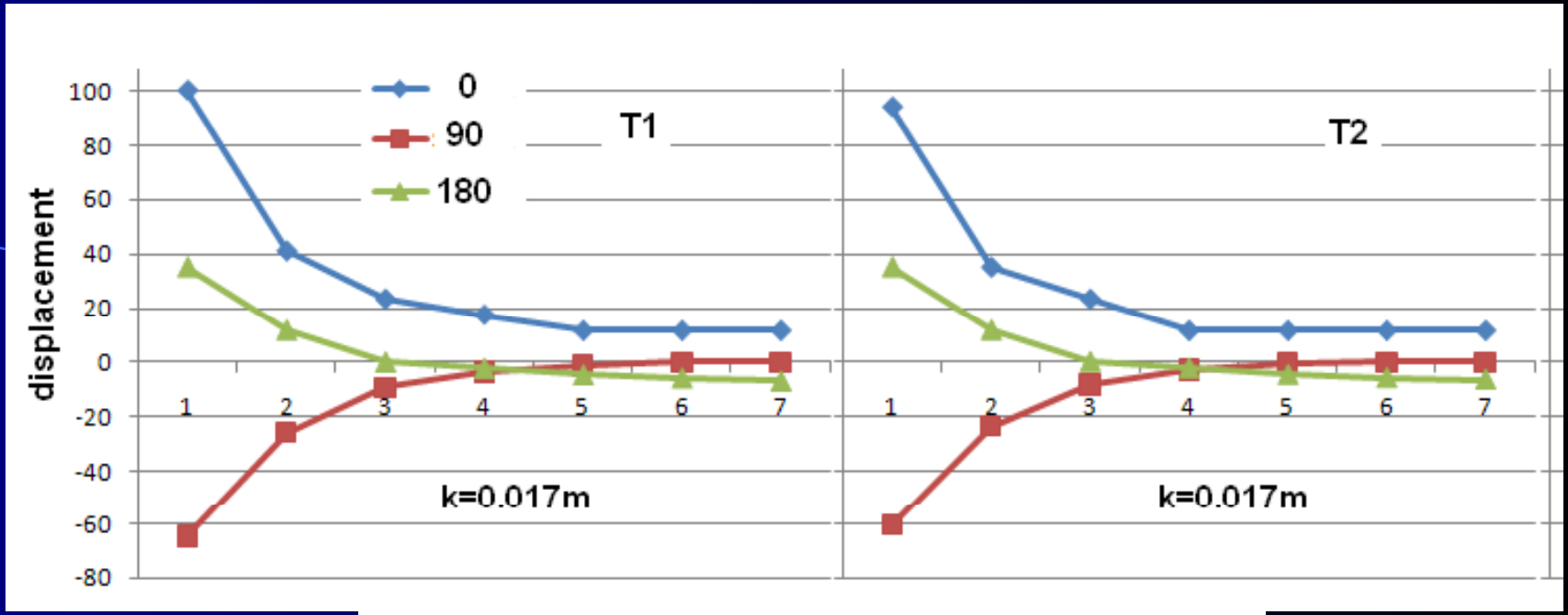
Z is the height above the ground.

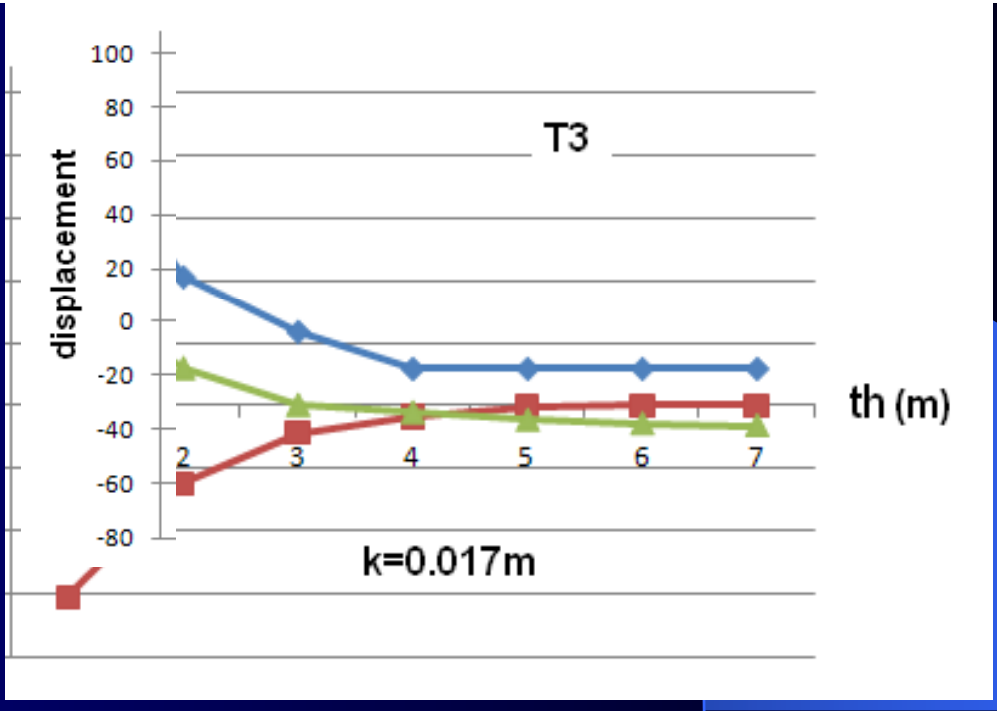
$$C_{pe}(\theta) = \begin{cases} 1 - 2.3\left(Sin\frac{90}{73}\theta\right)^{2.166} \rightarrow 0^\circ \le \theta \le 73^\circ \\ -1.3 + 0.80\left(Sin(\frac{90}{24}(\theta - 73)\right)^{2.395} \rightarrow 73^\circ \le \theta \le 97^\circ \\ -0.5 \rightarrow 97^\circ \le \theta \le 180^\circ \\ -0.56 \rightarrow Cf \end{cases}$$

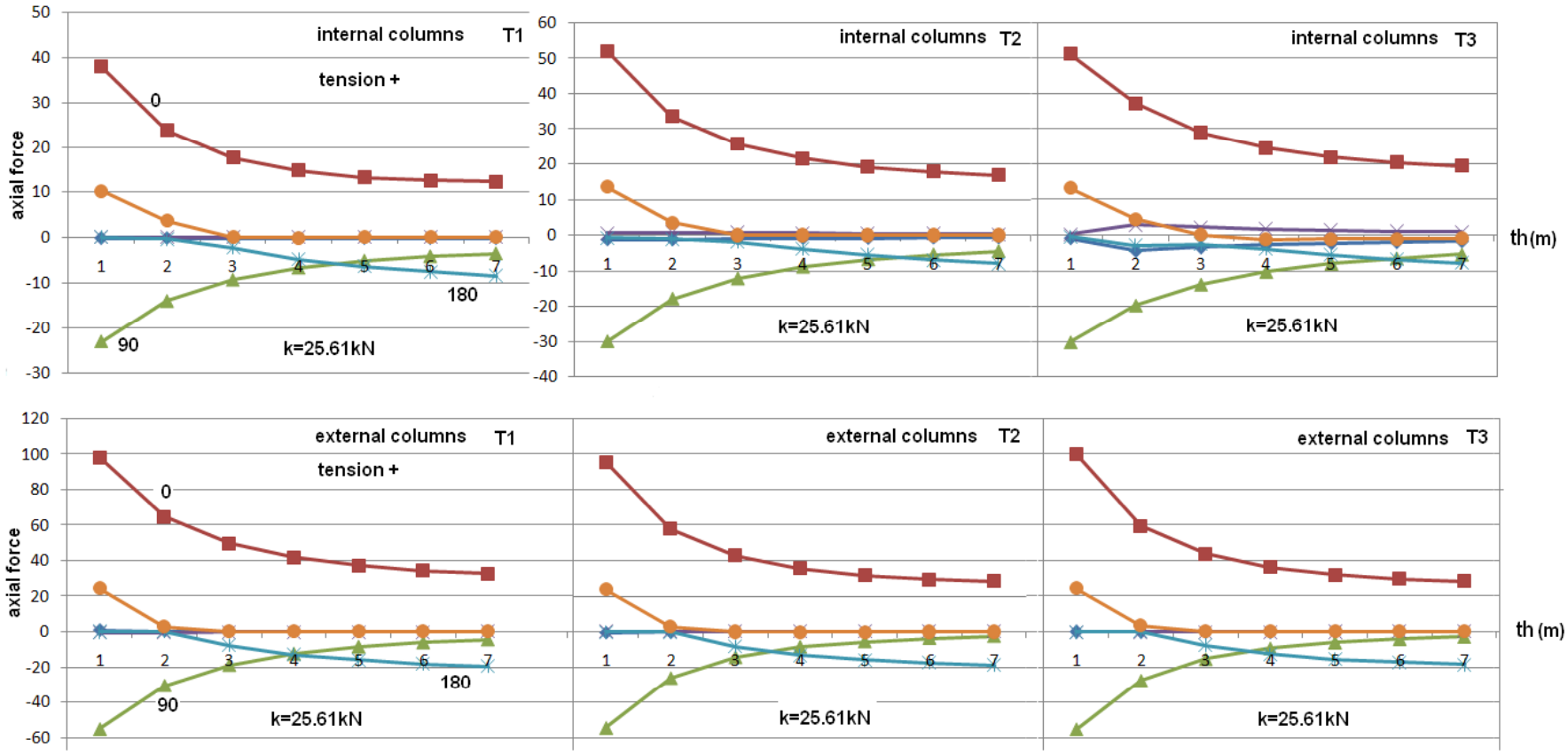
K1.3

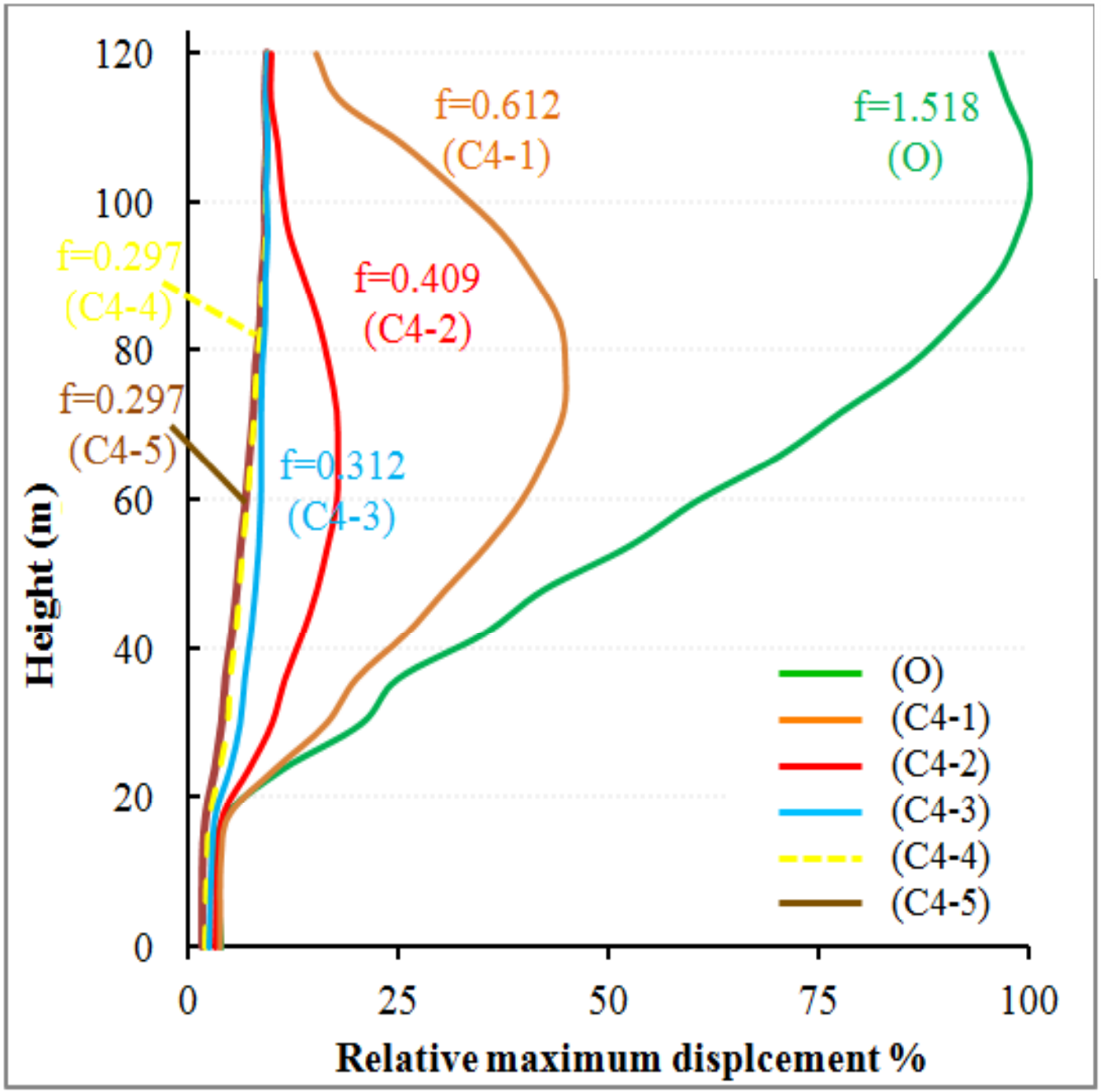


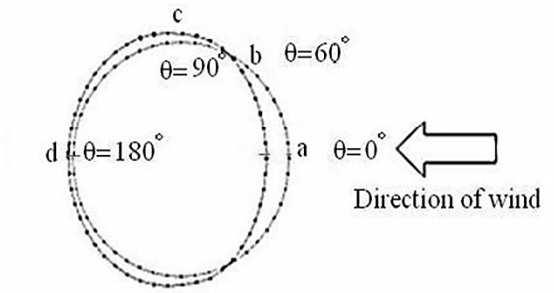

period (sec)
1.00
0.80
0.60
0.40
1
2
3
4
5
6
7
dp, depth of the tower (m)
IN
OUT
IN
OUT
IN
OUT
T1
T2
T3

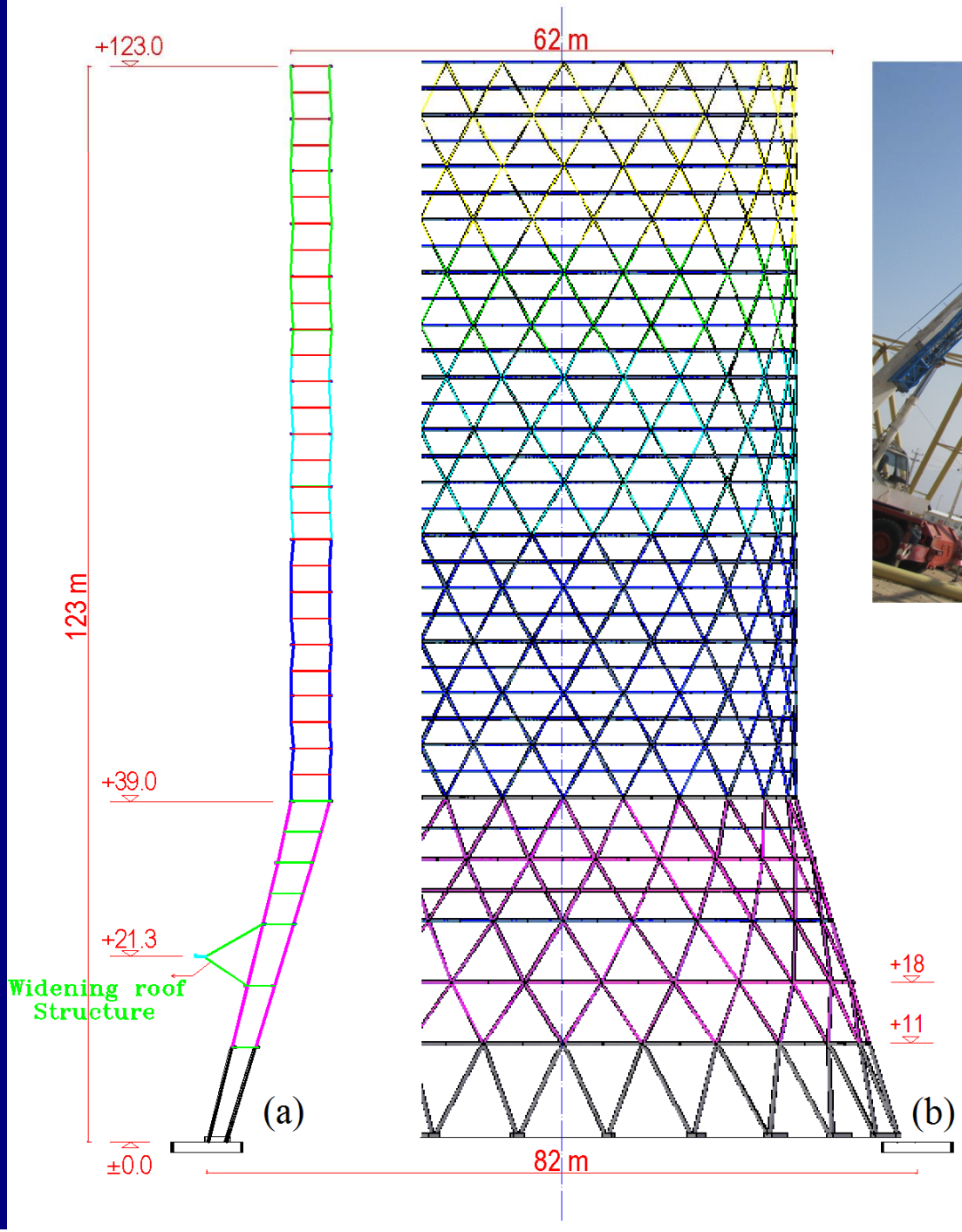

0
90
180
T1
T2
displacement
100
80
60
40
20
0
-20
-40
-60
-80
1
2
3
4
5
6
7
k=0.017m
k=0.017m


T3
displacement
100
80
60
40
20
0
-20
-40
-60
-80
2
3
4
5
6
7
k=0.017m
th (m)

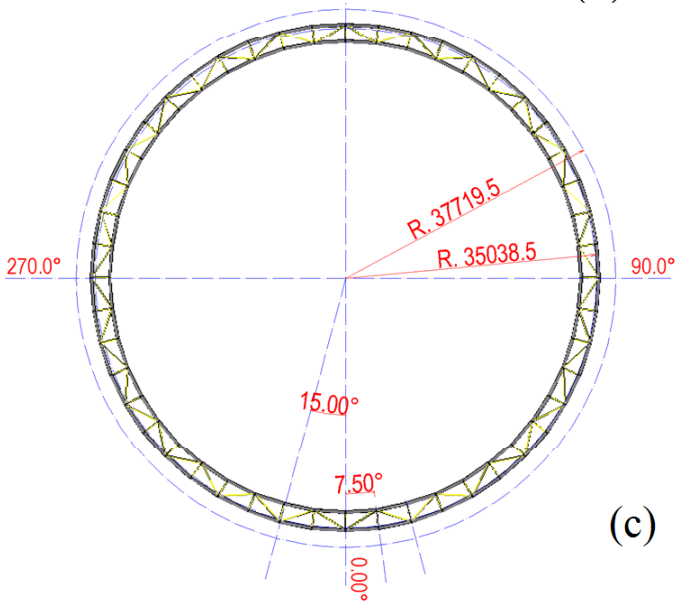

internal columns T1
tension +
axial force
0
90
180
k=25.61kN
internal columns T2
k=25.61kN
internal columns T3
k=25.61kN
th (m)
external columns T1
tension +
axial force
0
90
180
k=25.61kN
external columns T2
k=25.61kN
external columns T3
k=25.61kN
th (m)


120
100
80
60
40
20
0
Height (m)
0
25
50
75
100
Relative maximum displcement %
f=1.518
(O)
f=0.612
(C4-1)
f=0.409
(C4-2)
f=0.312
(C4-3)
f=0.297
(C4-4)
f=0.297
(C4-5)
(O)
(C4-1)
(C4-2)
(C4-3)
(C4-4)
(C4-5)

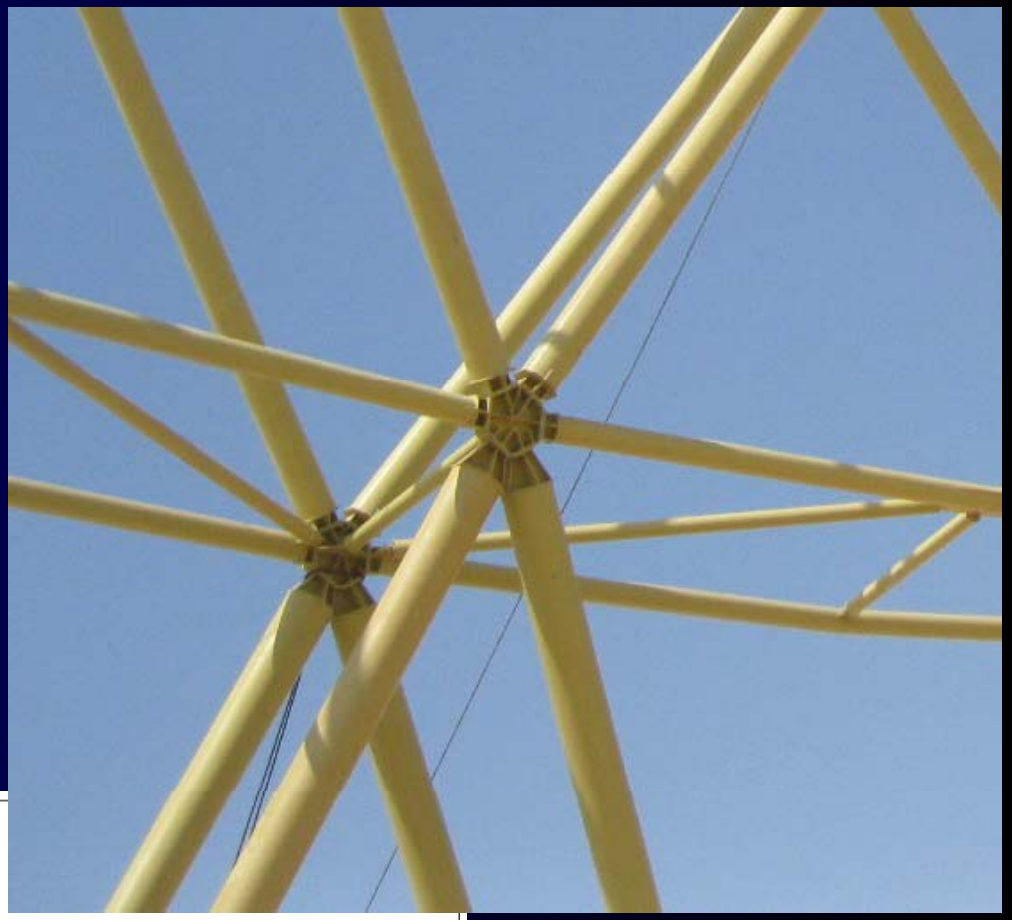

c
θ=90°
b
θ=60°
d
θ=180°
a
θ=0°
Direction of wind

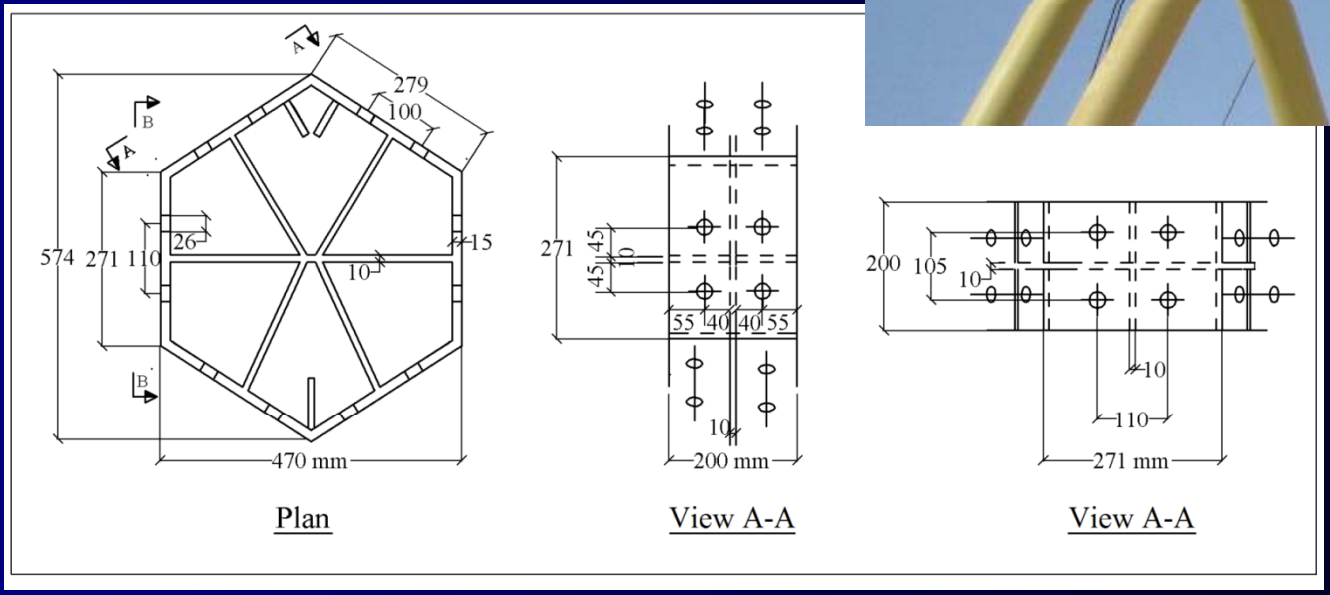

+123.0
62 m
123 m
+39.0
+21.3
Widening roof
Structure
+18
+11
±0.0
82 m
(a)
(b)

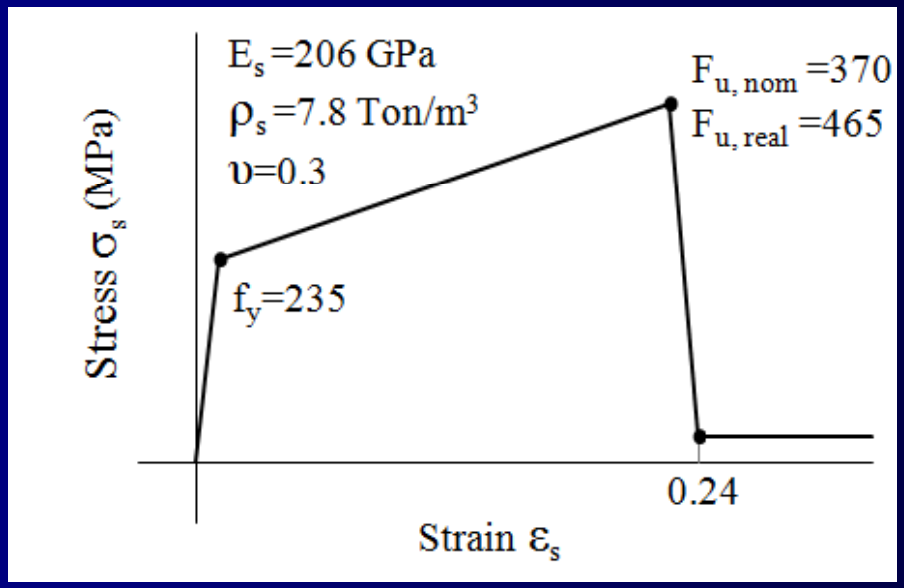
(d)

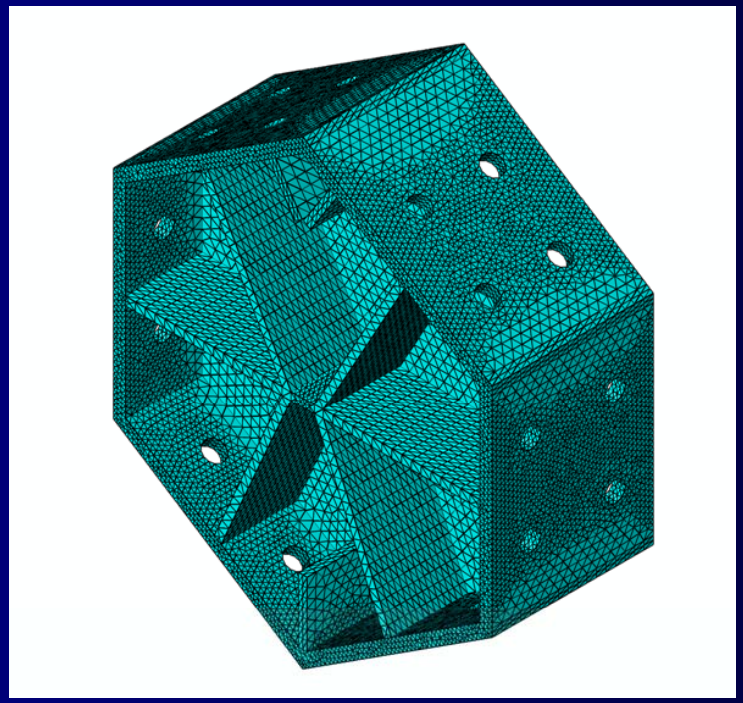

R. 37719.5
R. 35038.5
270.0°
90.0°
15.00°
7.50°
0.00°

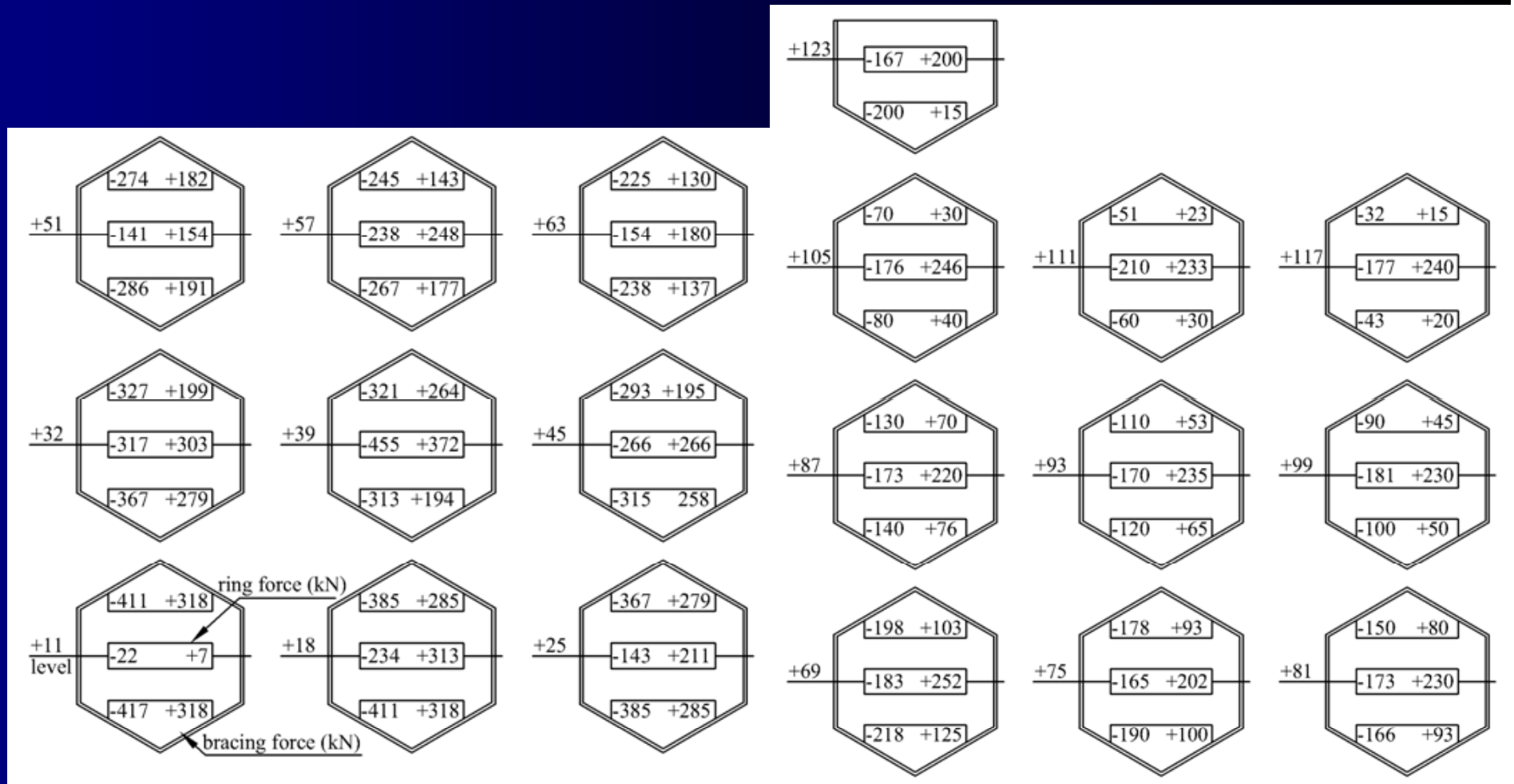
(c)

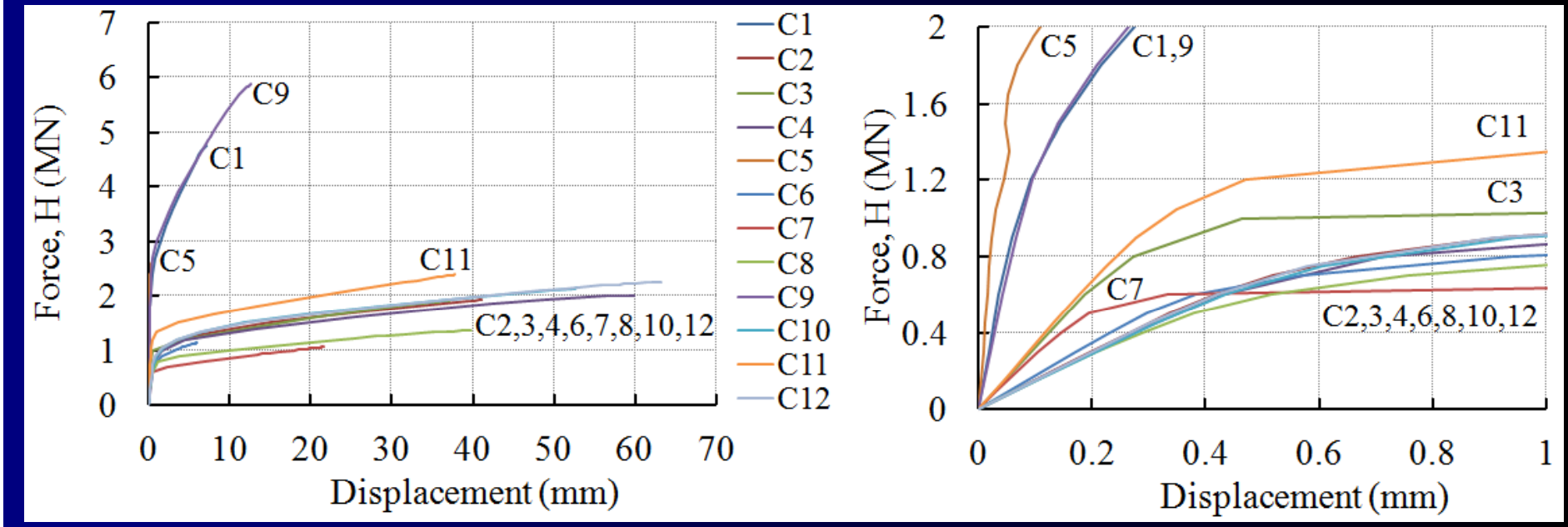


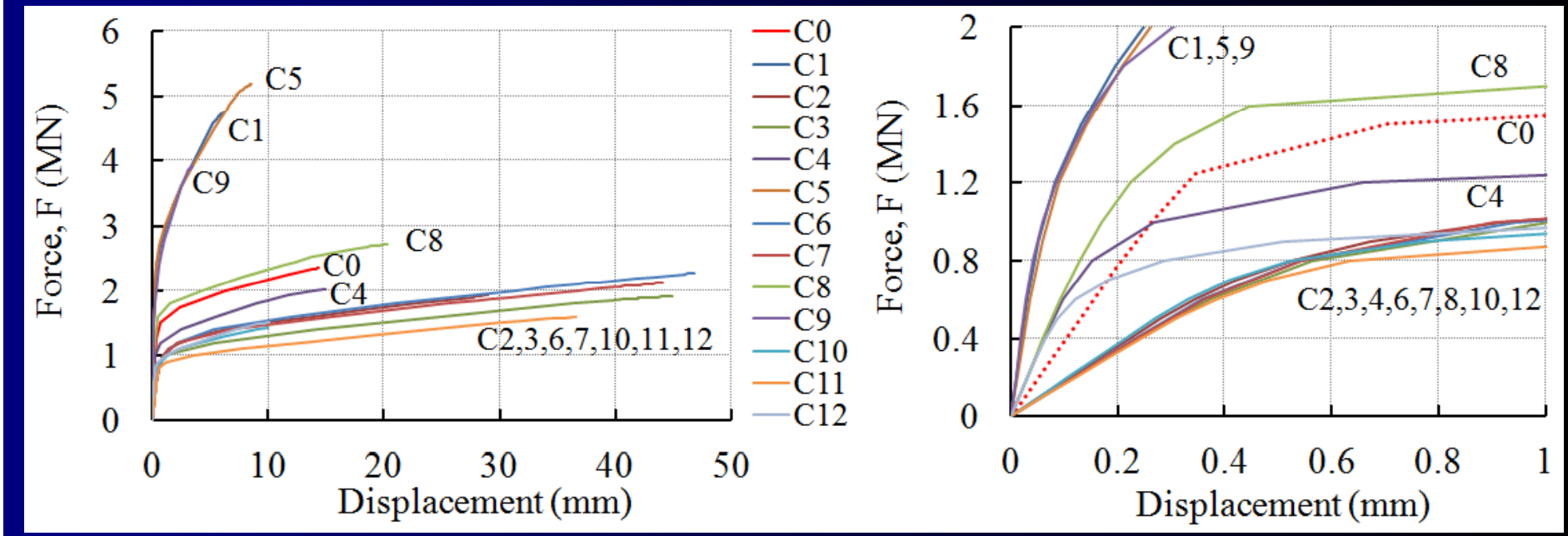

A
B
A
B
279
100
574
271
110
26
15
10
470 mm
Plan
271
45
45
10
55
40
40
55
10
200 mm
View A-A
200
105
10
10
110
271 mm
View A-A

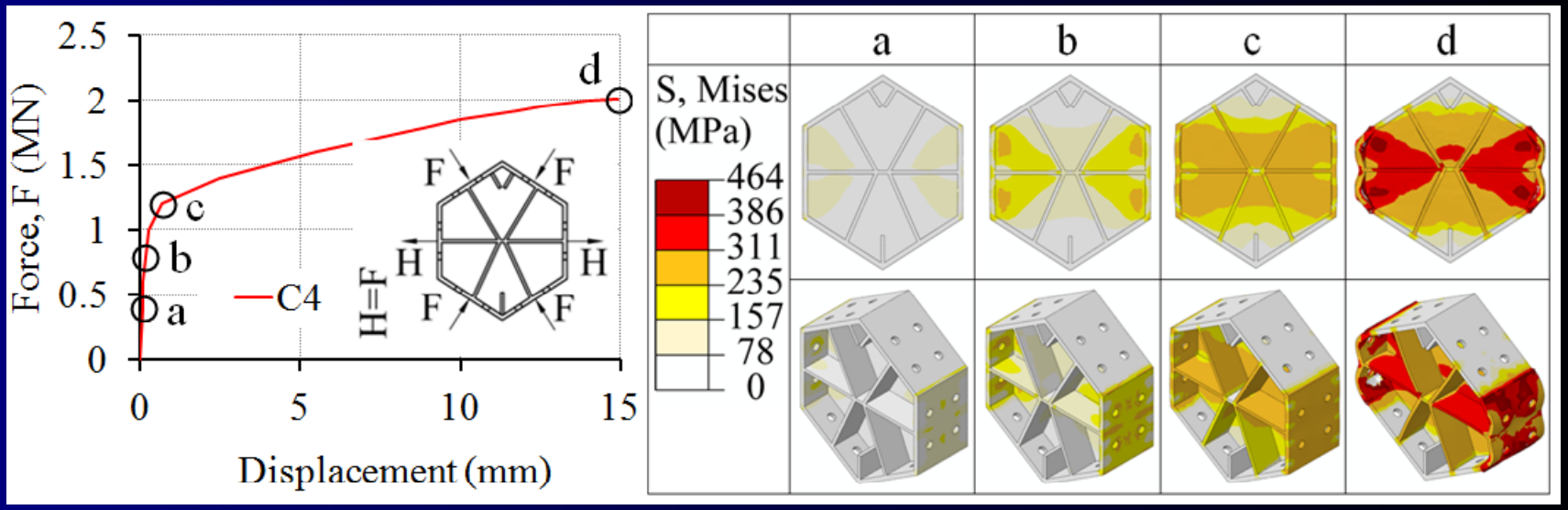

E_s=206 GPa
ρ_s=7.8 Ton/m^3
υ=0.3
f_y=235
$F_{u,nom}$=370
$F_{u,real}$=465
0.24
Stress σ_s (MPa)
Strain ε_s

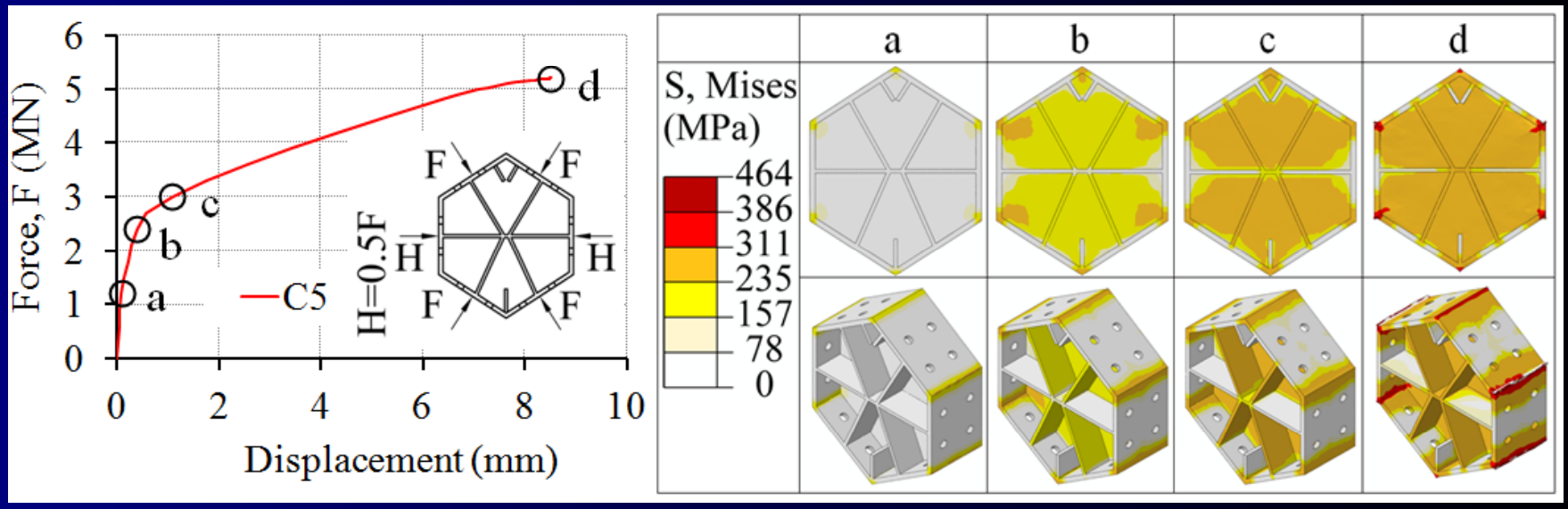



+123
-167 +200
-200 +15
+51
-274 +182
-141 +154
-286 +191
+57
-245 +143
-238 +248
-267 +177
+63
-225 +130
-154 +180
-238 +137
+105
-70 +30
-176 +246
-80 +40
+111
-51 +23
-210 +233
-60 +30
+117
-32 +15
-177 +240
-43 +20
+32
-327 +199
-317 +303
-367 +279
+39
-321 +264
-455 +372
-313 +194
+45
-293 +195
-266 +266
-315 258
+87
-130 +70
-173 +220
-140 +76
+93
-110 +53
-170 +235
-120 +65
+99
-90 +45
-181 +230
-100 +50
ring force (kN)
+11
level
-411 +318
-22 +7
-417 +318
+18
-385 +285
-234 +313
-411 +318
+25
-367 +279
-143 +211
-385 +285
+69
-198 +103
-183 +252
-218 +125
+75
-178 +93
-165 +202
-190 +100
+81
-150 +80
-173 +230
-166 +93
bracing force (kN)


Force, H (MN)
Displacement (mm)
C9
C1
C5
C11
C2,3,4,6,7,8,10,12
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
C12
C5
C1,9
C11
C3
C7
C2,3,4,6,8,10,12


Force, F (MN)
Displacement (mm)
C5
C1
C9
C8
C0
C4
C2,3,6,7,10,11,12
C0
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
C12
C1,5,9
C8
C0
C4
C2,3,4,6,7,8,10,12


Force, F (MN)
2.5
2
1.5
1
0.5
0
0
5
10
15
Displacement (mm)
a
b
c
d
C4
H=F
F
H
S, Mises (MPa)
464
386
311
235
157
78
0


Force, F (MN)
6
5
4
3
2
1
0
0
2
4
6
8
10
Displacement (mm)
a
b
c
d
C5
H=0.5F
F
H
S, Mises (MPa)
464
386
311
235
157
78
0

1. MAPNA Groups
2. Moshanir
3. Professor Hoshyar Nooshin
4. Porsaz-Norahan
5. Research and Msc students