Measurement and interpretation of disc cutting forces in mechanized tunneling

Martin Entacher, 30. September 2013

STRABAG
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AkerSolutions
STRABAG

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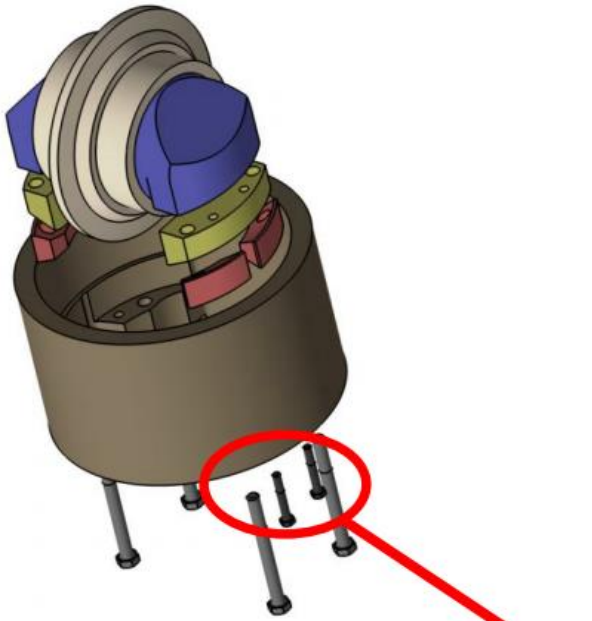
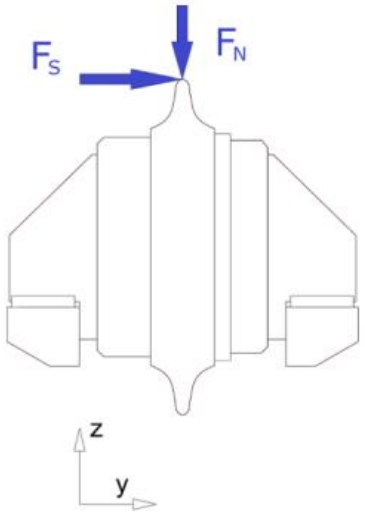
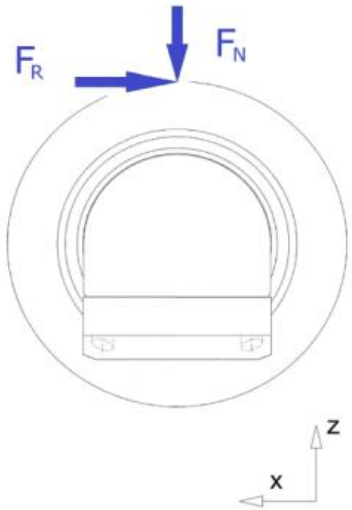
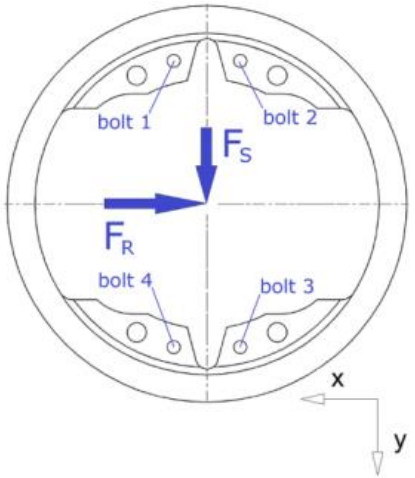
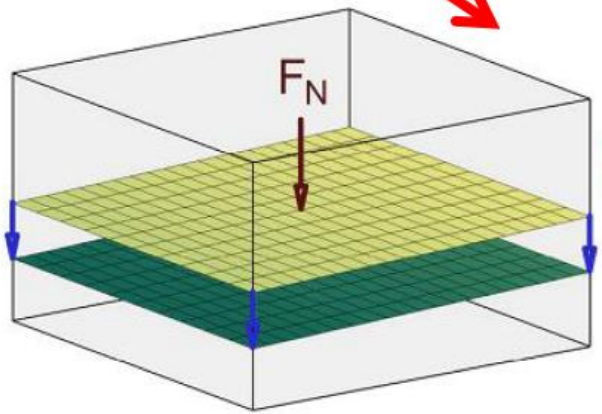
Final design

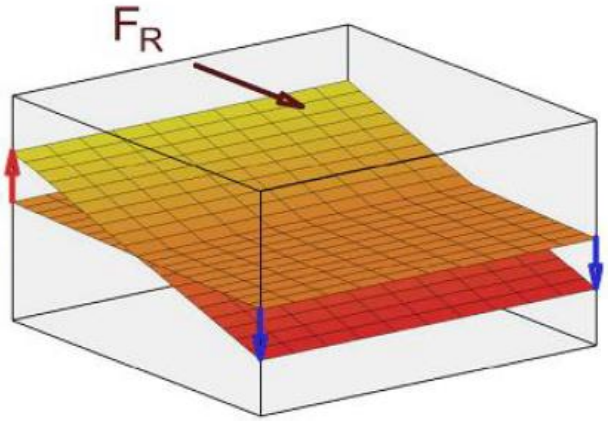


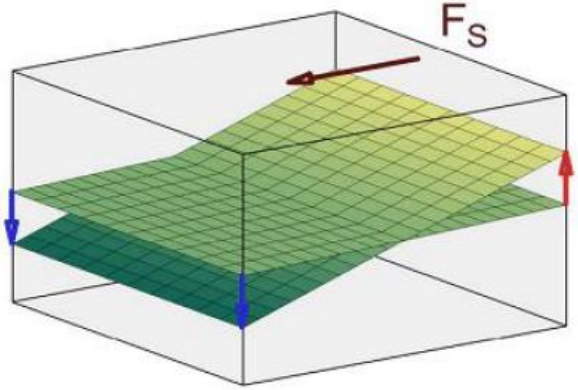


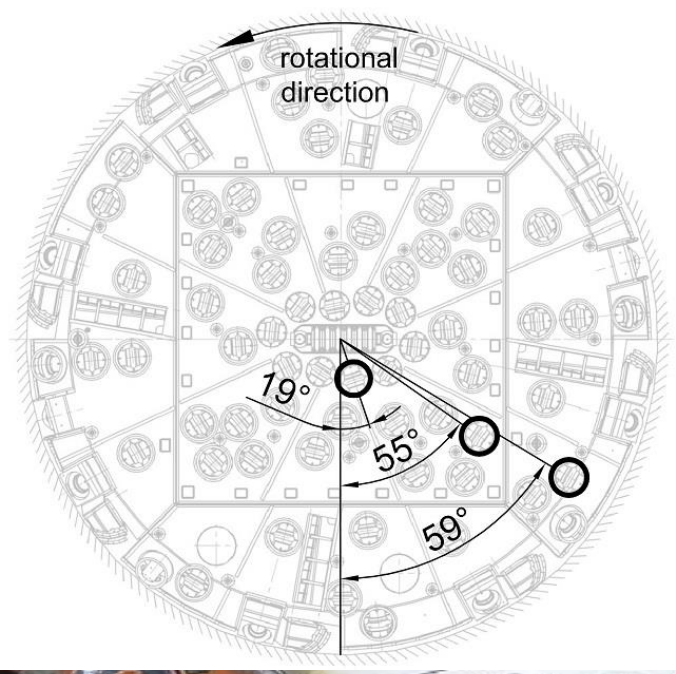


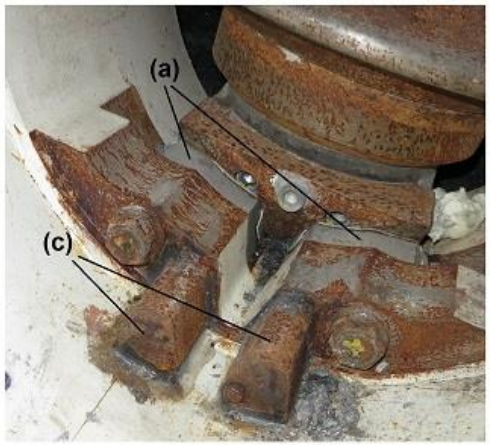


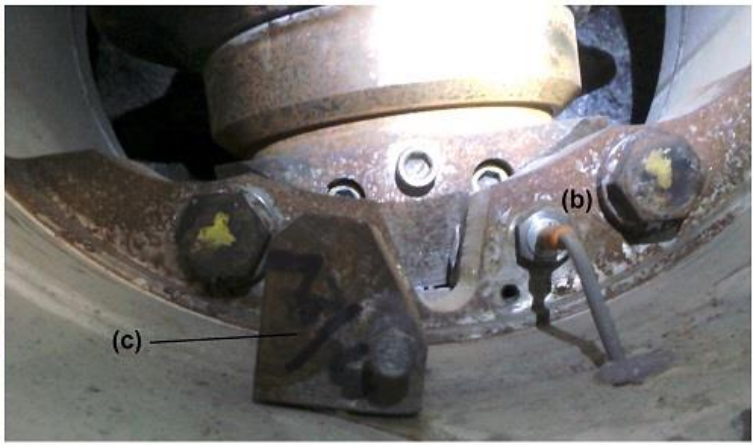










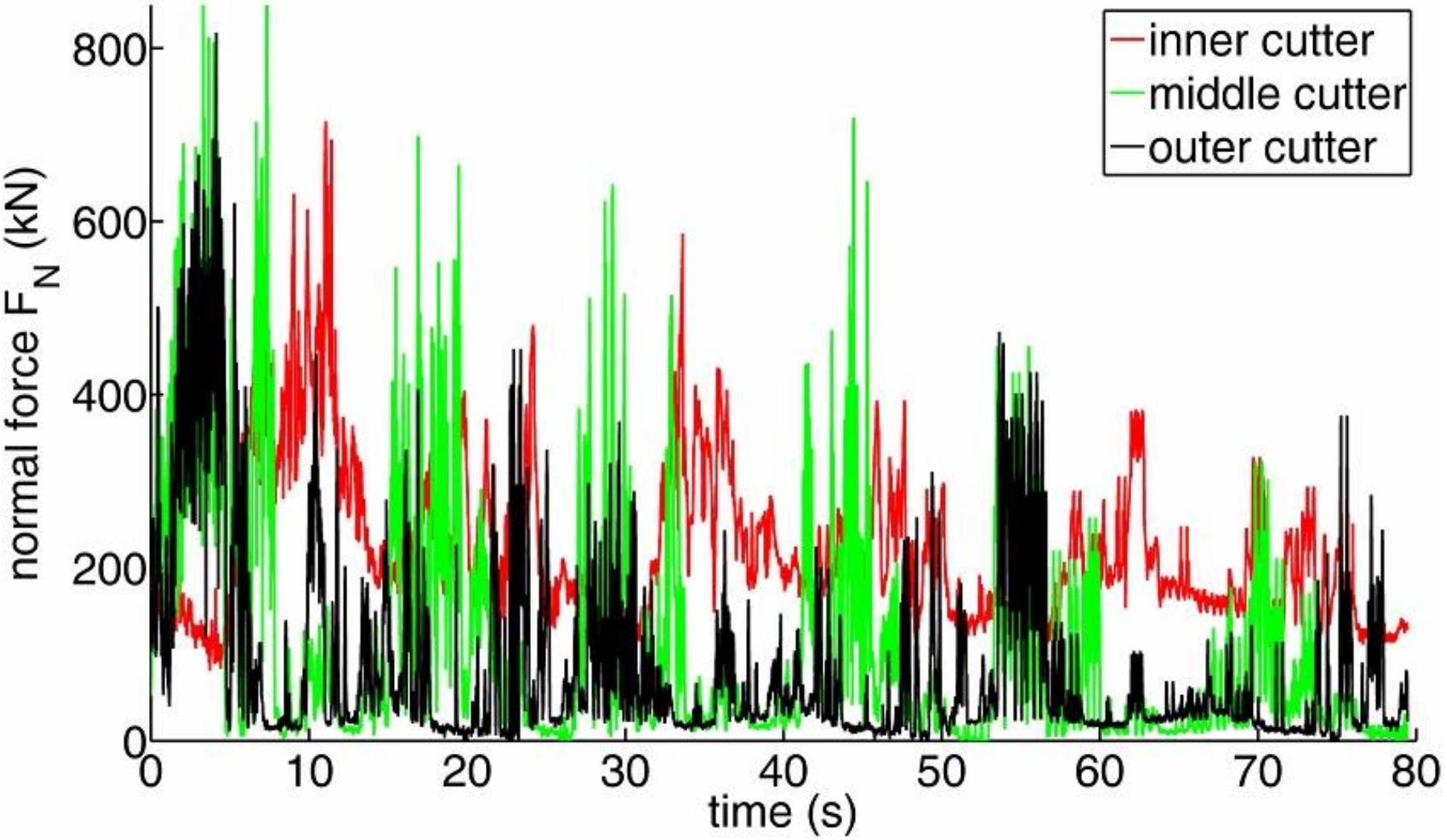


Subsurface Engineering

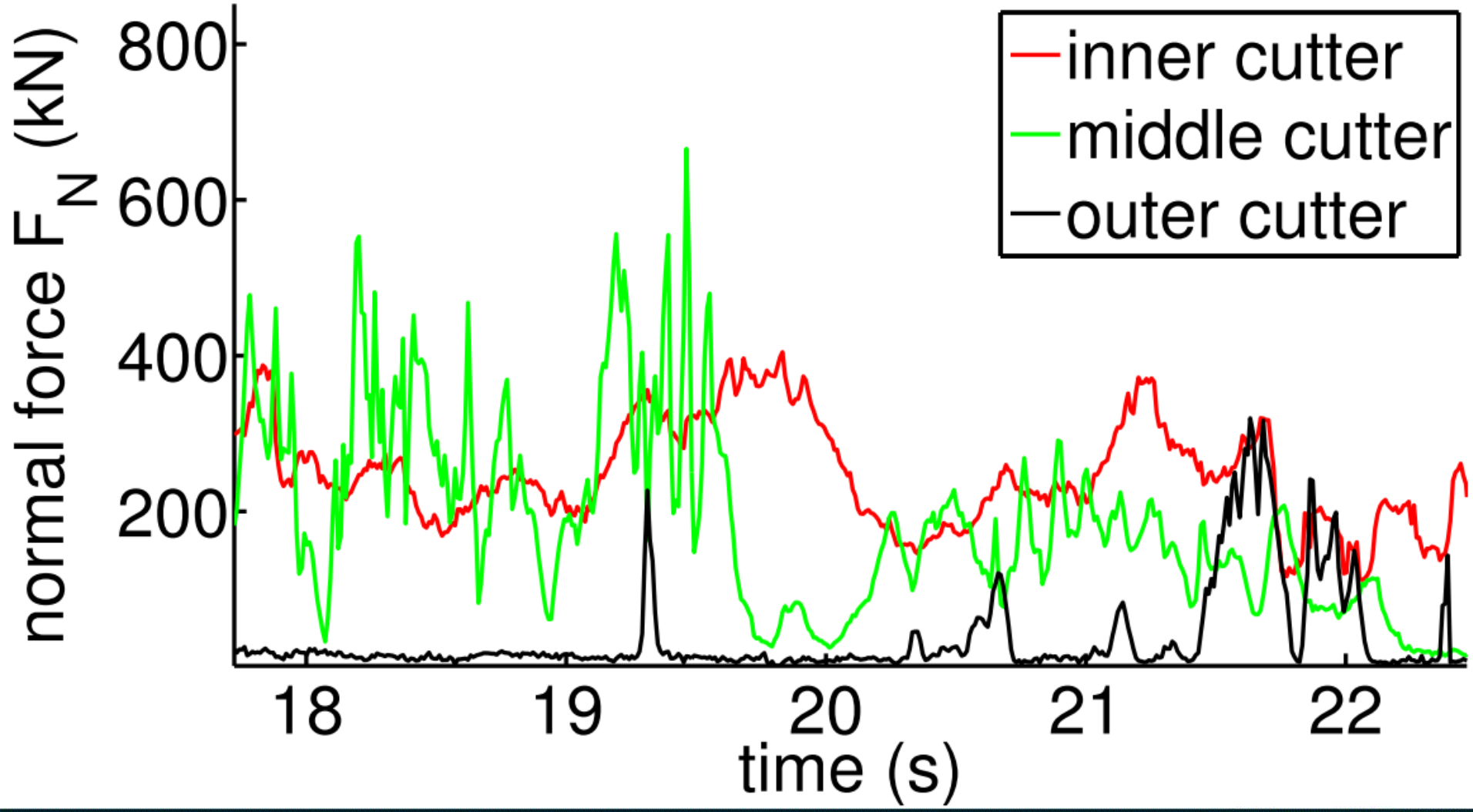
Geodata

Net-Automation

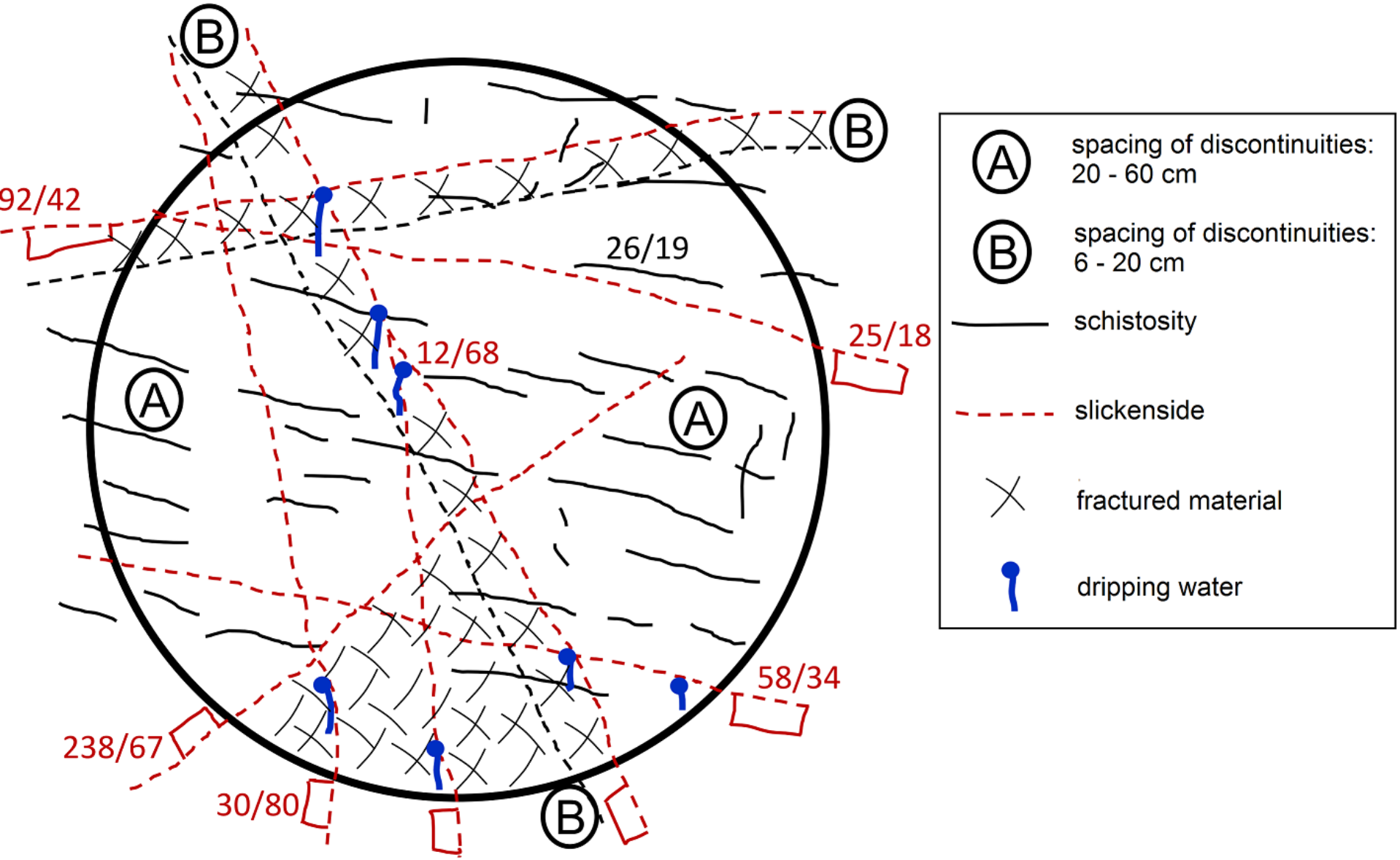
Results


inner cutter
middle cutter
outer cutter
normal force F_N (kN)
800
600
400
200
0
0
10
20
30
40
50
60
70
80
time (s)

Results

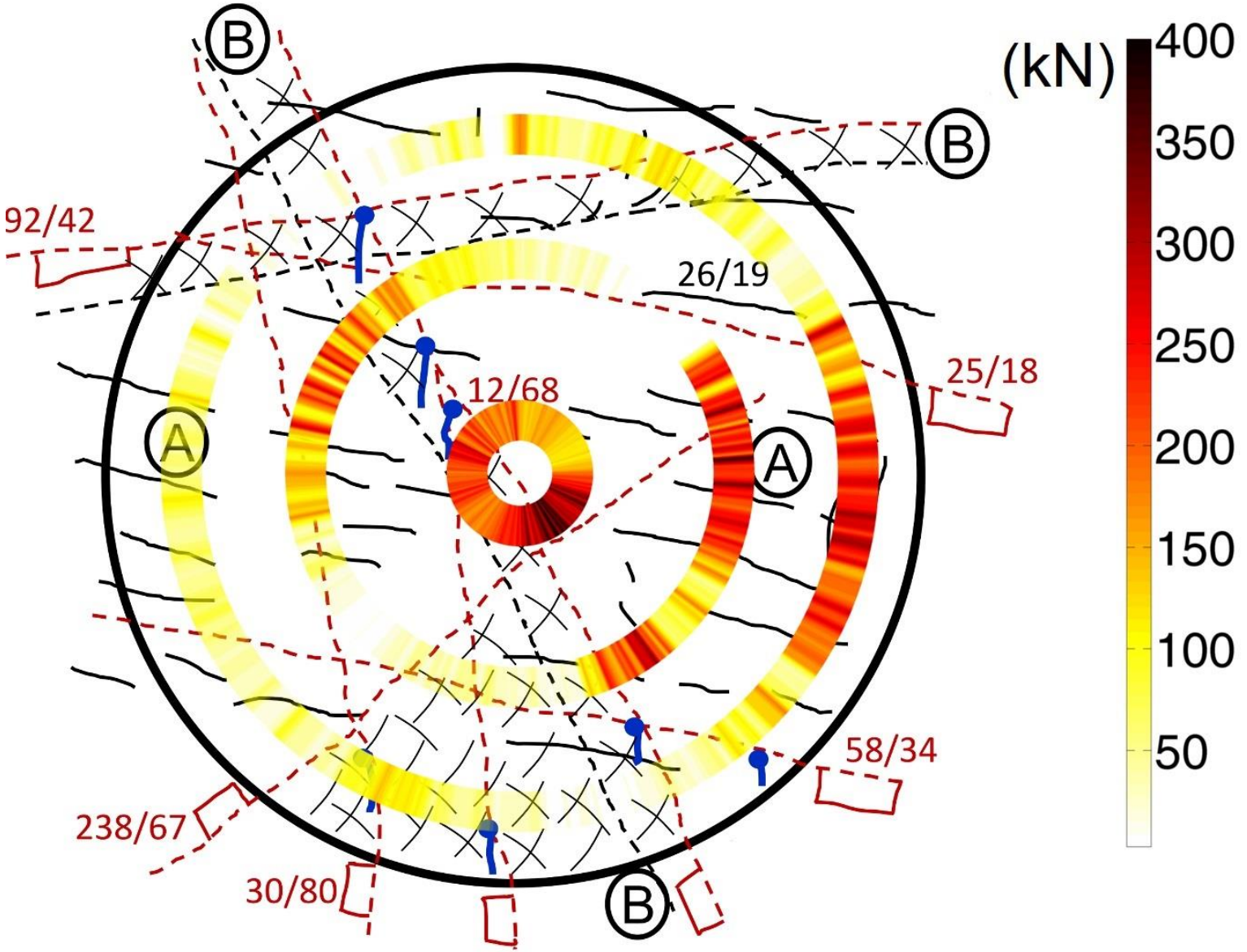

normal force F_N (kN)
800
600
400
200
18
19
20
21
22
time (s)
inner cutter
middle cutter
outer cutter

Geological mapping - Schiefergneiss



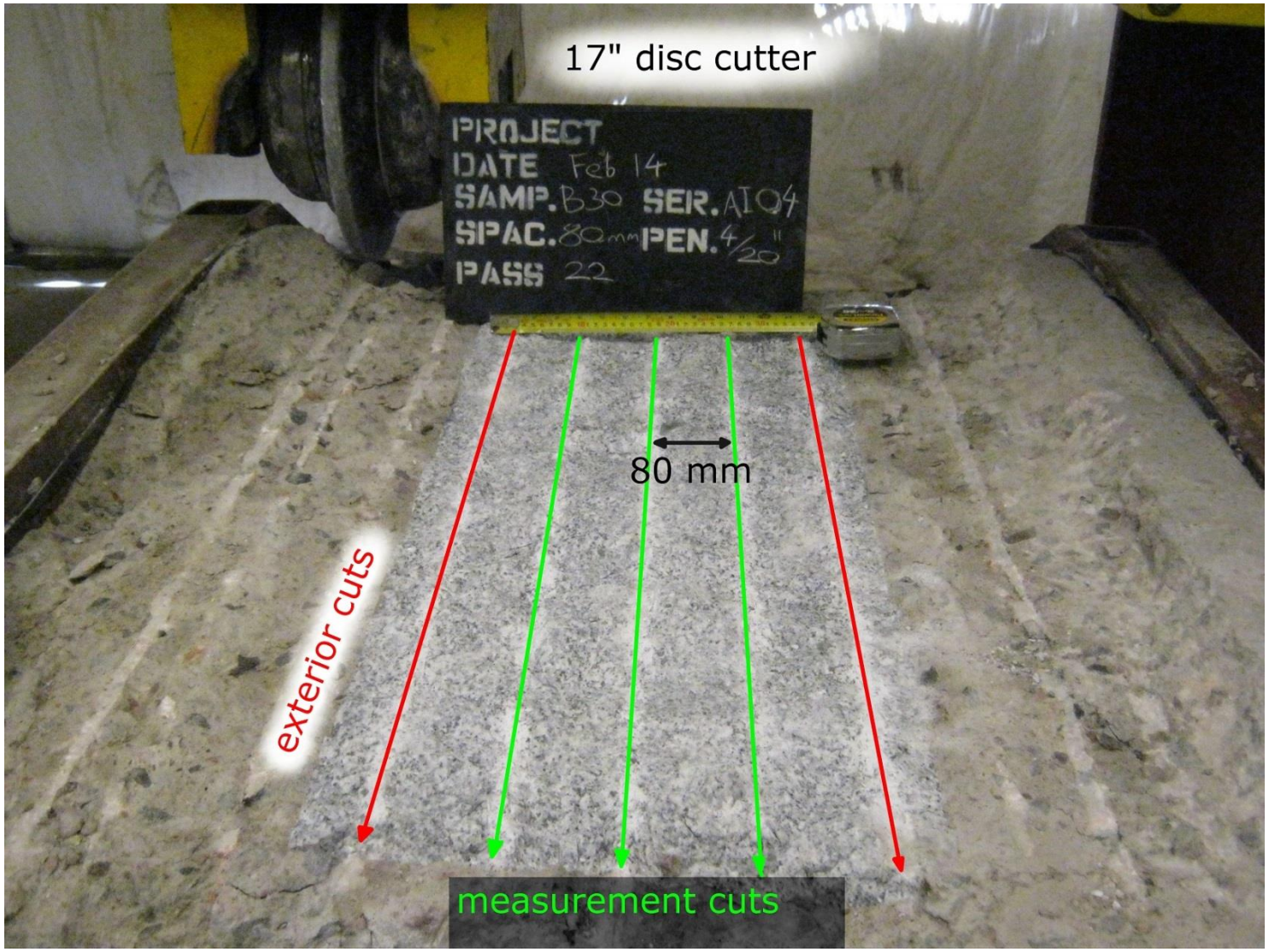
(nach Ritter 2013, 3G)

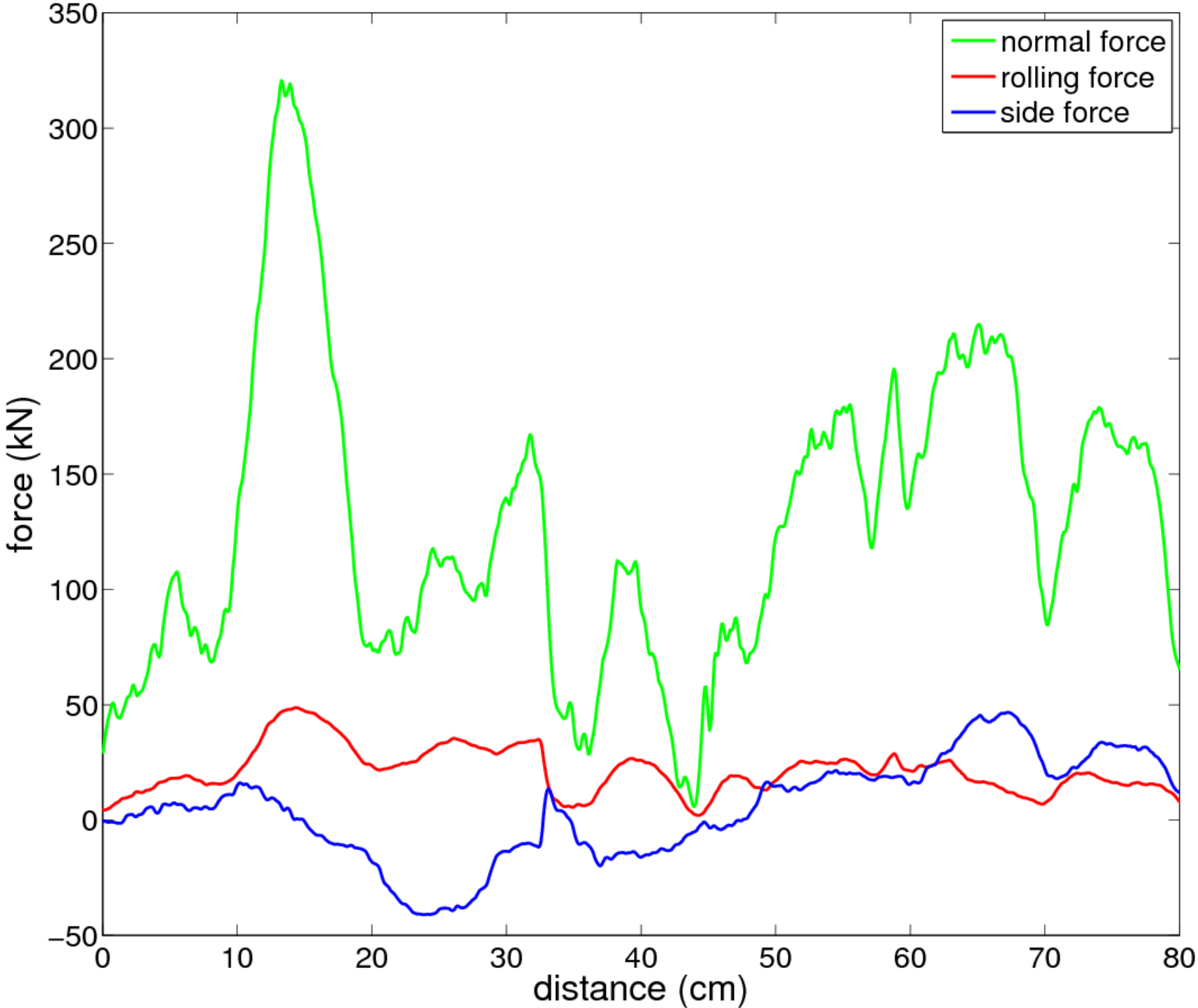
Results


B
B
B
A
A
92/42
26/19
25/18
12/68
58/34
238/67
30/80
(kN)
400
350
300
250
200
150
100
50

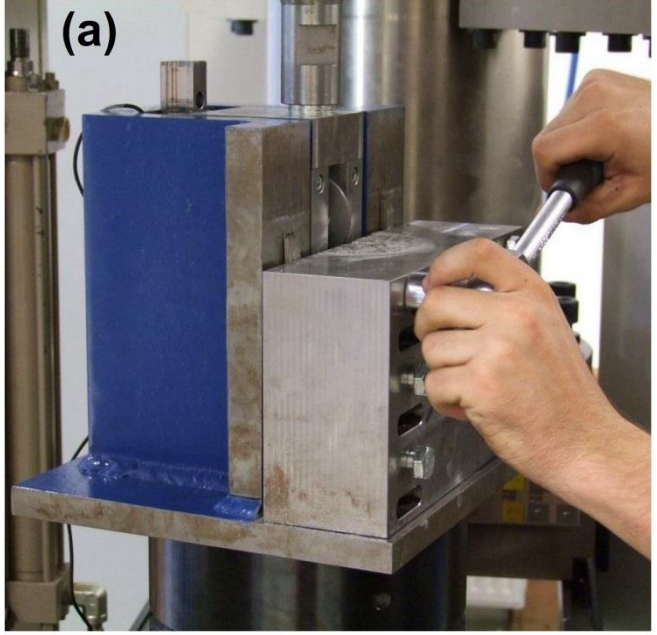
Full scale cutting tests - CSM

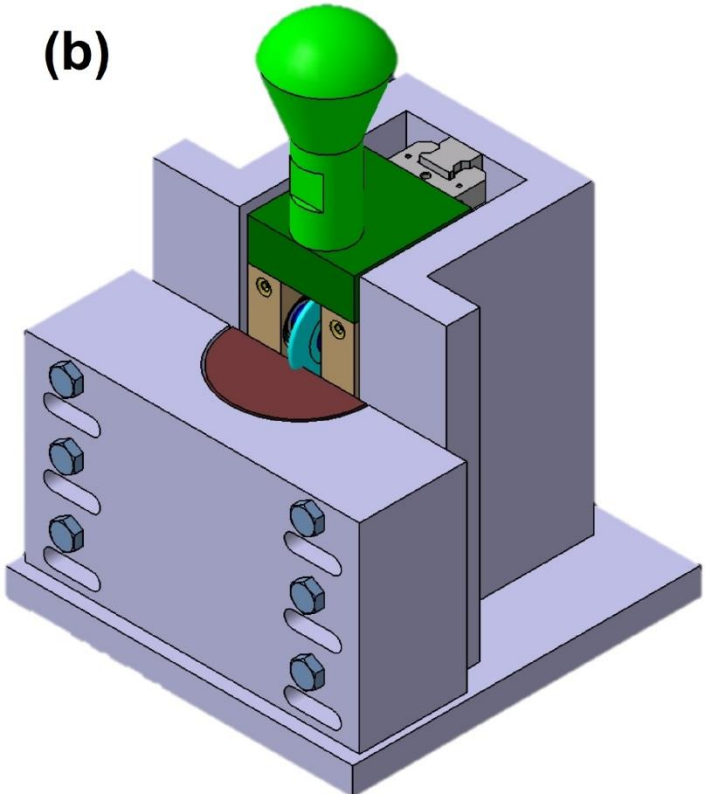
Full scale cutting tests




normal force
rolling force
side force
force (kN)
distance (cm)
350
300
250
200
150
100
50
0
−50
0
10
20
30
40
50
60
70
80

(c)


(a)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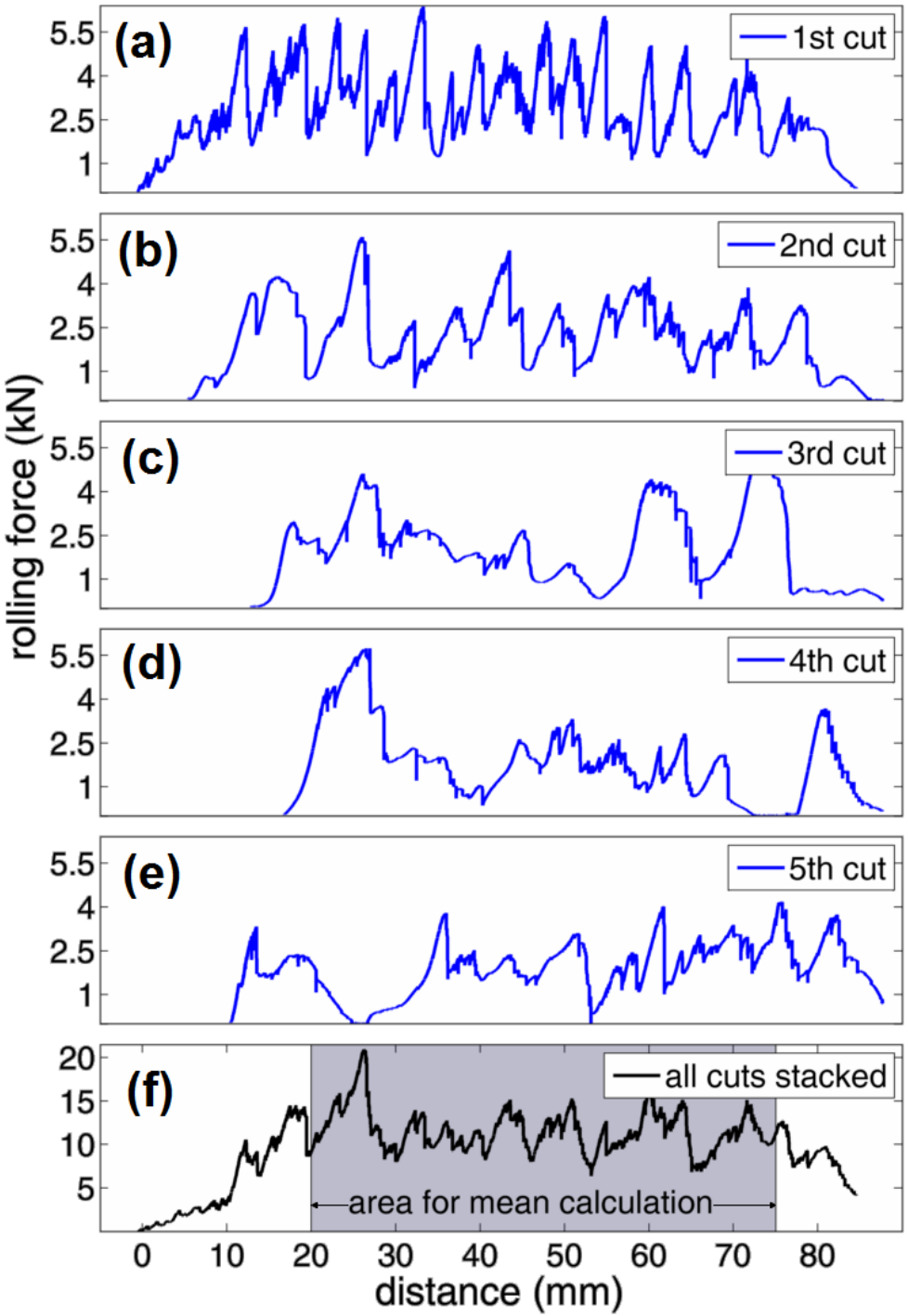


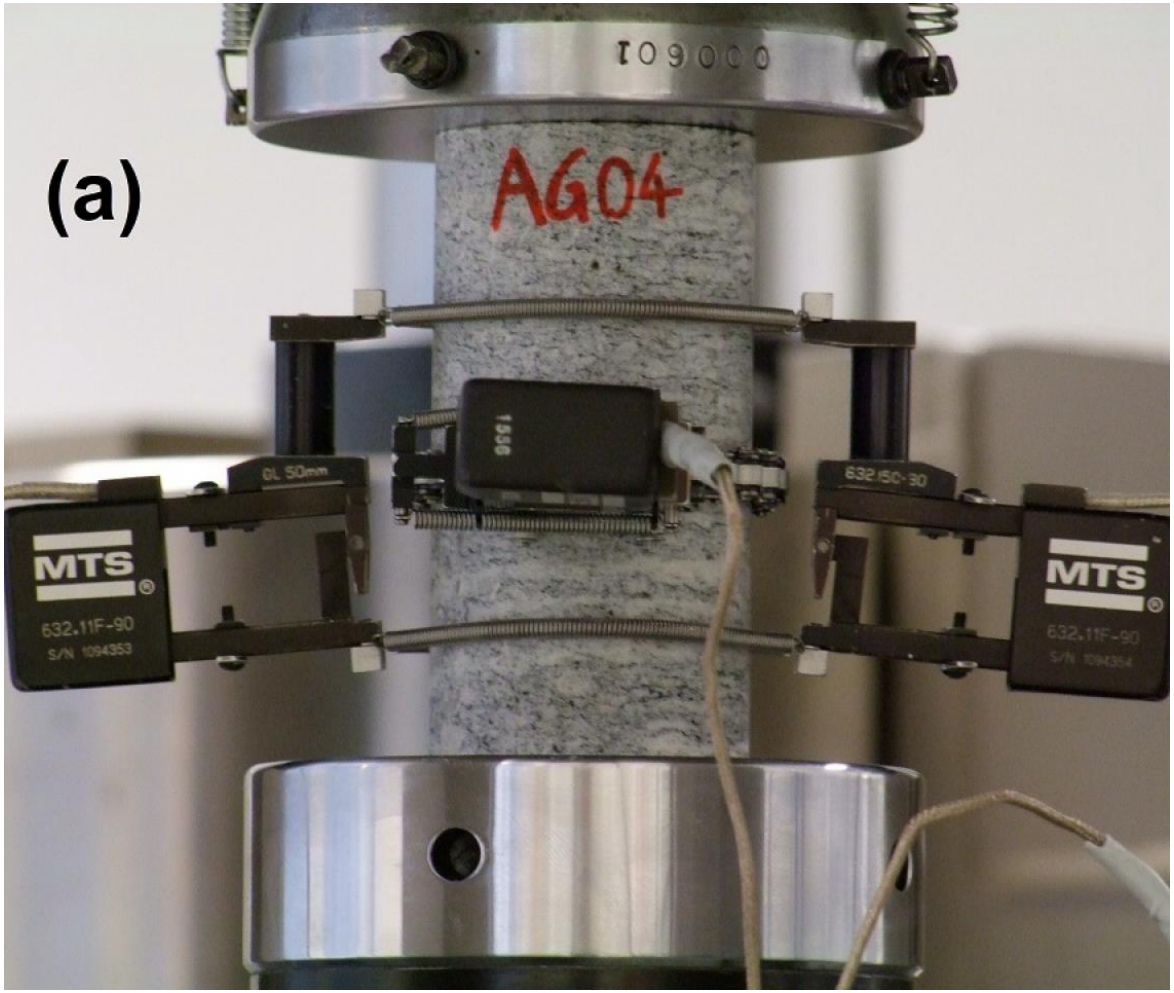
5 cuts, each with $p = 1.5$ *mm*

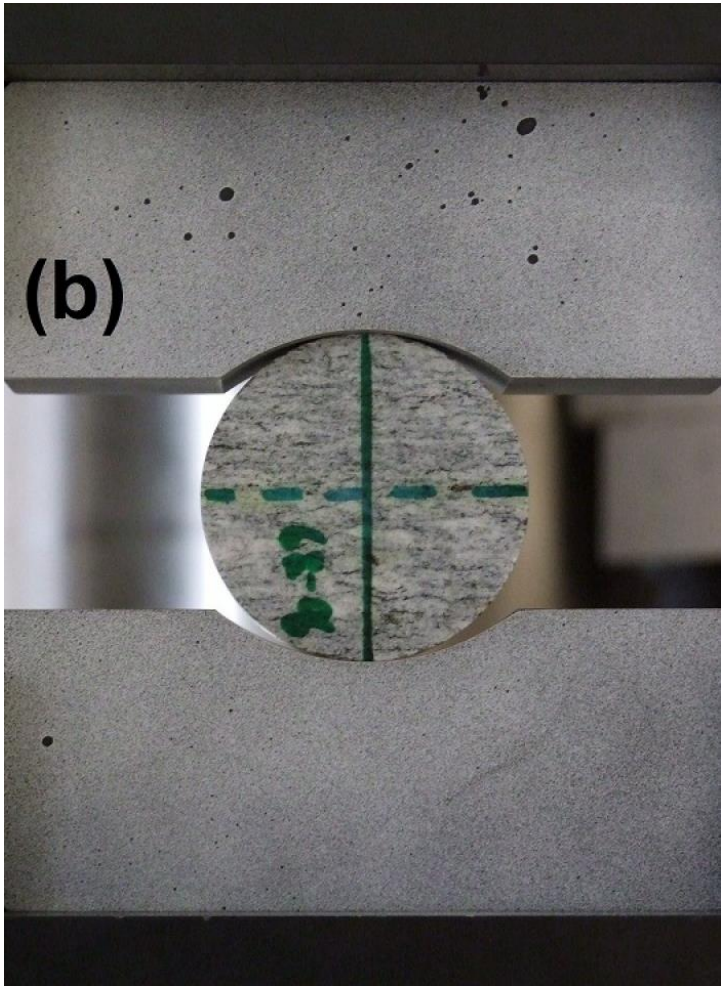
Sampling rate: *160 Hz*

Advance rate: *1 mm/s*

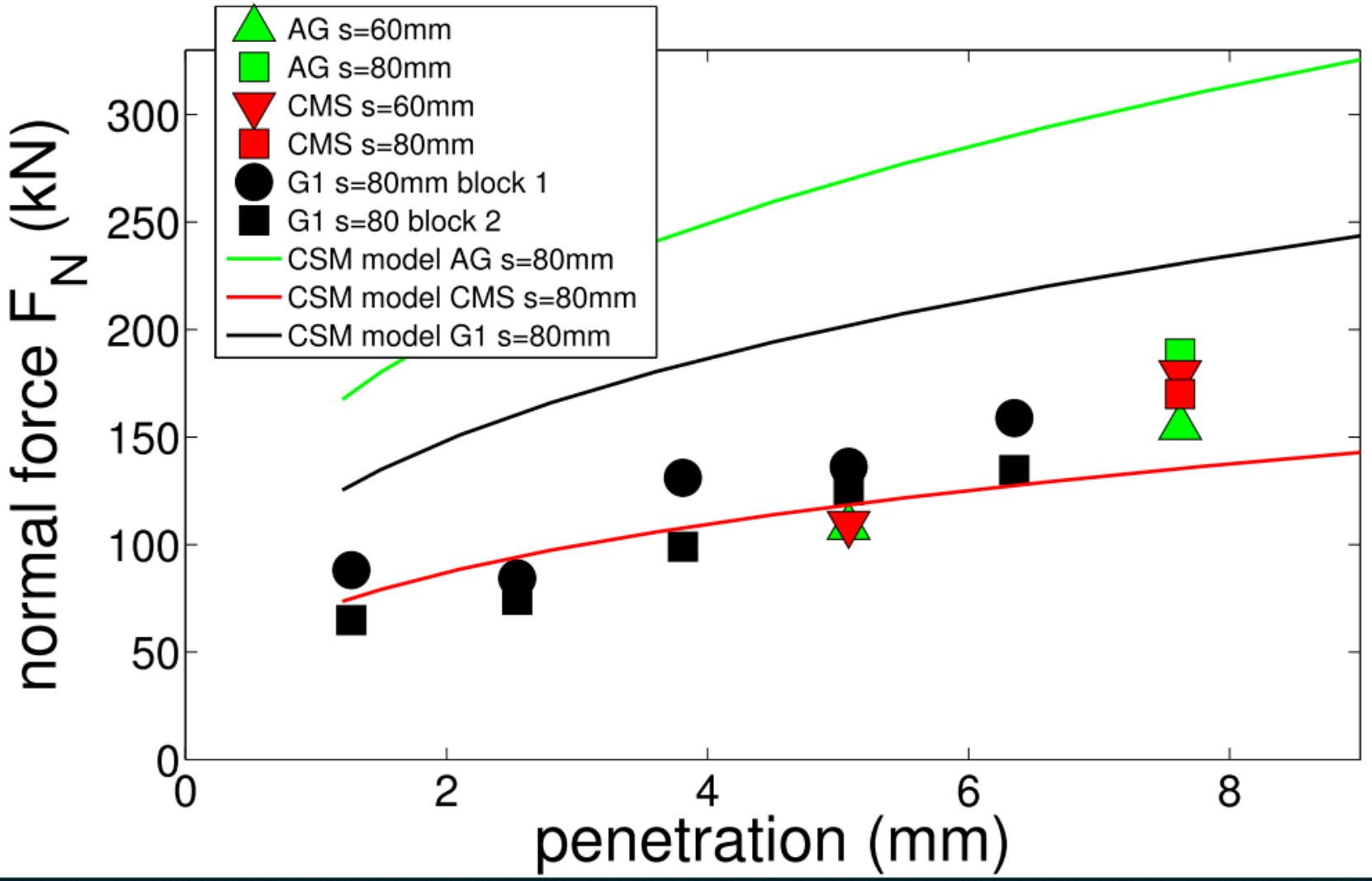
→ Very high resolution (*~15,000* data points for *90 mm* sample)

Geotechnical standard tests

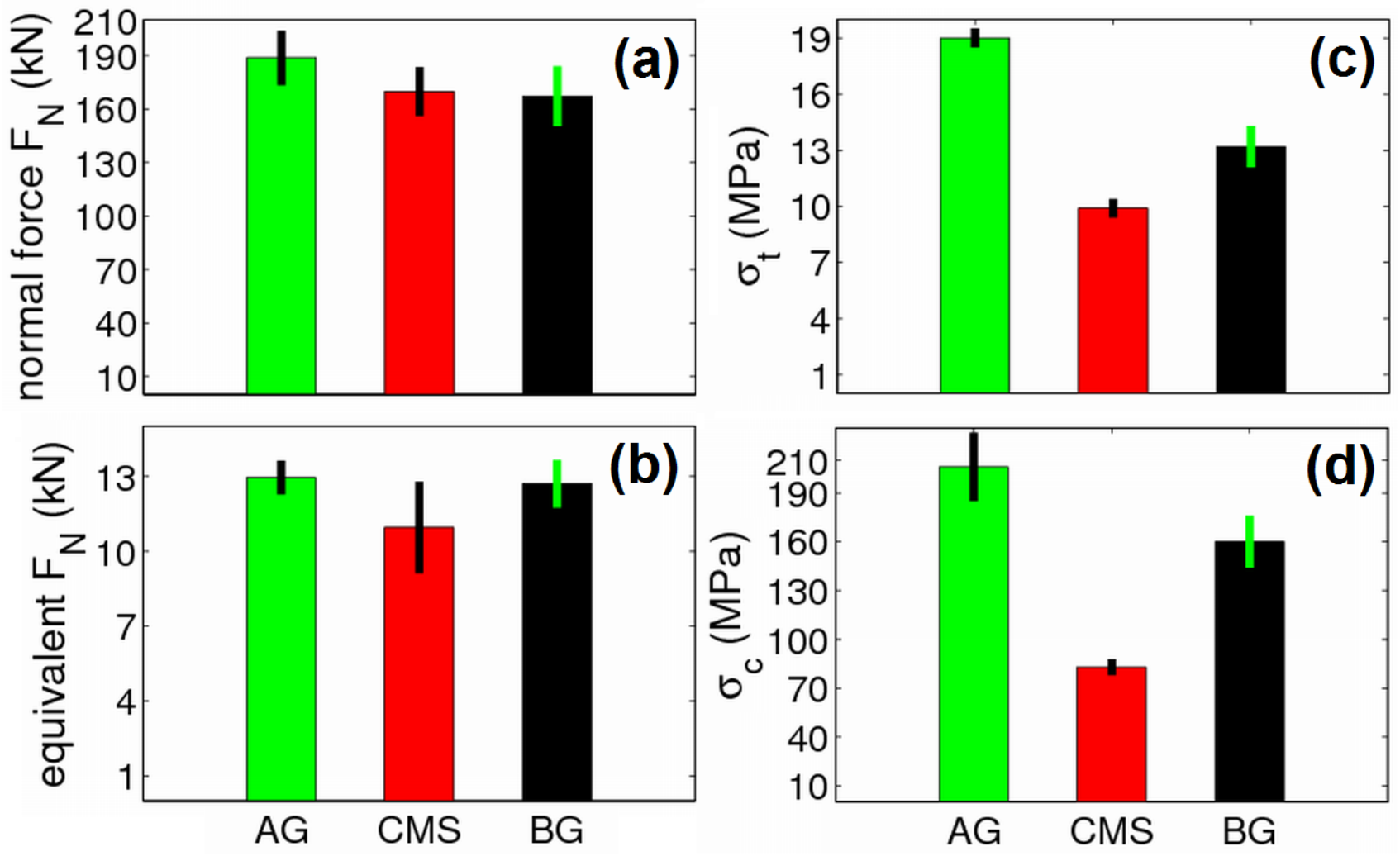


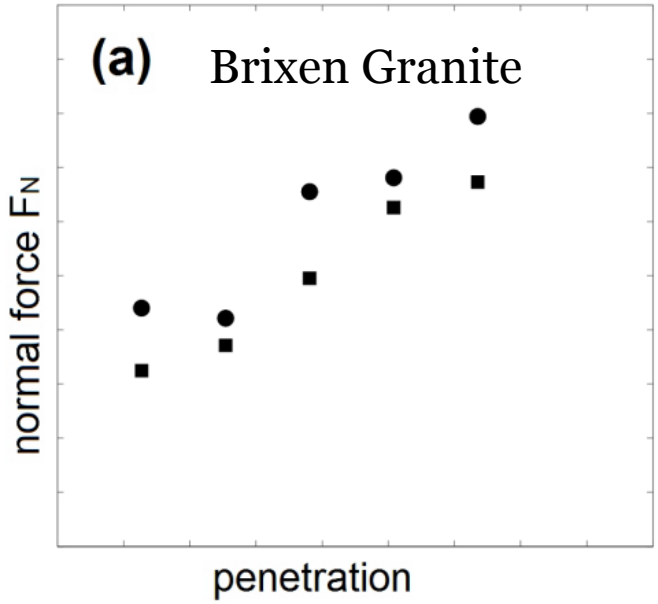


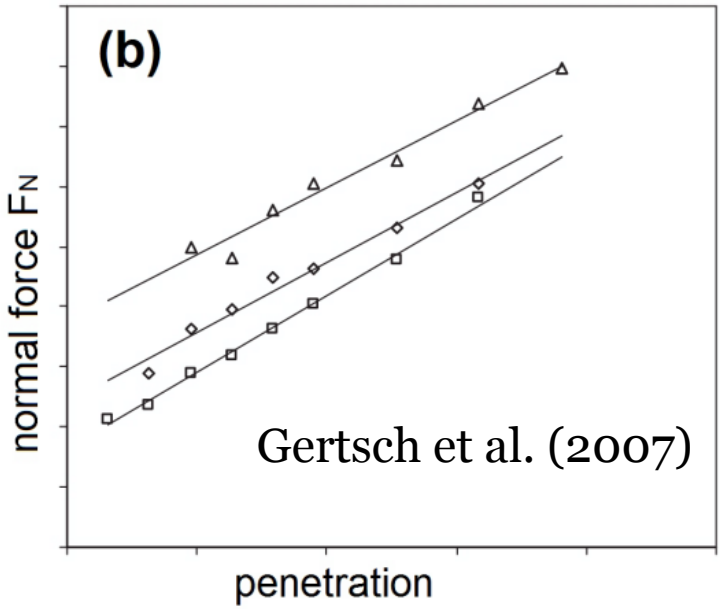
Full scale cutting tests / CSM model

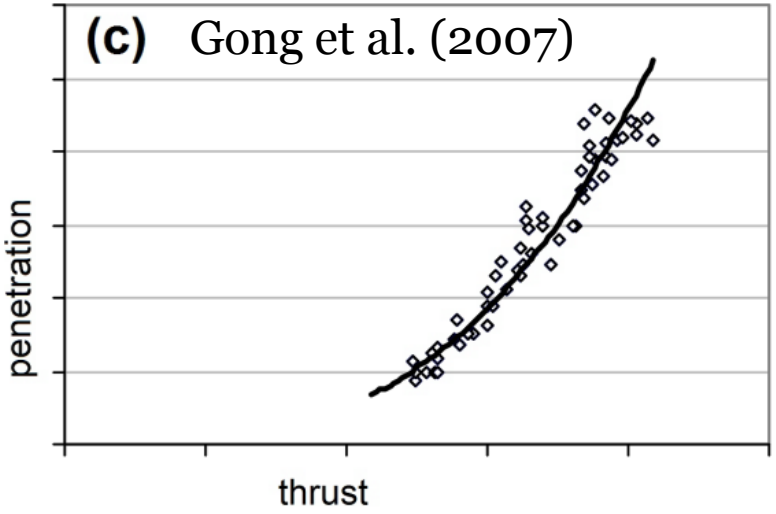


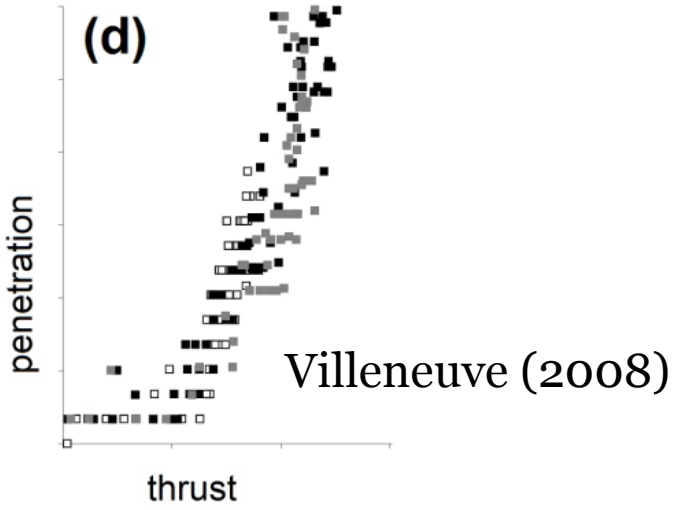
Comparison


(a)
normal force F_N (kN)
210
190
160
130
100
70
40
10
(b)
equivalent F_N (kN)
13
10
7
4
1
AG
CMS
BG
(c)
σ_t (MPa)
19
16
13
10
7
4
1
(d)
σ_c (MPa)
210
190
160
130
100
70
40
10
AG
CMS
BG









Frenzel et al. (2012) suggested to use a linear function without zero-crossing!

Model development

$$T = (P1 \cdot p + P2) \cdot n + F_F$$

total thrust

penetration

material properties

No. of cutters

Friction force TBM

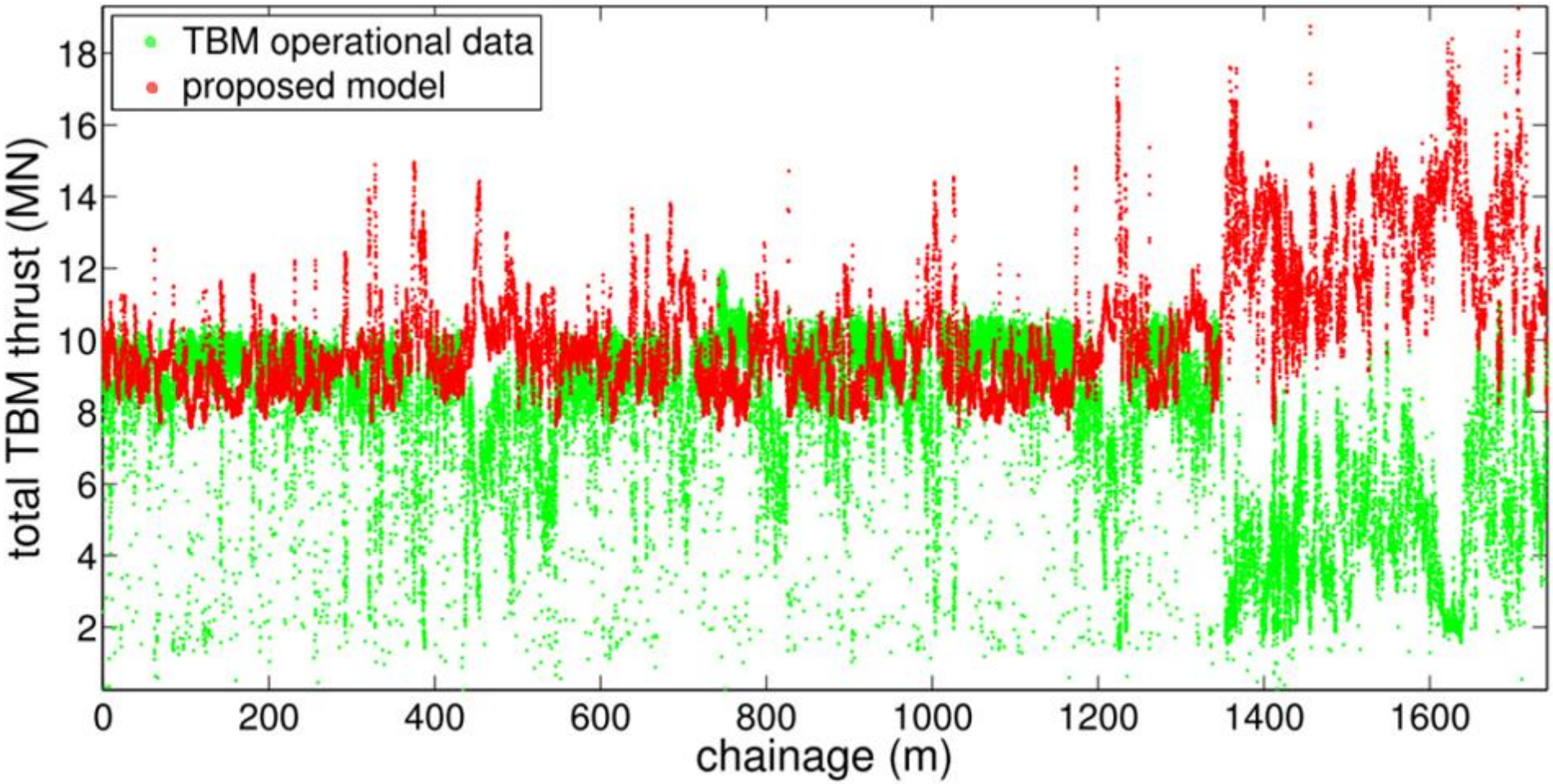
$$P2 = 3.5\, P1$$

$$P1 = F_{R,scaled}\, C$$

$$P1 = 2.43\, C \longrightarrow C = 6.2 \text{ (fitting result)}$$

Final model

$$T = \left(6.2\, F_{R,scaled} \cdot p + 21.7\, F_{R,scaled}\right) \cdot 45 + 4300$$



Measurement and interpretation of disc cutting forces in mechanized tunneling

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