Theoretical Analyses to Determine Risk of Buckling

Develop cncBuckle

- Buckling develops because of horizontal compression in the UTCRC
- Risk of buckling = Compression due to expansion (high temp. and humidity) **>** tensile stress due to shrinkage (high water content, fines, drying out)
- Interaction with support, reinforcement, variable cross section etc. complicates analysis: Finite Element Analysis

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WELCOME | CONTROL | WHAT IF

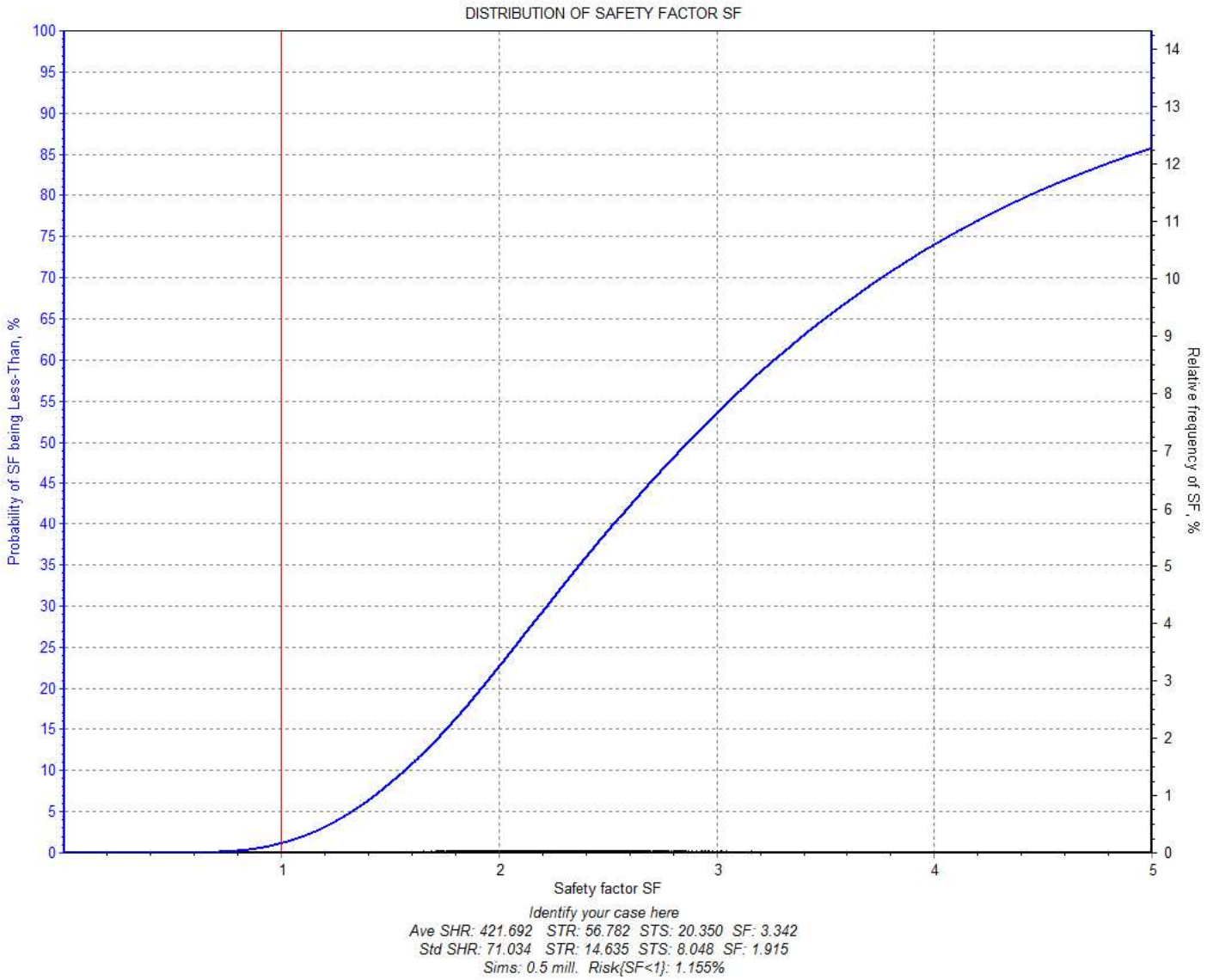
V	Variable	Min	Best	Max
1	wat, l/m3	165	175	185
2	aggc, %	57	60	63
3	f, MPa	9	11	13
4	hum, %	30	55	80
5	T, deg C	15	30	65
6	Unassigned	2	2.5	3
7	h, mm	48	51	56
8	hhoney, mm	0	0	20
9	hhump, mm	0	0	0
10	Bond	1	2	4

C	Constant	Value
1	t, years	1
2	Ls, m	200
3	|Grad|, %	4.5
4	hedge, mm	0
5	alpha	9.0e-6

Risk of SF<1:

1.2 %

Print ...



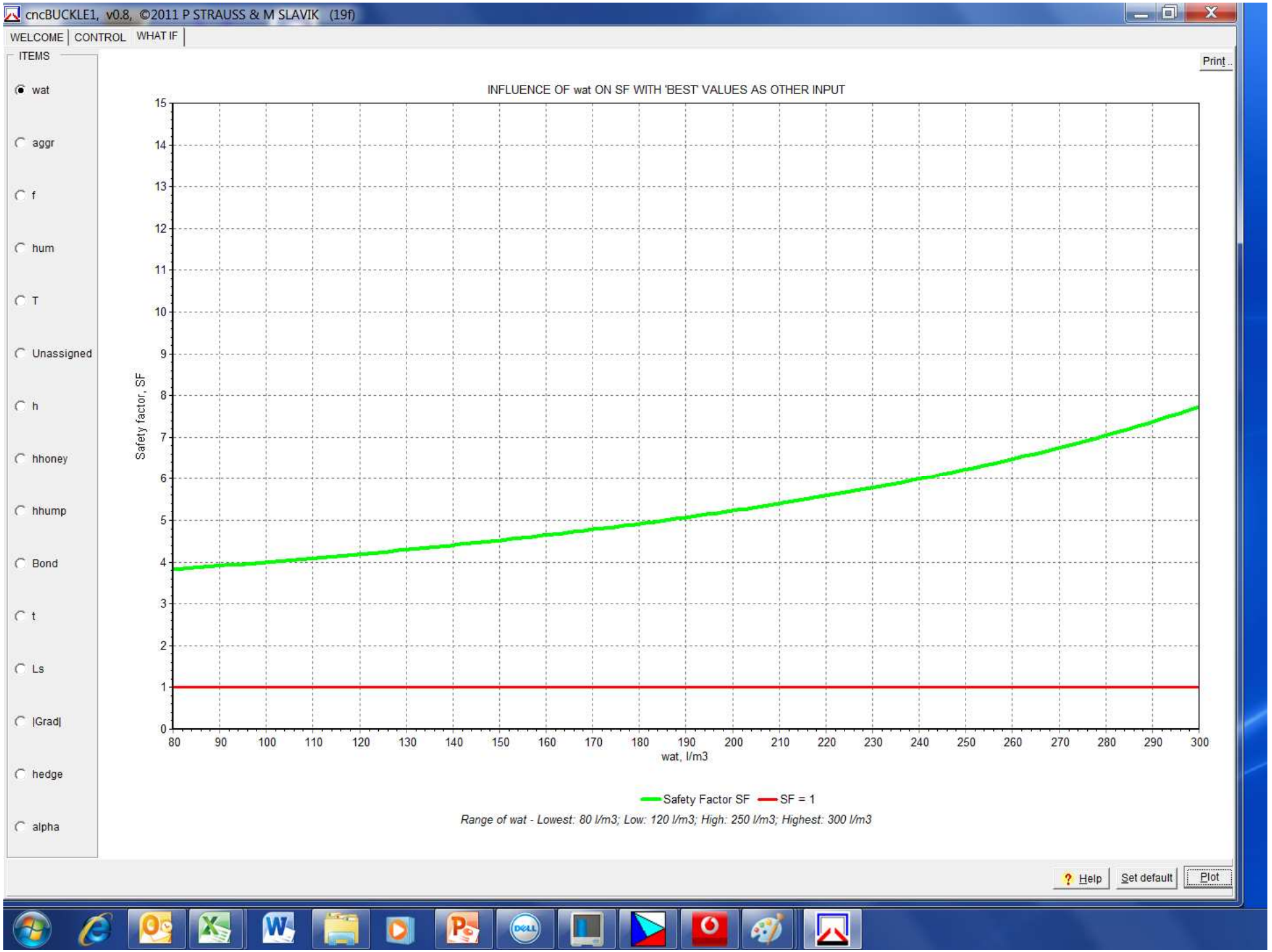
Identify your case here

Ave SHR: 421.692 STR: 56.782 STS: 20.350 SF: 3.342

Std SHR: 71.034 STR: 14.635 STS: 8.048 SF: 1.915

Sims: 0.5 mill. Risk{SF<1}: 1.155%

Identify your case here | Input guide | Help | Set default | 0.86 seconds | Abort | Evaluate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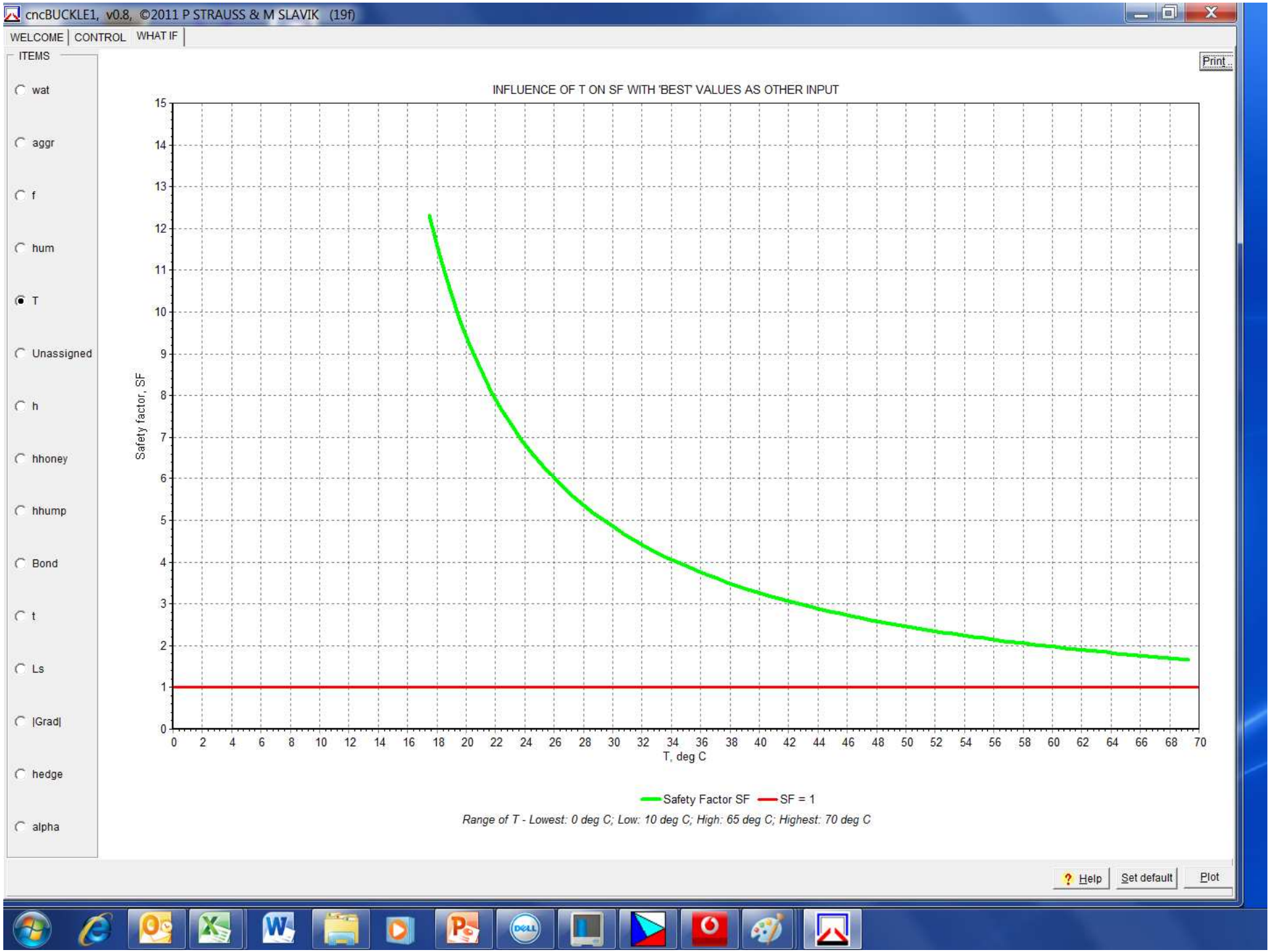
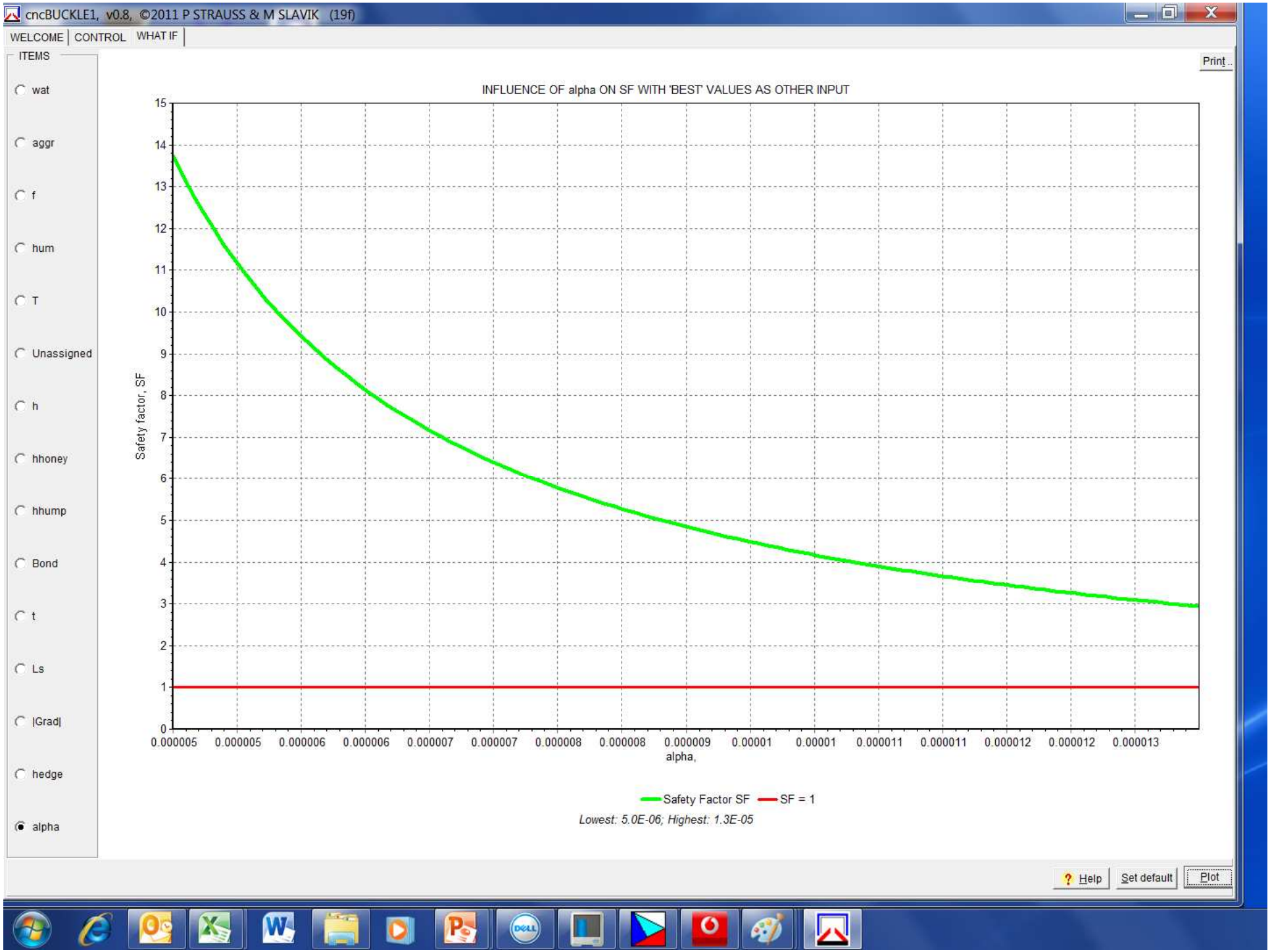
WELCOME
CONTROL
WHAT IF
ITEMS
wat
aggr
f
hum
T
Unassigned
h
hhoney
hhump
Bond
t
Ls
|Grad|
hedge
alpha
Print ..
INFLUENCE OF wat ON SF WITH 'BEST' VALUES AS OTHER INPUT
Safety factor, SF
wat, l/m3
Safety Factor SF
SF = 1
Range of wat - Lowest: 80 l/m3; Low: 120 l/m3; High: 250 l/m3; Highest: 300 l/m3
Help
Set default
Plot


cncBUCKLE1, v0.8, ©2011 P STRAUSS & M SLAVIK (19f)
WELCOME
CONTROL
WHAT IF
ITEMS
wat
aggr
f
hum
T
Unassigned
h
hhoney
hhump
Bond
t
Ls
|Grad|
hedge
alpha
Print...
INFLUENCE OF T ON SF WITH 'BEST' VALUES AS OTHER INPUT
Safety factor, SF
T, deg C
Safety Factor SF
SF = 1
Range of T - Lowest: 0 deg C; Low: 10 deg C; High: 65 deg C; Highest: 70 deg C
Help
Set default
Plot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WELCOME
CONTROL
WHAT IF
ITEMS
wat
aggr
f
hum
T
Unassigned
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hhoney
hhump
Bond
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Ls
|Grad|
hedge
alpha
Print ..
INFLUENCE OF alpha ON SF WITH 'BEST' VALUES AS OTHER INPUT
Safety factor, SF
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0.000005
0.000005
0.000006
0.000006
0.000007
0.000007
0.000008
0.000008
0.000009
0.00001
0.00001
0.000011
0.000011
0.000012
0.000012
0.000013
alpha,
Safety Factor SF
SF = 1
Lowest: 5.0E-06; Highest: 1.3E-05
Help
Set default
Plot


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WELCOME
CONTROL
WHAT IF
ITEMS
wat
aggr
f
hum
T
Unassigned
h
hhoney
hhump
Bond
t
Ls
|Grad|
hedge
alpha
Print ..
INFLUENCE OF hum ON SF WITH 'BEST' VALUES AS OTHER INPUT
Safety factor, SF
hum, %
Safety Factor SF
SF = 1
Range of hum - Lowest: 0 %; Low: 10 %; High: 85 %; Highest: 100 %
Help
Set default
Plot

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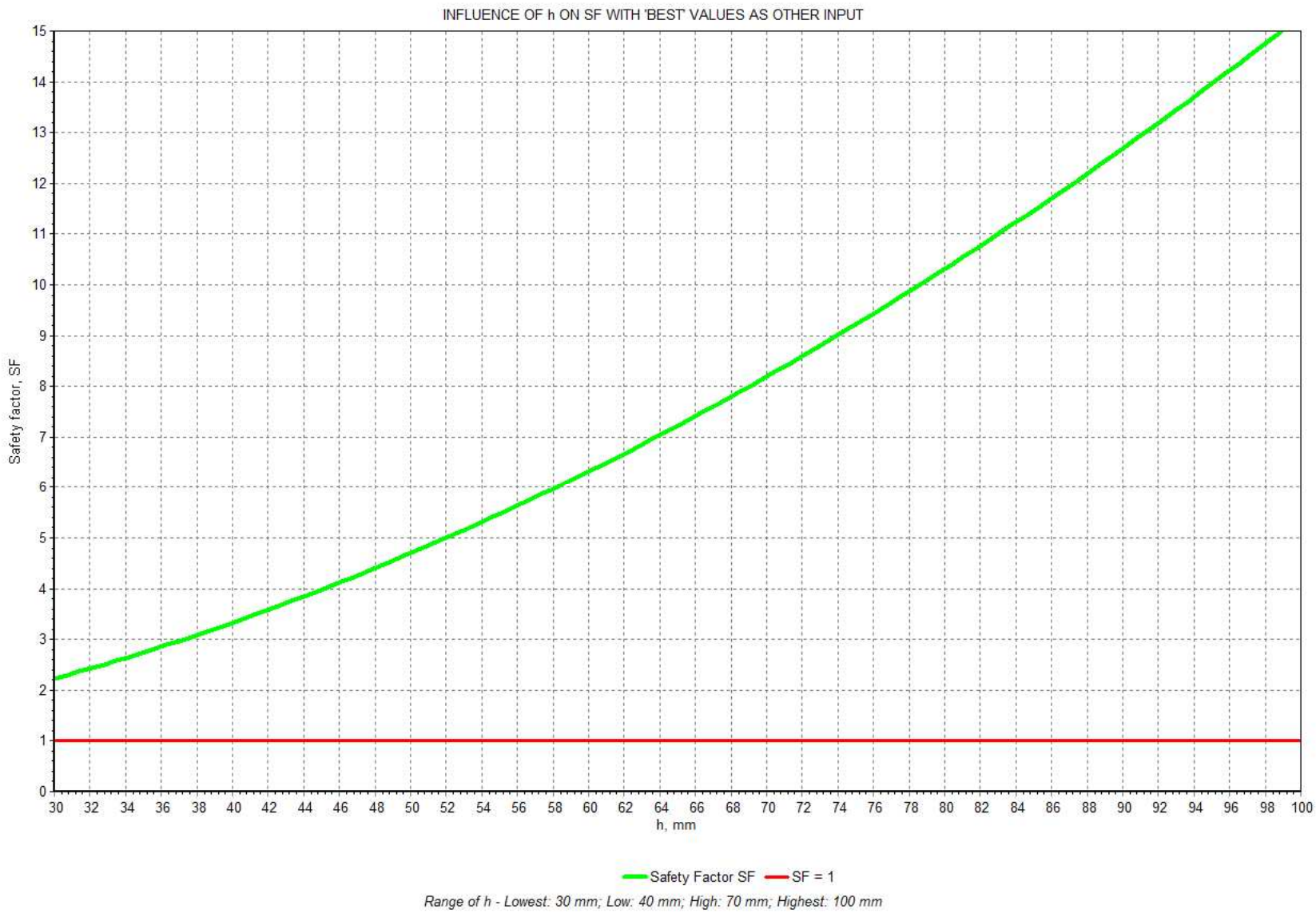
WELCOME | CONTROL | WHAT IF

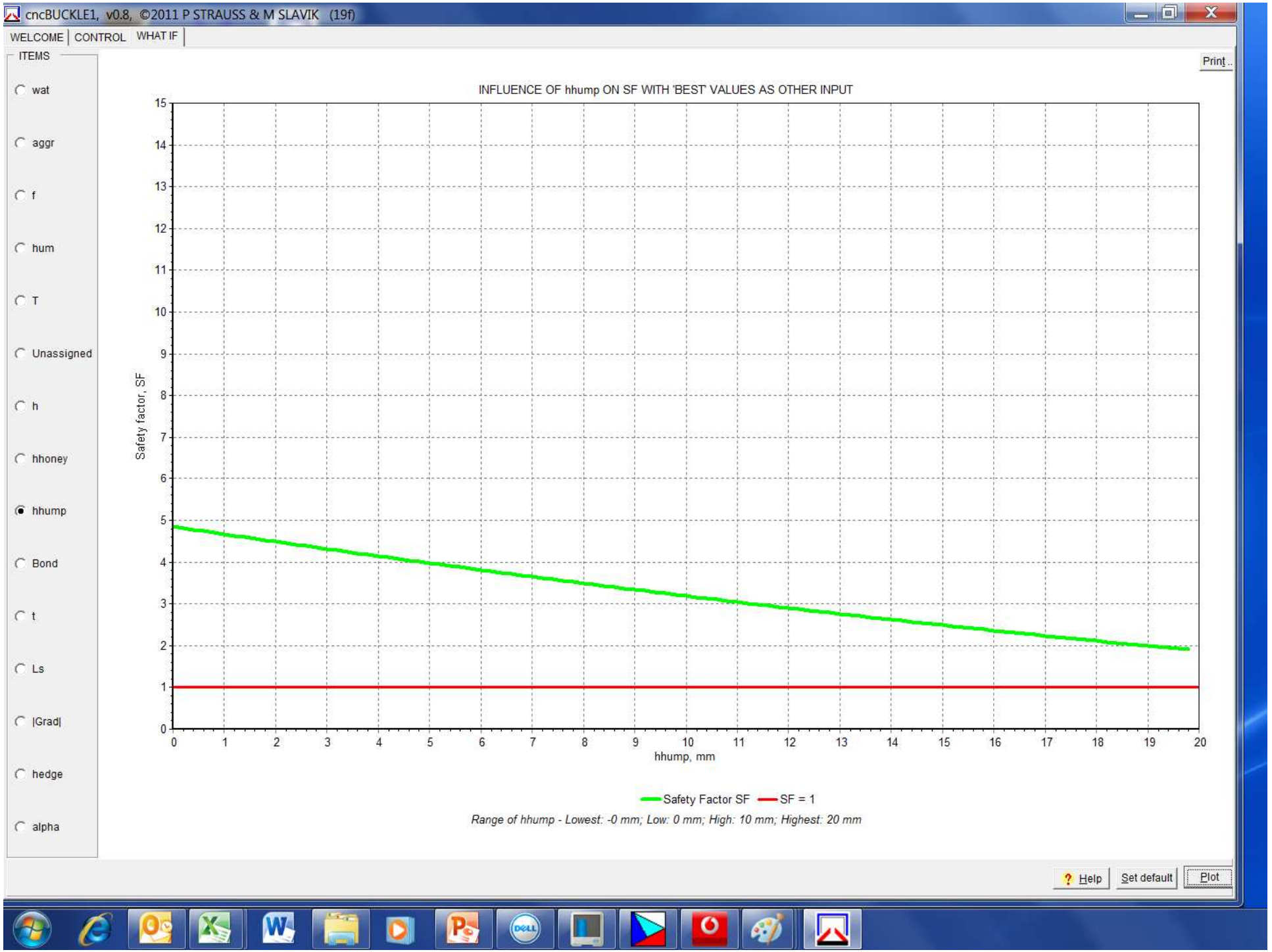
ITEMS

- wat
- aggr
- f
- hum
- T
- Unassigned
- (•) h
- hhoney
- hhump
- Bond
- t
- Ls
- |Grad|
- hedge
- alpha

Print ..



Help | Set default | Plot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WELCOME
CONTROL
WHAT IF
ITEMS
wat
aggr
f
hum
T
Unassigned
h
hhoney
hhump
Bond
t
Ls
|Grad|
hedge
alpha
Print ..
INFLUENCE OF hhump ON SF WITH 'BEST' VALUES AS OTHER INPUT
Safety factor, SF
hhump, mm
Safety Factor SF
SF = 1
Range of hhump - Lowest: -0 mm; Low: 0 mm; High: 10 mm; Highest: 20 mm
Help
Set default
Plot

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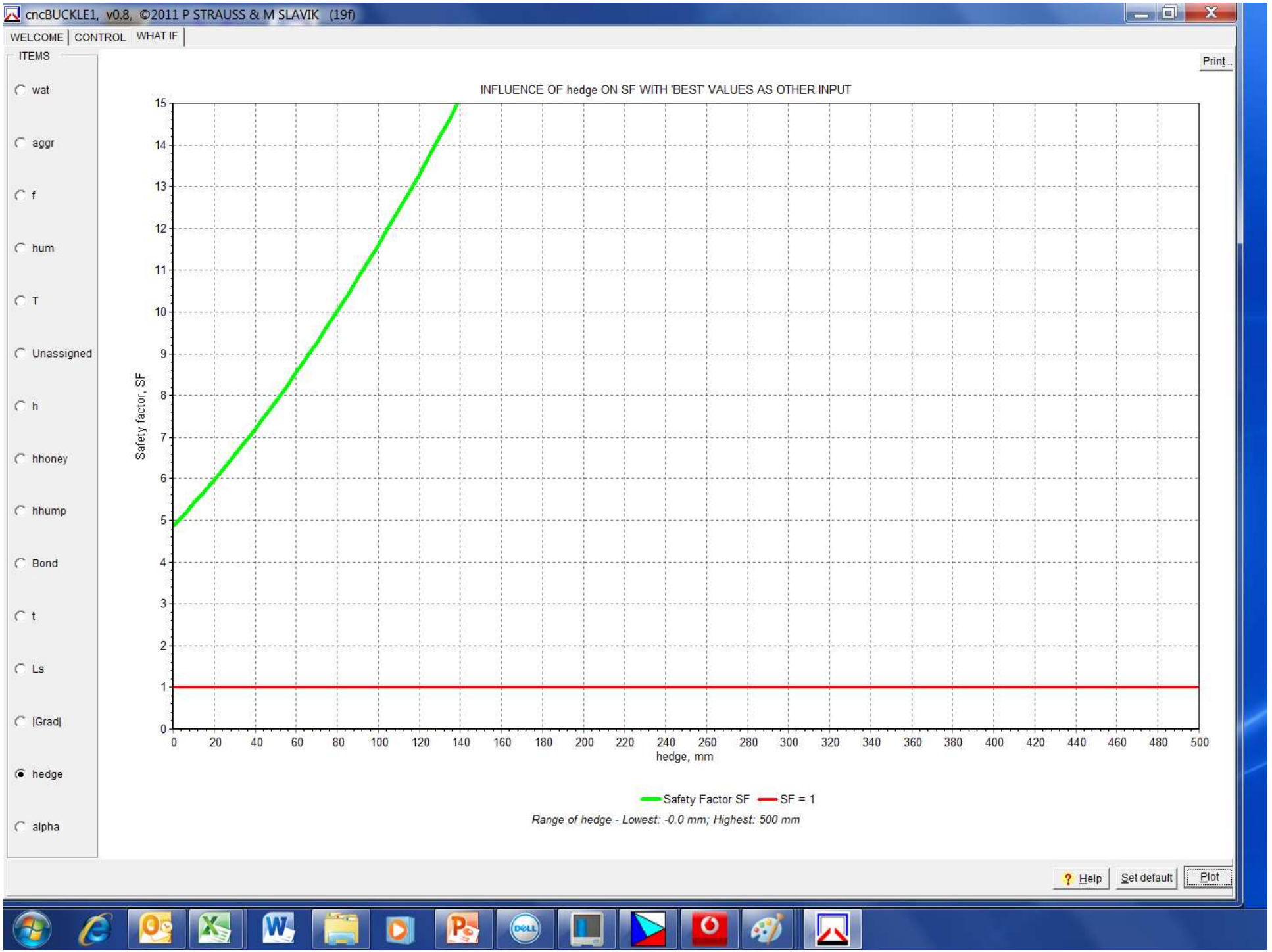
WELCOME | CONTROL | WHAT IF

ITEMS

- wat
- aggr
- f
- hum
- T
- Unassigned
- h
- (•) hhoney
- hhump
- Bond
- t
- Ls
- |Grad|
- hedge
- alpha

Print ..

Help | Set default | Plot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WELCOME
CONTROL
WHAT IF
ITEMS
wat
aggr
f
hum
T
Unassigned
h
hhoney
hhump
Bond
t
Ls
|Grad|
hedge
alpha
Print ..
INFLUENCE OF hedge ON SF WITH 'BEST' VALUES AS OTHER INPUT
Safety factor, SF
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
hedge, mm
Safety Factor SF
SF = 1
Range of hedge - Lowest: -0.0 mm; Highest: 500 mm
Help
Set default
Plot

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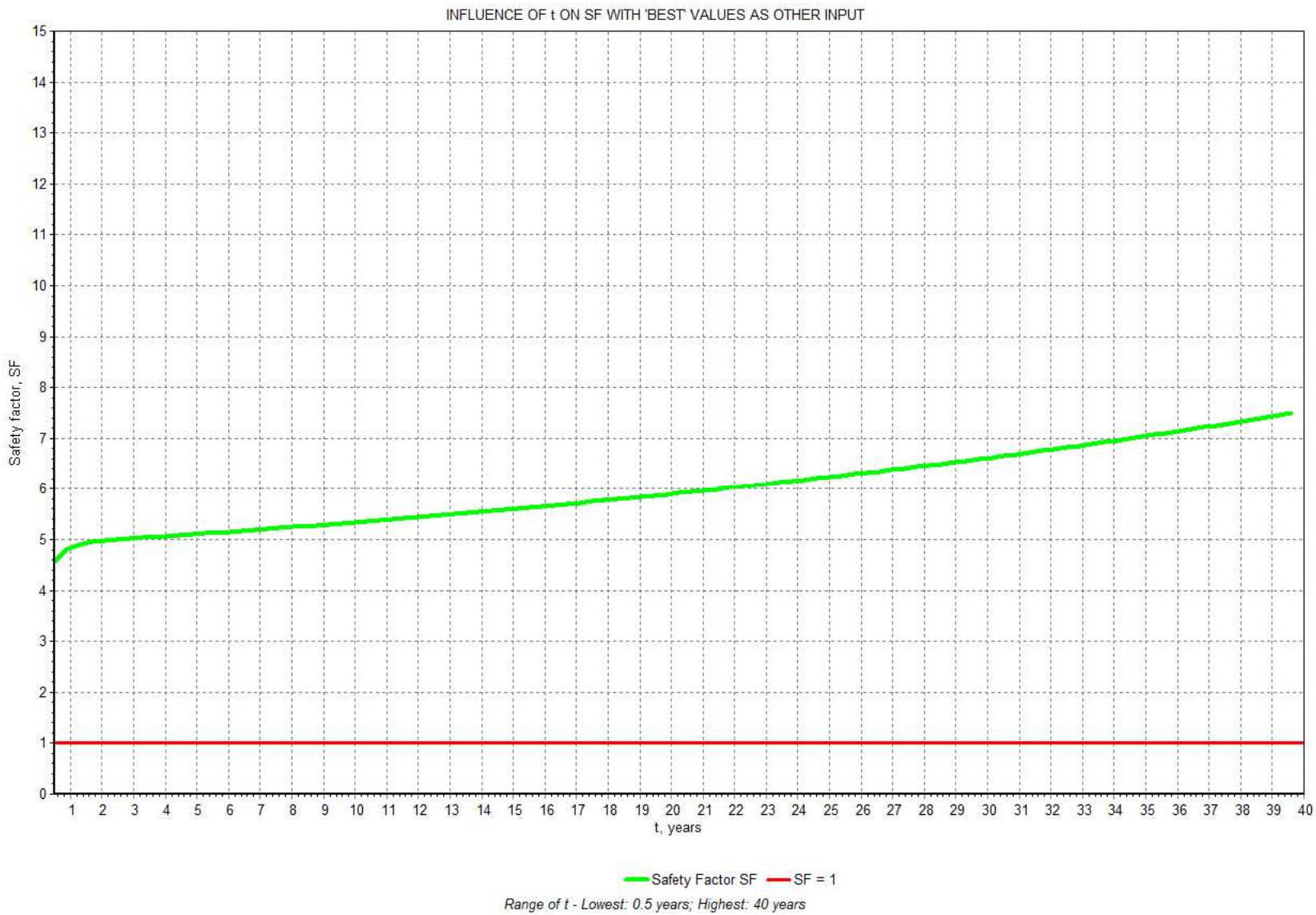
WELCOME | CONTROL | WHAT IF

ITEMS

- wat
- aggr
- f
- hum
- T
- Unassigned
- h
- hhoney
- hhump
- Bond
- t
- Ls
- |Grad|
- hedge
- alpha

Print ..



Help | Set default | Plot

Implications

- FEA indicated that normally shrinkage stress would be high enough to absorb any expansion
- Relaxation of tensile stress must have occurred
- Variation in thickness most critical
- Weakness such as construction joints may act as triggers
- Safety in joining with adjacent lanes (thickened edges), proper compaction, uniform slab thickness and support.

Less critical issues

- Position of the reinforcement in the slab
- Longitudinal slope of the pavement
- Aggregate content and strength of the concrete
- Bond between UTCRC and support
- Distance between construction joints

Thank you for your attention