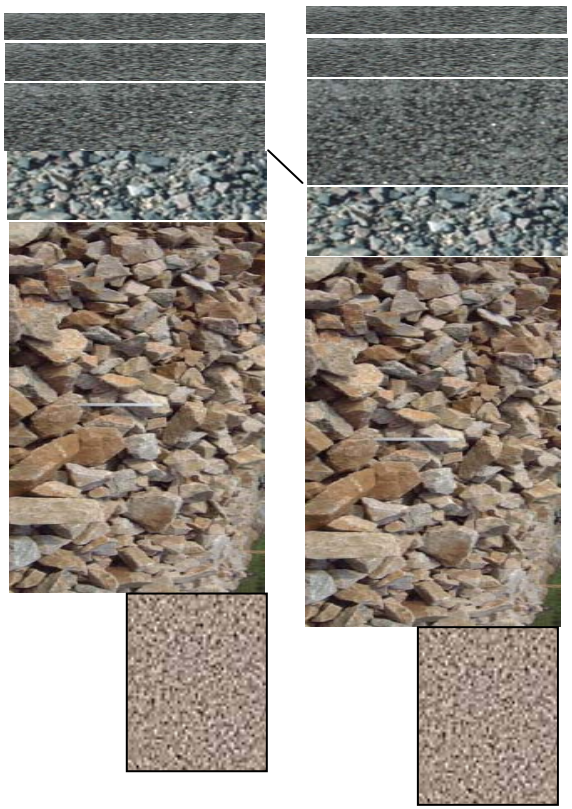
~~ROUTE 66~~ Road 68, comparing two structures.

A ”simple” question from a friend in our northernmost region:

Will this work?

80 mm recycled basecourse with soft binder (ÅAMJAG)

Instead of designed?



35 mm wearing course

50 mm binding course

130 mm recycled basecourse with soft binder (ÅAMJAG)

80 mm Base

420 mm subbase

200 mm frost protection layer when subground is silty

Object:

In a report from VTI (Said, Hakim and Jacobson) a design procedure was outlined for layers with soft binders.

They used lab-results for E-moduli and fatigue-characteristics for asphalt gravel with soft binder.

They also used time periods from ”measured” AC-temperatures instead of seasons.

I have *tried* to apply the procedure for the question asked.

”The concept”: (don’t blame VTI)

Temp.data from
a close weather-station with
a full year measurement

→

Calculate in depth-temperatures
using ”Bell3” algoritm
(no access to
VTI-method/Hermansson,
-probaby better)

↓

Calculate the E-moduli at
the interval ± 2,5 ° C
using
lab-results for the different
bound layers

→

Sort it at temp-intervals
and seasons
(E-mouli for unbound layers
according to
ATB VÄG)

Calculate the stress and strains in the bottom of the bound layers and on the top of the subground for the different intervals and the different seasons (unbound layers)

(Thank You programmer for the batch-running option)

Calculate the allowed number of ESALS using the fatigue characteristics from the report with a shift factor of 10

Compare the different constructions

Traffic load:

$AADT_k$: 1250 vehicles pr lane
20% heavy (≥ 3,5 ton)
2% growth/ year
Average # of eq_std.axles /heavy vehicle (B) =1,3

Summed for 20 years: $2,9 * 10^6$

BELLS3 (Routine testing methods)

$T_d = 0.95 + 0.892 * IR + \{\log(d) - 1.25\}\{-0.448 * IR + 0.621 * (1\text{-day}) + 1.83 * \sin(hr_{18} - 15.5)\} + 0.042 * IR * \sin(hr_{18} - 13.5)$

Where:

T_d = Pavement temperature at depth d, °C

IR = Pavement surface temperature, °C

log = Base 10 logarithm

d = Depth at which mat temperature is to be predicted, mm

1-day = Average air temperature the day before testing, °C

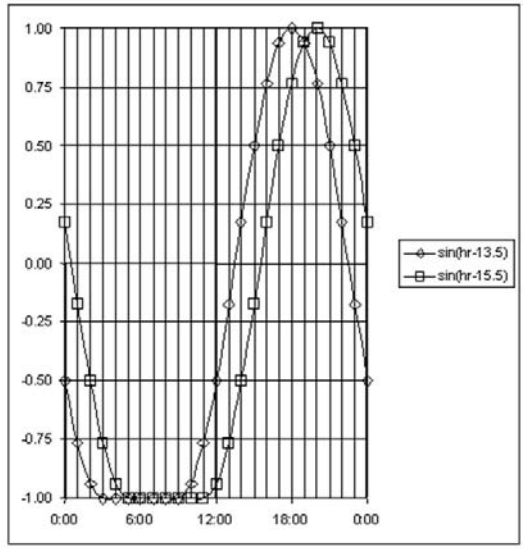
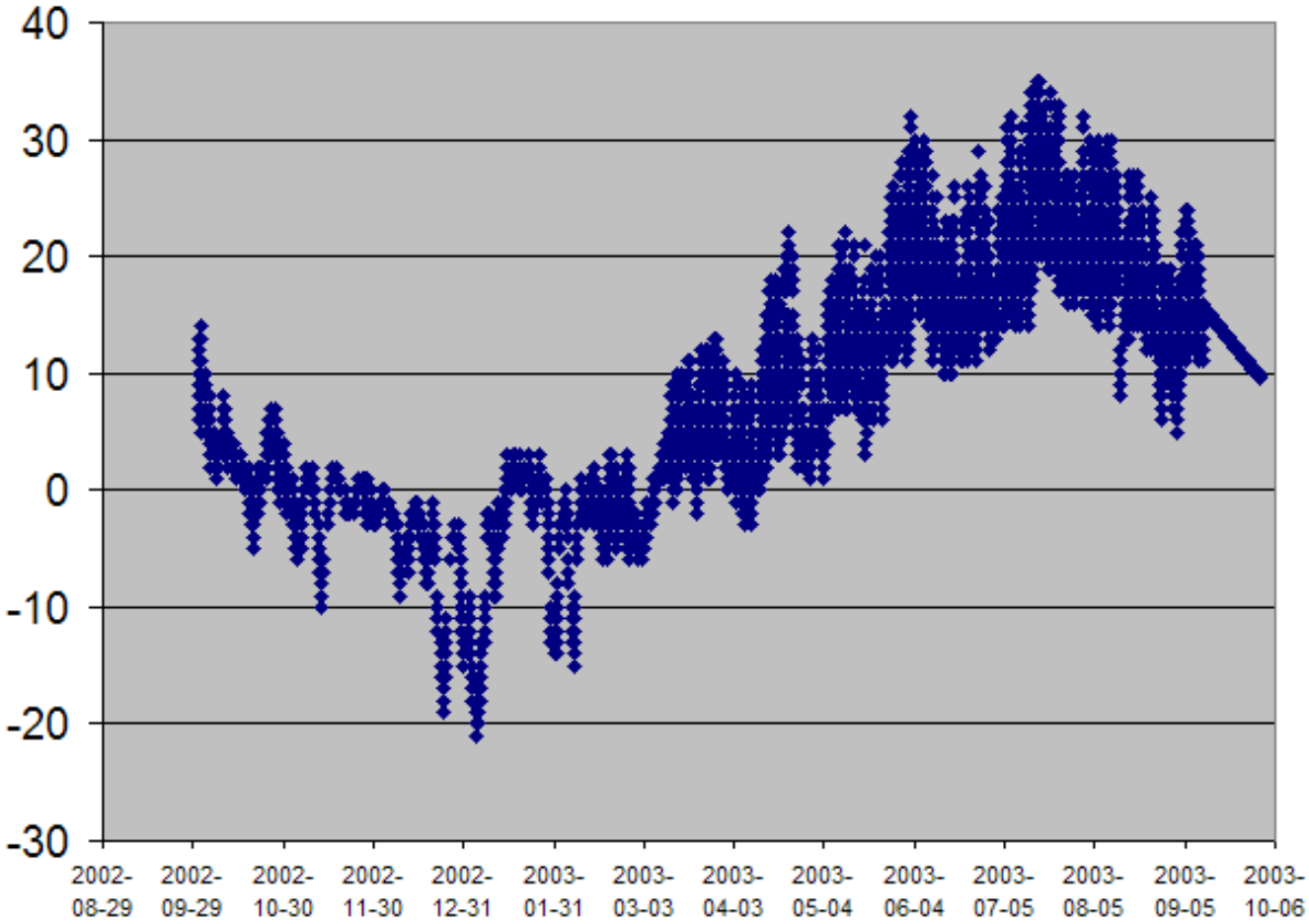


Figure 6. 18-hr Sine Function Used in BELLS Equations

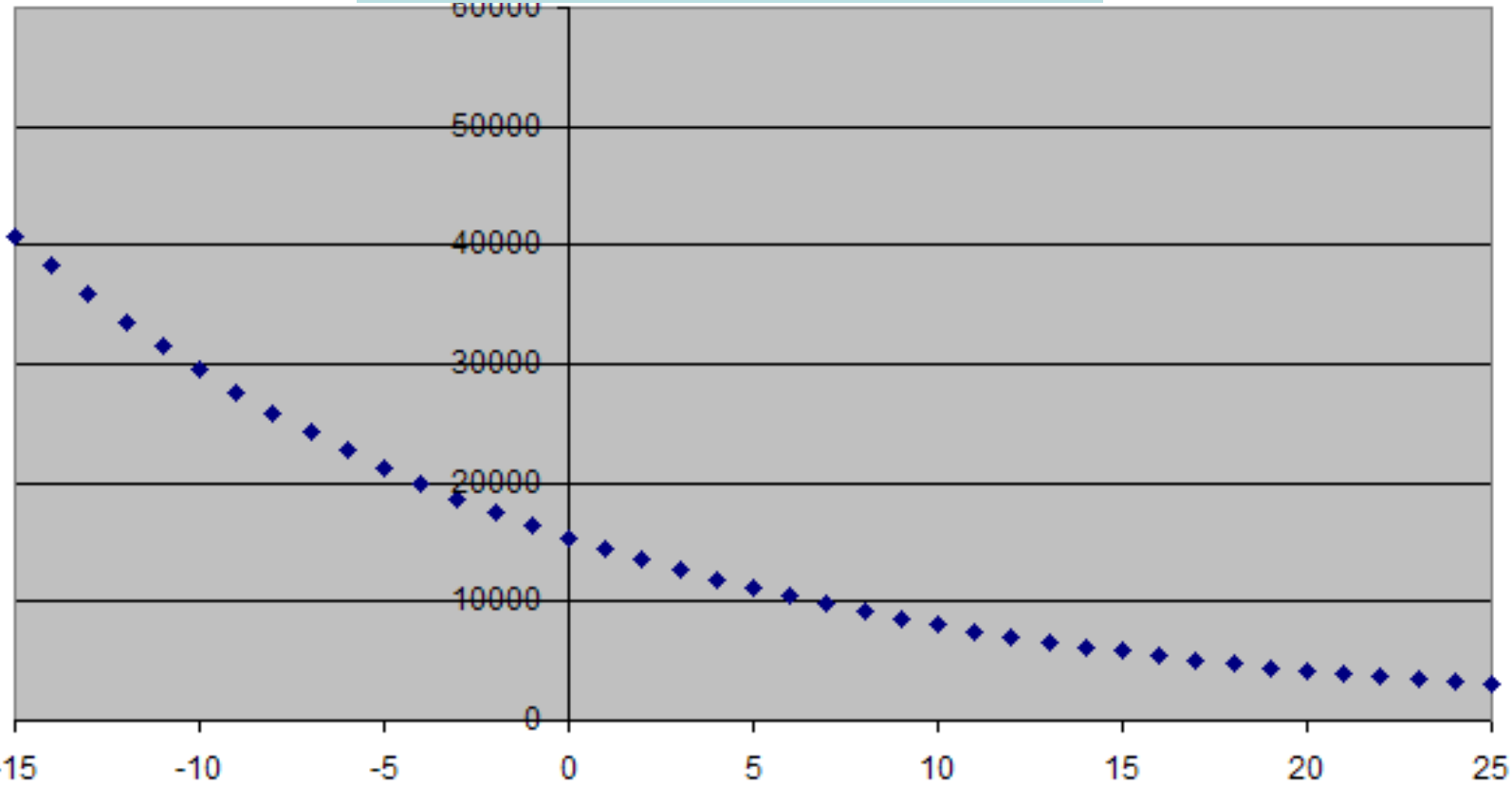
sin = Sine function on an 18-hr clock system, with 2π radians equal to one 18-hr cycle

hr_{18} = Time of day, in a 24-hr clock system, but calculated using an 18-hr asphalt concrete (AC) temperature rise-and-fall time cycle, as indicated in Figure 6

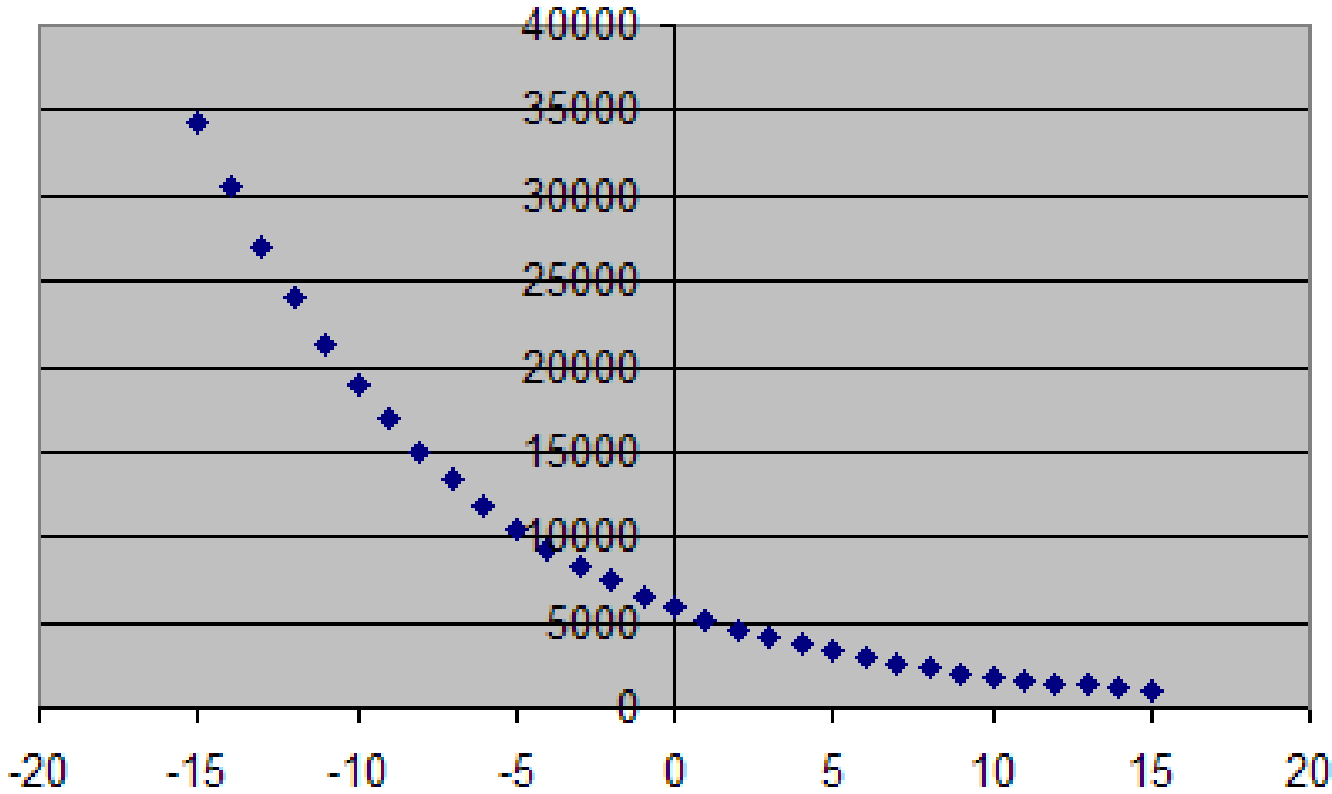
Exemple: Road 68 temperatures at 8 cm depth.



E-moduli used for ”standard” layers (=MS in ATB VÄG)



E-moduli used for ÅAMJAG



Cases

	Winter	Winter	Winter	Winter	Thaw	Fall	Thaw	thickness
	-20 - -11	-10 - -6	-5 - -1	0 - 4	0 - 4	0 - 4	5 - 9	mm
days	**15**	**18**	**71**	**52**	**18**	**22**	**31**	
E toplayer	40828	26013	18795	13580	13580	13580	9812	35
E Bind	40828	26013	18795	13580	13580	13580	9812	50
EÅAG	34300	15000	8300	4100	4100	4100	2580	**80**
E base	1000	1000	1000	1000	300	450	300	80
E subbase	450	450	450	450	450	450	450	420
E frost prot	1000	1000	1000	1000	70	100	70	0
Subgroun	1000	1000	1000	1000	35	100	35	
ε centrumlinj								
ε mitt under 1 hjul								

	tjällossn	sommar	Höst	Tjällossn	Sommar	Höst	Sommar	
	10 - 14	10 - 14	10 - 14	15 - 19	15 - 19	15 - 19	20 - 25	
days	**16**	**18**	**33**	**3**	**40**	**10**	**18**	
E toplayer	7089	7089	7089	5122	5122	5122	3590	35
E Bind	7089	7089	7089	5122	5122	5122	3590	50
EÅAG	14500	14500	14500	810	810	810	400	**80**
E base	300	450	450	300	450	450	450	80
E subbase	450	450	450	450	450	450	450	420
E frost prot	70	100	100	70	100	100	100	0
Subgroun	35	100	100	35	100	100	100	
ε centrumlinj								
ε mitt under 1 hjul								

	vinter	vinter	vinter	vinter	tjällossn	Höst	tjällossn	tjocklekar
	-20 - -11	-10 - -6	-5 - -1	0 - 4	0 - 4	0 - 4	5 - 9	mm
days	**15**	**18**	**71**	**52**	**18**	**22**	**31**	
E toplayer	40828	26013	18795	13580	13580	13580	9812	35
E Bind	40828	26013	18795	13580	13580	13580	9812	50
EÅAG	34300	15000	8300	4100	4100	4100	2580	**130**
E base	1000	1000	1000	1000	300	450	300	80
E subbase	450	450	450	450	450	450	450	420
E frost prot	1000	1000	1000	1000	70	100	70	0
Subgroun	1000	1000	1000	1000	35	100	35	
ε centrur	19	29	40	54	82	72	109	

	tjällossn	sommar	Höst	Tjällossn	Sommar	Höst	Sommar	
	10 - 14	10 - 14	10 - 14	15 - 19	15 - 19	15 - 19	20 - 25	
days	**16**	**18**	**33**	**3**	**40**	**10**	**18**	
E toplayer	7089	7089	7089	5122	5122	5122	3590	35
E Bind	7089	7089	7089	5122	5122	5122	3590	50
EÅAG	14500	14500	14500	810	810	810	400	**130**
E base	300	450	450	300	450	450	450	80
E subbase	450	450	450	450	450	450	450	420
E frost prot	70	100	100	70	100	100	100	0
Subgroun	35	100	100	35	100	100	100	
ε centrur	137	114	114	164	130	130	135	

Thaw
0 - 4
18
13580
13580
4100
300
450
70
35

Season

Temp interval

# of days

E AC

E AC

E ÅAMJAG

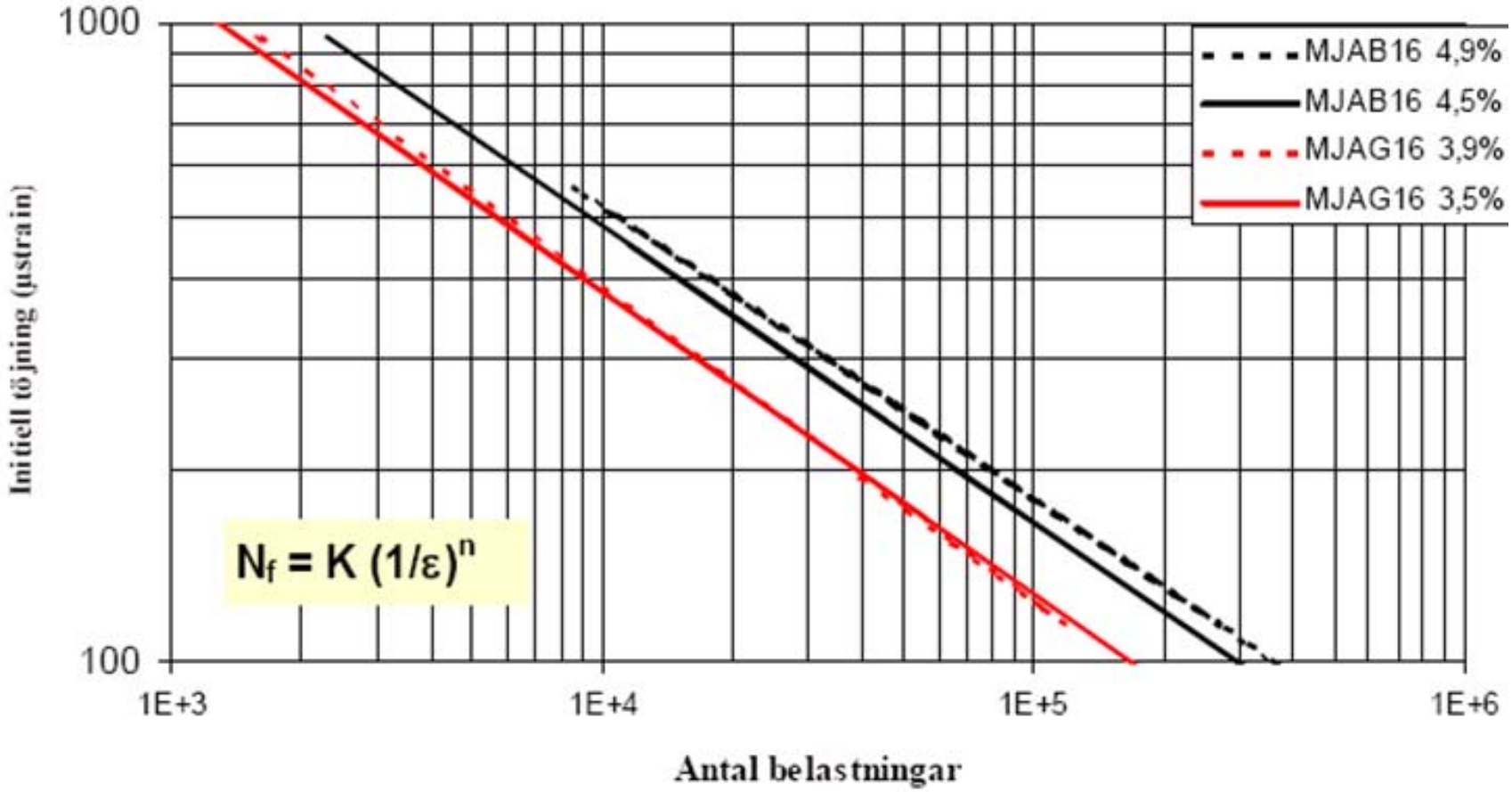
E Base

E Subbase

E frost pr. Lay

E Subground

Fatigue relation for AC with soft binder



Example of calculation of number of allowed ESALS

(Miner's hypothesis)

	Winter	Winter	Winter	Winter	Thaw	Fall	Thaw	Thaw	Summer
	-20 - -11	-10 - -6	-5 - -1	0 - 4	0 - 4	0 - 4	5 - 9	10 - 14	10 - 14
Days	**15**	**18**	**71**	**52**	**18**	**22**	**31**	**16**	**18**
	Horizontal strains in the bottom of the asphalt layers								
ε Asf micro	27	39	53	67	104	90	130	160	135
N_{BBi}	27683466	12742413	6670769	4067993	1608636	2182460	1004564	648193,7	927670,5
n_i/N_{BBi}	5,42E-07	1,41E-06	1,06E-05	1,28E-05	1,12E-05	1,01E-05	3,09E-05	2,47E-05	1,94E-05
N_{tillBB}	**1,45E+06**	st	**(number of allowed ESALS)**						

Drawbacks?

- **There was a gap for 1 month in the temp-recording.**

I used an airtemp-recording and assumed a linear relation to estimate the in-depth temperatures for that month.

- **What E-moduli would I use for unbound layers and subground?**

I used the **values stated in our design-system**

- **I assumed MJAG was equal to ÅAMJAG**
- **This could be a rather rough assumption**

Results:
No construction good enough!

- Constr. with 80 mm ÅAMJAG: 1,5 *10^6 ESALS
- Constr. with 130 mm ÅAMJAG: 2,03 *10^6 ESALS
- Requiered: 2,9 *10^6

The answer were given along with a few reservations – of course:

thick layers with soft binder, compaction, few data for the model and so on….

Final Questions:

- Should the temperatures be measured over a whole year on a number of VVIS-stations?
- Could we be more adequate when deciding moduli?
- Could we apply an analytic/empiric method for low volume roads?
- What criteria should be used on low-volume roads?

Thank You !