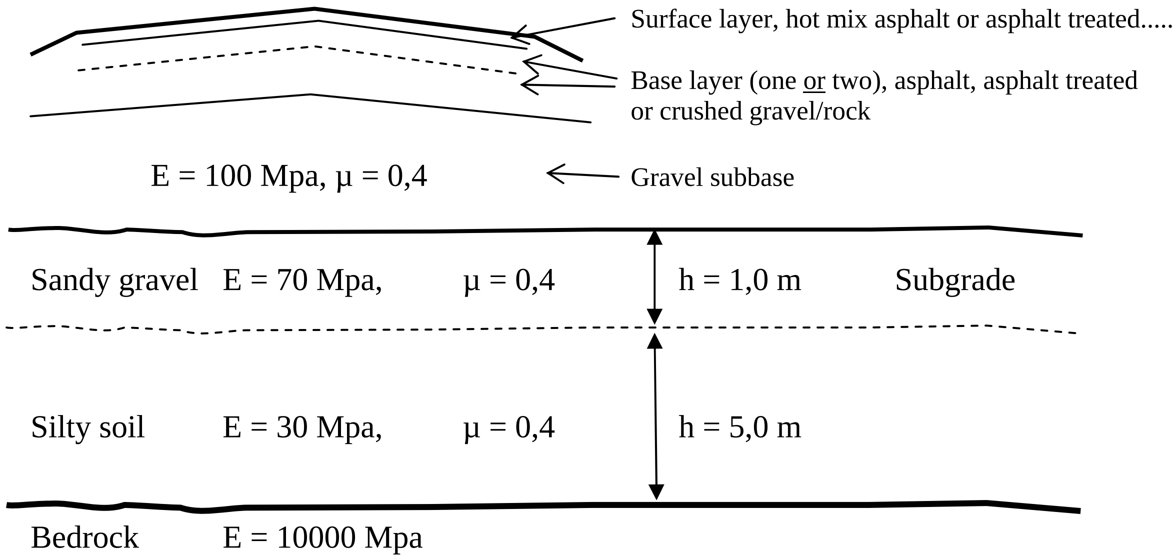
FLEXIBLE PAVEMENT DESIGN

Examples of design with different systems.

Design three types of highways, all main roads but with different traffic loads. The roads shall all be designed on the same subgrade. Surface shall be hot mix asphalt or asphalt treated material. The base layer shall be asphalt, asphalt treated material or crushed gravel or rock. Subbase layer shall be of well graded gravel with E value = 150 map.



Design period is 20 years, 2 lane roads, axel load 10 tons.

Design example					Residual lifetime*
Class	AADT	Annual growth	Heavy traffic		Change in heavy traffic*
			(a)		(b)
A	500	4%	10%		18%
B	3000	4%	8%		15%
C	15000	4%	5%		12%

* What would be the change in expected residual lifetime of the designed road, if heavy traffic would increase from % in column (a) to the % in column (b).

What we mean, you design first for heavy traffic as in column (a) and then we would like to see, what happens if you suddenly have more trucks on those roads and the amount of heavy traffic would be like as shown in column (b), how much will the lifetime reduce.

REASULTS SUMMARY

Road of class A, AADT = 500

Design	Surface Type/thickness	Base I Type/thickness	Base II Type/thickness	Subase Type/thickness	Reduced life years
Denmark	AB 160/220 40 mm	GAB I 70/100 87 mm	SG 160 mm	BL 300 mm	-11
Finland	AB 70/100 70 mm		M280 250 mm	SR200 500 mm	-7
Iceland	Dog 30 mm	Fk 200 mm		300 mm	(N/A)~ -9 yrs
Norway HB018	Agb 35 mm	Fk 200 mm		300 mm	(N/A)~ -9 yrs
Sweden, PMS ob	ABS 40 mm	AG 40 mm	OBBL 80 mm	FL 420 mm	-10 yrs *
England					
France	BB 60 mm	GB 80 mm	200 mm	150 mm	- 8 years
Design Guide					
Mn/Pave	HMA 80 mm	Agg. Cl-6, 160 0m		140 mm	- 7 years
Florida	HMA 150 mm	Agg. Grad. 305 mm		390 mm	-11 years
California					

Road of class B, AADT = 3000

Design	Surface Type/thickness	Base I Type/thickness	Base II Type/thickness	Subase Type/thickness	Reduced life years
Denmark	SMA 40/60 35 mm	GAB II 40/60 105 mm	SG 200 mm	BL 355 mm	-11
Finland	AB 70/100 40 mm	ABK 70/100 100 mm	M280 200 mm	Sr200 500 mm	-9
Iceland	Y16 (AB) 60 mm	Fp 200 mm		400 mm	(N/A)~ -9 yrs
Norway HB018	Ab 60 mm	Ag 50 mm	Fk 100 mm	300 mm	(N/A)~ -9 yrs
Sweden, PMS ob	ABS 40 mm	AG 90 mm	OBBL 80 mm	FL 420 mm	-9 yrs **
England					
France	BB 60 mm	130 mm	NA	300 mm	- 8 years
Design Guide					
Mn/Pave	HMA 140 mm	Agg. Cl-6, 160 mm		210 mm	- 8 years
Florida	HMA 150 mm	Agg. Grad. 305 mm		390 mm	-11 years
California					

Road of class C, AADT = 15000

Design	Surface Type/thickness	Base I Type/thickness	Base II Type/thickness	Subase Type/thickness	Reduced life years
Denmark	SMA 40/60 35 mm	ABB 40/60 60 mm and GAB II 40/60 85 mm	SG 200 mm	BL 395 mm	-9
Finland	AB 70/100 100 mm	ABK 70/100 100 mm	MR280 200 mm	Sr200 500 mm	-11
Iceland	SMA 50 mm	U16 60 mm	Fp 200 mm	600 mm	(N/A)~ -9 yrs
Norway HB018	Ska/Ab 45+35	Ag 60 mm	Ap 100 mm	600 mm + 410 mm*	(N/A)~ -9 yrs
Sweden, PMS ob	ABS 40 mm	AG 135 mm	OBBL 80 mm	FL 420 mm	-12 yrs ***
England					
France	80 mm	170 mm	NA	XX	XX
Design Guide					
Mn/Pave	HMA 180 mm	Agg. Cl-6, 160 mm		350 mm	- 11 years
Florida	HMA 165 mm	Agg. Grad. 305 mm		390 mm	-14 years
California					

Notes regarding results from Denmark:

All designs have been made using the analytical-empirical design method in the Danish design guide MMOPP (Mathematical Modelling of Pavement Performance).

For the traffic calculation, the following assumptions were made (standard for Denmark):

- The design is for a 2-lane road with equal amounts of traffic in each direction
- The design is made for a road with lanes with normal widths
- The design is made for a straight section of road
- Every truck contributes with 0,75 10-tonnes equivalent load (ESAL)
- Loading from super single axles is taken into account by increasing the number of vehicles per day (AADT) by 30 percent
- Only 86 percent of the included to account for less traffic at night and in week ends.

MMOPP can only handle four layers in the design of new pavements:
1 surface layer (typically asphalt consisting of several sub-layers)
1 unbound base layer
1 unbound sub-base layer
1 subgrade layer

Hence, for the example the layered subgrade is converted into an equivalent layer with an E-modulus of 37 MPa.

Further assumptions:

- Traffic speed: 60-80 km/h
- Moderate frost susceptibility of subgrade
- The road is drained properly.

Material types:
AB 160/220: traditional hot-mix asphalt surface course with soft bitumen
SMA 40/60: stone mastic asphalt surface course with hard bitumen
ABB 40/60: rut resistant asphalt binder course with hard bitumen
GAB I 70/100: asphalt bound base layer
GAB II 40/60: course asphalt bound base layer
SG: granular base layer 0-63 mm
BL: granular sub-base layer 0-90 mm

Gregers Hildebrand, 23rd February 2007

FINLAND

All designs have been made using the analytical-empirical design program APAS 3 (Analytical Pavement Design System). The design against frost has not at all been taken into account. Combining the frost and loading resistance dimensioning would mean usually thicker unbound frost resistant layers and somewhat thinner bitumen bound layers.

ESALs have been calculated from given AADT values with average coefficients given in FinnRA's guideline (without using heavy traffic percent in column a). In residual lifetime calculations initial ESALs have been multiplied with the proportion of values column (b)/column (a) to take into account the change in heavy traffic.

Material types:
AB 70/100 asphalt concrete with bitumen penetration 70-100 (25 °C, 1/10 mm)
ABK asphalt concrete for base courses
M280 crushed aggregate with nominal E modulus 280 MPa (because of the stress dependency E modulus varies in these calculations from 215 to 284 MPa).
Sr200 gravel with nominal E modulus of 200 MPa (because of the stress dependency E modulus varies in these calculations from 138 to 151 MPa).

NORWAY

* Assuming the road is build in Trondheim the additonal subbase is frost protection.

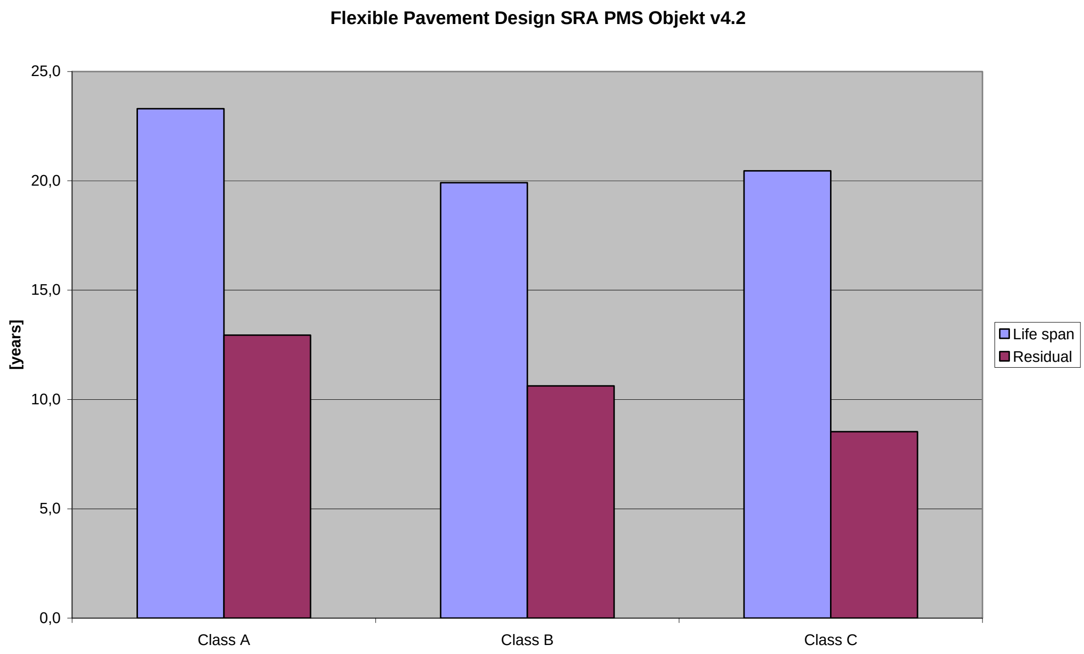
I also assumed that the the silty soil was very likely to give frost heave T4 and the sandy gravel was only moderatly likely to give frost heave T2.

It is possible to use the method to backcalculate the reduced life in years due to increased traffic. However, the design method was not intended for this use and I belive this would be very inacurate.

SWEDEN

* The loss in life span is equivalent to 2,5 cm AG
** The loss in life span is equivalent to 3 cm AG
*** The loss in life span is equivalent to 3,5 cm AG

No special measures to take in consideration concerning frost heave.
The road is situated in the middle of Småland, this area has been greatly affected by the hurricane Gudrun and the storm Per. A great amount of heavy vehicles has been using the roads here. There is 1,5 ESAL’s / heavy vehicle in this calculation.



Flexible Pavement Design SRA PMS Objekt v4.2
25,0
20,0
15,0
10,0
5,0
0,0
[years]
Class A
Class B
Class C
Life span
Residual

Mn/Pave

Running the simulations in MnPAVE worked fine, but had to omit the bedrock layer because the WES5 model used in MnPAVE only allows 5 layers. Comparison with and without bedrock at given depth, it had a slight effect (reducing Miner's damage from 1.00 to 0.98).

Finland