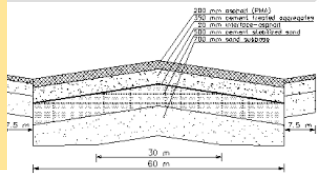
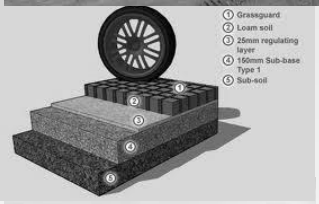
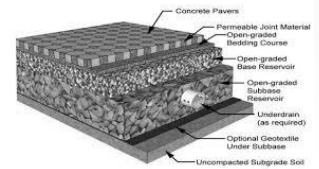
LECTURE 14: Design systems







13.1 Introduction

In the last decades many computerized design systems have been developed which calculate e.g. the required asphalt thickness needed to carry the design traffic. Nice examples of such systems are the SPDM system as developed by Shell, KENLAYER, CARE as developed by the Dutch ministry of Transport, RUBICON, the Australian APDS (specially developed for airport pavement design) etc. It is far beyond the scope of these lecture notes to discuss these design systems in detail and the reader is strongly suggested to surf on the web for pavement design freeware and to try some of these programs to find out which program is the most preferable one for his specific situation. It will be clear that research institutes and specialized consulting firms will require more advanced software than those users who just want to have an idea about the thickness required for their pavement network.

In general all these programs require input on the expected traffic loads, the expected temperature variations during the year, the characteristics of the materials used. The required information can be very detailed e.g. in terms of nr. of axles per axle load group, wheel configurations and contact pressures, or can be rather general in terms of expected number of equivalent single wheel loads. Transfer functions for e.g. the fatigue of the asphalt layer can be defined by the user himself or can be selected from a material library. The required asphalt thickness is either automatically generated or should be selected by the user himself.

Hereafter the output as generated by means of the SPDM system will be briefly discussed. This is merely an example of the type of answers provided by a computerized design system. After that a brief discussion will be given about the Dutch design system ASCON [56] and finally some attention will be paid to the South African TRH4 design manual [57].

14.2 Shell pavement design software

The Shell pavement design software, the principles of which are discussed in [27] and [28], allows the user to determine the required asphalt thickness given the traffic load, the mean monthly air temperature, the stiffness of the subgrade and the stiffness and thickness of the base layer. Furthermore the volumetric composition of the asphalt mixture can be used as input as well as the pen and Tr&b of the bitumen used. The user can select his own fatigue criterion for the asphalt layer and his own subgrade strain criterion or he can use the relationships developed by Shell. The load configuration is fixed. It is an 80 kN axle load and the analysis takes into account a dual wheel configuration having a 20 kN load on each wheel. The contact pressure is assumed to be 600 kPa. The centre to centre spacing of the two wheels is 320 mm.

Table 28 is an example of the output produced by the design system. The result is printed in the lower left box “Asphalt Stiffness and Layer Thickness”. The input that is provided by the user is printed in the boxes “Traffic & Design Life” and “Climate”. As one will observe, the required asphalt thickness for this particular example is 0,084 m.

SPDM 3.0 - Thickness Design Report

ct4860

Asphalt Thickness designed at 0,084 m
(Determined by the Subgrade Strain Criterion)

Climate

Location: ct4860
w-MAAT (°C): 13,7

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3,0	2,0	7,0	10,0	12,0	17,0	19,0	20,0	19,0	15,0	6,0	5,0

Base Layers & Subgrade Strain

Description: ct4860

Layer	Thickness (m)	Modulus of Elasticity (MPa)	Poisson's Ratio
Sub-base	0,300	250,00	0,35
Subgrade	infinite	100,00	0,35

Subgrade criterion at 85% confidence level

Traffic & Design Life

80kN Standard Axles per Day per Lane:	600
Rate of Traffic Growth per Year (%):	1,5
Number of Days with Traffic per Year:	365
Design Period (Years):	20
Design Life:	5,14E+06
Lateral Distribution Factor:	2,0
Healing Factor:	4,0

Asphalt Mix Composition & Fatigue

Name of Asphalt Mix	% Bitumen	% Aggregate	% Voids
ct4860	10,00	85,00	5,00

Standard Fatigue Nomograph

Asphalt Stiffness & Layer Thickness

Layer	Thickness (m)	Mix Stiffness (MPa)	Poisson's Ratio
Asphalt Layer	**0,084**	6016,3	0,35

Asphalt Layer Temperature (°C):	20,7
Bitumen Stiffness (MPa):	40,5
Loading Time in Seconds (Required):	0,02

Bitumen Properties

Bitumen Name	Softening Point (°C)	Pen (.1mm)	Pen Temp (°C)	Pen Index
ct4860	59,0	35,0	25,0	0,0

Calculated: 19 Mar 2007 17:57:42 Print Date: 19/03/2007 Page: 1

Table 28: Output of the SPDM software.

The program also gives a so called iteration report (table 29), which shows how many calculations were done to arrive to the end result and which intermediate results were obtained.

SPDM 3.0 - Thickness Design Iteration Report

ct4860

Asphalt Thickness designed at 0,084 m
(Determined by the Subgrade Strain Criterion)

		Strain (μm/m)				Life (x 1 million), 80 kN s.a.			
		Asphalt		Subgrade		Asphalt		Subgrade	
Case	Thickness (m)	Under a wheel	Between wheels	Under a wheel	Between wheels	Under a wheel	Between wheels	Under a wheel	Between wheels
1,00	0,200	77,82	80,68	-177,00	-188,20	516,62	431,32	208,75	163,32
2,00	0,250	56,62	59,56	-132,70	-139,90	2458,62	1908,83	660,73	534,86
3,00	0,056	250,50	214,80	-511,30	-564,50	1,76	3,80	3,00	2,02
4,00	0,089	188,10	179,00	-391,20	-430,40	6,95	8,91	8,75	5,97
5,00	0,084	197,10	185,90	-407,60	-449,20	5,59	7,49	7,42	5,03
	Design:	200,42	200,42	-446,82	-446,82	5,14	5,14	5,14	5,14

Table 29: Iteration report.

14.3 ASCON design system

The ASCON design system is developed by the Road and Hydraulic Engineering Division of the Dutch ministry of Transport. The system is based on the principles of the Shell design system. The program uses fixed values for the stiffness of the asphalt mixtures used as well as a fixed fatigue relation for the asphalt base course. Ample attention is placed on the traffic analysis where aspects like percentage of axles having super single tires are taken into account. The traffic load is expressed in terms of 100 kN equivalent single axles. The method takes into account the fact that road materials and pavement layers always show a certain amount of variability and that for that reason, the number of load repetitions to failure is never a fixed number. Some portions of the pavement may fail earlier for that reason than other portions of the pavement. For main roads, the design reliability is set at 85% implying that there is only 15% chance that the pavement will fail before the anticipated nr. of axle loads.

The calculations are done assuming a two layer system, being an asphalt layer on top of a subgrade. After the required asphalt thickness has been determined, part of the asphalt can be replaced by using an unbound base.
The system can also be represented by means of a design chart. This chart is shown in figure 124. Table 30 shows how many mm of asphalt can be replaced by using a specific base course material.
The method is illustrated by means of an example. Let us assume that the expected amount of traffic (100 kN equivalent single axles) is 9 * 106 and the subgrade modulus is 100 MPa. From figure 124 we determine that the requires asphalt thickness is 260 mm. If we apply a base course of crushed concrete / crushed masonry which shows self-cementation then we can derive from table 30 that the total asphalt thickness can be reduced with 55 mm. The final structure therefore becomes 205 mm asphalt on top of a 250 mm base course.