ECO-SERVE Questionnaire

Semi-rigid pavements

Introduction

The European Thematic Network *ECO-SERVE - European Construction in Service of Society* was launched by the European Commission in November 2002. The Network will run for 4 years and has been set up by around 50 participants representing the European cement, concrete and pavement construction industry.

The specific objectives of the Network are:

- Reducing the adverse environmental impact of the pavement and concrete construction industry on the external environment
- Improving the working environment within this industry
- Ensuring European growth and wealth by increasing the productivity and competitiveness of the raw materials, production and the construction industry as well as enhancing the quality, durability and service life of pavements and concrete structures through sustainable developments

The ECO-SERVE Cluster 4 will deal with innovative pavement design. It is the objective based on assessment of available research and design methods to select the most suitable approach for design of low strength, cementitious base course layers.

Such base course layers may be produced using materials (sand, gravel), which are available at the location of construction instead of applying standardised high quality components with proven performance.

The Cluster will address possible new types of unbound or cementitious pavements, materials and the correlated design models, which will allow for the introduction of:

- Local materials, possibly of marginal quality compared with standard materials
- Pozzolanic binders with low CO_2-emission during production
- Design of pavements based on present needs (load) with future strengthening options built-in (stepwise design and construct principle)
- Reduction of the bituminous pavement layers.

The aim of the Cluster is to develop performance based criteria and guidelines for ECO-SERVE type pavements, i.e. pavements that ideally fulfil all of the following requirements: Low strength base course, hydraulically bound, no reflective cracking, thin asphalt surfacing, based on local materials, low environmental impact, low cost, maintenance free.

Current members of ECO-SERVE Cluster 4 are Dansk Beton Teknik, COWI Consulting Engineers, Technical University of Denmark and Danish Road Institute (Denmark), Dura Vermeer and Intron (Netherlands), LCPC (France), TRL (UK), Road and Bridge Research Institute (Poland), Hellenic Cement Research Centre (Greece) and Centre of Laboratorial Tests (Lithuania).

The first cluster activity is a mapping of design methodologies and pavement performance data for semi-rigid pavements. The questionnaire will form the basis for this activity.

Notes for guidance

A semi-rigid pavement is defined as a pavement with a bituminous surfacing and a hydraulically bound material as the main structural layer (base course).

The first part of the questionnaire aims at establishing the general situation (design, requirements etc.) for semi-rigid pavements in the individual countries, whereas the last section *Performance Record etc.* gives the opportunity to contribute experiences with standard semi-rigid pavements and also alternative materials, designs and construction methods.

Both traditional mixes with cement bound sand/gravel and more special mixes with alternative aggregates or binders like fly ash or blast furnace slag can be included.

The *Design Method* section is partly based on questions from the *COST 333 – Development of New Bituminous Design Method* questionnaire.

The *Materials* and *Construction* questions are mainly focused on the base course layer. Specific comments relating to other pavement layers like subgrade or wearing course can be given in the *Comment* fields.

The questionnaire is only concerned with the Primary Road Network, as it is defined by the individual countries.

Please indicate *not relevant*, *no requirement* etc. where appropriate. Supplementary information to the individual questions can be given in the *Comments* field of each section.

At the end of this document we have included three pages with tables, where some of the data for a number of countries are given for information. The tables are based on data from an Austrian report by H. Sommer et al*: Überarbeiten der RVS 8.05.13 Zementstabilisierte Tragschichten, Austrian Ministry for Traffic, Innovation and Technology, Heft 520, 2002*, supplemented with data for a few other countries.
Please consult these tables for guidance and feel free to correct/update the tabled values via the questionnaire answers.

Thank you for your help!

General

Length of Primary Road Network in km

Percentage of Primary Road Network constructed with semi-rigid pavements
(All roads, i.e. historic situation)

Semi-rigid pavements in new construction on Primary Road Network (%)
(Current situation)

Comments

Design method

Design method
(Name, year, type: design guide, pavement catalogue or computer program)

Design pavement life
(Years)

Terminal condition at the end of pavement design period
(More than one tick box can be marked for this and the following questions)

- Need of strengthening ☐
- Requiring reconstruction ☐
- Change of serviceability index ☐
- Other

Parameters used in design calculations

- Elastic stiffness modulus ☐ value:
- Fatigue resistance ☐
- Strength of mix ☐
- Coefficient of thermal expansion ☐
- Subgrade characteristics ☐
- Other

Climatic factors considered in design

- Number of climatic zones ☐
- Air temperatures ☐
- Pavement temperatures ☐
- Frost index ☐
- Frost penetration depth ☐
- Precipitation ☐
- Other

Pavement deterioration controlled by design criteria
(What types of distress are considered?)

- Reflection cracking in wearing course ☐
- Rutting in bituminous layers ☐
- Cracking of base layer by traffic ☐
- Cracking of base layer by thermal stresses ☐
- Serviceability index ☐
- Other

Comments

Materials and mix according to specification

Specification
(Name, publication year)

Strength requirement
(Please also state test method, e.g. compression or splitting tensile and number of days)

Cement content
(kg/m^3)

Cement type
(According to EN 197, e.g. CEM I 32.5)

Content of fly ash, blast furnace slag etc.
(Maximum allowable)

Mixing in plant prescribed no
(Yes/no)

Gradation envelope given no
(Yes/no)

Crushed aggregate prescribed no
(Yes/no)

Comments

Construction requirements

Quality control
(Density, coring, FWD etc.)

Compaction
(e.g. % Proctor, please state reference)

Curing
(e.g. bitumen emulsion)

Pre-cracking/notching of base layer
(Method, spacing etc.)

Comments

Typical pavement structure for heavy traffic

Sub-base thickness
(Unbound material, mm)

Base course thickness
(Hydraulically bound material, mm)

Asphalt thickness
(All asphalt layers, mm)

Strength level
(MPa, as constructed, e.g. compressive strength from cores)

Comments

Performance record etc.

In-service pavement performance
(Common forms of deterioration, please list by severity, distress types e.g. rutting in the bituminous layers, rutting originating in the subgrade, transverse reflective cracking, general surface cracking, longitudinal cracking in wheel-path, longitudinal unevenness, loss of skid resistance, ravelling, wear due to studded tyres, low temperature cracking, frost heave)

Reflective cracking
(Serious cracking, estimate % of total length with semi-rigid pavements)

FWD testing on semi-rigid pavements
(Range of E-values, reference to reports, papers)

Pre-cracking methods
(Test sections with various methods, experiences, references to reports, papers)

Special designs
(Test sections with ECO-SERVE type pavements, i.e. low strength base course and/or thin bituminous wearing course, no reflective cracking, references to reports, papers)

Comments

General comments/suggestions

(Relating to semi-rigid pavements with the following characteristics: Low strength base course, hydraulically bound, no reflective cracking, thin asphalt surfacing, based on local materials, low environmental impact, low cost, maintenance free)

Other contact persons

(In your country who could be interested in contributing to and communicating with the ECO-SERVE Network cluster 4 on semi-rigid pavements)

Questionnaire filled in by:

Name

Organisation

Address

Telephone

E-mail

Tables adapted from *H. Sommer et al: Überarbeiten der RVS 8.05.13 Zementstabilisierte Tragschichten, Austrian Ministry for Traffic, Innovation and Technology, Heft 520, 2002.*

Country	Austria	Belgium		Switzerland	Germany (Niedersachsen)		Spain		
Pavement layer	sub-base/base	base			sub-base		sub-base	base	
		light traffic	heavy traffic		light traffic	heavy traffic		light traffic	heavy traffic
Minimum strength c (compression) or st (splitting tensile) (days)	$R_{c7} \geq 2,5$	$R_{c90} \geq 10$ (average)	$R_{c90} \geq 10$ (single values)	$R_{c7} \geq 2$-4	$R_{c28} \sim 7$		$R_{c7} \geq 2,5$ or $R_{c28} \geq 3,8$	$R_{c7} \geq 6$ or $R_{c90} \geq 9$ $R_{st7} \geq 0,5$ or $R_{st90} \geq 0,75$	
Cement content (kg/m^3)	min. 90	min. 100		min. 60	uniform sand ~180 well-graded aggregate ~ 95		usually 100-120	usually 90-100	
Cement type	CEM II 32,5	CEM I or CEM III/A 32,5 or CEM III/A 42,5		CEM I 32,5	CEM I 32,5		CEM IV/B 32,5		
Fly ash/slag content (%)	≤ 35	≤ 65		0	0		36-55		
Plant mix prescribed	no	yes			no		no	yes	
Gradation prescribed	no	no			no		no	yes	
Crushed aggregate prescribed?	no	yes			no		no	no	yes min. 50%
Compaction (% Proctor)	min. 97			97	min. 98		100	97 mod.	
Curing	Bitumen emulsion	bitumen emulsion + sand		bitumen emulsion	keep moist		bitumen emulsion + sand		
Groove joints	no	no		no	per 2,5 m (asphalt < 14 cm)	per 5 m (asphalt > 14 cm)	no	no	since 1997
Asphalt cover (cm)	15-17 (heavy traffic)	15	17-18		≥ 12	30		12	15
CTB thickness (cm)	25-30	20	20			15 – 20	20	20	22-25
Reflective cracking	yes	often		often	none, when groove joints			often, when no groove joints	
Experience	35 years	25 years		30 years	groove joints since 1982			since 1988 300 km with groove joints	
Max. axle load (kN)	105	130		100	115		130		

Country	France			UK			Italy
Pavement layer	sub-base	base		sub-base	base		sub-base for heavy traffic
		light traffic	heavy traffic		light traffic	heavy traffic	
Minimum strength c (compression) or st (splitting tensile) (days)	$R_{st360} \geq 1,1$ ($R_{st28} \geq 0,66$)			3 classes: R_{c7} 4,5; 7 and 10	3 classes: R_{c7} 10; 15 and 20		R_{c7} 2,5 -4,5 R_{st7} 0,25
Cement content (kg/m^3)	min. 70						60 – 100
Cement type	CEM I, II or III 32,5						CEM 32,5
Fly ash/slag content (%)	≤ 80						40 FA
Plant mix prescribed	no	partly	yes	no	yes		no
Gradation prescribed	partly	yes	yes	no	yes		yes
Crushed aggregate pre-scribed?	no	partly	yes	no	yes		yes, min. 30 – 60%
Compaction (% Proctor)	95 mod.		98 mod.	min. 95			100 (mod. AASHTO)
Curing	bitumen emulsion + sand			bitumen emulsion			Bitumen emulsion
Groove joints	no	per 3 m		being investigated			no
Asphalt cover (cm)		6-8	14	0	10-15	20	20-25
CTB thickness (cm)	15-25	15-25 depending on traffic and subbase		min. 15	15 – 25 depending on traffic and CTB type		20 – 30 depending on subbase
Reflective cracking	no			yes, with no groove joints			no
Experience	25 years, 5000 km main roads, 1500 km motor-ways			25 years			20 years, 3500 km
Max. axle load (kN)	130			105			120

Country	Denmark (1968)	Sweden (ATB Väg 2003)	Netherlands
Pavement layer	base	base, heavy traffic	Base
Minimum strength c (compression) or st (splitting tensile) (days)	$R_{c7} \geq 5$	$R_{c7} \geq 9$ average on cores from base layer (E_{dim} = 17000 MPa)	asphalt granulate: $R_{c7} \geq 2,5$ / $R_{c28} \geq 3,0$ MPa sand: $R_{c28} \geq 5,0$ MPa in situ: $R_c \geq 1,5$ MPa
Cement content (kg/m^3)	90 – 120		asphalt granulate: 75 – 125 kg/m^3 sand: 100 – 200 kg/m^3
Cement type		CEM I, CEM II/A-LL	CEM II/B-V or CEM III/B
Fly ash/slag content (%)			Slag: 0 – 25 %
Plant mix prescribed	yes	no	No
Gradation prescribed	yes	yes	coarse granulates: yes sand: no
Crushed aggregate prescribed?	no	no	no
Compaction (% Proctor)	92% of max. theoretical density (no air)		asphalt granulate:≥ 98 % average ≥ 102 % sand: ≥ 95 % average ≥ 100 %
Curing	bitumen emulsion	bitumen emulsion, plastic sheets or water	bitumen emulsion + fine crushed aggregate
Groove joints	no	optional	no
Asphalt cover (cm)	12 - 16	9	12 – 20 cm
CTB thickness (cm)	18 - 21	24 (Väg 94)	12 – 25 cm
Reflective cracking	sometimes		Sometimes
Experience	30 years		asphalt granulate: 15 years sand: > 40 years
Max. axle load (kN)	115		no requirement