LIFE02 ENV/FIN/329

Report 2003

KUKKIA CIRCLET
Interim Impact Assessment Report 2003

Annex of Progress Report 3
1.10.2003 – 31.3.2004

FOLLOW-UP OF PILOT CONSTRUCTIONS
1.10.2002 – 31.12.2003

26.4.2004

Finnish Road Enterprise

RAMBOLL

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1. INTRODUCTION

Kukkia Circlet is a LIFE-Environment financed demonstration project about the economically and technically feasible and environmentally sound use of industrial by-products for the maintenance and renovation of secondary road networks. In the background of the project are the bad condition and repeating frost damage of the secondary network mainly gravel roads (see Figure 1), the high costs of the improvement, maintenance and renovation of the secondary road network versus the scarce financing resources for those measures, the continuously reducing availability of economically feasible sources of natural aggregates needed for construction, and the availability of economically and technically interesting sources of alternative materials for construction from the industry. The full-scale and established use of industrial by-products for any construction purposes requires projects that will demonstrate the economical, technical and environmental feasibility of the alternative materials. The demonstration projects have to be implemented at least in a pilot scale and monitored over a longer time period – like Kukkia Circlet.

Figure 1: Frost damage of a gravel road section in the spring 2002. Luopioinen

The Kukkia Circlet project is testing and demonstrating different types of renovation processes but also the feasibility to construct groundwater protection structures and light-traffic lanes based on industrial by-products. The project has used fly ash from the bark/peat incineration, fibre sludge (fibre clay) from the de-inking process of the paper industry, and filtercake from the production of calciumchloride. The project involves several tasks, including material tests, planning and construction of the pilots in 2002 and in 2003, the follow-up and impact assessment, and the dissemination of the processes, methods and technology.

The pilot processes have been described in the Progress Reports, and Technical Report 2002 (the annex of Interim Report) and Technical Report 2003[1] that are available in the project web pages (http://www.tieliikelaitos.fi/5_4.asp). The pilot processes will also be described as DVD-presentations (available in the summer 2004).

[1] Technical Report 2003 is available only in Finnish but described also in the Progress Reports for the Commission

This report will shortly describe the follow-up measures that have been carried out for the impact assessment of the pilots 2002 and 2003. The first technical and environmental follow-up monitoring, measurements and tests were performed for the reference results before the start of the pilot constructions. The actual follow-up measures started after the first pilot (pilot 2002) had been constructed in the autumn 2002. The follow-up of the second pilot (pilot 2003) has only started in the autumn 2003. The follow-up will continue during the project period, and also after the project is concluded, at least with environmental follow-up.

The actual and final Impact Assessment Report, including the technical, environmental and economical assessment of the project, will be submitted at the end of 2004.

2. FOLLOW-UP PROGRAMME

The follow-up programmes of Pilots 2002 and 2003 are described in Tables 1 and 2 below.

Table 1: Follow-up programme of Pilot 2002

Pilot 2002	Year/Quarter												
	02	03				04				05			
	4	1	2	3	4	1	2	3	4	1	2	3	4
Quality check	→x		x				x				x		
Bearing capacity					x		x		x				
Studies of structures				x				x					
Water samples				x				x				x	
Soil samples				x				x				x	

Table 2: Follow-up programme of Pilot 2003

Pilot 2003	Year/Quarter											
	03				04				05			
	1	2	3	4	1	2	3	4	1	2	3	4
Quality check	→E			x		x		x		x		
Bearing capacity				x		x		x				
Studies of structures				x			x					
Water samples			E				x				x	
Soil samples			E				x				x	

3. DESCRIPTION OF THE PILOTS

Pilot 2002 (see also Progress Report 1 and Interim Report of the project):

Pilot 2002 involved stabilisation of a local gravel road MT 3201 in Luopioinen, Finland. In the stabilisation process the existing road was stabilised into the depth of about 20 cm after the removal of biggest stones and levelling of the surface. Three different types of stabilised sections and reference sections (based on conventional methods) were constructed for a length of total 12 kilometres. Each stabilised section has a specific stabiliser; thus, there are three different stabilisers or binder admixtures each based on fly ash. The amount of binder admixture was about 10 % (dw[2]). After stabilisation the stabilised sections as well as most of the reference sections were covered with a mixture of crushed rock and filtercake (stabiliser for the covering aggregate).

Pilot 2003 (see Progress Report 2 and Technical Report 1/2003 – the latter in Finnish):

Pilot 2003 consists of several different types of structures based on fibre-ash and fibre clay. Fibre-ash is a mixture of fly ash and fibre clay. Fibre-ash mixtures were used for the structural courses of separate light-traffic lanes, safety lanes (for light traffic at the sides of the narrow local road), and a local, badly frost-damaged road section. The fibre-ash mixture for the light-traffic and safety lanes differs from the mixture used for the renovation of the local road (different proportions of materials and types of additives). The thickness of the fibre ash course is around 200 mm. All these structures have been covered with crushed aggregates (50 mm) and the crushed aggregates mixed with filter cake (50-70 mm). Fibre clay was used for a short test section for groundwater protection in order to test the technical feasibility, i.e. adequate impermeability of the fibre clay course.

[2] dw = dry weight of the road material or aggregate to be stabilised

4. FOLLOW-UP OF PILOT 2002

Quality check

Quality check is a visual and driving performance check of the condition of a road. During the reported period the stabilised sections have remained in clearly better condition than the reference sections. The stabilised sections are very hard and impermeable. This has caused the covering course to become too soft at places where the inclination of the road has not been adequate to prevent rain water from staying on the stabilised, hard surface.

Bearing capacity

The reference values of the bearing capacity have been measured in the spring 2001. The first measurements after the construction were carried out in the late autumn of 2003 (the period between the autumn 2002 and spring 2003 was unusually dry). The next measurements will be made during the spring 2004. After this the results will be compiled and reported in the final Impact Assessment Report (at the end of 2004).

Studies of structures

The studies of structures include drill sampling at different places of the pilot sections (at the middle and on the sides of the driveway). The UCS or unconfined compression strength, density and water content were then measured in the geotechnical laboratory. Also the condition of the structure was assessed and the thickness of the structural course was measured when sampling.

The results of the laboratory measurements are compared with the results of the test pieces made of the corresponding material mixtures during the construction in the laboratory (UCS after 28 days stabilisation in the room temperature), and with the corresponding laboratory test results for the determination of the binder admixture recipes before construction. The latest results are given in the Figures 2 and 3.

The figures 2 and 3 show that the tests made for the determination of recipes give not too good results when compared with the results from the actual construction. However, the tests before and during construction have been made on 28 days old test pieces, but the drilled test pieces are from a more than 12 months old construction.

Further assessment of the results will be performed for the final Impact Assessment Report after the structural assessment in the autumn 2004.

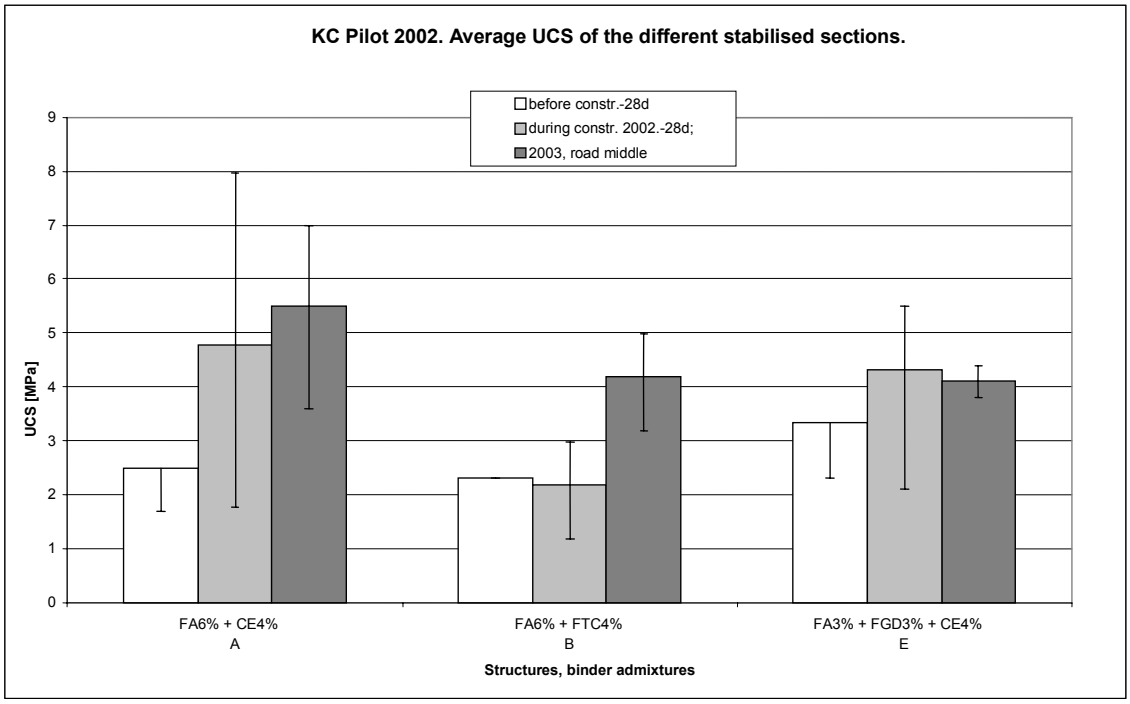

Figure 2: UCS of stabilised sections in 2003 (2003, road middle), test pieces made for the determination of recipes before construction (before constr. – 28d) and test pieces made of the corresponding mixture used for the construction (during constr. – 28d). FA = Fly Ash, CE = cement, FTC = a commercial mixture of process gypsum and lime, FGD = flue-gas desulphurisation residue from the semi-dry system. Ramboll Finland Oy 2003.

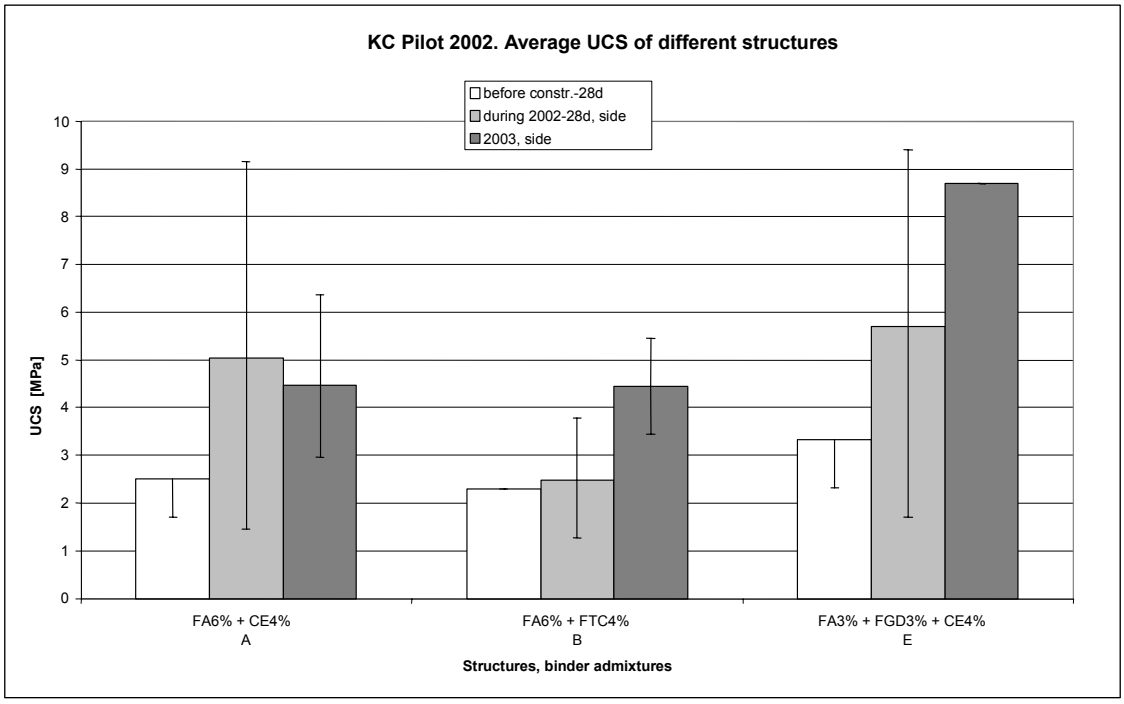

Figure 3: UCS of stabilised sections in 2003 (2003, road side), test pieces made for the determination of recipes before construction (before constr. – 28d) and test pieces made of the corresponding mixture used for the construction (during constr. – 28d). FA = Fly Ash, CE = cement, FTC = a commercial mixture of process gypsum and lime, FGD = flue-gas desulphurisation residue from the semi-dry system. Ramboll Finland Oy 2003.

The filter cake is a by-product from the manufacture of calcium chloride, and contains also calcium chloride. The demonstration of the covering course mixture should show, that this kind of method is a long-term dust prevention method for a gravel road. The granulate used in the mixture with crushed aggregate in 2002 contained about 21 % $CaCl_2$, and the amount filter cake granulates was about 0,006 % in the covering course mixture. The samples taken from the covering course in the autumn 2003 were analysed in the laboratory of Kemira Oyj. The results show that the calcium chloride content varies between 0,004 – 0,314 % one year after the construction (Figure 4).

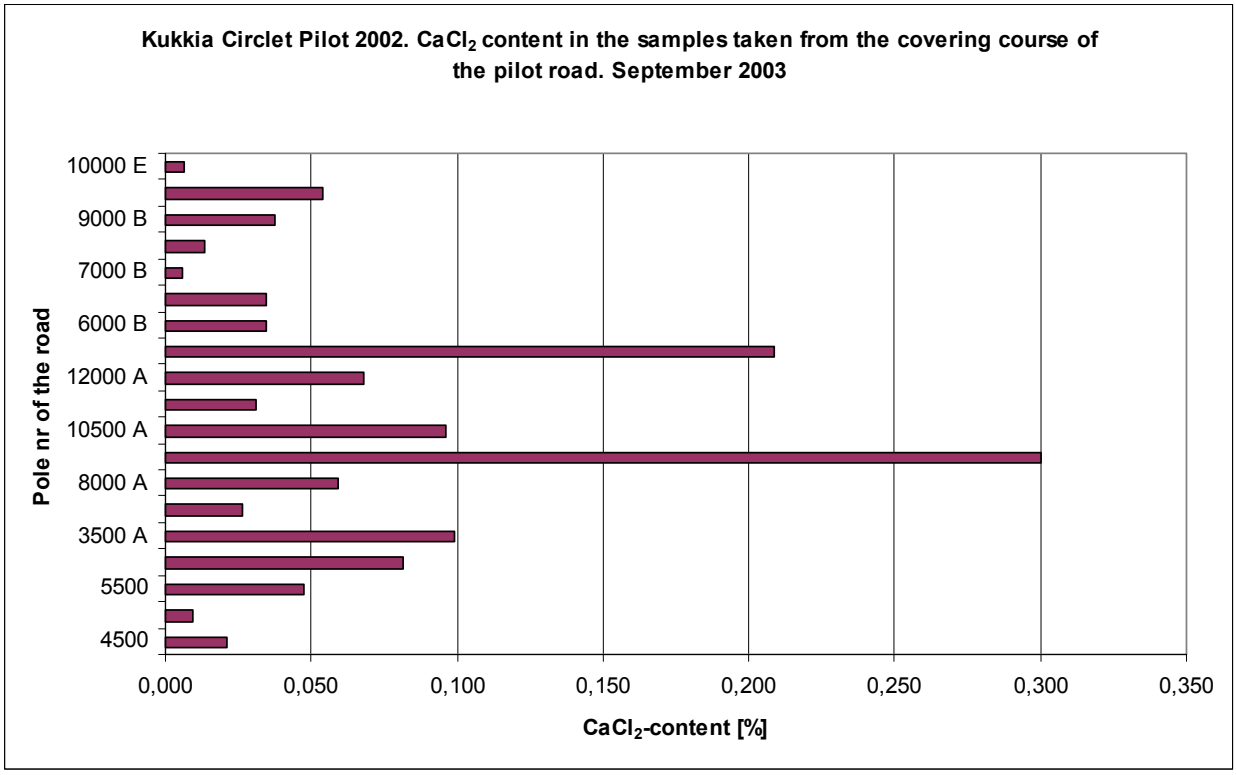

Figure 4: Content of CaCl2 in the covering course of Pilot 2002 road, at different places indicated by the pole-number. Ramboll Finland Oy 2003.

Also the thickness of the covering course was checked during the sampling. The covering course was not quite even on the road; the targeted thickness was 100 mm, but the results of the measurements proved significant variance the average being about 87 mm in the autumn 2003. At places the covering course was totally missing at the sides of the road. See Figure 5.

Figure 5: The thickness of the covering course varies significantly in the autumn 2003, one year after the construction of Pilot 2002. Ramboll Finland Oy 2003.

Environmental follow-up

According to the project plan and the municipal environmental permit for Pilot 2002, the environmental impacts will be followed by analysing samples of appropriate wells and ditches as well as of soil from the sides of the stabilised road and reference sections. The environmental permit requires the follow-up to continue until the end of year 2005.

Soil reference samples were taken from seven places from the sides of the stabilised and reference sections of the road (beneath the slope of the road's ditch) in May 2002 before construction. The follow-up samples were taken close to the reference places in August 2003. The samples have been analysed for the content of several inorganic substances (analysis with ICP-MS/AES from extracts with nitric acid); also pH and electrical conductivity have been determined. Figure 6 shows the follow-up results of 2003 and the reference results of 2002. The results of 2003 differ naturally from the results of 2002 (being either higher or lower), but all the determined values are significantly lower than the suggested guide lines for contaminated soil in Finland. There has been no possibility for the rain water to penetrate the structure and transport anything through the structure and towards the environment because of the impermeable and hard surface and the relatively low amount of precipitation in 2002-2003. All rainwater has run along the stabilised surface under the covering course. Further assessment is possible after the sampling and analysis in the autumn 2004.

Drinking water samples were taken from 12 houses (getting water from a well) and one solitude well situating in the vicinity of the stabilised sections. Reference samples were taken in the spring 2002 and follow-up samples in August 2003. Reference samples were taken also from three drainage ditches that run from the road down towards the lake Kukkia. Follow-up samples could be taken only from 6 houses because of the longer dry period in the district. The water samples were analysed by ICP-MS/AES. The results are given in the table of Figure 7. It can be noted that the water quality meets the guide lines set for the drinking water in Finland. Next samples will be taken in August-September 2004.

Guide Values, Finland 2002**			pH	EC	As	B	Ba	Cd	Cr	Cu	Mo	Ni	Sb	Se	Zn	Al	Mn
Target value, clean soil			-	-	4	5	600	0,15	37	18	5	19	5	1	23	-	-
Limit value, contaminated soil			-	-	60	50	600	10	500	400	200	300	40	10	700	-	-
Reference samples 2002																	
Sampling point	Section	Pole distance	pH	EC	As	B	Ba	Cd	Cr	Cu	Mo	Ni	Sb	Se	Zn	Al	Mn
				mS/m 25°C	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
PL 3600	Stab A	PL2850-4350	5,2	2,4	12,1	<1	64,7	0,05	40,5	28,1	2,56	11,3	<0.02	0,81	36,2	9880	151
PL 4600	Ref	PL4350-5800	5,2	2,7	9,61	<1	70,5	0,05	42,6	29,5	2,18	11,6	<0.02	0,89	39,6	10700	173
PL 6400	Stab B	PL5800-7640	5,0	2,4	5,15	<1	42,2	0,03	26,1	18,4	1,38	7,48	<0.02	0,54	25,8	6780	121
PL 8230	Stab A	PL7640-8690	4,7	3,1	7,70	<1	42,6	0,09	27,4	21,1	1,01	12,4	<0.02	<0.5	34,1	10100	129
PL 9010	Stab B	PL8690-9150	5,0	5,7	12,2	<1	76,5	0,11	46,0	**36,8**	2,45	13,1	<0.02	**1,07**	47,7	11700	179
PL 9885	Stab E	PL9320-10340	4,6	7,8	11,0	<1	68,2	0,05	41,4	32,4	2,67	10,9	<0.02	0,96	38,0	11000	163
PL 11675	Stab A	PL10340-12180	4,9	9,9	8,09	<1	68,4	0,06	31,7	29,6	1,21	13,5	<0.02	0,52	39,5	11800	157
Follow-up samples 2003																	
Sampling point*	Section	Pole distance	pH	EC	As	B	Ba	Cd	Cr	Cu	Mo	Ni	Sb	Se	Zn	Al	Mn
				mS/m 25°C	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
PL 3600	Stab A	PL2850-4350	5,1	4,6	9,41	<1	26,2	0,06	41,1	25,0	1,08	20,3	<0.02	0,60	37,1	14300	105
PL 4600	Ref	PL4350-5800	5,5	1,7	8,30	<1	43,5	0,05	28,2	20,4	1,23	8,97	<0.02	0,72	29,2	7840	122
PL 6400	Stab B	PL5800-7640	4,9	6,0	9,60	1,5	66,2	0,15	44,6	**47,0**	1,67	18,1	<0.02	0,82	**103**	12800	272
PL 8230	Stab A	PL7640-8690	5,2	1,8	7,19	<1	47,9	0,07	31,5	23,4	1,01	17,8	<0.02	0,68	44,1	12100	153
PL 9010	Stab B	PL8690-9150	5,1	**26**	8,11	2,10	83,6	**0,69**	30,5	29,0	2,09	23,6	0,07	**2,04**	57,4	8540	112
PL 9885	Stab E	PL9320-10340	4,9	11	11,5	2,10	76,5	0,09	59,6	**72,1**	1,48	25,1	<0.02	**1,50**	76,5	22200	205
PL 11675	Stab A	PL10340-12180	5,7	6,7	6,66	1,75	41,9	0,08	39,1	22,9	1,23	22,7	<0.02	**1,10**	49,7	17900	164

* samples +/- 5 metres from the sampling point of 2002

** Jaana Sorvari: Ympäristökriteerit mineraalisten teollisuusjätteiden käytölle maarakentamisessa. Suomen ympäristö 421/2000. Taulukosta 19 (s. 94): mediaanipitoisuus maaperälle, jossa saves on 4,9 % ja orgaaninen aines 1,2 %

Figure 6: Analysis results of soil samples from 2002 (ref.) and from 2003. Pilot 2002

		Al	As	B	Ba	Cd	Cr	Cu	Mn	Mo	Ni	Sb	Se	Zn	pH	EC
		µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l		mS/m 25°C
Finnish guide values for drinking water / STM 461/2000																
Chemical quality (max)			10	1000		5	50	2000			20	5	10			
Quality recommendations (max target values)		200							50						6,5-9,5	250
Older guide values / STM 1994					700					70				3000		
Reference samples 2002																
Wells	1.Laine	<1	0,34	3,23	4,93	<0.02	<0.2	33,3	**59,7**	0,22	2,57	<0.02	<0.5	242	7,1	9,04
	2.Kankaanpaa	1,78	0,08	34,0	6,84	<0.02	<0.2	19,9	18,8	1,01	0,77	0,04	<0.5	99,2	7	26
	3.Alenius	62,1	0,13	27,9	15,5	0,07	0,3	96,5	4,46	0,07	1,71	0,06	<0.5	113	6,5	9,59
	4.Tulokas	29,5	0,09	7,60	11,3	0,07	<0.2	395	22,1	0,07	1,63	0,02	<0.5	79,3	6,6	10,3
	5.Makinen	35,9	0,23	20,1	9,09	<0.02	0,29	3,81	5,7	0,24	0,89	0,05	<0.5	5,02	6,8	9,78
	6.Lappi	21,5	0,38	31,4	17,5	0,02	0,31	19,7	2,67	0,20	0,94	0,08	<0.5	61,5	6,8	17,2
	7.Laine K.	10,6	0,09	8,83	6,40	0,08	<0.2	123	18,0	0,15	1,40	0,05	<0.5	290	6,5	9,99
	8.Laine S:	5,69	0,13	5,59	8,21	0,03	<0.2	51,0	0,88	0,35	0,78	0,03	<0.5	68,2	6,5	9,95
	10.Lehto	13,8	0,27	10,2	10,2	<0.02	<0.2	70,4	**84,4**	0,31	2,59	0,02	<0.5	25,3	6,4	11,8
	15.Koivuniemi	<1	**33,2**	84,7	0,49	<0.02	<0.2	0,21	4,84	2,99	0,35	0,66	<0.5	4,51	8,1	37,1
	16.Huttunen	<1	0,10	13,2	6,86	0,19	<0.2	127	21,0	0,35	15,1	0,02	0,89	65,0	6,3	16,3
	19.Setala	2,94	0,34	7,29	11,2	<0.02	0,30	2,82	2,70	0,13	0,29	0,05	<0.5	12,0	6,8	17,2
	Lahde	16,9	0,36	7,99	5,70	0,05	0,27	4,53	0,65	0,16	1,02	0,04	<0.5	9,08	6,6	13,6
Ditches	Oja 4830	173	0,66	5,29	8,74	0,02	0,51	1,39	**66,1**	0,15	2,89	0,04	<0.5	5,39	6,3	6,47
	Oja 5060	54,1	0,46	5,33	5,67	0,02	0,24	0,58	31,3	0,09	2,90	<0.02	<0.5	2,93	6,8	14,9
	Oja 8690	**547**	3,15	3,64	8,04	0,1	0,85	2,25	38,9	0,16	3,31	0,04	<0.5	18,1	5	5,87
Follow-up 2003																
Samples could be taken from only the given wells																
Wells	1.Laine	<1	0,20	2,52	3,85	<0.02	<0.2	36,4	37,7	0,27	1,46	<0.02	<0.5	157	6,8	8,3
	4.Tulokas	4,46	0,07	7,71	12,3	0,06	<0.2	225	31,5	0,41	1,47	0,02	<0.5	85,7	6,6	13
	7.Laine K.	1,27	0,07	6,68	6,67	0,09	<0.2	62,2	**53,8**	0,12	1,41	0,20	<0.5	611	6,7	9,8
	8.Laine S.	4,04	0,12	5,05	8,17	0,03	<0.2	80,8	1,15	0,40	1,09	0,03	<0.5	86,6	6,7	9,5
	10.Lehto	1,19	0,18	10,7	11,0	<0.02	<0.2	34,7	**65,4**	0,34	3,85	0,02	<0.5	17,5	6,9	14
	16.Huttunen	<1	0,11	12,8	8,93	0,20	<0.2	109	24,4	0,27	18,4	0,02	0,83	85,6	6,5	17
Differences 2002 - 2003																
Wells	1.Laine	0	0,14	0,71	1,08	0	0	**-3,1**	22	**-0,05**	1,11	0	0	85	0,3	0,74
	4.Tulokas	25,04	0,02	**-0,11**	**-1**	0,01	0	170	**-9,4**	**-0,34**	0,16	0	0	**-6,4**	0	**-2,6**
	7.Laine K.	9,33	0,02	2,15	**-0,27**	**-0,01**	0	60,8	**-35,8**	0,03	**-0,01**	**-0,15**	0	**-321**	**-0,2**	0,19
	8.Laine S.	1,65	0,01	0,54	0,04	0	0	**-29,8**	**-0,27**	**-0,05**	**-0,31**	0	0	**-18,4**	**-0,2**	0,45
	10.Lehto	12,61	0,09	**-0,5**	**-0,8**	0	0	35,7	19	**-0,03**	**-1,26**	0	0	7,8	**-0,5**	**-1,7**
	16.Huttunen	0	**-0,01**	0,4	**-2,07**	**-0,01**	0	18	**-3,4**	0,08	**-3,3**	0	0,06	**-20,6**	**-0,2**	**-0,3**

Figure 7: Analysis results of water samples from 2002 (ref.) and from 2003. Pilot 2002

5. FOLLOW-UP OF PILOT 2003

Quality check

The quality check of the sites of Pilot 2003 has been made in September – October 2003, in the connection of sampling for the structural studies. Shortly after the construction the condition of the sites was good and the users seem to be satisfied (according to the comments from the local inhabitants).

Bearing capacity

The reference values of the bearing capacity have been measured in the spring 2001. The first measurements after the construction were carried out in the late autumn of 2003. The next measurements will be made during the spring 2004. After this the results will be compiled and reported in the final Impact Assessment Report (at the end of 2004).

Studies of structures

The structural studies have been performed to fibre-ash samples taken from the sites in September - October 2003. Thus, the stabilisation time for the structures has been 30 – 45 days after the construction. The samples were tested for UCS (unconfined compression strength). The results are given in Figures 8 – 10, and can be compared with the results from test pieces made of materials taken from the construction site before construction, and with the laboratory results for the determination of recipes before any construction. Here we can clearly note the effect of compaction efficiency on the stabilisation in the short term; see especially Figure 10 for safety lanes.The results will be completed with results from samples to be taken in the autumn 2004.

The follow-up of the fibre clay structure for the groundwater protection will include measurements of water infiltration capacity or permeability. The measurements will be made in the autumn 2004.
Additionally, there are thermometer devices installed in the renovated road structure (Pihtisalmentie), in a reference site and in the groundwater protection structure. The monitoring will be continuous throughout a year. The meaning is to determine the thermal insulation properties and to follow-up the temperature at different depths beneath and above the structural courses, in order to determine the long-term durability and behaviour of the structures. The results will be reported in the final Impact Assessment report.

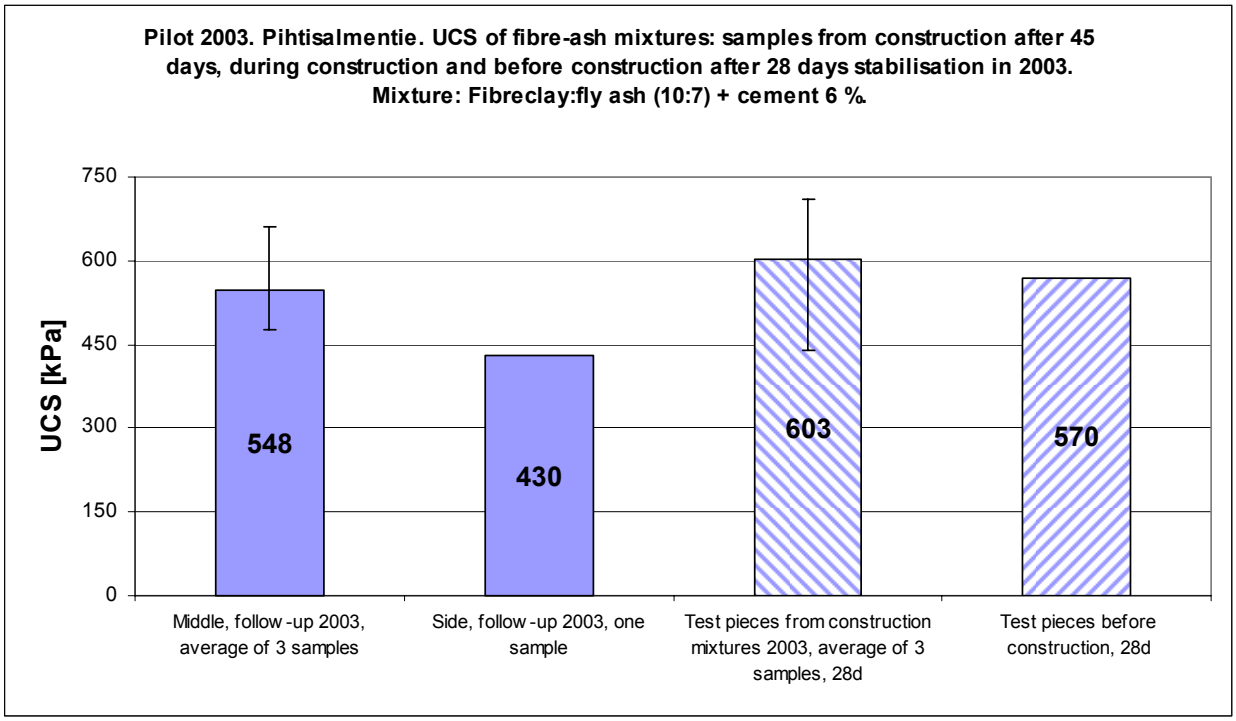

Figure 8: Structural studies of Pilot 2003 at Pihtisalmentie (renovation of badly damaged road section) in the autumn 2003. The fibre-ash mixture is FC:FA 10:7 + Ce 6 %; FC = fibreclay, FA = fly ash, Ce = cement.

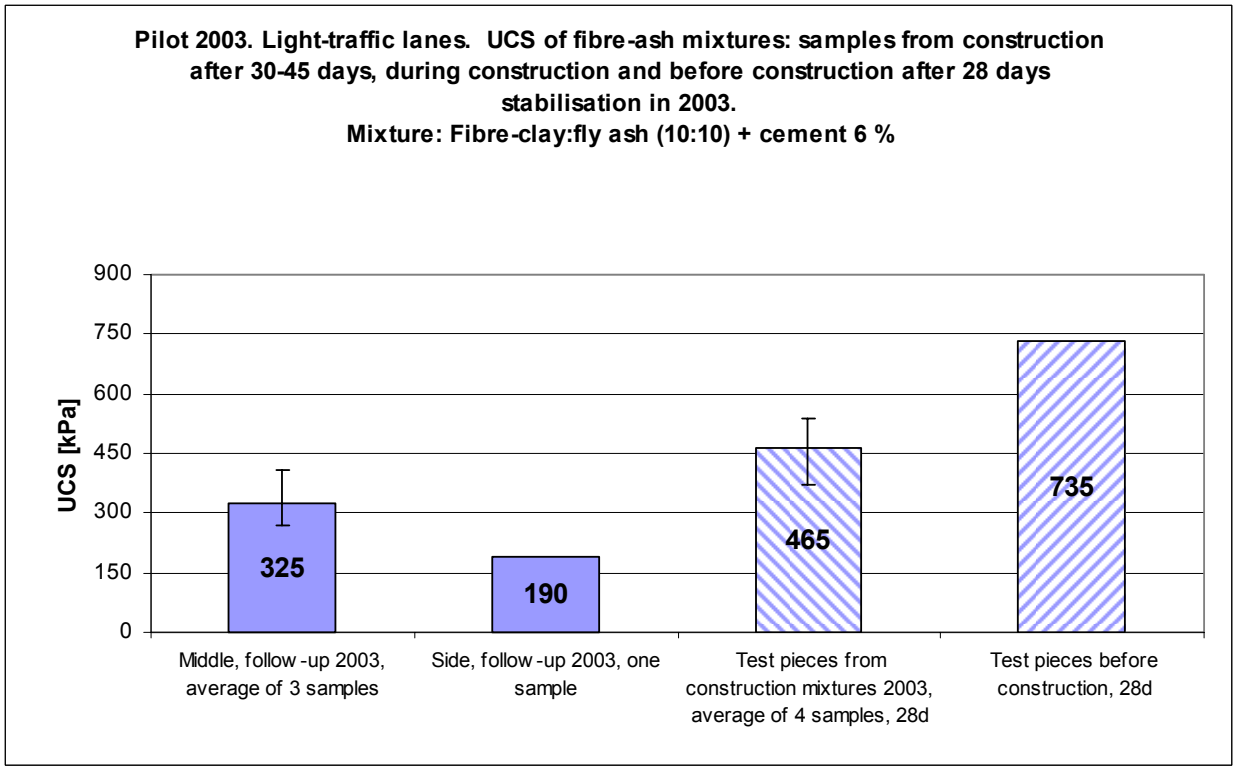

Figure 9: Structural studies of Pilot 2003 light-traffic lanes in the autumn 2003. The fibre-ash mixture is FC:FA 10:10 + Ce 6 %; FC = fibreclay, FA = fly ash, Ce = cement.

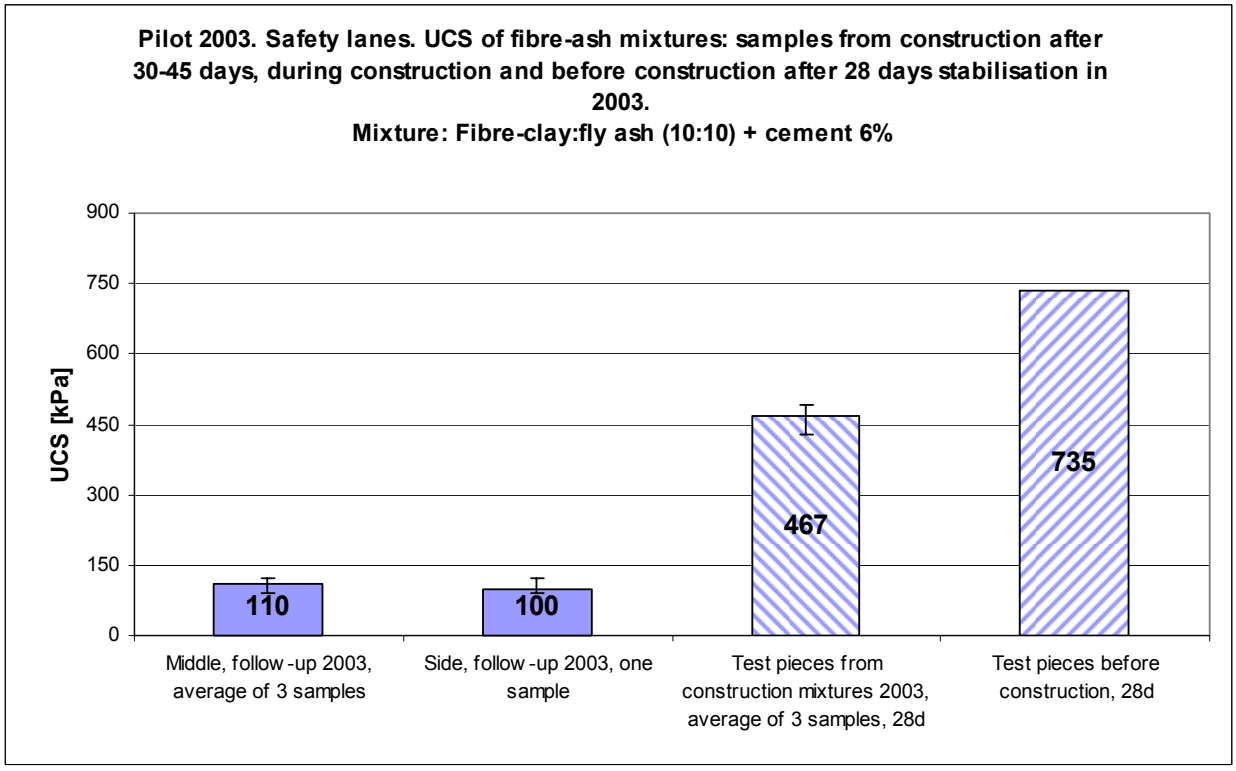

Figure 10: Structural studies of Pilot 2003 safety lanes in the autumn 2003. The fibre-ash mixture is FC:FA 10:10 + Ce 6 %; FC = fibreclay, FA = fly ash, Ce = cement.

Environmental follow-up

According to the project plan and the environmental permit of the Pirkanmaa Environment centre, (PIR-2002-Y-743-111/3.7.2003) the follow-up of the Pilot-2003 sites' environment will include sampling and analysis of appropriate water and soil samples. The reference samples were taken in the summer 2003 before construction, and the first follow-up samples will be taken in August-September 2004. With respect to the environmental permit the environmental follow-up continues at least until the end of year 2005. Following substances will be determined from the samples: As, B, Ba, Cd, Cr, Cu, Mo, Ni, Sb, Zn, Al and Mn, pH and electrical conductivity, and TOC.