Proceedings of the 16th International Conference on Soil Mechanics and Geotechnical Engineering

doi:10.3233/978-1-61499-656-9-2407

Environmentally friendly systems to renovate secondary roads. Life-Environment Project: Kukkia Circlet. LIFE02 ENV/FIN/000329

Systèmes ayant un impact réduit sur l'environnement pour la remise à neuf des routes secondaires. Projet de protection de l'environnement: Kukkia Circlet. LIFE02 ENV/FIN/000329

P.O. Lahtinen & A. Maijala
Research and Development unit, Ramboll Finland Oy, FIN-36760 Luopioinen, Finland
S. Kolkka
Hämeen Kuljetus Oy, FIN-33900 Tampere, Finland

ABSTRACT
Innovations for the improvement, renovation and maintenance of secondary road networks are reviewed : new types of road construction materials based on industrial by-products, different types of applications and structures for the new materials, new types of methods for the mixing of the materials and in-detail controlled construction processes to ascertain the target quality and economic benefits of the renovation. The project has demonstrated the innovations by pilot-scale construction. A long-term follow-up of the performance of the construction will finally show the real performance of the pilot application. However, already the short term experience and results indicate that the environmentally friendly and sustainable construction systems produce significant benefits for the society.

RÉSUMÉ
Les innovations en matière d'amélioration, de remise à neuf et d'entretien des réseaux routiers secondaires sont réexaminées : de nouveaux types de matériaux de construction routière industriels par produits, différents types d'applications et de constructions pour les nouveaux matériaux, nouvelles méthodes de mélange des matériaux et processus de construction détaillés pour assurer la qualité cible et les bénéfices économiques des travaux de remise à neuf. Le projet a présenté les innovations par construction à l'échelle-pilote. Un suivi à long terme de l'exécution des travaux mettra en évidence les performances réelles de l'application pilote. Toutefois, l'expérience à court-terme et les résultats prouvent d'ores et déjà que les systèmes de construction écologiques et durables présentent un avantage notable pour la société.

1 INTRODUCTION

The project (Kukkia Circlet) is about the demonstration of sustainable, environmentally friendly methods and processes to improve, renovate and maintain secondary road networks. The project has been co-financed by EU Life-Environment, Finnish Road Administration and the industry.

In the background of the project there are certain major problems: On the one hand there are 1) the inferior quality of the gravel roads due to the frost and other structural damage the repair of which being slow because of the high costs of conventional renovation, and 2) the dangerous, narrow roads with almost non-existent safety lanes for cyclists and pedestrians in the rural and sparsely populated areas because of the high costs of conventional light-traffic paths. On the other hand there are 1) needs for high volumes of non-renewable stone resources in the conventional road construction and maintenance operations, 2) environmental problems in connection with the exploitation of natural stone resources from rocks, hills and eskers, 3) the increasing societal and legislative constraints to the exploitation of natural stone resources, and 4) the high volumes of alternative mineral materials that are being generated in the industrial processes, considered obsolete and dumped in the landfills.

The project innovations are based on earlier R&D in Finland, and include new types of road construction materials and different types of applications and structures based on industrial by-products, new types of equipment for the mixing of the materials, and in-detail controlled construction processes to ascertain the targeted quality and economic benefits of the renovation. The paper reviews applications and systems for the renovation of existing roads with fly ash stabilisation and fibre-ash structural courses, and for the construction of light-traffic paths and wider safety lanes based on fibre-ash.

The project has been implemented during 2002 – 2004, and the pilot construction partly in the summer 2002 and partly in 2003. The follow-up programme has been extended partly until the end of 2005. The results so far indicate that the society will environmentally and economically benefit from the sustainable renovation systems, the durable quality of the secondary roads, and the increasing safety of the pedestrians and cyclists of the rural and sparsely populated areas.

2 STABILISATION OF OLD GRAVEL ROAD STRUCTURES

The problems of the old gravel road have been very typical: frost heave and low bearing capacity causing damage, and dusting. The problem solving (Lahtinen, 2001) has been tested during the project, at first by stabilisation of a pilot road in 2002 (Fig.1).

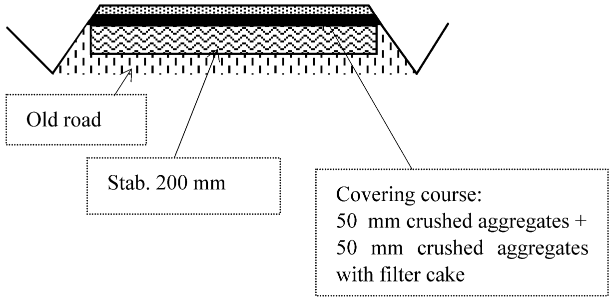


Figure 1: Principle of the stabilised road structure (Kukkia Circlet, Pilot 2002)

The frost resistance and bearing capacity of the gravel road have been improved by stabilisation with fly ash containing admixtures. Three different binder admixtures are being tested: 1) fly ash + cement, 2) fly ash + desulphurisation residue + cement, and 3) fly ash + process gypsum + lime + cement. Fly ash is so-called "bio" fly ash, i.e. from the forest industry's incineration of bark with peat and/or sludge.

The dusting problem has been helped by mixing the crushed aggregate with filter cake. The filter cake is a by-product from the manufacture of calcium chloride, the salt used for dust prevention. Thus, the filter cake contains both salt and other minerals.

The clear environmental benefits are based on the saving of virgin materials and recycling of industrial by-products. This kind of renovation method uses virgin non-renewable materials only for the covering course (100 mm). The bearing capacity of the renovated road has been clearly improved for example in comparison with the reference sections based on conventional improvement methods.

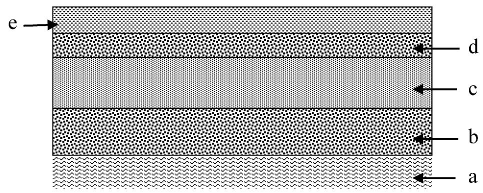
The stabilisation process started with the mixing of the binder components in a high-capacity stationary mixing system. Also the mixing of filter cake into the crushed aggregate for the covering course was carried out with the stationary mixer. The binder mixture was transported to the construction site, spread over the graded road surface and mixed into the road with a stabilising cutter (Fig. 2).

Figure 2: On-going stabilising process (Kukkia Circlet, Pilot 2002)

3 SOLVING OF FROST HEAVE PROBLEMS WITH HELP OF FIBRE-ASH STRUCTURAL COURSES

The fibre-ash structural course –system (Lahtinen, 2001) has been tested for the renovation of a gravel road section suffering from very heavy frost damage. The principle of the construction is given in Figure 3. The fibre-ash course was covered with crushed aggregate (50 mm) and crushed aggregate mixed with filter cake (50 mm).

Fibre-ash is a mixture of fibre sludge from the paper industry and fly ash, and a small amount of cement as additional binder. The fibre-ash mixture was made with a stack mixer (Fig. 4). After batching the appropriate amounts of the components in the stack, the mixing head was made to run 2 to 4 times over the stack.



a. Pohjamaa / *Subsoil*
b. Vanha tierakenne / *Existing old road structure*
c. Kuitutuhka, 200 mm / *Fibre-ash, 200 mm*
d. Murske, 50 mm / *Crushed rock, 50 mm*
e. Suotokakkumurske, 50 mm / *Crushed rock with filtercake, 50 mm*

Figure 3: Principle of a fibre-ash structural course –system (Kukkia Circlet, Pilot 2003)

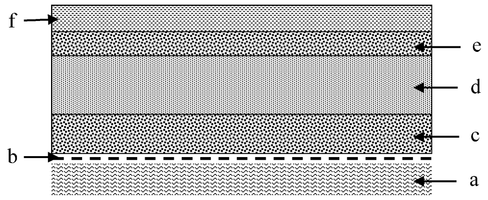
Figure 4: Stack mixer mixing fibre-ash (Kukkia Circlet, Pilot 2003)

4 LIGTH-TRAFFIC PATHS WITH FIBRE-ASH STRUCTURAL COURSE

The project carried out pilot constructions of different types of light-traffic paths. One of the paths was made on soft peat soil. The light-weight, "floating" embankment was constructed with help of geo-reinforcement (geotextile) and fibre-ash structural course (Fig. 5).

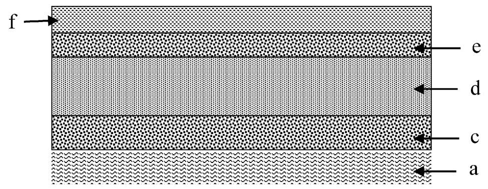
Another light-traffic path was constructed on a silty, frost sensitive soil with help of fibre-ash structural courses (Fig. 6). Different types of new covering mixtures are being tested on this path in order to find feasible alternatives to the asphalts. The new covering mixtures include crushed aggregate and filter cake and some of the following components: fibre-clay (fibre sludge), cement and bitumen emulsion.

The third pilot structure was made as a safety lane extension for the narrow roadway with help of fibre-ash structural course and geo-net as reinforcement (Fig. 7).



a. Pohjamaa, turve / *Subsoil, peat*
b. Vahvistekangas / *Geotextile, reinforcement*
c. Murske, 100 mm / *Crushed rock, 100 mm*
d. Kuitutuhka, 150 - 200 mm / *Fibre-ash, 150 - 200 mm*
e. Murske, 50 mm / *Crushed rock, 50 mm*
f. Suotokakkumurske, 50 - 70 mm / *Crushed rock with filtercake, 50 - 70 mm*

Figure 5: Principle of the light-traffic path structure on soft soil (Kukkia Circlet, Pilot 2003)



a. Pohjamaa, siltti / *Subsoil, silt*
c. Murske, 100 mm / *Crushed rock, 100 mm*
d. Kuitutuhka, 150 - 200 mm / *Fibre-ash, 150 - 200 mm*
e. Murske, 50 mm / *Crushed rock, 50 mm*
f. Suotokakkumurske, 50 - 70 mm / *Crushed rock with filtercake, 50 - 70 mm*

Figure 6: Principle of the light-traffic path structure on a frost sensitive soil (Kukkia Circlet, Pilot 2003)

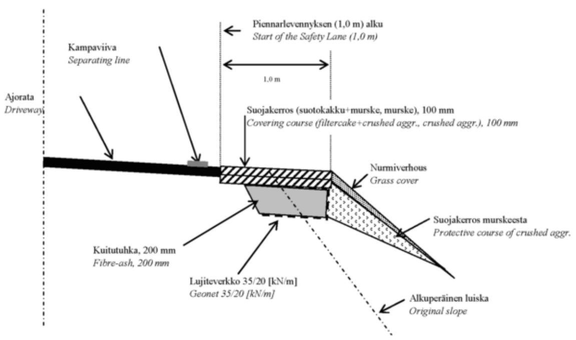


Figure 7: Principle of the safety-lane extension with help of fibre-ash and geo-net (Kukkia Circlet, Pilot 2003)

5 TECHNICAL AND ECONOMICAL ASSESSMENT OF THE ENGINEERED RECYCLED STRUCTURES

The pilot structures of the project have performed well and like expected. The short assessment of the different structures is following:

Table 1: Assessment of the different pilot structures of Kukkia Circlet

Stabilisation of old gravel road structures with binders based on fly ash		
	Benefits	- Significant savings of non-renewable natural resources - The particularly good bearing capacity of the stabilised structure - Less dusting problems due to filter cake component in the covering course - Efficiency of the construction process: the daily production is around two kilometres of stabilised road
	Needs for development	- The wearing-out of the covering course on the stabilised layer is a problem
	Economy	- The costs of renovation are about 30 % smaller than the costs of the conventional renovation method (filter cloth and 300 mm crushed aggregates) for gravel roads
Fibre-ash structural road courses for renovation		
	Benefits	- The significantly smaller frost heave - The improved bearing capacity - Savings of non-renewable natural resources
	Needs for development	- The compaction method of the fibre-ash course - The inclinations needed for the road in order to allow the drainage of water from the structure
	Economy	- The construction costs are close to the costs of the conventional renovation method. The potential savings will be obtained from the reduced needs for maintenance.
Ligth-traffic paths with fibre-ash structural course		
	Benefits	- Savings of non-renewable natural resources - The potential for new, feasible covering materials for light-traffic paths - Good technical performance
	Needs for development	- The methods to construct safety lanes on steep slopes - Further development of the covering materials
	Economy	- Construction less expensive than the construction of light traffic paths with conventional methods

6 CONCLUSIONS

The earlier R&D, including the promising experiences from the field tests, on different types of fly ash and fibre-ash constructions have been the encouraging background for the start of the project Kukkia Circlet. The doctoral thesis of Pentti Lahtinen (2001) is one of the concluding works of the research and experiences during the 1990's in Finland.

The paper has reviewed the pilot structures of a project, Kukkia Circlet, which has been mainly implemented during the years 2002 and 2003. Thus, the follow-up period has been too short to make any final conclusion about the long-term performance of the pilot structures. However, the technical, environmental and economical performance of the pilot structures have so far been according to expectations and very promising with respect to the longer term.

The project has indicated some indisputable benefits of the engineered recycled materials in road construction: the savings of virgin, non-renewable natural resources and the technical versality and potential of the fly ash and fibre-ash as well as filter cake materials for different road construction applications.

REFERENCES

Lahtinen, P.O. 2001. Fly Ash Mixtures as Flexible Structural Materials for Low-Volume Roads. Finnra Reports 70/2001. 95 p. + annexes 55 p. ISSN 1457-9871, ISBN 951-726-826-2, TIEH 3200716[E].

Reports of LIFE02 ENV/FIN/000329, Kukkia Circlet: http://www.tieliikelaitos.fi/5_4.asp