

The SCORE project: Superior cold recycling

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INTRODUCTION

Cold in-place recycling of old pavements is a typical example of environmentally friendly technology (Environmentally Friendly Construction Technology, EFCT). Indeed, this technique generates savings of;

- transportation since new materials transfer are limited,
- energy associated with the use of cold materials,
- Natural resources by making maximum use of in-place materials and reducing waste of materials coming from the old pavement.

Use of cold techniques also improves safety on site and impact on the environment.

Although it may sound surprising, considering the social and economic pressure toward EFCT, cold in-place recycling is not developed in most European countries. Indeed, this technology suffers today from a lack of general understanding of the system that would allow for a common rational approach to mix designing. Furthermore, the advantages and limitations of the process remain unclear. Consequently, engineers in charge of pavement management do not consider cold in-place recycling as a standard solution for pavement maintenance and rehabilitation.

Considering this situation, eight partners have decided to put their research capabilities together to improve existing technologies: Probisa (Spain), in charge of the project co-ordination, Nynas (UK), Eurovia (France), SSZ (Czech Republic), Produktion (Sweden), LCPC (France), Cedex (Spain) and Université Joseph Fourier (France). The project is called SCORE "Superior Cold Recycling based on benefits of bituminous microemulsions and foamed bitumen. A EFCT system for the rehabilitation and maintenance of roads".

The program started in June 2002 for a duration of three years within the framework of the 5th Framework Program of Research and Development of the European Commission in the area of Research, technology development and validation¹.

The project represents a workload of 281 man.months for a budget of 3M€. Three objectives have been assigned to this project:

- Improve the knowledge of cold recycling, from milling of the old pavement to mix design and mechanical properties of recycled materials in order to propose criteria for an optimum use of this technology.
- Investigate the possibility of making better use of the aged bitumen through a detailed analysis of the interaction between the old bitumen and rejuvenators.
- Improve the technique through use of foamed bitumen and microemulsions, or an association of both.

In order to define a realistic work program, it has been decided to focus the project on cold in-place recycling of bituminous materials. First results are being processed and analysed, which will take a large amount of work. This paper proposes to describe the project organisation and provide preliminary results illustrating the method selected.

PROJECT ORGANISATION

Project co-ordination is provided by J.-J. Potti from Probisa. The program is divided in nine tasks, each addressing a specific aspect of cold in-place recycling as detailed later on. Each task is lead by one of the partners (table 1). A key element in the management of the project has been the creation of an orientation committee gathering expert from different countries (Germany, Spain, France, Portugal, Czech Republic, UK) as well as managers of road networks: manager of road structures for a urban community of a large city in France, members of road directorate for Andalusia, consultants involved in the road maintenance scheme for UK and the Czech Republic. The orientation committee underline the critical points to be studied or to be improved to make cold in-place recycling a more attractive maintenance solution. Suggestions from the Orientation Committee are then translated into research programmes by the Technical Committee that discuss the details of the testing programme.

[table 1]

HISTORIC

The project started on June 1st, 2002 for a duration of three years. During the first year, four tasks have been covered (figure 1). Task 9 has also been started and will continue until the end of the project. A detailed description of each task is presented later on.

[figure 1]

TECHNICAL PROGRAMME

The general objective of the project is to optimise the existing technologies in order to apply the best materials as possible. This naturally implies the development of mix design and evaluation methods, as well as a better characterisation of the materials to be recycled and a follow-up of construction sites. Within this objective, it is naturally required to start with a review of current knowledge, which includes in particular the work carried out by PIARC under the leadership of J.-F. Corté². From the review of current practices, and thanks to the input from the Orientation Committee, a detailed programme has been defined to address the important issues to be improved at each stage of the programme. Each task is autonomous investigation. In summary, tasks 1 through 4 are focusing on individual components taking part to the finish mix. Task 5 is a validation of task 4, dedicated to the manufacturing process of microemulsions. Results and materials from the first tasks are then used in the mix design work of task 6, followed by an in-depth analysis of mechanical characterisation in task 7. Results are then validated through trial sections in task 8. Task 9 has a particular role in the sense that it addresses no specific technical issue but the exploitation and diffusion of the project's results. Organisation of the tasks is illustrated in figure 2.

[figure 2]

Task 1: Selection and characterisation of representative aggregate

Purpose of this task is to gather and characterise materials representative of the various European sources. Aside from geographical variations, this task also addresses the effect of mix formulation and milling parameters on the properties of the RAP (Reclaimed Asphalt Pavement) aggregate. Possible outcome from this task could be a list of recommendations for milling conditions adapted to the pavement to be recycled as well as a list of relevant tests to characterise the RAP aggregate.

This work was carried out on several sites throughout Europe where samples were collected from different milling conditions before characterisation.

As an example, figure 3 presents the particle size distribution of materials collected on the Ždár site in the Czech Republic using a Wirtgen WR 2500. The different parameters investigated include high and low milling drum rotation speeds (130 and 200 rpm), milling depth of 60 and 100 mm as well as two machine translation speeds (2 and 6 m/min). Some key elements from such sites have then been confirmed by an experiment by the Rouen road study centre (CETE) on a section built specifically for this project.

Another aspect of this task concerns the implementation of a characterisation methodology for the aggregate. Methods available in each country have been collected before selecting the most appropriate ones.

[figure 3]

Task 2: Interaction between old and new bitumen

Purpose of this task is to address the following two questions: up to which level can an old bitumen be rejuvenated? How much time does it take to reach equilibrium? This work should lead to rational criteria for the selection of the new binder: "normal" bitumen or a rejuvenator.

The study was carried out at a fundamental level where kinetics of diffusion between an old bitumen and a soft base or a rejuvenating oil have been analysed. Rheological tools, as described in figure 4 have been used for that purpose: thin layers of hard and soft bitumen are positioned between the plates of a rheometer and the viscous modulus of the system followed through time. Based on this approach, analysis allows to reach key parameters on diffusion³. In parallel, diffusion kinetics is evaluated directly on mixes to determine to which extend fundamental elements can explain the behaviour of a finished mix.

On the practical side, the SCORE task 2 team has developed an oil based cold rejuvenation emulsion active at very low treat rate (0.1 to 0.2% by weight of dry aggregate) and capable of rejuvenating about 1% of the old bitumen provided a maturation time of 7 to 10 days.

This emulsion has been formulated from environmentally friendly components and is therefore not labelled; this is quite important, as most rejuvenating agents used in the past would be too toxic to be acceptable today.

Suggested injection point of this emulsion is in the milling machine cooling water flow where it presents the added advantage of behaving as a cutting oil reducing milling teeth wear. This emulsion therefore cumulates the following advantages:

- Reduction of teeth wear, extend of this reduction is under investigation at industrial scale as part of task 8
- Rejuvenation of up to 1% of aged bitumen, leading to a reduction in the demand for new binder
- Lubricating effect on the mix leading to substantial decrease in void content.

While investigating the effect of ambient temperature on diffusion speed, collateral finding is that RAP aggregate compactability is affected by temperature even in the range of temperatures that can be expected on site. Figure 5 shows the void reduction associated to the combined use of rejuvenating emulsion and temperature within a range that can be encountered on site. Substantial reduction in void content can be achieved by slightly raising rejuvenated RAP aggregate temperature at time of compaction to 40/50°C. Practical implications of this finding are under investigation.

[figure 4]

[figure 5]

Task 3: Optimisation of foamed bitumen

Purpose of this task is to improve and better control bitumen foaming properties at laboratory scale in order to provide recommendations at the industrial scale. The scientific approach is based on a detailed understanding of the phenomenon's involved in the development of a laboratory scale apparatus providing good control on the formulation and manufacturing parameters. Results are then compared to the ones achieved on a commercial foam rig using different types of nozzles (figure 6). Finally the influence of foam quality on the final mix is also investigated.

[figure 6]

Task 4: Manufacturing microemulsions

This task is dedicated to the development of a laboratory scale prototype to manufacture bitumen emulsions with particle sizes below 1 micron.

In a first step, small quantities of emulsions with a median diameter of 0.6 µm have been produced (figure 7). Objective is to find out which formulation and manufacturing parameters control the emulsification process of such emulsions.

[figure 7]

Task 5: Evaluation of the potential of micronised emulsions

This task is directly related to the previous one: purpose is to highlight the advantages and limitations of micronised emulsions. Investigation will aim at the potential of such emulsions in cold recycling and possible improvements of the mix performances.

Task 6: Mix design – Optimisation of recycled materials

Purpose is here to determine optimum formulations using materials selected in task 1. It is also intended, at the end of this exercise, to propose recommendations to select the most appropriate technique (emulsion, micro-emulsions, foamed bitumen) for a given type of RAP. It is, therefore, a formulation study where different means at laboratory scale are used (?) to investigate compactability, workability, water sensitivity and mix cohesion build-up. Results from the OPTTEL programme⁴ as well as from more recent work on workability⁵ will be implemented in this study.

Main tests envisioned are presented on table 2. Tests will be carried out on materials selected from the previous tasks: RAP from task 1, rejuvenator or new bitumen following the conclusions from task 2, improved foamed bitumen from task 3 and micronised emulsion (provided task 5 demonstrates an advantage) based on formulations developed within task 4 and 5. Furthermore, attractive options will be investigated, such as the addition of a small amount of cement according to the Spanish experience⁶, i.e. at lower treat rates than recommended in the German guide⁷.

Effect of mix parameters on mix performances will then be used to issue recommendations for each technique (emulsions, micro-emulsion and foamed bitumen).

[table 2]

Task 7: Mechanical performances of optimised mixes

This task naturally follows the previous one, since the objective is to evaluate the mechanical performances of optimised formulations from task 6. This will allow for an estimation of the impact of the different techniques investigated on the mix structural performances and life expectancy, as well as compare them on a cost versus benefit basis. Different testing methods to determine stiffness modulus will be investigated⁹ and appropriate fatigue tests will be eventually developed.

The objective of task 7 is, therefore, a complete mechanical characterisation of the mix formulations optimised in task 6, that will provide a rational comparison based on performance and in situ behaviour.

Task 8: Full scale validation trials

The objective of this final technical task is to demonstrate at the industrial scale the different results gathered through the project. It is scheduled to evaluate on site the relevance of the different tests carried out in the laboratory as part of task 6 and 7. This will, in particular, allow to confirm or not the predictions in term of workability and compactability (task 6) and structural behaviour (task 7). Trials will take place in as many countries as possible in order to test the conclusions of this project in various environments (climate, traffic, type of pavement). List of trial sites is under development as well as the follow-up testing methods. This will most likely be depending upon geographical location of the sections and the technical choices to be validated. At least the volumetric characteristics (voids and densities) and mechanical performances will be evaluated as a function of curing. Follow-up will hopefully be carried out after the end of this project, particularly if the results are sufficiently interesting to justify an additional effort.

[cold recycling project picture]

Task 9: dissemination and exploitation of the results

Finally, a specific task is dedicated to the dissemination and exploitation of the results of this project. It is within this task that, through responses from outside the SCORE team, we will be able to redirect as needed the project. For this purpose, a trilingual Internet site has been set-up specifically for SCORE (figure 8). Literature review, carried out at the beginning of the project, was part of this task which is the only one covering the entire project duration.

[figure 8]

CONCLUSION

The methodology followed to reach our target is to better understand each step of the technology. Thanks to this approach, the SCORE team is convinced that it will be possible to improve our know-how of cold in-place recycling and turn this technique a more widely accepted solution for pavement maintenance and rehabilitation.

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