ON-SITE RETREADING OF ROAD SURFACES WITH BITUMEN EMULSION

J.C.VALEUX
CETE Normandie Centre
Laboratoire Régional des Ponts et Chaussées de Rouen, France
jean-claude.valeux@equipement.gouv.fr

D.THOURET
COLAS Sud-Ouest
thouret@floirac.colas.fr

ABSTRACT

The on-site retreading of road surfaces is an economically interesting and technically reliable solution to the rehabilitation of roads and runways.
It is a low-cost solution in that it helps:
- Avoid the removal of "noble" aggregates from quarries
- Reduce the production of waste products from roads
- Reduce the quantity of road material dumped in landfills
- Reduce the pollution caused by the transport of aggregates
It is a technical solution to road maintenance
- In the case of structural weakness of the road surface
- In the case of defects observed in surface layers (profiles, crazing, potholes, stripping, cracks etc.)
- In the case of slippage of the courses forming the road or runway surface.
The advantage of this technique in relation to other rehabilitation techniques is that it protects the level of the road threshold and reduces the inconvenience for users by enabling work in alternation on each lane. It is also encouraged by the French Highways Department.
For the first time in France this particular study has been carried out based on the French technical guide for on-site retreading of road surfaces. The present paper describes the specification for retreading work with a bitumen emulsion on departmental roads located in the Caribbean area, from the analysis of the deposits on-site, the preliminary studies, and the recommended retreading technique, to the drafting of the technical specifications of the contracting authorities for the call for tenders and the assessment of the technical proposal of the successful tenderer.

KEY WORDS

SURFACE LAYER / MAINTENANCE / RECYCLING / ON-SITE RETREADING / EMULSION

1. ROAD SURFACE REHABILITATION METHOD

The solution of on-site retreading was considered for the following reasons:
- It was impossible to heighten the level of the road surfaces by a new layer by more than 4cm (presence of concrete gutters);

- The layers of blacktop implemented during successive maintenance operations needed to be rebound;
- Improvements could be made to the operational quality of the wearing course (regeneration of the bitumen, improvements in roughness, repairs of potholes and crazing, improvement of profiles etc.);
- It was possible to work in alternation on each lane without interrupting traffic;
- It was possible to work quickly (5 to 10000 m² per day, or about 1km to 1.6km of road surface);
- It protected the environment (no dumping of road surface materials and no borrowing of aggregates);
- It did not involve any transport of materials that might cause damage to the neighbouring road network;
- It saved natural resources in aggregates

Given the predominance of road surface structures made with materials treated with hydrocarbon binders, the feasibility of on-site retreading with a bitumen emulsion was considered and studied.

2. TECHNICAL EXPLORATION OF THE ROAD SURFACES TO BE RETREADED

Technical exploration of the various sections of road surface was carried out by the Ponts et Chaussées Laboratory of Rouen, in order to assess on-site:
- The environment of the road surface, its geometry, profiles, traffic load;
- The presence of valve boxes and various utility networks etc.;
- The number and location of test bores (coring) to be carried out;
- The need for preparatory work (planing of shoulders, auxiliary girders, drainage work etc.);
- The treatment of roundabouts and other specific points;
- The treatment of local access roads.

In all, the four sections of Departmental Road to be retreaded represent a kerbside distance of 10km. They are located in four different sites on the island of Martinique and sometimes have high gradients, which meant that the road surface retreading plant had to be mobile.

On all the sections inspected, the characteristics of the road surface (roughness, adhesion) were found to be very poor and insufficient in case of rain.
In certain areas, cracking was caused by a structural defect in the road surface, in particular at roundabouts (Figure 1). On the road bank, due to lack of support for the shoulder or in backfill areas, longitudinal cracks were found 30/40 cm from the edge of the road into which rainwater had infiltrated and damaged the structure of the road surface; this problem had to be treated before retreading the road surface and was part of the additional work to the construction contract.
On the other hand, in certain places water was channelled into the road banks by the grassy shoulder. Planing of the shoulder level was required before the retreading work.
On one section, the presence of numerous valve boxes located on the road surface meant that they had to be driven into the surface before the passage of the fragmentation machine of the retreading plant, and then releveled after compaction of the wearing course.

Figure 1 – Cracks and crazing

3. ANALYSIS OF EXISTING DEPOSITS

After the technical exploration, test bores were positioned at the rate of at least one test bore every 250m and at locations where doubts subsisted about the homogeneity of the structure of the road surface.
Over the 10km of road surface, 41 core samples (figure 2) were taken and sent to the Ponts et Chaussées Laboratory of Rouen.

Figure 2 – Core samples of road surface taken on-site

The following features were analysed:
- The thickness of the various layers displayed on a diagram with the photo of the core sample;
- The particle size analysis of the materials and their binder content;
- The rheological characteristics of the binder (Penetrability and Ball and ring temperature).

The penetrability test at 25°C, 100g, 5s expressed in 1/10 of mm (NF standard EN 1426) makes it possible to assess the hardness of the bitumen; the value obtained makes it possible to classify the bitumens by categories (20/30, 25/50, 50/70 etc.). The harder a bitumen, the lower its penetrability. Given the fact that the penetrability of a bitumen decreases over time due to the natural hardening of the bitumen, this residual value is important for choosing the retreading binder.
The Ball and ring temperature in °C (NF standard EN 1427) or "softening point", makes it possible to assess the thermal sensitivity of the bitumen; the harder a bitumen, the higher its sensitivity. Given the fact that bitumen hardens with age, its Ball and ring temperature increases with time.

It should be noted that the structure of the road surface generally comprised several successive layers of blacktop graded from 0/12 to 0/20 mm laid on a sub-base of pit-run coarse gravel with a particle size distribution of 0/31.5. The thickness of blacktop varies from 8 cm to 27 cm. The thickness of the core samples taken on-site showed that most of the blacktop layers forming the structure of the road surface had separated from each other. In this case it was necessary to use a technique making it possible to rebind the layers and a material enabling a tack coat to be first of all laid under the reprocessed material.

The rheological analysis of the bitumen of the core samples of blacktop resulted in penetrability values < 10/10° per mm with a ball and ring softening point > 70°C, indicating that the bitumen had considerably aged and had reached a high level of hardness, resulting in the cracking of the road surface under the effect of the high thermal stress in the Caribbean region.

4. FEASIBILITY OF RETREADING

The diagnostic survey carried out on all the 4 sections of the Departmental Roads as well as the analysis of the layers of blacktop forming the road surface indicated the feasibility of an on-site cold-mix retreading technique using a bitumen emulsion over a thickness of 8, 10 or 12 cm according to case, without any borrow material to correct the particle size distribution of the blacktop aggregates.
The retreading technique using a bituminous base course with a cold sealant, due to its self-repairing nature, in this case was well-suited for preventing any upwelling of cracks from the subjacent layers. In addition, this technique would enable the structural reinforcement of the worn road surfaces and provide correct surface characteristics for the user (reprofiling, evenness, adhesion, regeneration of old binders etc.).
In the present case, the technique made it possible to anticipate a cost of rehabilitation of the road surface 30% lower than a conventional resurfacing technique.

4.1. Class of retreading

The on-site retreading with a bitumen emulsion recommended in this case was class III and level R1 according to the technical retreading guide.
Class III is recommended when the materials of the old road surface to be retreaded are exclusively bituminous materials, and when the retreading is designed to solve problems relating to the slippage of interfaces and / or the ageing and wear of the blacktop. The thickness is limited to 12 cm and is always a few centimetres more than the thickness of the old surface layer(s) in order to treat the interface.
The largest size of material after fragmentation must be less than 25 mm and the characteristics of the old binder have a penetrability rate higher than 10/10th mm and a Ball and ring temperature lower than 70°C.
The R1 quality (table 1) is the level of on-site retreading quality required by the Contracting authorities as part of the call for tenders, given that the new layer in the road surface was to act as a base layer.
This level of quality can only be reached under two conditions:
i) when the preliminary survey carried out before the work by the successful tenderer shows that the quality of the material available in the old road surface means it is possible to effectively obtain the level of quality required (homogeneity, mechanical performance characteristics etc.), and
ii) when the materials considered for retreading make it possible to reach the quality objective of R1. This condition is met by the value of the HEPIL coefficient of the material stipulated by the Contracting authorities in the contract.

Table 1 - Choice of retreading quality according to worksite

Class of retreading	**Function of the reprocessed layer**	**Class of traffic**	**Quality of retreading**	**Quality of compaction**
I	Base or foundation	T>T2	R1	Average percentage of cavities less than or equal to 20 %
		T3=T=T2	R1 required R2 admitted in foundation	
		< T3	R2 admitted	
II or **III**	Base or binder	T>T2	R1	
		T3=T=T2	R1	
		T < T3	R2 admitted	

The HEPIL coefficient corresponds to the precise characteristics of the retreading plant: H corresponds to the homogenisation quality of the machine, E to the thickness control, P to the available power, I to the presence of a water injection system and L to the metering of binder, in this case the metering of the emulsion.

By stipulating a value for this coefficient in the contract, prior to site work, the Contracting authorities can ensure that the retreading materials proposed by the successful tenderer are capable of obtaining the R1 retreading quality determined after the feasibility survey.

4.2. Retreading Plant

To satisfy the quality requirements of the Contracting authorities and to eliminate the transversal heterogeneities found on the road surface, the HEPIL coefficient was set to 33333 (table 2). Only a milling loader combined with a mixer (multifunction machine) or a milling loader combined with a finisher would be suitable.
In addition, to ensure the binding of the reprocessed layer with the milled structure of the old road surface, an emulsion tack coat was required and justified a technique capable of guaranteeing its implementation.

Table 2 – Retreading quality according to equipment performance characteristics

NOTE	**3**	**2**	**1**
Homogeneity			
E (Thickness)	**R1**		**R2**
Power			
Injection			
Binder			

It is only possible to obtain R1 retreading quality with equipment of this type. R2 is also possible.

Equipment corresponding to these criteria only enables R2 retreading quality.

Equipment refused

4.3 Wearing course

On the reprocessed road surface, the wearing course comprised 4 cm of Bituminous Concrete 0/10. On a T5 traffic section (therefore relatively low-level) an ECF (cold-mix macadam) was recommended as an experimental section for follow-up, in order to obtain information for the future.
It should be noted that to facilitate the "curing" of the retreaded emulsion layer, the laying of the wearing course that is to cover it must be postponed for 2 to 3 weeks depending on the weather conditions, on the traffic it has to withstand, and on any changes after initial laying.
The roundabouts were to be processed apart by laying a Bituminous Concrete with a High Modulus 0/14, 8 cm thick after milling 4 cm (the blacktop aggregates could be recycled in hot-mix plant for the blacktop of the wearing course, in accordance with the specifications of the standard for hot-mix recycling of blacktop aggregates).

4.4 Additional work

Some specific work had to be carried out before retreading. This includes the levelling of valve boxes, the planing of shoulders and the installation in certain places of auxiliary

girders, excavated and reinforced 50cm deep to support the road surface. Finally, the general rise in the road surfaces of 4cm would create an additional thickness of 4cm at the level of the concrete gutters and shoulders, which would have to sloped during compaction to avoid accidents caused by the rail effect.

5. TECHNICAL SPECIFICATIONS

During this survey, the authors prepared a standard contract comprising a Call for Tenders Memo (RPAO), a deed of commitment, a detailed cost estimate, a price schedule and a standard specific requirements schedule (CCTP) established on the basis of the French guide for the on-site retreading of road surfaces, all of which were provided in computer format.
The object of the CCTP is to define the specifications for the materials and products, the conditions for on-site retreading of the old road surface with a bitumen emulsion without borrow material, as well as the methods for manufacturing, transporting and implementing the surface layer.
The main points developed in the CCTP are:

5.1. The general indications and the description of the works to be carried out:

These include a summary table describing the characteristics of the sections of departmental roads, the ancillary works to be carried out and the type of retreading adopted by the Contracting authorities. The tenderer must remit to the Contracting authorities in support of its offer an Organisation Chart of its Quality Assurance Plans (SOPAQ), which should contain a precise presentation of the technical characteristics of the equipment proposed (in particular with regard to the HEPIL coefficient) and the main lines of the methods of execution and organisation of the worksite.
The tenderer must also provide a Quality Assurance Plan (QAP).
After the worksite has been completed, the tenderer must also supply a Work Completion File (DOE), summarising the results obtained.

5.2. Specifications of constituents:

The tenderer must also indicate the source and quality of the materials and products used (emulsion, input water, wearing course).
The tenderer must also indicate the method of on-site cold-mix retreading by bitumen emulsion (studies of formulation and objectives to be reached, performance characteristics to be reached after retreading).
Remark: before starting the worksite, the successful tenderer must carry out a formulation study using materials representative of the road surface, and check the mechanical performance characteristics to be reached.
For class III retreading, the tests must results in the following performance characteristics:
Duriez test: % of cavities < 14, r/R >0.7, Rc 14 days > 5MPa
PCG test: % of cavities < 25 to 100 gyrations.
Gain of ball and ring temperature: 5 to 15°C
Content in cavities of the retreaded material after compaction < 20%

5.3. Manufacturing and implementation specifications

This section is particularly designed to stipulate the quality level adopted by the Contracting authorities (R1) and the HEPIL coefficient of the equipment that will be presented by the contractor, the depth of retreading, the realisation of the longitudinal and transversal construction joints, connections with the existing road and utility networks, the tack coat, and the compaction and sealing of the surface if the weather conditions are unfavourable.
The work was to be carried out in alternation on each lane in order not to interrupt traffic.
The wearing course is defined and a technical file must be provided by the contractor when remitting its offer (tests carried out on the material of the wearing course and the performance characteristics obtained such as binder/aggregate cohesion, adhesiveness, stripping etc.) as well as the proportions of the various constituents in the mix.

5.4. Specifications and conformance checks

Acceptance testing of equipment before site start-up
Test and reference beds making it possible to calibrate the worksite and ensure that the requisite quality is obtained.
The nature and the rate of checks carried out by the contractor's in-house inspection and the external inspection by the Contracting authorities
Checks of service qualities: macrotexture, thickness, transversal profile, wanes, longitudinal evenness etc.

6. THE RETREADING MARKET

Road surface retreading work has been the subject of a European call for tenders with an exclusive base solution "on-site cold-mix retreading by bitumen emulsion", without any variants.
This solution obviously requires a feasibility study before the CCTP is drafted by the Contracting authorities, and the feasibility report of the Ponts et Chaussées Laboratory must be attached to the call for tenders.
Note: In the other case, in which the contractor proposes an alternative solution to on-site retreading, the contractor is responsible for carrying out the feasibility study in the time allocated to it to begin the worksite, which is sometimes very short.
At the present time, the successful tenderer is the contractor COLAS, which made an offer proposing the NOVACOL technique of on-site cold-mix retreading with a bitumen emulsion (Figure 3). This technique consists in milling the road surface on-site to a fixed thickness over a width of 3.5m and mixing and metering the water and the emulsion with blacktop aggregates. The reprocessed materials are placed in bands in the axis of the fragmentation machine and are taken by a band elevator into the hopper of the finisher. During this time a ramp integrated with the band elevator applies the tack coat before the reprocessed material is reused on the road surface and precompacted. Final compaction is carried out by a tandem vibrocompactor and a multityred roller.

Figure 3 – NOVACOL on-site retreading plant (COLAS)

7. FINDINGS

On-site retreading of road surfaces with a bitumen emulsion is a technique that dates back to the 1950s. Site failures due to the lack of quality control or to the use of unsuitable agricultural equipment have slowed the development of the technique until the present day.
More accurate specifications detailed by the French Highways Department in the form of technical guides, as well as the progress made by contractors in supervising work, and the efforts of constructors to develop suitable, effective equipment will enable this fully-fledged road-building technique to achieve its reputation today as an answer to sustainable development.

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