QUALITY ASSURANCE AND TRACEABILITY OF RECYCLED MATERIALS PROCESSED CONTINUOUSLY ON SITE

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Abstract

On-the-road recycling processes are more and more complex and the engineers are willing to use the conventional functions typical of stationary plants even when self-propelled machines are to be employed on the job site. Today, the recycling of recycling asphalt product (RAP) is becoming a primary concern in order to ensure long lasting treatments and good adhesion of the recycled material to the remaining layers. As far as the first point is concerned, the manufacturers have not succeeded in integrating the following functions with the new recycling processes:

1. Particle size control of RAP and aggregates (if required),
2. Particle size correction by using an on-board crusher,
3. Continuous weighing of wet recycled material,
4. Continuous measuring of moisture contents in the recycled material,
5. Continuous addition of mixed binders, such as cement or modified bitumen emulsions, according to the actual through-flow,
6. Change to the moisture contents in order to better control emulsion breaking for optimum compaction,
7. Forced mixing of the elements by using a pugmill similar to those employed in stationary plants.

The whole process is monitored through the use of an advanced controller so that the data can be regularly transmitted via telephone modem to a service centre where the problems can be diagnosed and instructions are given to change the operating procedures.

As far as the second point is concerned, a special machine has been developed. It comes with cleaning brushes and an automatic collector for all the material to be recycled. The re-handled material is stored on a thoroughly clean surface. An emulsion tack coat layer is pulverized throughout the entire section by using a specific piece of equipment on board the machine. This arrangement is essential to guarantee long service life and to ensure the layers are firmly joined together.
1. INTRODUCTION

Cold and in-place recycling of roadbeds has acquired over these past years a growing importance focused on by the publication of many guides devoted to this technique, notably when emulsions are used (1, 2, 3).

Italy carried out its initial tests during 1985, but they were modified: decisive for low-traffic roads as well as the Salerno - Reggio autostrada highway in Calabria, debatable for heavy-traffic roads such as the Northern Italy’s autostrada highways.

The Pavimental company’s approach initiated in 1995, was deliberately pragmatic and broken down into the following successive phases:

The “fine tuning” of modified emulsions with simultaneous testing in the laboratory and in place in the region of Orvieto and Portocovitanova.

The observation of the results and the behaviour of road pavements under heavy traffic loads for several years under the cumulative effect of 8 to 10 million 12-ton axle cycles.

A sectorial analysis corresponding to different assumptions either related to the mix (particle size, emulsion type, residual bitumen, polymer type) or related to the thickness (10, 15 and 20 centimetres). Different application drafts were tested to evaluate the performances of the compactors (vibrating or static types).

The selection of the best application draft for the industrial phase.

The good results obtained were mainly attributed to the use of the modified emulsions, but also to the new generations of compactors, which allowed effectively treating 20 centimetres of retreated materials.

This opened some promising perspectives and convinced the company to carry out large-scale worksites mobilizing high-performance recycling equipment specifically designed for this purpose.

Thus, the work performed in 2001, on 20 km of the autostrada network allowed testing 35 different cases in order to constitute a repository, a kind of library of possible cases. This work was reported by Pavimental during the Lyons 2002 Congress on Emulsions (4) and more recently in a general review article on the Italian recycling experience (5). The publications listed in the bibliography should be referred to for details on the subject.

The recycling machine designed and fine-tuned by Marini unquestionably contributed very heavily to this success by rationalizing production and controlling all its phases. All the players could work under good conditions and today the method is considered to be an industrial and repeatable method within the scope of an exemplary quality approach. Two recycling trains have been working all year long on the Italian autostrada network, and the 2004 annual program will cover about 100 kilometres. The purpose of this paper is to describe the characteristics of this recycling train and the reasons behind the technical selections made.

2. REVIEW OF THE POSED PROBLEM

The surface layers were degraded and required multiple maintenance work to be performed on them in the long term. The residual characteristics were dispersed and the recycling of these layers without disqualification was hypothetical. The roadbed layers were sometimes thirty years old and had been altered and subjected to forces creating a phenomenon of fatigue. Therefore, the project consisted of recycling the surface layer and the base layer into only a new base layer by adding a new binder and a rejuvenator (Figure 1).
After compacting this layer, a new surface layer was applied. This combination was thicker by at least the thickness of the new surface layer, that is, approximately 5 cm. If necessary, a part of the recycled layer was reshaped, thereby allowing settling questions of passage under engineering structures and those of cross-sections. A major advantage of the method entailed proceeding with coordinated reinforcements, notably in the event where structural deteriorations resulting from fatigue occurred before the end of the estimated service life.

The autostrada network manager imposed the following: a quick recycling process; a 48-hour “reopen to traffic” deadline; and a minimum overall dimension of 2.50 meters in width for the machine being transported.

3. COLD RECYCLING TRAIN MCR 250

This phase consisted of the following elements (Figure 2):

- An optional chip spreader allowed correcting the particle size curve, wherever necessary. The reuse of a part of the wear courses as base layer was frequently translated by a deficiency in large chunks.

- Two 2-meter milling machines working in parallel, which destroyed the two road layers according to a predetermined depth. This depth could exceed 20 centimeters if an uncasing was required. Resectioning was taken into account in this phase. The “grain size correcting” materials were mixed with the milled materials during this operation.

- Any excess materials were extracted after milling before the passage of the recycler (in the strict sense) by means of a small loader on tires.

- The recycling train MCR 250 (Marini cold recycler) consisted of two main elements (Figure 3):
- **A tracked tractor trailer**, which allowed collecting the materials by means of a lifting drum fed by two hydraulic arms equipped with a cleaning and brushing device. The tractor is outfitted with a control cab and bitumen tank, as well as a boiler and an auxiliary heater.
- **The trailer**, which included all the functional elements of a conventional fixed production plant:
  - a screen, operating at the rate of 250 tons/hour, down to a 35 mm passing depth, mounted on a gradient or level compensating system, allowing to control angular variations on the road of up to 10 °.
  - a granulator, operating at the rate of 40 tons/hour, destructuring chunks greater than 35 mm (Photo 1).
  - a reception hopper, with a weighted extractor equipped with a natural moisture measuring probe.
  - a storage system for cement or any hydraulic binder, equipped with an also weighted continuous metering system.
  - a water pump, controlled with an electromagnetic flow meter.
  - a continuous twin-shaft mixer, operating at the rate of 250 tons/hour (Photo 2).
  - bitumen binders ramps, either emulsified bitumen or foamed bitumen.
4. QUALITY APPROACH AND PRODUCTION CONTROL

The objective was to obtain a geotechnical quality as regular as possible. However, the contractor has not a full control on the materials entering in the process, which is the case for a standard production run with a fixed plant. Therefore, the MCR had to have all the attributes of conventional equipment, but also had to be able to eliminate or correct for products with unallowable deviations.

The following production qualitative objects were therefore fixed:
- Particle size control of the materials entering in the cycle: no chunk greater than 35 mm; a grader disk- and star-type screen was responsible for this control. It was modifiable. The criterion respected the rules proposed particularly by AIPCR (1).
- Correction of the 35 mm remainders by means of a twin-shaft hydraulic crusher.
- Continuous measurement of the water content during the extraction of the wet recycled materials, allowing correcting the water content in the mixer.
- Weighted measurement of the solid flow and regulated adjustments of the complements and additions regardless of their nature: cement, water, additives, rejuvenators, and bitumen binders. Since all the weightings were continuously performed, there was no deviation and the quality was that of a conventional plant.

The weighing of all the components and their sequenced entry in the production cycle were the guarantors of the process according to the flowchart illustrated in Figure 4.

![Figure 4 – Regulation process](image)

Thanks to this rigor, the results obtained were decisive; the moduli were always greater than the following values:
- Modulus at 12 hours: 700 Mpa
- Modulus at 24 hours: 1000 Mpa
- Modulus at 90 days: greater than 4500 Mpa.

In parallel with the resistance to traction, Rt was greater than 0.43 N/mm² at 72 hours and 0.74 at 70 days.

These values were the limit values fixed by the company, given that the property of the emulsions was supposed to have a long curing process time, translated by a gradual improvement of the characteristics under the effect of traffic.

5. QUALITY APPROACH AND APPLICATION

Surface preparation insufficiency and poor application conditions are risk factors which alter the service life of the materials. The process was equipped with side and middle cleaning brushes (Photos 3 and 4) which completely cleaned the milled surface, since the recovered products were re-integrated in the production cycle in order not to generate pollutions.
At the back of the recycling train an emulsion spray bar applied a tack coat over the entire width of the application area; a special spray assured the vertical “resticking” and the junctions between the lanes (Photo 5).

The emulsion used for the tack coat was not modified and retained its special characteristics, which were different from those used for the recycled product. The reasons for the “unsticking” between the layers were thus controlled and the service life of the coat significantly increased according to the calculations made with software such as Alizé.

The application (in the strict sense) was made by means of an independent paver finisher and not with a screed linked to the train in order to be able to reshape the road in the best possible way. Compacting was carried out as quickly as possible to control the breaking of emulsions and to speed up the curing process.

6. TRACEABILITY AND REMOTE CONTROL, THE ADDING OF TELETRANSMISSION CAPABILITY

Since the machine was completely automated and controlled by a central processing unit and delocalized units connected via a Can Bus, not only the “progress” but also the “production” parameters were easier to remotely control thanks to the use of a transmission model. The MCR was localized by GPS positioning and a teletransmitter sent either online or offline the control elements, such as the quantities of bitumen, emulsions or cement used by the sections, or the machine’s energy consumptions.

Thus, the engineer could remotely monitor the retreating machines and intervene, wherever necessary, in the event of an abnormal condition.

This process was not used in Italy since the contractor was responsible and performed his own self-checking, but was developed for a large-scale exporting initiative. For instance, this was the case for Iran, where Asphalt Nemoneh, a local contractor, requested the technological
assistance needed for a complete transfer, and this will also be the case for China, where the in place recycling technology is in its infancy.

7. CONCLUSION

Succeeding with in place recycling required, of course, rigorous and systematic preliminary studies to understand the composition of the road and its history.

Furthermore, particle size corrections and the selection of binders constituted a basic phase in the mix design, which had to be correlated with laboratory tests. But the variability of the parameters, such as thickness and especially the geotechnical characteristics of the layers required resorting to strict production and control methods, authorizing corrections needed just like those implemented during conventional fixed production processes.

The key advantage of the process described here is two-fold: a continuous monitoring of the “progress” and “production” parameters remotely, and the teletransmitting of these characteristics to the expert engineer who can analyze these observations. Any application fault is identifiable and localized on the road. The engineer will then be responsible for deciding whether to apply more materials, if any, to the defective section or to reinforce observations on its behaviour.

The cost-effective advantages of in place recycling are well known by the trade, but some qualitative problems attributable to badly controlled processes have been a braking force for many years. The new technologies and control rigor deployed in the design and application of this MCR technique will allow users to find quantitative objectives similar to those of a conventional plant.

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