

New Developments in Road Maintenance Equipment: Chip Seals and Current Maintenance

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In this paper are presented the state of the art of chip sealing equipment in France (asphalt distributors and chip spreaders) and the methods and tools that have been developed and used during the last 15 years to improve this equipment. Equipment test benches appear to improve quality control of the equipment. Success to date is due to coordinated action of equipment manufacturers, road contractors, and the administration. An automatic patching machine or flexible compound spreader that incorporates technologies of asphalt distributors, chip spreaders, and compactors is discussed briefly.

Maintenance of the road network is essential for the economy and requires a large investment. In France, 450 million square meters of chip seals are placed each year; these seals represent three-fourths of road asphalt consumption. Patching with asphaltic emulsion uses 300 million tons of emulsion a year. The equipment used for chip seals (asphalt distributors, chip spreaders) has been improved during the last 15 years, and innovations in equipment for maintenance are now developing. The characteristics and capacities of the most representative equipment are discussed.

CHIP SEALS

Design, adjustment, and method of operating equipment are major factors in quality control. That is why the French administration has developed evaluation tools for use on chip sealing equipment. Constant communication with contractors and equipment manufacturers makes it possible to improve and optimize design and operation of equipment. To maintain these links, a National Road Equipment Committee was created in 1973 to bring together contractors, manufacturers, and the administration. That committee has issued acceptance rules for equipment and has defined the work program of equipment test stations. The rules, programs, and stations deal with all kinds of road construction equipment, but only chip seals and current maintenance are discussed here.

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Asphalt Distributors

Technology

Approximately 1,200 asphalt distributors are working in France; two-thirds of them are less than 10 years old or have been improved with recently designed parts. Most of them use an asphalt dosing pump bound to the speed of the vehicle through hydrostatic transmission. The spray bars are fitted with middle pressure jets (100 to 200 kPa). Pneumatic outfits are also sometimes used. Features of the asphalt distributors include

- Transverse displacement and lifting of the bar to travel position by pressure cylinders and
- Traditional fittings changed for pneumatically controlled valves.

During the last 15 years, the multijet spray bars have gone through the following evolutionary stages:

- 1974–1975: position of the nozzles designated,
- 1976–1977: improvement of the pipe of the spray bar,
- 1978: beginning of the use of electronics and automation of asphalt distributors (Figures 1 and 2), and
- 1982: process control managed by microprocessor.

Present asphalt distributor technology appears to be optimal for traditional chip seals. However, new chip seal techniques require new equipment to spread high-viscosity asphalt binder (> 1500 cSt). Even though these high-viscosity binders represent only 2 percent of all spread asphalt binders, 50 percent of the asphalt distributors are outfitted at the beginning to allow the spreading of binders the viscosity of which is between 200 and 2500 cSt. This is the result of the contractors' decision to invest in tools that will allow technological evolution (at present 90 percent of asphalt distributors are used with traditional binders). Improvements of the equipment include

- Reinforced thermal insulation and thermofluid heating (now with regulation of the burner),
- Increase in the diameter of pipes upstream of the pump, and
- Use of larger pumps.



FIGURE 1 Modern asphalt distributor, for all asphalt binders, outfitted with electronic drives to provide uniform distribution of material.

Innovation in chip sealing techniques requires new equipment. For instance, two techniques for using foamed asphalt are being developed; one uses a mixture of asphalt, foaming additives, and water; the other uses a mixture of asphalt, foaming additives, and water in an air flow through a grid.

Automation

Electronics for asphalt distributors with "automatic proportioning" allow calculation and on-line regulation of the rpm of the pump depending on the speed of the vehicle, the density of the binder at the spreading temperature, and the number of open nozzles.

Microprocessor units have been developed to improve reliability and ease of command. Use parameters are displayed by the operator either with an input keyboard or from the microprocessor memory. Pump rpm, running speed, and temperature data are collected from sensors and processed by the calculator. To ensure that the correct running speed is

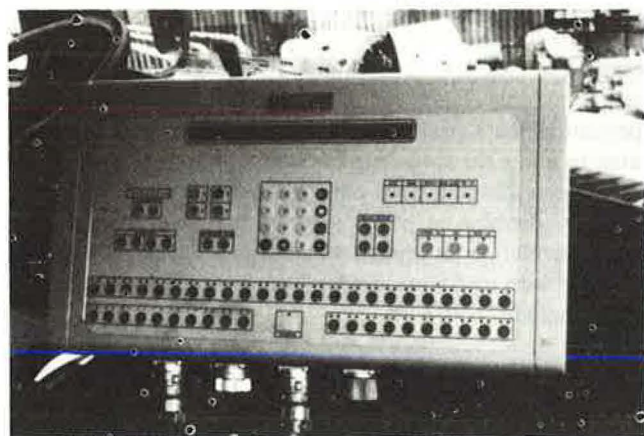


FIGURE 2 Cab control desk of automatic asphalt distributor.

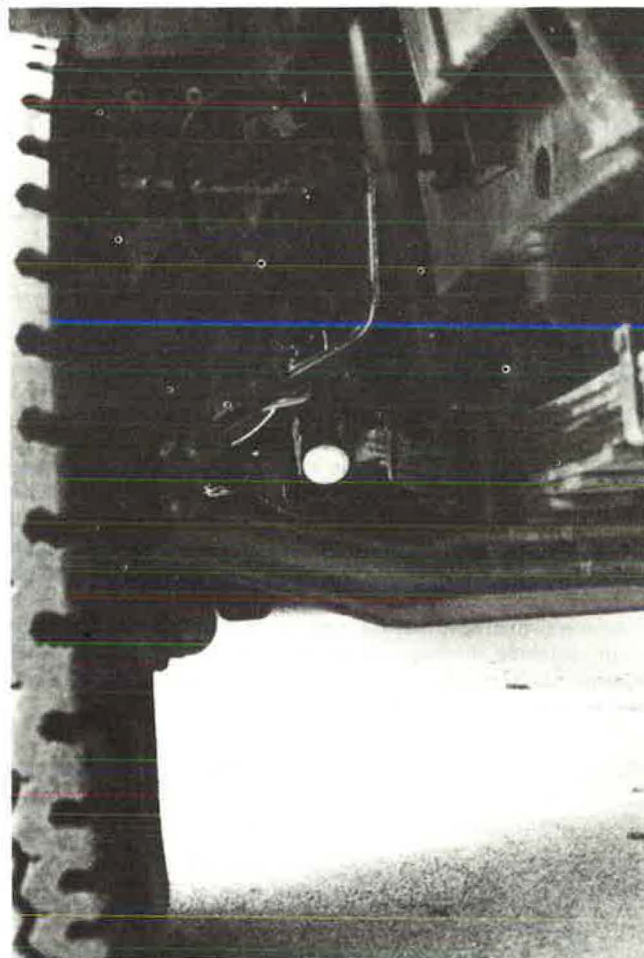


FIGURE 3 Doppler radar for measuring running speed.

input, one of the French manufacturers of asphalt distributors uses a radar placed between the axles under the truck chassis (Figure 3).

Optimal Operating Conditions

The test bench of the Road Equipment Test Station has permitted study of the operation of asphalt distributors and quantification of improvements. The results of the tests have shown the necessity of

- Redetermining and maintaining the position of the nozzles and
- Maintaining correct spray bar height so that the output of the nozzles overlaps on the road during spreading.

It has also been determined that an optimal value of the pump rpm can be identified by using asphalt jets of steady geometry. This is shown in Figure 4; the pump rpm depends on the number of working nozzles.

These asphalt distributors can be used in accordance with the fixed regulations for chip seal work:

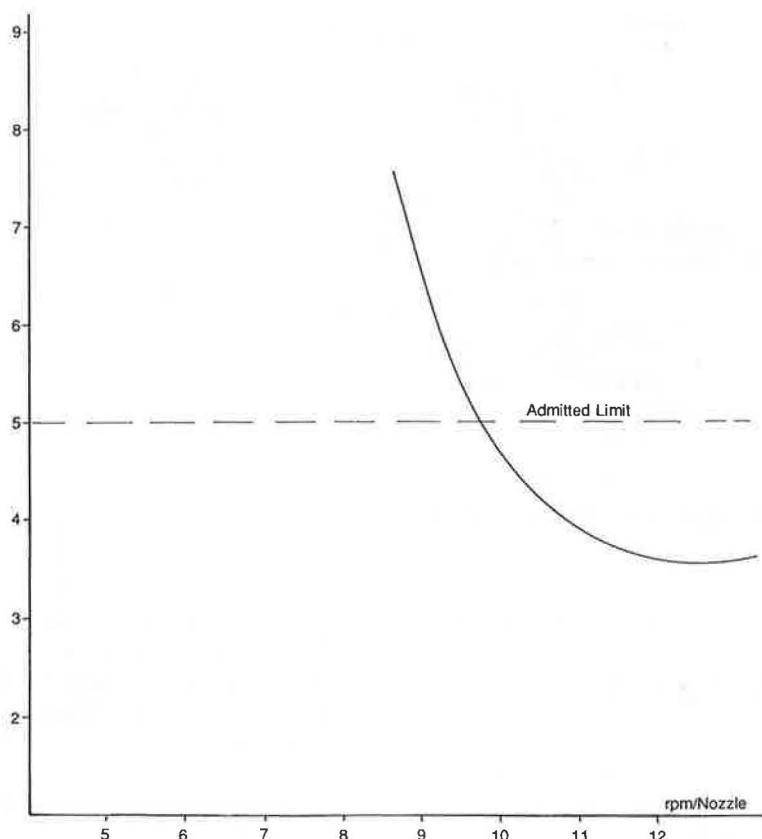


FIGURE 4 Regularity as the ratio $CV = (\text{dosage standard deviation})/(\text{dosage mean value})$ in reference to pump rpm/working nozzle.

- Transverse regularity of dosing with a coefficient of variation of less than 5 percent and
- Actual dosage within 5 percent of the predicted value.

Evaluation and control tools permit a drift to be measured and corrected.

Evaluation Tools

There are three types of evaluation tools: a test bench for spray bars and two methods of controlling the regularity of spreading. One method uses radioactive tracers, the other sampling in couples or boxes. Continuous data collection during operation of an asphalt distributor allows continuous control of the equipment.

Spray Bar Test Bench The testing bench for spray bars in the Road Equipment Test Station of Blois (Figure 5) is used before field operation to check the operation of asphalt distributors either at the design stage or during operational checkout of new equipment. It is also used for periodic control tests of working asphalt distributors. In 1984, 115 pieces of equipment were tested; in 1985, 104 were tested; and, in 1986, 127 were tested.

The test bench is composed of a pit in which is placed a large storage tank that contains oil with a heating capability similar to that of asphalt. Above the tank, 35 weighing receivers are placed. A bypass device is located between the grid and the tested spray bar and allows the bypassing of the test product either directly in the storage tank or in the 35 weighing receivers. Spray bar height is determined by the distance between the nozzles and the division grid.

A sample is taken during a predetermined time, and comparison of the quantities of product received in the 35 weighing boxes (the width of one box is 10 cm) gives an evaluation of the transverse spraying regularity of the tested bar.

Tests are run using an oil the temperature of which is adjusted to obtain a viscosity that is the same as that of the binders during spreading (100 cSt).

Each year, 120 spray bars are tested. These tests are quite useful and necessary for maintaining the quality of chip seals. More than 50 percent of the equipment tested needs an adjustment or maintenance of the spray bar (shift of nozzles, adjustment of valves, etc.) to give it a coefficient of variation of less than 5 percent; in some cases, adjustment of the automatic components is necessary.

Printing of Asphalt Binder with a Radioactive Tracer This nondestructive method is used to test the quality of an asphalt distributor under real operating conditions.

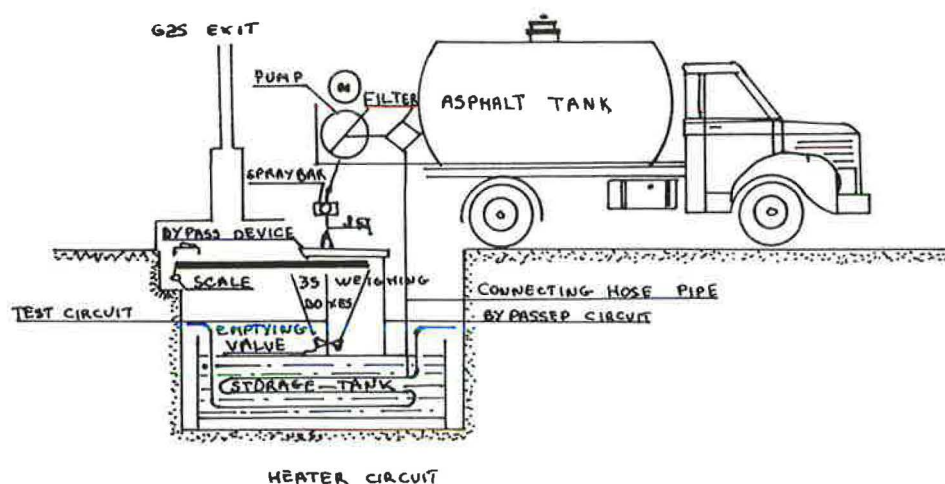


FIGURE 5 Spray bar test bench: schematic diagram of a test.

Asphalt is marked with a gamma-emitting radioactive tracer, indium 113, that has a short half-life (1.5 hr). After the tracer and binder are mixed, the marked asphalt is spread and gritted.

A collimated detector (Figure 6) is moved over a chip-sealed section of road. The detector delivers a counting rate that is proportional to the asphalt dosage per surface unit.

Data are collected each 8 cm by a microcomputer. For each section, the asphalt mean dosage per surface unit and the ratio of the standard deviation to the dosage mean value (transverse regularity) are calculated.

The rapidity of the method makes it possible to test two asphalt distributors per day and to immediately correct spreading faults of all types of equipment and binders.

Local Control of Asphalt Dosage and Regularity with Transverse Sampling Bars and Boxes This destructive method is often used on a test section at the beginning of a chip seal campaign. A metallic bar outfitted with 40 to 80 couples (50 × 100 mm) of synthetic material is placed in a transverse section of the road. The couples are filled with asphalt during spreading and weighed.

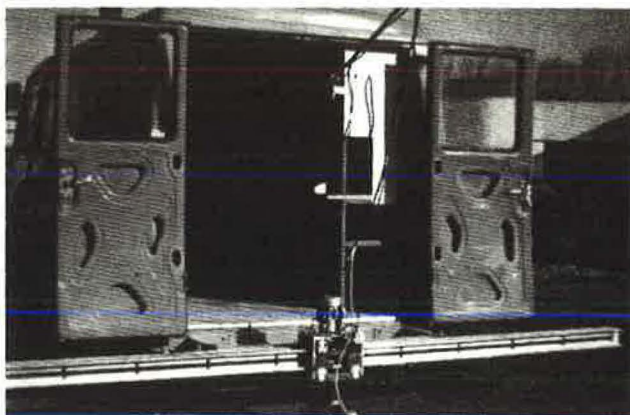


FIGURE 6 Collimated detector mounted on a rail.

This method gives a picture of a transverse section at a fixed time and allows calculation of a regularity coefficient as the ratio of the standard deviation to the mean value of the asphalt dosage of the different couples. Because of outflow from the couples, it is not possible to determine the mean value of the dosage. A good regularity coefficient is less than 10 percent, and it has been verified that the sampling bar value of 10 percent is in agreement with the value of 5 percent at the spray bar test bench in Blois.

Boxes that measure 400 × 500 mm are used to determine the mean value of dosage and, if necessary, to modify the calibration of the asphalt distributor.

These methods are long, boring, and destructive, but they give a good evaluation of the regularity of spreading.

Control with a Data Collection System Attached to the Asphalt Distributor This method affords continuous control of asphalt distributor operation and makes it possible to determine

- The mean value of the spread asphalt dosage per surface unit and
- The lengthwise regularity of asphalt spreading.

It has also been used to qualify the validity of interlocking systems and displays of automatically controlled asphalt distributors. Data-oriented sensors are used to collect the values of the following parameters: truck running speed, pressure in the bars, bar height, and number of open nozzles. These data are processed by a microprocessor unit.

Chip Spreaders

Types of Equipment

There are three types of chip-spreading equipment:

- **Built-in-bottom gritter:** A chip spreader attachment is fixed at the back of the truck body in place of the tailgate. The spreader can be fitted with enlarging tools to increase the chipping width, but this type of spreader always needs two passes whereas the asphalt distributor needs only one. This type of chip spreader is the most often used because rear-dump trucks are used for hauling agricultural products or materials when they are not being used for chip sealing. This equipment can also be easily moved because its width is less than the road clearance.

- **Truck-pushed chip spreader:** This equipment is self-contained but not self-propelled. It is composed of a chip distribution hopper and a device that couples the hopper with the truck axles, the motion of which is used to run the hopper. Chipping in traffic with this equipment is not easy, and many problems occur during coupling with the truck and operation. Chip seal degradation can also be caused by slippage of the carrying wheels. Because the hopper is wider (3 m) than the road clearance, this chip spreader must be pulled sideways from site to site. For these reasons, development of this kind of spreader has been limited.

- **Self-propelled chip spreader:** The working principle of this specialized self-propelled equipment is similar to that of the asphalt finisher. The chip spreader pulls the truck with an automatic coupling device. The rear wheels of the spreader run outside of the front wheel track, which prevents rutting. The driver's cab is placed either in front in the middle of the chipping hopper or on the left just before the rear hopper. The width of the "chipping front hopper" can vary between 2.30 and 4.30 m. This equipment can perform one-pass chipping of a width that is equal to that of the asphalt spreader. However, moving this equipment from one site to another presents problems due to the "over road clearance" hopper. Traffic on other lanes is generally disturbed because of the width of the hoppers. This type of spreader allows high daily productivity. A self-propelled spreader outfitted with extendable hoppers (Figure 7) has been developed recently. This chip spreader can work on secondary roads and in traffic.

Two types of built-in-bottom gritters can be defined: the hopper gritter with feed roll and the gravity flow gritter:

- **Feed roll:** The roll is hydrostatically driven, and the speed of the roll is adjusted to the running speed of the truck. A dosing blade or individual hopper gates are adjusted to a fixed opening. The chip dosage on the road is theoretically constant when the opening of the gate or gates and the ratio of roll rotation speed to truck running speed are properly selected.

- **Gravity flow:** The output of chips is fixed by the opening of a dosing gate and the nature (essentially the granularity) of the chips. The running speed of the spreader must be kept constant to obtain uniform chip coverage.

Gravity flow can be disturbed by the tipping of the truck body and the vibrations of the vehicle caused by roughness of a road. To avoid these disturbances, one French manufacturer has introduced storage bins at the end of the truck body and before the design gate, which is located in the



FIGURE 7 Self-propelled chip spreader with extendable hopper.

bottom part (Figure 8). The bins ensure lead regularity for the chipping flow, which takes place in a portioned enlarging device.

Equipment Capacity

Until the last 3 years, chip spreader technology could not benefit from the results of a test bench. Table 1 gives results obtained on site test sections using sampling boxes 20×50 cm. The figures in the table indicate the necessity of improving the quality of chip spreaders to obtain better control of that stage of chip seal works.

Ongoing research programs that use the chip spreader test bench at the Road Equipment Testing Station are intended to improve the capacities of built-in bottom gritters by de-



FIGURE 8 Gravity flow system with storage bins.

TABLE 1 RESULTS USING 20- BY 50-CM SAMPLING BOXES

ChipSpreader Type	Compliance with the mean dosage	Lengthwise Variation	Transverse Variation
Built in bottom type gritter	Bad - (depending of the tipping of the truck body)	5 % (if good roughness of the road)	10 to 20 %
Self-propelled chipperspreader	Good - Easy to obtain	6 à 9 %	6 to 9 %
Truck pushed chipperspreader	Bad - Difficult to obtain	Depending of the mechanical drive between wheels and feed roll	8 to 12 %

creasing their regularity coefficient to the range of 5 to 10 percent.

Evaluation and Research Tools—Chip Spreader Test Bench

Because of the potential for significant payoffs (economies in aggregates consumption and fewer rejects), it was decided in 1983 to build a test bench at the Road Equipment Test Station of Blois (Figure 9). The chip spreader test is run without moving the equipment, and chip spreading is continuous, as shown in Figure 10.

The mean value of chip dosage is measured with a continuous conveyor scale placed on one of the conveyor belts. The regularity of a curtain of chips no more than 4 m wide is analyzed with an optical device: the chips fall near a source of light, and a video-numeric sensor fitted with 2,048 cells remotely detects occlusion of the light caused by the falling chips. Data transfer is by optical fibers to a microcomputer. Software arranges the 2,048 cells of data on 128 counting and measuring paths.

Screen analysis is done by sampling the 128 measuring paths. Total sampling time is about 5 sec and represents a road spreading length of about 5 m at a running speed of 3.6 km/hr.

Different ways of arranging the 2,048 cells with the 128 measuring paths permit the following limit analysis:

- A curtain 4 m wide with a 3.2-cm sampling pitch and
- Local detection of a curtain the maximum width of which is 25.6 cm with a 2-mm sampling pitch.

The operational checkout of this bench was completed in October 1984, and it appears to be giving rise to innovative ideas for improving chip spreaders.

Ongoing Research with the Chip Spreader Test Bench

Two examples are given of ongoing research programs.

Study of Feed Roll Devices A study of feed rolls has indicated several problems (Figures 11 and 12), and the aim of that study is to design withdrawing feed rolls that would cause the output of chips to be proportionate to the speed of rotation of the roll over a large range of operating conditions.

Study of an Aggregate Flowmeter For all types of equipment, it is difficult to rapidly calibrate output. Research is now under way on the design of an aggregate flowmeter that would use an optical device placed on the chip spreader near where the chips fall. Information from this sensor could be used to determine the opening of the tailgate.

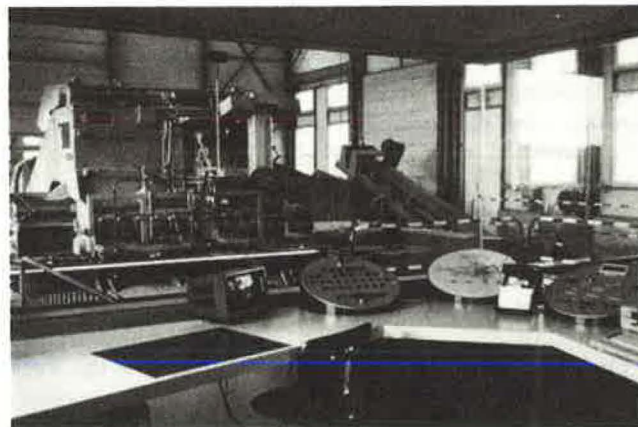


FIGURE 9 Chip spreader test bench, light source, and control desk.

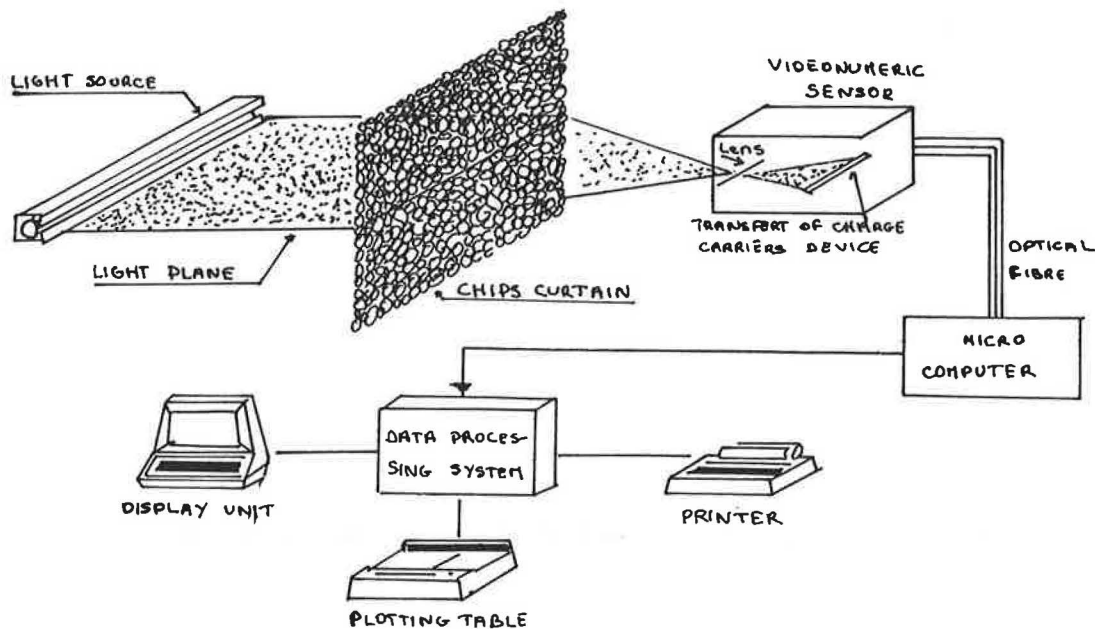


FIGURE 10 Chip spreader test bench: principle of measuring device.

CURRENT MAINTENANCE

A value analysis study was done in 1983 at the request of the Road Innovation Council Committee (see Paper by M. Point in this Record). Since 1986, a Road Maintenance Group has been created to ensure technical coherence and exchange of information among the different administrative districts.

One of the most innovative pieces of equipment that have been developed by a French manufacturer is a flexible compound spreader also known as automatic patching equipment (Figure 13) (Point A Temps Automatique or PATA).

The flexible compound spreader is designed to apply "partial chip seals." The spreader is used for current maintenance such as road sealing to cure highly cracked surfaces in order to avoid the appearance of potholes or deformations.

The flexible compound spreader is also used in scheduled current maintenance as defined by the French Road Current Maintenance Guide. It is not used for emergency repairs.

In addition, it can be used to chip seal larger surfaces such as carparks, town places, and school courts. It can also be used to seal local leveling if the surface treated daily is sufficiently large.

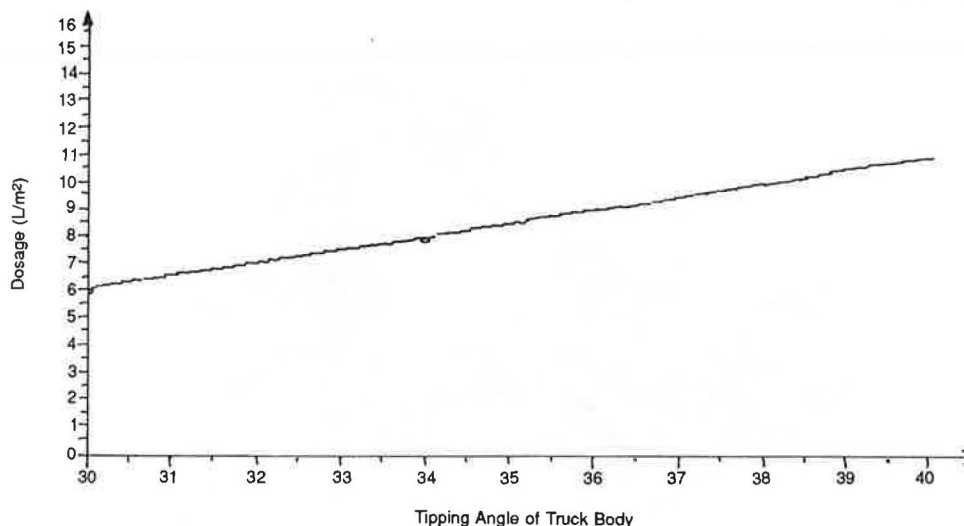


FIGURE 11 Feed roll output versus tipping angle of truck body.

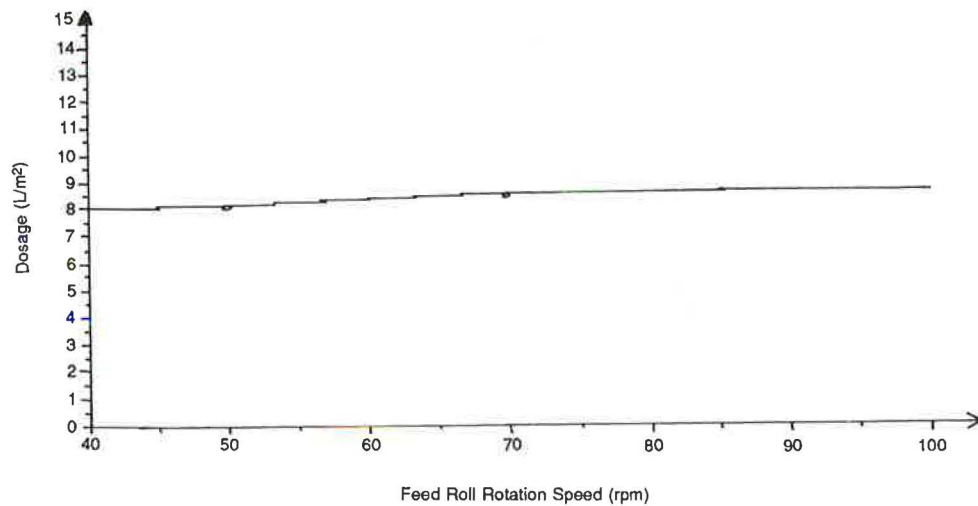


FIGURE 12 Linearity indicating insensitivity of aggregate output to feed roll rotation speed.

The technology of the flexible compound spreader resembles that of asphalt distributors, chip spreaders, and compactors. The following components are used:

- An asphalt emulsion tank,
- A spray bar,
- A multiple-tailgate chip spreader, and
- A compacting set of pneumatic tires.

All of these parts are mounted on a truck.

The flexible compound spreader works in reverse, and the running speed of the truck determines the emulsion dosage (if pressure in the bar and bar height are constant). Two operators are necessary; the one in the rear determines the individual pairs of tailgate nozzles that need to be open, depending on the width and length of the repair.

It was estimated that by the end of 1987 about 200 flexible compound spreaders would be at work in France, and that 30 of them would be owned by administrative districts. Other

spreaders (170) were to have been purchased by contractors or town associations.

The first prototype spreader was demonstrated in 1985; since then, the technology of the equipment has evolved as the result of site tests and other research. For example,

- The flexible compound spreader can now spread hot binders as well as emulsion by using a dosing pump to create bar pressure.
- Three improvements to the spray bar have been developed: (a) duplicate arrangement of the spray bar, which allows the nozzles to overlap; (b) transverse displacement of the bar in relation to the road crossfall, which ensures perfect coverage of the spread binder by chips; and (c) automatic adjustment of the height of the bar to ensure that it is parallel to the road surface.

Use of this equipment has led to better quality patching (better compliance with the fixed binder and chip dosage and



FIGURE 13 Flexible compound spreader.

systematic compaction of repairs), to big pay-offs due to its large capacity (as much as 9 tons of emulsion per day or five times more than that of traditional patching equipment), and to decreased costs (repair cost per square meter is 40 to 60 percent less than that associated with traditional equipment). Furthermore, security of operators is improved because nobody is working on the road and only two operators are necessary to control the equipment.

CONCLUSIONS

Since the 1970s the French highway administration has followed a policy of chip seal quality and has developed the necessary tools to control quality and improve chip seal engineering.

It became apparent that the quality of equipment was a determining factor of chip seal quality. Therefore road equipment test stations have been built. A spray bar test bench was installed at the Blois station in 1973 and a chip spreader test bench in 1983. Each year 120 asphalt distributors that belong to contractors and district equipment centers are tested; more than 50 percent of these distributors need adjustment or other maintenance. These benches are also used in working with manufacturers to improve the design and technology of the equipment.

Constant communication among contractors, equipment manufacturers, and the administration (state agencies and laboratories) has been maintained through a National Road Equipment Committee. The work of that committee has contributed to the quality control of chip seals.

Many improvements of chip seal equipment and techniques have been realized in the last 15 years:

- Optimal design of spray bars,
- Automation of asphalt distributors,
- Better quality control, and
- Improvement of chip spreaders (e.g., extendable-width self-propelled equipment).

Improvements to chip seal equipment have led to new patching equipment, such as the flexible compound spreader and automated patching equipment.

The technology of asphalt distributors appears to be optimal; however, chip spreader technology must still be improved. The chip spreader test bench at the road equipment test station in Blois facilitates working with contractors and equipment manufacturers.

Publication of this paper sponsored by Committee on Maintenance Equipment.