

Two Major Innovations in Current Maintenance: The Multipurpose Vehicle and the Integrated Surface Patcher

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Since 1987, a systematic approach to determining what major innovations are needed in maintenance equipment and a value engineering analysis have led to the development of two new units, the multipurpose vehicle and the integrated surface patcher, that represent important advances in routine maintenance equipment. In this paper the development of these two new machines is traced and their performance after 2 or 3 years of field service is assessed.

A working group presided over by J. F. Coste classified the various fields of research into three categories:

1. Main works including improving ways of doing tasks that are often done manually. The objective is to save more than 100 million francs (MF) (about \$16,700,000) nationally.
2. Secondary works include tasks the present improvement of which is difficult or the cost of which is less. Savings here should be between 20 MF and 100 MF (about \$3,500,000 to \$16,700,000).
3. Minor works represent savings of less than 20 MF (about \$3,500,000).

Research and improvement policies have so far taken into account:

- The desire to automate,
- Quality improvement needs,
- Comfort improvement needs,
- Ergonomics,
- The search for multitask equipment, and
- Radio telephone equipment improvements.

Table 1 gives a summary of economic and technological tasks. It can be seen that the main lines of action concern

- Repairs to carriageway surfaces using bitumen emulsion;
- Grass and brush clearing of roadsides, banks, ditches, and central reserves;
- Digging and permanent maintenance of ditches; and
- Deep-level repairs to hot- and cold-surfaced carriageways.

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ORGANIZATIONAL ATTITUDE

There is a generally favorable attitude toward the modernization of road maintenance equipment. This is not just a question of fragile enthusiasm born of the excellent atmosphere, peace, and good relationships that have prevailed in each of the working groups. Every officer knows that innovation is part of his working life even if it leads to far-reaching changes in the organization of his work.

To confirm this de facto situation, two concrete examples of new equipment, the respective conception of which took quite different paths, will be discussed.

MULTIPURPOSE VEHICLE

This design first saw the light of day in the District Public Works Management Committee of the Charente District (Working Group DDE 16). The multipurpose vehicle (MPV) is in use today as the result of the following events:

1. 1983: Working Group DDE 16 Study of Mowing Equipment,
2. End of 1983: Conversations with manufacturers based on DDE 16 specification lists,
3. January 1984: Responses from industry,
4. February 1984: The manufacturer's choice and view of the project,
5. February to May 1984: Continuing discussions between the manufacturer and DDE 16 officers,
6. June 7, 1984: Presentation of the prototype to the Public Works Vehicle Congress,
7. July to October 1984: Trials and national presentation of the prototype,
8. November 1984 to April 1985: Modifications by the manufacturer following trials and presentation in other districts,
9. May to September 1985: DDE 16 mowing campaign, and
10. September 1985: Preproduction version of MPV with various accessories.

Some of these phases are described in greater detail in the following subsections.

TABLE 1 ECONOMIC AND TECHNOLOGICAL TASKS

	Work Cost for Main and District Roads (MF)	Improvements Required			Ongoing Improvements	Research and Improvement Methods
		Work Quality	Produc- tion	Safety and Comfort		
Main Works						
Surface repairs with emulsion	1400	***	***	**	Automatic patching	Automation
Mowing and bush clearing	700	*	***	***	Highly productive equipment	New equipment
Ditch cleaning	250	***	**	*	None	Current treatments
Deep surface repairs—hot and cold	300	*	***	***	Insulated containers	Improvement of compacting and cutting
Secondary Works						
Special road marking	150	*	***	***	None	Automation
Verge trimming	80	**	***	*	None	Special equipment to be designed
Aqueduct and trench cleaning	70	***	**	***	None	New equipment to be designed
Sweeping	50	***	*	***	None	Equipment halfway between general and specific
Tree pruning and gantry sign cleaning	100	**	**	***	None	Equipment for working at heights
Road marking (traffic lanes and roadsides)	200	*	**	***	Equipment now being tested	Automatic markers
Reshaping with aggregate and bitumen mixture	100	***	***	*	None	Premarking On-site mixing equipment
Minor Works						
Surface repairs with hot materials	*	***	*	**	Trials now taking place	Equipment and materials to be defined
Road marker cleaning	30	*	***	**	Improvements under way	Automation

NOTE: *** = needs urgent improvement;
 ** = needs moderate improvement; and
 * = needs little improvement.

1983 Working Group DDE 16 Study of Mowing Equipment

Very aware of economic factors, as well as the financial aid granted by the Charente District, the DDE 16 decided to study mowing equipment design and use. The working group was made up of

- Equipment users,
- The head of equipment maintenance, and
- Training personnel.

The working group was chaired by the department head and studied

- Mowing quality,
- Road users' safety and locally elected representatives' comments,
- The performances of brushwood clearing and rotary mower equipment powered by farm-type tractors,
- Equipment and labor costs,
- Personnel safety problems,

- Drivers' comfort, and
- Equipment maintenance problems.

The conclusion of this working group was to reconsider the intrinsic properties of farm-type machinery in order to

- Improve the ergonomics of the driver's cab,
- Increase hourly production,
- Ensure road user safety during and after road works, and
- Intervene more quickly and simultaneously throughout the national and district road network.

Conversations with Manufacturers

Tractor and grass-cutting equipment manufacturers were consulted about the specifications drawn up by the working group. To these specifications were added two other requirements:



FIGURE 1 Multipurpose vehicle.

- The cutter should be placed at the front of the vehicle and
- The mowing speed should be more than 5 km/hr.

Manufacturers' responses were of two sorts:

1. The status quo: considerable improvement made to existing equipment, but not enough to meet the specifications and
2. Innovation: creation of new equipment by just one company, the Société Nicolas.

These results led the DDE 16 to choose the Société Nicolas' truly innovative ideas.

Presentation of Prototype

The prototype was presented with its main feature, the "Rotomower" (Figures 1 and 2). Other features included

- Air-cooled 120-hp Deutz engine;
- Overall length, 5.45 m;
- Overall width (Figure 3), 2.10 m;
- Wheelbase, 3.20 m;
- Height, 3.10 m;
- Dead load without tools, 6.50 tonnes;
- Authorized gross weight (with tools, platform and load), 13.50 tonnes;
- Towing weight (including 2 tonnes towed), 15.50 tonnes;
- Working speed between 0 and 20 km/hr;
- Maximum speed, 35 km/hr;
- Variable (300-mm) height hydraulic suspension allowing automatic loading and unloading;
- Hydraulically assisted steering;
- Hardened-steel one-piece welded chassis;
- Tires, F 22.5 pilot XL tubeless;
- Hydraulic drum brakes on four wheels;
- 300-L fuel tank (= 1 normal working week);
- Seven hydraulic connectors front and rear; and
- Three connecting points in front.

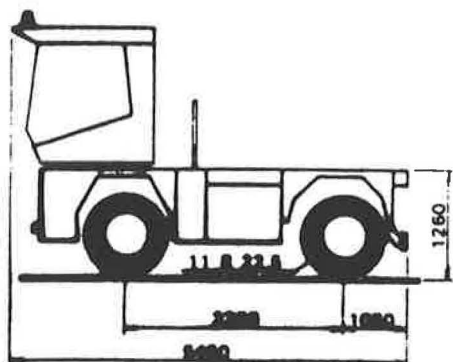


FIGURE 2 Position on road.

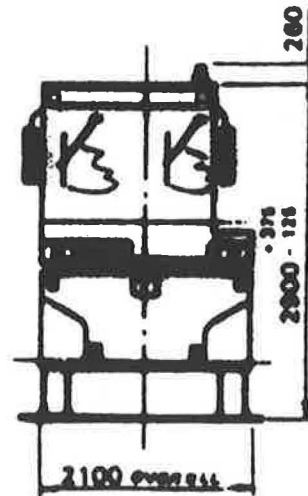


FIGURE 3 Overall width.

The official French classification is Service des Mines: Engin T.P. The prototype is two wheel drive. A four-wheel-drive version is also possible.

Cutting Tool

The Rotomower is attached to the front of the MPV (Figure 4) thus forming a single unit. In two passes it can cut a width of about 2.5 m.

Wide-View Tilttable Cab

Mowing equipment should be designed to limit noise and heat in the cab, to avoid rocking, and to provide good visibility. The driver's seat in the MPV is in a roomy wide-view cab with the following features:

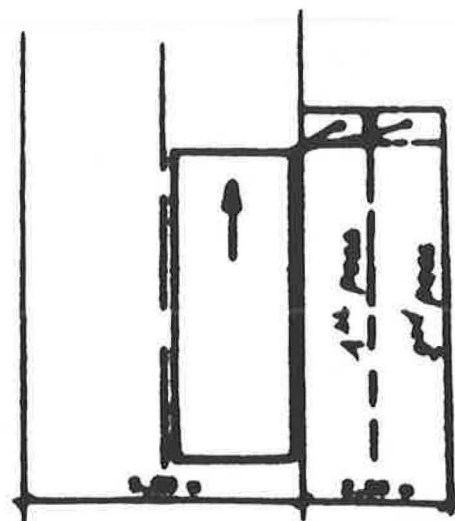


FIGURE 4 Cutting tool.

- The driver's seat is on the right and is accessible from the rear kerbside footplate. Visibility is excellent in front, to the sides, and upward on the right side.
- The seat is adjustable for height, inclination, and fore and aft position. Its suspension is also adjustable, and its arms are retractable and adjustable to provide correct elbow and body support for the driver.
- Lifting the left-hand seat arm activates a cutout switch that stops the Rotomower by cutting the vehicle drive.
- All controls are within easy reach of the driver's hands and feet. Each seat arm has three double-effect hydraulic levers.
- Numerous well-positioned screens and warning lights keep the driver constantly informed.
- The sound level inside the cab is less than 80 decibels.
- Windows exposed to flying objects are made of Lexan.
- Incoming air is filtered and cooled to the desired temperature even in extremely hot weather.
- There is a refrigerated box for food and drinks.
- Other conveniences include a window sunscreen, a clothes locker, and a small folding table.

Connecting System for the Rotomower

Tools can quickly be attached to the front of the MPV (Figure 5) thanks to its suspension and the "Nicolas" interface.

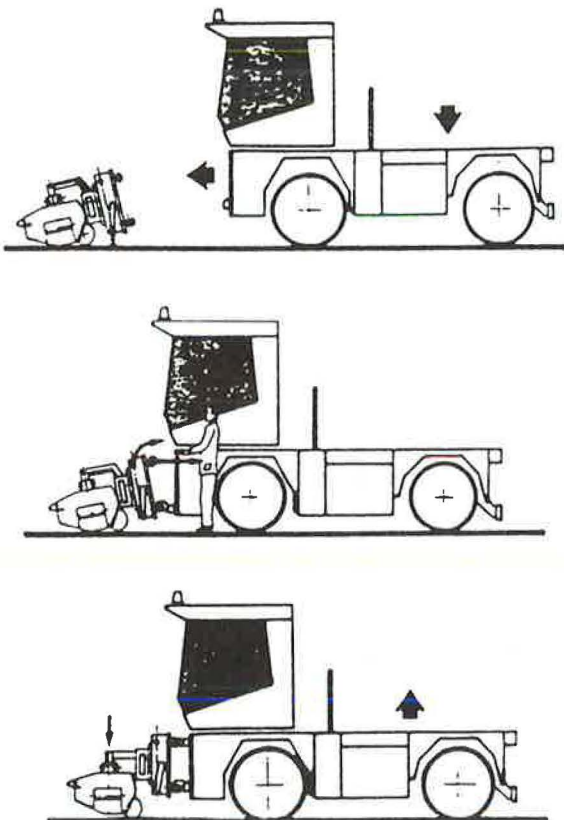


FIGURE 5 Front-attaching system.

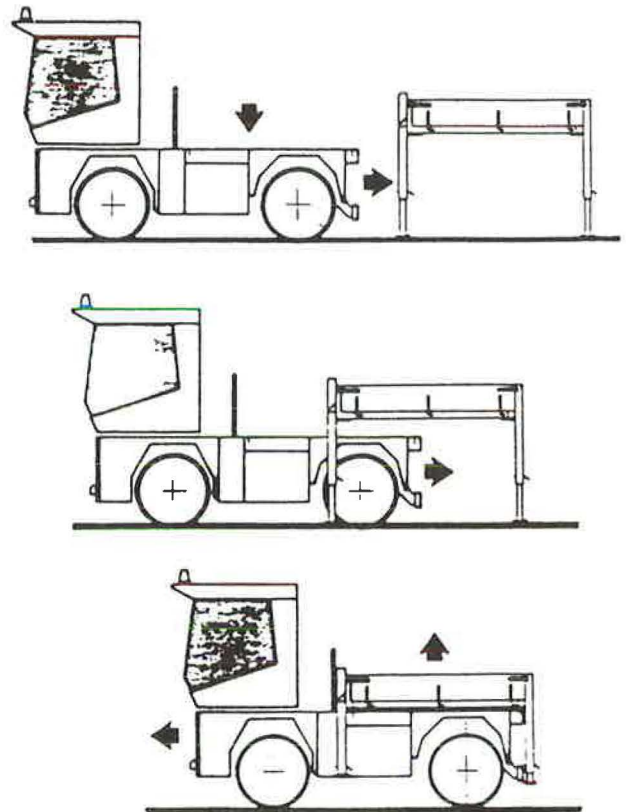


FIGURE 6 Palletization system.

Pallet System

The variable-height suspension system facilitates palletization, thus making the MPV a very fast automatic pallet loading and unloading carrier (Figure 6). Tools or other loads can be carried on pallets.

Trials of the Prototype

The test period was between July and November 1986. During this time,

- Performance was tested and compared with specifications;
- The behavior and reliability of hydraulic parts were studied;
- Cab ergonomics were compared with conventional arrangements, and the various cab features were evaluated;
- The prototype was driven by people of very different backgrounds, including executives, local counselors, mechanics, and managers;
- The prototype was demonstrated to decision makers in various districts, and the development path followed by DDE 16, economic importance, and safety problems were explained; and
- Mowing costs were evaluated.

Other functions and features were discussed as well:

- Sowing,
- Ditch digging,
- Elevator cabin,
- Snow cutter,
- Road marker cleaning,
- Sweeping,
- Surface cutter,
- Loader,
- Salt truck, and
- Painting.

Preproduction Series

During prototype trials the machine met specification requirements. The manufacturer also analyzed and took into account many of the suggestions and criticisms made. This type of testing and the resulting suggestions proved to be a source of interest and encouragement for the manufacturer as he developed a truly new prototype in this hitherto conventional area.

This process took about a year and the preproduction MPV series was launched in 1986.

Evolution of the MPV

Between 1984 and 1986 nine units were produced. These units had three additional accessories: a coring machine, a brushwood clearer, and a vehicle-carrying platform.

Coring Machine

The main technical specifications for this machine, made by the Société Cerimon at Moncoutant in France (79320), are

- The coring machine is attached to the front of the MPV,
- It consists of a hydraulically commanded sliding arm,
- The cutter is driven by a hydraulic motor with an intermediate reducer,
- The cutter has tungsten carbide tips and interchangeable blades,
- It can eject and pile regularly to one side,
- It weighs 1700 kg,
- Cutter rating is 90 hp,
- Maximum distance from MPV to ditch is 4 m, and
- Working rate is between 300 and 500 m/hr.

Brushwood Clearer

The brushwood clearer fits perfectly to the front of the MPV and is used for mowing banks and trimming hedges. Obstacles are automatically avoided by a floating head system. The driver can see the work area clearly through side and top

windows. The horizontal part is 4.6 m long, and the rotor power is 60 hp.

Vehicle-Transporting Platform

By using an electric winch, vehicles can be hoisted up aluminum ramps onto the platform for transport. Drivers can thus easily be relieved and the MPV used by two drivers from 6 a.m. to 9.30 p.m.

In 1987 15 units with the following improvements should be in use:

- Power increased to 160 hp,
- Suspension improvements,
- Tubular chassis,
- Tool-attaching system redesigned,
- Mowing height adjustable from the cab, and
- Breakdown localization system installed in the cab.

First Results

Three years after delivery of the prototype, some preliminary results can be examined. Initial results that stem from working experience with the first six attachments show that mowing is economically viable with equipment costing 1.2 million French francs (about \$200,000). Practical experience also shows that the MPV was not really used to its full potential, because only a few were equipped with tools other than mowers. Other cases include

- Brushwood cutting in the Vendée District,
- Ditch cleaning in the Charente District,
- Road marker cleaning in the Mayenne District, and
- Snow clearing in the Loir-et-Cher District.

The cost of mowing roadsides with the MPV varied between 4 and 7 centimes per linear meter (less than 1 U.S. cent to about 1.2 U.S. cents). These costs can be compared with those of conventional equipment, which are on the order of 10 to 15 centimes. These figures include driver, amortization, maintenance, and operating cost.

It should be noted that this subject is quite controversial; although the costs of using the MPV are known, the same is not true of traditional equipment. It is safe to say though that the MPV reduces mowing costs by 30 to 50 percent.

It is clear that this equipment has not yet reached its final evolution, and it is probable that in 1987 the MPV will be virtually perfected. On the other hand, more tools remain to be improved or designed.

Comments

Negative Factors

- MPVs are difficult to set up, and in-depth studies are needed to avoid time wasted in traveling.

- Initial investment: how can this system be integrated into existing program renewal requirements?
- Cost: a two-wheel drive 160-hp MPV, a Rotomower, a brushwood cutter, a coring machine, and a vehicle-loading platform cost 1.6 MF (about \$270,000).

Positive Factors

- Ergonomics and comfort: possibility of having a tea break during a continuous 7-hr day.
- Safety: improved productivity due to good visibility, control layout, and vehicle appearance.
- Road users' safety: faster working reduces accident risks.
- Good public image reported by local counselors as the result of work on specific routes.
- Personnel: job interest for driving and maintenance staff; increased productivity alleviates staffing reductions.
- Management: reduction of costs; multiple uses ensure profitability if market share is reduced.

Looking Ahead

After 2½ years, the basic principles of the MPV—its hydrostatic transmission and advanced ergonomics—have proved their worth.

On the other hand, this new approach has also demonstrated the necessity of an overall plan and precise usage definition, hence its polyvalence. It now appears that the underlying principle should be used for mowing, brush clearance, and ditch cleaning. Further study is needed to determine the role of the MPV in winter work and other tasks.

Further efforts are needed to optimize and improve the present MPV. It appears to be necessary to rethink certain tools; for example, easier width adaptation may be more desirable than maximum speed for the mower. A definite policy needs to be developed in cooperation with the company that is developing the MPV.

INTEGRATED SURFACE PATCHER

Bitumen emulsion surfacing is another costly part of standard road maintenance. To maintain carriageways at a suitable service level, it is often necessary to deal with local problems by a stopgap measure or by preparing a surface support for another type of technique. This requires that there be on site

- Materials,
- Binders,
- Spreading equipment, and
- Energy supply for compaction.

Patching

Low-cost cold binding materials that are easy to use and stock and can be used under many geographic and climatic conditions are widely used in road works.

Thus patching techniques were born. Binders can be stored in drums, aggregates can be kept near or on site, and spreading and compaction (when done) can be done manually using a tamper or a small roller.

Continuing technological developments have made it possible to perfect pressurized containers that allow the emulsion to be sprayed and containers for transporting and loading chippings as they are spread manually.

These last two pieces of equipment can be made as a single unit to be towed, carried, or self-driven. Compaction particularly favors the breakdown of the emulsion and has traditionally been done by vibrating rollers or by compacting with tires.

Patching Problems

Existing machinery requires the presence of many people:

- One driver per vehicle,
- One spraying man,
- At least two people to spread and smooth the chippings, and
- One person for compaction.

Thus it can be seen that a team consists of at least four people working directly at road level. This presents many safety problems for both road users and personnel.

Because spreading is manual, quantities applied depend on acquired skills, which can lead to bleeding due to too much binding agent or considerable aggregate wastage.

Compaction is not part of the overall operation and so is not generally very well done because there are

- Transport and equipment-moving problems and
- Coordination and productivity level differences that lead to cumulative backlogs that result in reduced production.

Automatic Patching

Traditional patching problems of quantity, compaction, and safety, plus the growing need to maintain and preserve the national road network and constantly rising costs, have led to the notion of consolidating these various activities. This decision is borne out by a value analysis carried out by the French Ministry of Housing, Town Planning and Transport (MULT) of "minor maintenance of highways."

The patching equipment described here (Figure 7) is made by the SECMAR Company and is a prototype that will be studied; evaluation reports will be produced by users (DDE 32 group) as well as the technical services of the ministry.

The unit consists of

- A carrier (GR 190) of 19 tonnes gross weight with rear-wheel steering and spreading from the rear;
- Storage facilities: a 3-m³ emulsion tank (Figure 8) and a 4-m³ aggregate container (Figure 9);



FIGURE 7 Automatic patching unit.

- A built-in spreader, working from the tipper tailboard, that has a pneumatic chip spreader with 10 flaps and a 10-nozzle pressurized bar (Figure 10); and
- A compaction unit consisting of the rear wheels of the vehicle plus three pairs of tires mounted on an axle and operated by three hydraulic rams through a load distributor (Figure 11).

Energy requirements are supplied by

- A compressor to pressurize the emulsion tank and operate the chip-spreading flaps;
- The truck's hydraulic system that is used (with an additional motor) to operate the tipping mechanism, the operator's platform level, the compacting wheels' axle, and the truck's rear steering system; and
- The truck's electrical system that is used to operate the valve controls.

Hot Resurfacing Repairs

The tipper body is replaced by an insulated container with a distributor chute. The available emulsion can be used for tack coats, and the power available can be used to prepare the area to be repaired (surface cutting, blowing, etc.).

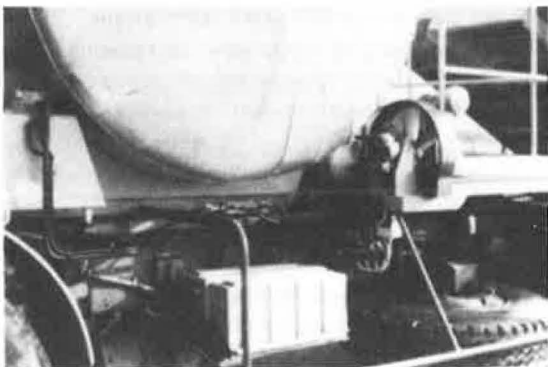


FIGURE 8 The 3-m³ emulsion tank and compressor.



FIGURE 9 The 4-m³ tipper with built-in tailboard spreader.

Repairs Using Continuous Treated or Nontreated Granular Materials

The rear gate to which spreading equipment is attached can be rapidly removed and replaced by a twin chute after a longitudinal separator has been fitted inside the tipper unit. This unit is therefore suitable for deep repairs using aggregate-bitumen mix, cement-bound granular materials, untreated well-graded aggregate, and the like and for sealing wearing courses with granulates.

Results After 2 Years of Operation

Fields of Application

The present design of the Integrated Surface Patcher allows only single-layer sealing coats that consist of a binding base



FIGURE 10 Spreader.

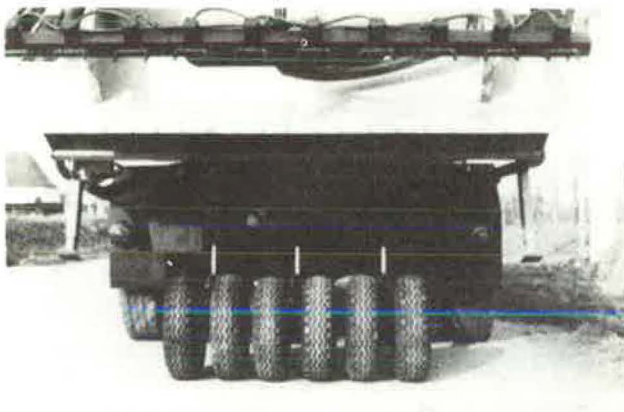


FIGURE 11 Compaction unit.

and a chippings base. It is primarily intended for carriageway surface sealing and not for reshaping or pothole filling.

The patcher carries out "partial surface dressing." This type of repair is used to seal carriageways where surfaces are damaged so as to avoid pothole formation or surface deformations. This equipment is therefore quite suitable in cases in which it is possible to consider and define well in advance the work to be done. The patcher should therefore be used for planned routine maintenance. It should be emphasized that this equipment should not be used for emergency stopgap repairs.

In addition to the uses already described, the Integrated Surface Patcher can also be used for small areas such as carparks, squares, and school playgrounds. It can also seal localized reshaped surfaces provided the area to be treated per day is large enough. For these special uses it may be necessary to use a roller with tires or even a smooth metal roller to finish compaction.

Operation

The Integrated Surface Patcher is a conventional patcher inasmuch as chippings are fed into containers under the operator's control stand from a distributor, and there is a spreading spray.

Manually Started Automatic Patching

The rear stand is fitted with a control panel to carry out the following maneuvers:

- Adjusting bar levels;
- Putting additional compacting wheels in use (or not); and
- Simultaneously spreading binders and chippings, flap by flap.

The patcher needs a team of three:

- One in the vehicle cab to control steady forward movement,
- One on the rear stand to steer the unit, and
- One at the control panel to regulate spreading dosages by 25-cm steps.

Compaction takes place during the first spreading pass and again during a return of the vehicle.

Automatic Patching with Automatic Start

If a line is painted on the road to indicate the beginning and end of the area to be covered, this line can be detected by a battery of optical readers, placed about 1 m above ground level in front of the spreaders as they advance, that open and close the spreaders automatically.

Preliminary Economic Studies

It can be shown that, in the case of superficial surface repairs before coating, savings are on the order of 40 percent both in value and labor time.

This type of equipment can ensure the degree of efficiency demanded nowadays for repairing particular surface conditions, without in any way detracting from the work done by existing enterprises.

State of Present Development

Technical Progress

Since the prototype was demonstrated in June 1985, many modifications have been carried out by the SECMAR Company, the only firm to manufacture this type of machine at present. In order of importance, the main modifications are

- Equipment size: A majority of Integrated Surface Patchers are now fitted to 26-tonne vehicles instead of the 19 tonners used for the prototype. Size should, however, be adapted to each context, and there is now a prototype patcher called Reparetout ("Fixall") that weighs around 5 tonnes.
- System for loading chippings: The manufacturer has developed a lifting arm system to load the tipper. This system appears to be a satisfactory addition to the basic unit and solves the problem of loading chippings, which leads to greater independence.
- Type of binding materials used: Recent Integrated Surface Patcher models can use hot binders or bitumen emulsions equally well. Spreading under air pressure could be replaced by a mixed system of dosage pump pressurizing.
- Spreading bar: Three modifications have been adopted: the bar has been doubled, lateral movements are controllable, and height is automatically adjusted. These modifications contribute to increased work quality.

- Storage tank: The Integrated Surface Patcher can now tow a storage tank of binding materials, thus increasing its daily work capacity and productivity.

Marketing Progress

The first prototype used by the Public Works Management Committee (DDE) in the district of the Gers was operational in June 1985. In 1986 about 50 Integrated Surface Patchers were sold, but only 3 to DDEs. By the end of 1987 there should be around 200 in operation of which 30 will be in public works services.

At present, the majority of Integrated Surface Patchers operates in the West of France, but their use is becoming generalized. It is thought that the Integrated Surface Patcher fills a gap in the market and that its development will continue. This is the result of an excellent adaptation to meet an existing, but hitherto unsatisfied, need.

Use

Approval of the quality of work produced by the Integrated Surface Patcher is virtually unanimous. The machine's cleanliness and improved safety are also appreciated.

The Integrated Surface Patcher can be used either directly by a DDE or through a contractor. If the DDE is directly responsible for the work, a team of specialists is necessary. In either case, road repairs must be carried out at precisely the required site, and there are three ways to ensure this:

1. Mark on the carriageway the areas to be repaired. This is a costly solution but has the advantage of reliability because planning is separated from execution.
2. Allocate to the team a subdivisional officer who is familiar with the road to be repaired; this increases labor costs by 50 percent.
3. Pay for road works in two steps: (a) a daily equipment charge and (b) a charge for materials used (emulsions and chippings).

These recommendations are intended to achieve close cooperation throughout the country in order to unite productivity, quality, and on-the-spot knowledge.

Comments

Positive Points

- Ergonomics and safety: personnel do not work on the carriageway.
- Technical factors: precise binding material and aggregate dosages are used; repairs are systematically compacted.
- Economic factors: high productivity; only two officers

are required instead of the usual five; costs are reduced 40 to 60 percent per square meter.

Negative Points

- Planned road repairs: It is necessary to study routes to avoid wasting time.
- Not very suitable for cleaning jobs.
- Large investment: The cost is between 700,000 and 1,200,000 French francs (about \$120,000 to \$240,000) depending on the specifications chosen.

CONCLUSION

1. The systematic approach adopted by a task force, which included representatives of all administration levels and evaluated each maintenance task and the needs for major equipment innovations, was necessary and has led to a positive balance.

2. The value engineering analysis method has been useful for questioning some habits and has led to the specifications for new equipment.

3. The rapid development of the Integrated Surface Patcher, and its high efficiency in terms of cost and personnel needed, confirms the idea that "these devices may revolutionize routine highway maintenance."

4. The multipurpose vehicle appears to be an important step toward the modernization of routine maintenance; greatly increased productivity, better safety for manpower and road users, and new possibilities for maintenance organization are the three main points that arise after more than 2 years of field use.

LOOKING TO THE FUTURE

"All things on Earth are in perpetual flux" (Heraclitus).

The road network represents an important part of the French national heritage. The perpetuation of this heritage requires the mobilization of energies to ensure design quality and roads maintained in good working order.

The in-depth actions carried out during the past 5 years by the Roads Management have created a general awareness that modernization of road maintenance equipment is one of the major preoccupations not only of decision makers but also of cadres and officers. This cultural evolution is all the more encouraging and enriching because it is backed by a strong desire on the part of manufacturers to stride resolutely along the modernization path.

The way is thus wide open to the year 2000 for forward-looking enterprises to use technologies the social uses of which must be rigorously based on three principles: humanism, innovation, and economic productivity.

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