Innovative Solutions for Partial Overhaul of Bituminous Roads Using SPRIDER

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The vast majority of roads in Poland have asphalt pavement. Often these were surfaces designed and made in 80s. Today, many of these roads are in operation under much greater traffic and exceeded load design values. This results in degradation and destruction of the road surface. Due to the large backlog of road repairs and many years of negligence regarding road infrastructure resulting from financial constraints of road managers, an urgent need arose to repair several kilometers of asphalt roads, colloquially speaking, at the drop of a hat. Resurfacing and overhauls were first performed on national roads and, to a limited extent, on the roads of lower functional classes.
Technologies currently used leave much to be desired in terms of quality and economy. One way to reduce the cost of labor and contracting, while increasing the quality of the work, is to search for solutions using new technologies. Those using SPRIDER are certainly innovative.
This paper presents this technology compared to those commonly used and the very system for evaluating the condition of roads and classifying them for repairs.

Keywords: road surface, repair asphalt pavement, SPRIDER.

1. INTRODUCTION

The vast majority of roads in Poland have asphalt pavement. Often these were surfaces designed and made in the 1980s. Today, many of these roads are in operation under much greater traffic and exceeded load design values [1]. This results in degradation and destruction of the road surface. Due to the large backlog of road repairs and many years of negligence regarding road infrastructure resulting from financial constraints of road managers, an urgent need arose to repair several kilometres of asphalt roads, colloquially speaking, at the drop of a hat. Resurfacing and overhauls were first performed on national roads and, to a limited extent, on the roads of lower functional classes.

In order to maintain the serviceability of lower-class roads and the safety of users, but with a limited budget and lacking the capability to resurface roads of all classes within a short period, one has to apply temporary solutions. One such solution is a partial overhaul allowing for cost-effective repair of the damaged part of pavement until complete resurfacing. Partial overhaul is also used on new roads which need resurfacing, e.g. after sewage, electricity, etc. works. [3]

Technologies currently used leave much to be desired in terms of quality and economy. One way to reduce the cost of labour and contracting, while increasing the quality of the work, is to search for solutions using new technologies. Those using SPRIDER are certainly innovative. This paper presents this technology compared to those commonly used and the very system for evaluating the condition of roads and classifying them for repairs.

2. THE CONDITION OF ROADS IN POLAND

A regular annual evaluation of the condition of roads in Poland is made only for roads owned by General Directorate for National Roads and Motorways. This evaluation is not performed for provincial, county, municipal, and cooperative roads due to limited funds.

The Regulation of the General Director for National Roads and Motorways of 2007, which introduced the "Strategy of measurements for the

pavement condition evaluation system (SOSN) [2] and the roadside and road drainage condition evaluation system (SOPO)" for use on national roads in 2007 and the following years is the basis for the evaluation of condition of national roads in Poland. Based on the Regulation and specific SOSN rules, a report is prepared on the technical condition of the national road network at the end of each year.

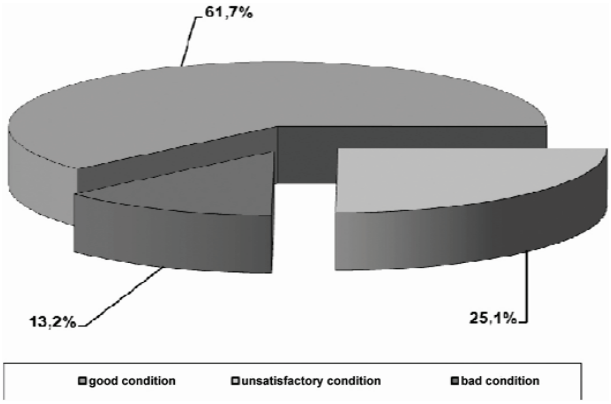
Four classes: A, B, C, D of the road surface technical condition are used to determine the overall state of the road surface, i.e. assign three levels for decision making:

- The desired level – good condition – includes two pavement condition classes: Class A, which means the pavement is in good condition, and Class B, which means satisfactory condition.
- Class C is a warning level which is a pavement in an unsatisfactory condition.
- Class D denotes critical level – bad condition.

Table 1. The relationships between technical classes of parameters and overall evaluation of the pavement condition [3].

Class A - good condition	Desirable level good condition	New surfaces, renewed and exploited, occasional damage may occur, surface does not require maintenance
Class B - acceptable condition		
Class C - unsatisfactory condition	Premonitory level unsatisfactory condition	Surface with damage that require scheduled repairs
Class D - bad condition	Critical level bad condition	Surface with damage that require immediate repairs

At the end of 2014, 61.7% of the distance of the national road network does not require repair. In contrast, 38.3% of the distance of the national road network requires repair, of which over one third, or 13.2% of the required repairs should be performed immediately, and the remaining 25.1% has to be made in the next few years.



Condition	*2014* *LENGTH [km]*	*2014* *SHARE [%]*
good	12 743	61,7
unsatisfactory	5 189	25,1
bad	2 724	13,2
Total	20 656	100

Fig. 1. Technical condition of the national road network managed by GDDKiA at end of 2014 [2].

Partial overhaul of the pavement is applied in order to carry out immediate road repairs, which eliminate the destruction of the pavement classified for urgent repairs, shown in red in the graph below.

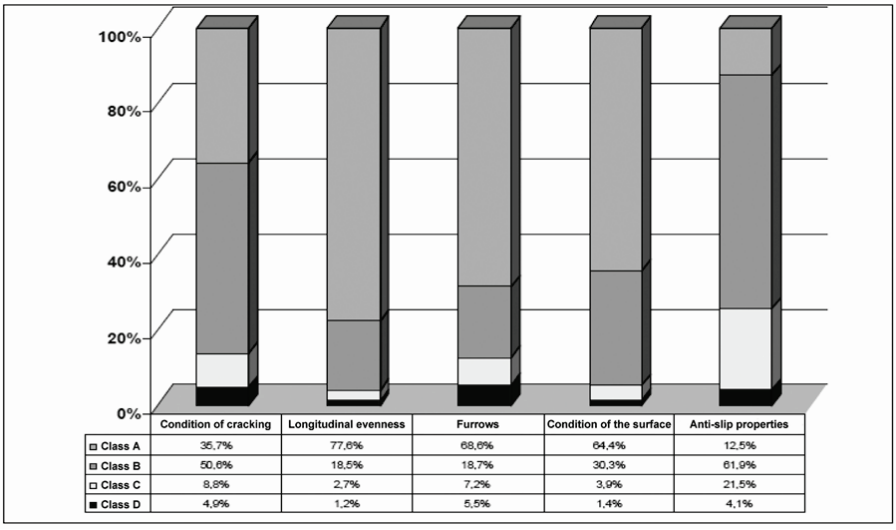


Fig. 2. The percentage of sections in each surface condition class for each of the technical and operational parameters [2].

3. PARTIAL OVERHAULS OF BITUMINOUS ROADS CARRIED OUT BY CONVENTIONAL HOT BOXES

Partial pavement overhaul is a set of technical procedures performed on an ongoing basis or in cases of urgent repair needs related to the removal of surface damage threatening the security of traffic as well as includes works on small surfaces, inhibiting the expansion of damage.

Partial repairs are distinguished by the way of transport and incorporation of the mix, i.e., repairs with hot mix using hot boxes, repairs with grit and emulsion using a specialized patcher, and repairs using cold mix involving laying of bagged mix manually. Repairs using hot mix are often carried out by incorporating the mix from mobile recyclers.

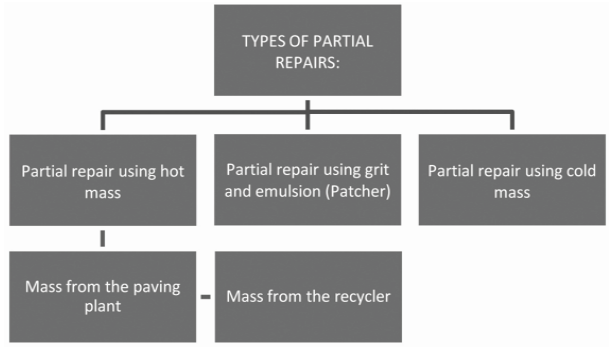


Fig. 3. The division of partial repairs [5].

Preparation of the damaged area (holes, bumps or broken pavement edges, etc.) for a partial repair should be performed very carefully by:

- Cutting the edge of the damaged area vertically (preferably using diamond circular saw blades) to a depth that allows levelling of the bottom and shaping a simple geometric figure, e.g. a rectangle, and alternatively by milling
- Removal of loose bits of pavement
- Removal of water, bringing the damaged spot to an air-dry state, thorough cleaning of the bottom and the edge of the damaged area from loose grains of grit, gravel, sand and dust

After preparing the damaged pavement area for the repair, the bottom and sides of the repair site should be sprayed by rapid setting cationic asphalt emulsion in the amount of 0.5 l/m2 when using "cold" mineral-asphalt mix for repairs. Alternatively, the adhesive rubber and asphalt tapes can be glued when using "hot" mineral-asphalt mix instead of spraying the side walls of the repaired damage. A mineral-asphalt mix shall be spread using shovels, floats, and moldings. Under no circumstances one should dump the mix from the means of transport directly to the prepared repair spot, and then spread it. The mix should be fluffed uniformly over the entire surface of the repaired spot and laid with a certain excess, so that it will be flush with the surface of the adjacent portions of the pavement after compaction. Differences in the level of the repaired spot and the existing surface designed for traffic at speeds above 60 km/h should not be more than 4 mm. Spread mix should be compacted using a roller or a compactor plate (see guidelines OST D - 05.03.17 “Remont cząstkowy nawierzchni bitumicznych” — Partial overhaul of bituminous surfaces [5]).

According to OST guidelines, it is prohibited to dump the mix from the means of transport directly into the hole and then spread it using rake. Unfortunately, in order to speed up the work and reduce labour costs, this type of mistake is committed routinely using standard hot boxes.

When using traditional hot box for carrying the mix, spreading is done by dumping the material from the chute at a considerable height, directly into the hole in one place and then spreading the material across the repaired surface using hand rakes, shovels, and floats.

This type of technology often resulted in:

- Mix defractionation (coarse grains remaining on top) and consequently the formation of ravelling and non-uniform structure after compacting
- Heterogeneous fluffing of mix on the entire repaired surface which in turn caused the initial local self-compacting due to the weight of the falling mix, and after vibrating with the roller, upheavals formed on the surface where initial self-compacting took place, and rutting formed in places where the mix had been fluffed evenly (not pre-compacted).

There has been excessive loss of temperature of the mix before rolling when using conventional hot boxes due to manual spreading of the mix which took a long time. The result was also the formation of ravelling and uneven structure of the repaired pavement.

Fig. 4. Partial repair using a conventional hot box (from the authors' collection).

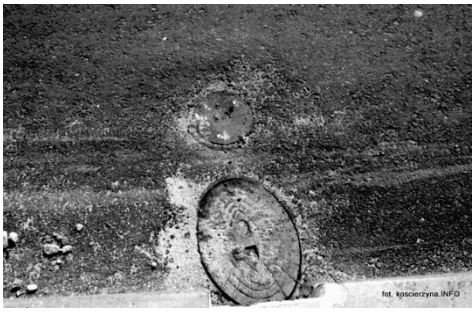


Fig. 5. Examples of pavement defects - ravelling (from the authors' collection).

Factors necessary for a proper partial repair

In addition to the adequate quality of MMB, the transport itself and the method of incorporating the mix is extremely important.

Extremely important factors and those which are necessary to maintain the quality of work are:

- Maintaining the proper temperature of mix until the incorporation and compaction – provided only by SPRIDER
- Distribution so as to ensure an even fluffing of the mix over the entire surface – provided only by SPRIDER with little human effort

It was found that spreading, and specifically, the moment of dumping the mix from the means of transport is vital to proper quality of partial repairs. The search began for solutions that enable to easily incorporate the mix from means of transport to the hole without defractionation and at the same time corresponding to OST. Contractors began to use hot boxes with conveyor screw in Poland in order to provide continuous mixing of the mix, but the mix was continued to be dumped from a height, causing the zones of initial self-compacting and defractionation. Only SPRIDER, which has adjustable conveyor screw arms, allows proper incorporation of the mix with low labour input and the desired quality.

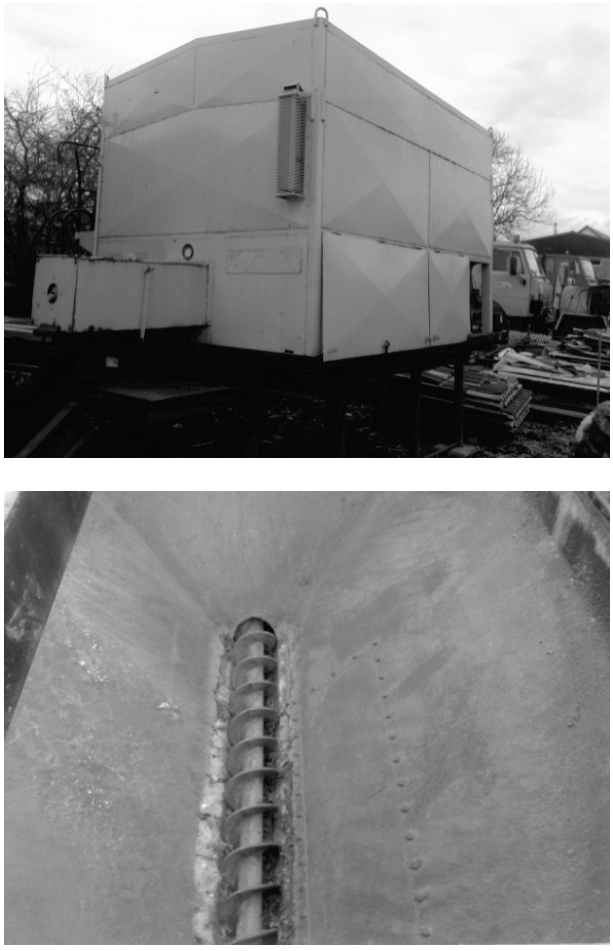


Fig. 6. Typical hot box with a conveyor screw without dump arms (a dump from a considerable height) (from the authors' collection).

4. SPRIDER – AN INNOVATIVE SOLUTION FOR PARTIAL OVERHAUL OF BITUMINOUS ROADS

SPRIDER is the result of the search for a solution designed for fast incorporation of evenly fluffed mix with little effort and dumping from a small height while maintaining the proper temperature until compaction. The machine equipped with a movable, padded conveyor screw arms allowing for mix dumping from a small height, properly fluffed and at the right temperature.

The machine is mass-produced in Sweden and used for road construction. It is a little-known novelty on the Polish market. It is indispensable wherever a large paver is ineffective or manual work is the only alternative.

Fig. 7. The set of carrier + hot box + SPRIDER (from the authors' collection).

Technical specification

- Max capacity of 30 tonnes per hour
- Weight – 1200 kg
- Working range – 4.6 m or optional 5 m
- Width 2550 mm
- Height in the transport position – 2550 mm above the load-carrying body floor

- Length in the transport position – 2,650 mm or optional 1,200 mm (from the rear edge of the load-carrying body)
- Working surface (area of the spread mix or crushed stone) – 40 m² or optional 48 m²
- Maximum grain size 30 mm
- Requirements for the truck hydraulic system – min 60 l/min
- Minimum pressure in the hydraulic system of the truck – 200 bar
- SPRIDER is made of high-quality HARDOX 500 steel
- Transport arms – HARDOX 500 steel
- Electric heating of arms
- Insulation – heat-resistant polyurethane
- Hydraulic drive of moving parts
- Control using solenoid valves
- Wireless control from the portable console by the driver
- Emergency control from the panel on the machine
- Control electronics – SCANRECO 6
- Hydraulically adjustable amount of mix flow
- Maximum height of arms lifting (the height at which SPRIDER can distribute asphalt) – 2.2 m
- Arms operate in two planes

Spider's working range enables to easily access the locations with a restricted manoeuvre room so that the mix is spread efficiently without time-consuming manual work. One can begin to compact the mix in a short time while maintaining proper temperature.

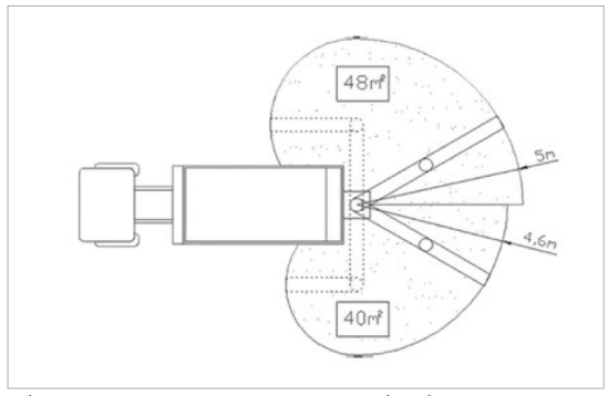
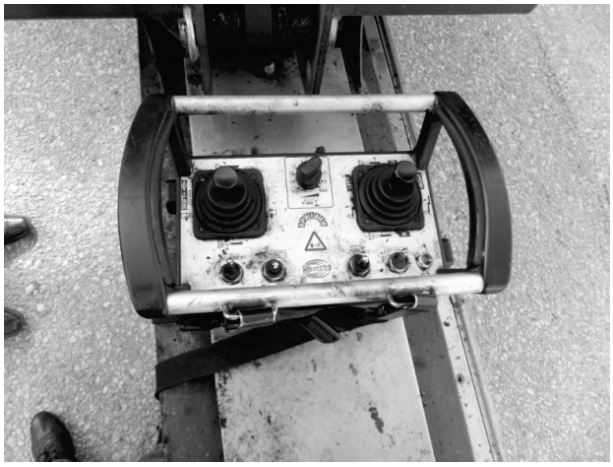


Fig. 8. SPRIDER range [7] and operation in tight spaces (from the authors' collection).

It is possible to lay the mix on a surface area of 40 – 48 m^2 without having to change the position of the vehicle. This enables to efficiently incorporate the mix on a given surface. As the result of the short paving time, one can immediately begin compacting without excessive cooling of mix.

SPRIDER is controlled wirelessly from the control panel by the driver, who also acts as the operator. It is an extremely cost-effective solution allowing for savings in manpower. The operator can change the location of the device (the carrier) during SPRIDER operation remotely without entering the carrier cabin, and move the vehicle using the remote control of RECO - DRIVE.

a)|



b)

Fig. 9. a) control panel b) RECO-DRIVE system (from the authors' collection).

The minimum heat loss and evenly fluffed mix is ensured by insulated moveable arms with a conveyor screw. Paving using conveyor screws allows uniform fluffing of mix over the entire repaired surface. Due to automatically closed hatch and insulated conveyor screw arms, heat loss is minimal and the surface after rolling is uniform without ravelling and chipping. Dump height is adjustable with the capability of setting such a value so that defractionation of the mix does not occur.

Fig. 10. The arm with conveyor screw, automatic hatch of the SPRIDER (from the authors' collection).

Only three-person team is needed for the work using SPRIDER. For comparison, at least 5 people are required for the conventional hot box, making SPRIDER an extremely economical technology. Also, working in confined areas is not a problem and eliminates a lot of labour-intensive manual work.

Fig. 11. Work using SPRIDER (from the authors' collection).

5. CONCLUSION

The introduction of modern technology has many benefits. Undoubtedly, these include economy and the quality of work. It raises the level of "labour culture". Certainly, SPRIDER is an innovative solution which contributes to eliminating some of the deficiencies associated with the work on bituminous pavements.

SPRIDER ensures:

- Maintaining the proper temperature of mix until the incorporation and compaction
- Distribution so as to ensure an even fluffing of the mix over the entire surface with little human effort

It is often beneficial to employ a foreign idea and consider the possibility of introducing modern technological solutions to the Polish market.

For the sake of welfare and safety of road users, let us hope that the introduction of modern high-level technological solutions will contribute to positive change.

REFERENCES

[1] Kozłowski W., Surowiecki A., Kielanowski W.; Functioning of the international highway development and management system in the Polish Road network. Proc. of the 13-th International Scientific Conference Log VD 2010, „Transport Logistics and Crisis Situations", Zilina, 23-24. September 2010, p.117-122

[2] Radzikowski M. : *Raport o stanie technicznym nawierzchni asfaltowych i betonowych sieci dróg krajowych na koniec 2014r.,* GDDKiA,warszawa, 2015

[3] Radzikowski M., Rolla M.: *System Oceny Stanu Nawierzchni SOSN, Wytyczne stosowania, Aktualizacja związana z wykorzystaniem wyników pomiarów ugięć nawierzchni,* GDDKiA, Warszawa, 2010

[4] Rolla S., Rolla M., Żarnoch W.: *Budowa dróg*, WSZiP, Warszawa, 1998

[5] OST D - 05.03.17 Remont cząstkowy nawierzchni bitumicznych

[6] www.gddkia.gov.pl

[7] Swedish SPRIDER folders

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