INFRARED TECHNOLOGY FOR THE REMEDIATION AND RECYCLING OF ROAD DRESSING

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Rezumat. *Lucrarea îşi propune să informeze cu privire la utilizarea tehnologiei infraroşu (ir) pentru repararea drumurilor pe timp friguros şi nu numai. Tehnologia de remediere a defecţiunilor apărute la îmbrăcămințile rutiere bituminoase datorită fenomenului de îngheț-dezgheț, a traficului intens şi greu, capacității portante necorespunzătoare se realizează prin utilizarea surselor de încălzire cu raze infraroşii. Remedierile au caracter permanent şi nu provizoriu, lucrările au o perioadă de garanție de cel puțin 24 de luni, iar costurile anuale se reduc semnificativ printr-o mentenanță cu caracter preventiv executată prin intervenții rapide ce opresc agravarea stării de degradare şi o mentenanță corectivă de calitate superioară.*

Abstract. *The paper aims to inform about the use of infrared (IR) technology to repair roads in cold weather and beyond. The technology for repairing faults in bituminous road dressing due to the frost-thaw phenomenon, intense and heavy traffic, and inadequate carrying capacity is achieved by using infrared heating sources. Remedies are permanent, not temporary, the works have a warranty period of at least 24 months, and annual costs are significantly reduced by preventive maintenance executed through rapid interventions, stopping the aggravation of the degradation state and having a corrective maintenance of superior quality.*

Keywords: technology; infrared; repairing; bituminous road.

1. Introduction

Infrared (IR) technology is a method of remediation of asphalt coating by controlled heating of the defective area, followed by scarification, regeneration, hot-fill, levelling and compacting.

Applications of IR technology are used to repair the following defects: peelings, potholes, corrugations and ridging, streaking surfaces, intervention levels and down hills, spalling, cracks, alligator cracking, longitudinal rut, or local settlements [1], [2].

Advantages of IR technology:

- a strong bonding between the old and the new layer ("welding" instead of "gluing");
- sealing the joint by merging the old material with the new one;
- the possibility of emergency intervention and on cold weather;

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- lifetime high;
- upper levelling;
- rapid intervention, short execution time;
- requires low workforce;
- low consumption of fresh mixture;
- the possibility to use the milled mixture (or stripping) recycling;
- low intervention costs, reduction of annual maintenance costs;
- environmentally friendly technology [3], [4], [5].

2. Technological process

2.1. Cleaning the defective area

Remove any material (earth, stones, asphalt, dust, etc.) and, as the case may be, water (Fig. 1).

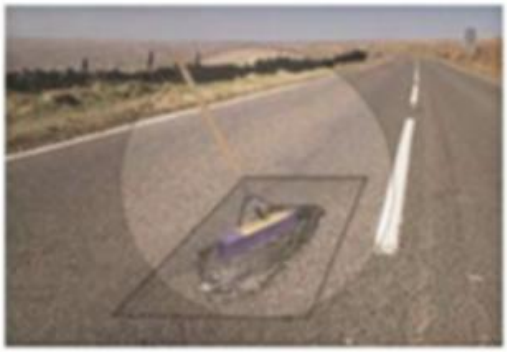

Fig. 1. Cleaning the defective area filler.

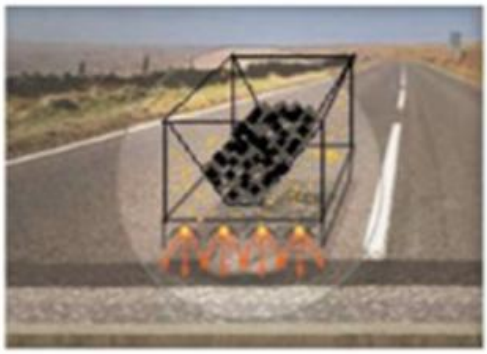

Fig. 2. Heating the defects and material.

2.2. Heating the defects and material filler

The defective area is heated with a radiant panel equipment up to 160^0C, where the asphalt becomes machinable (Fig. 2).

With the same machine, in addition to a recycling thermocontainer, the addition material (freshly briquetted mix or recycled milling mix) is simultaneously heated.

2.3. Scarifying the heated zone

The heated area is scarified with a spade and a rake, inside an outline so as to leave 5-10 cm of un-scarified edge (Fig. 3).

Fig. 3. Scarifying the heated zone

Fig. 4. Spraying of rejuvenating agent

2.4. Spraying of rejuvenating agent

The scarified area is sprayed with emulsifiable rejuvenating agent in order to correct the adhesives and elastic properties of asphalt bitumen (Fig. 4).

2.5. Filling with addition and levelling material

The addition material heated up to 160^0C slides over the scarified area and is levelled (Fig. 5).

Fig. 5. Filling with addition and levelling material.

Fig. 6. Compacting.

2.6. Compacting

Compact with the vibrocompactator plate, checking the start temperature at 140^0C and the end at 110^0C (Fig. 6).

Comparative analysis technologies (Fig. 7 and Fig. 8)

Classical technology	**IR technology (infrared)**
Milling, Priming, Additions of material and levelling, Compaction	Heat, Scarification, Rejuvenating, Addition of material and levelling, Compaction

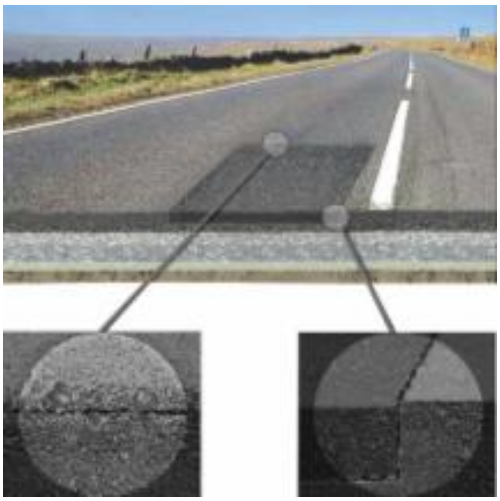

Fig. 7. Classical technology.

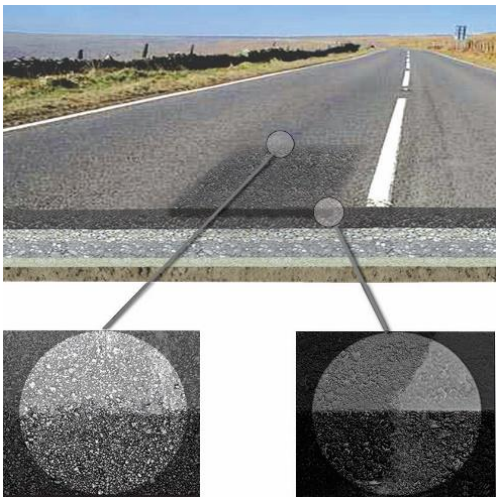

Fig. 8. IR technology.

The quality of the repair:

- There is no interpenetration of the new asphalt with the old one;	- Because of the hot connection the new and the old asphalt are interwoven;
- The connection is weak and vulnerable to water penetration even in the case of a repair that complies with all requirements;	- Strong and resistant to water penetration;
- The life of the "seal" is limited and normally does not last as long as existing asphalt clothing;	- The life of the "seal" is long, normally resists as much as the asphaltic apparel it has been applied;
-Levelling difficult to achieve;	- Possibility of good levelling;
- Correct degree of compaction difficult to achieve due to non-compliance with prescribed temperatures.	- Optimal compaction rate by allowing to meet prescribed temperatures.

Execution time:

- Continuous operations, performed in stages, which are not usually done the same day: milling, cleaning, priming, material addition and compacting;	- Maximum 20-30 minutes to repair a defective portion of the surface covered by the radiant panel.
- Cutting surfaces much larger than the total defect area.	---

Necessary labour:

- At least 4 to 5 workers and 2 drivers	-3 workers

Fig. 9. Equipment required for classical technology.

Fig. 10. Equipment needed for IR technology.

Required equipment (Fig. 9 and Fig. 10):

Fig. 11. Milling the defective area

Fig. 12. Warming the defective area

Consumption of materials:

-high asphalt mixture consumption;
-the area under repair is mowed, the removed material is replaced with fresh asphalt mixture (Fig. 11);

-low asphalt mixture consumption;
-the repaired area is completely recycled, the fresh asphalt mixture being just for completion (Fig. 12);

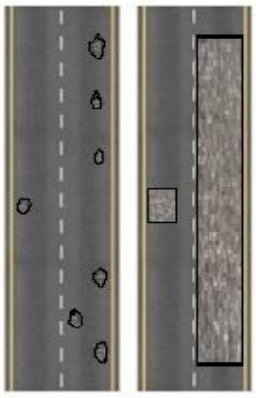

Fig. 13. Large surface milling.

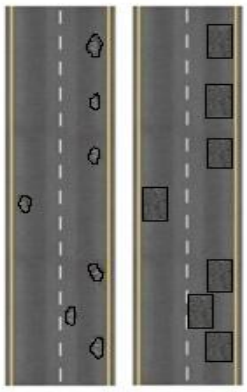

Fig. 14. Heat defective areas

- Remediation involves milling both around the hole and, unjustifiably, between pits spaced apart from each other (Fig. 13).

- The remedy is strictly in the defective area. The addition material may be milling or scraped mixture, recycled (Fig. 14).

Cost:

-High labour costs, materials, transport and necessary machinery. They cannot cover for isolated pits because of which they are forced to cut large areas, thus reducing costs per unit area. Because the lifetime of a fix is low, the annual cost becomes very high.	- The cost of the remediation operation is reduced by at least 30% for the use of fresh asphalt mix as a feed additive. If asphalt mix obtained by recycling the asphalt milling is used, costs are much lower. - The ability to carry out maintenance and preventive maintenance dramatically reduces annual costs.

Technological limitations:

-Remedy in low temperature and humidity conditions it is not allowed; -Emergency "seals" are temporary and very expensive.	- Low temperature or moisture fixations can be performed successfully.

Flexibility at the scale of works:

- Properly applied technology involves high training costs, small scale local repairs are not cost-effective; - Maintenance work and preventive repairs are avoided, preferring to repair with asphalt mat; - Large quantities of repairs involve a cumbersome and prolonged procurement procedure.	-Technology is fast with short-term intervention and can be cost-effective for large and / or small scale projects; - Fast and inexpensive maintenance and preventive repairs can be done; - Small quantities of work, with low values, involve a simple and quick public procurement procedure through direct crediting.

Environment protection:

-Large asphalt consumption makes the ambient air strongly polluted both in the manufacturing process and in the process of putting it into operation; - Milling or scraping with a pick-picker results in intense noise pollution.	- Small asphalt consumption reduces significantly air pollution; - Low and short-term noise pollution.

3. Analysis of classical technology for remediation, frequent nonconformities, causes, consequences and preventive measures

Nonconformities that negatively influence the degree of compaction and uniformity of the layer (Fig. 15):

1. The low temperature at the beginning of the mixture asphalt compaction

Causes:

- low ambient temperature;

- long-time transport, unloading and handling before putting into operation;

- low degree of thermal insulation of the truck's bumper;

- lack of sheet for covering the material;

- the large dimensions of the bonnet in relation to the quantity of conveyed mixture;

2. Thermal segregation of asphalt mix layer during transport, handling and putting into operation;

Causes:
- Chilled crust on the surface of the cargo, in the vicinity of the walls and bottom of the truck;
- Rapid cooling in contact with ambient air and cold surfaces with which the mixture comes in contact (front loader volume, temporary storage surface until putting into operation);
- Rapid cooling over the substrate and perimeter areas in contact with cold and wet surfaces;
- rapid cooling on the surface of the seating due to the low air temperature and intense wind.

Fig. 15. Effect of low and non-uniform compaction - deployment of the seal starting with perimeter areas.

How IR Technology helps eliminate the main impediments that can lead to inadequate and uneven compaction:

- The hot asphalt mix transport, unloading and handling times are eliminated, the addition material (admixed mash or fresh briquetted mix) is heated in the thermocontainer at the optimal setting temperature in strictly the amount necessary to achieve the previously prepared defect remedy;

- The risk of thermal segregation is reduced, the surface of the substrate and the edges of the defective area are dried and heated up to a temperature equal to the temperature of the asphalt mixture (Fig. 16).

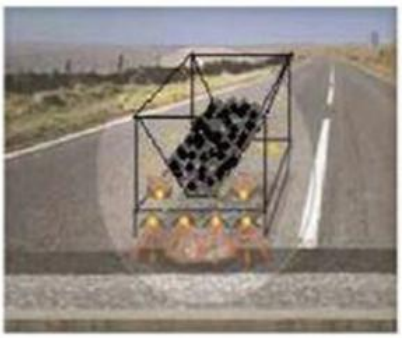

Fig. 16. Prior to the filling, the defective area is heated at the same time as the addition material up to 160°C

Nonconformities that weaken the adhesion of the additive to the substrate and reduce the tightness of work joints:

1. Inappropriate priming of the substrate

Causes:
- non-priming the support layer;
- insufficient amount of bituminous emulsion used;
- uneven priming;
- uncoated support surfaces;
- cold and humid priming;

2. Putting the asphalt mixture into operation with temperatures below 100^{0}C.

Causes:
- low ambient temperature;
- long time: transport, unloading and mixing handling, before putting into operation;
- low degree of thermal insulation of the truck's bumper;
- lack of sheet for material coverage;
- the large dimensions of the bonnet in relation to the quantity of conveyed mixture;

4. Putting the asphalt mixture into operation in cold weather, with wind, on cold and humid support;

5. Substructure aging.

Consequences of low adhesion and leaking joints (Fig. 17):

1. The joints lose their tightness by:
- aging of the bituminous mastic used to clogging, reducing its malleability and flexibility;
- mechanical stress in heavy traffic;
- high and low temperatures, weathering.
2. Water penetrates into the leak;
3. At freezing temperatures the water rises, increasing the volume and compressing the adjacent portion of the seal causing cracks in it;
4. As a result of traffic demands, the portion of the fissure affected by cracks is deployed;
5. Dislocations continue especially on the sealed side;
6. The degradation extends also in the vicinity of the seal.

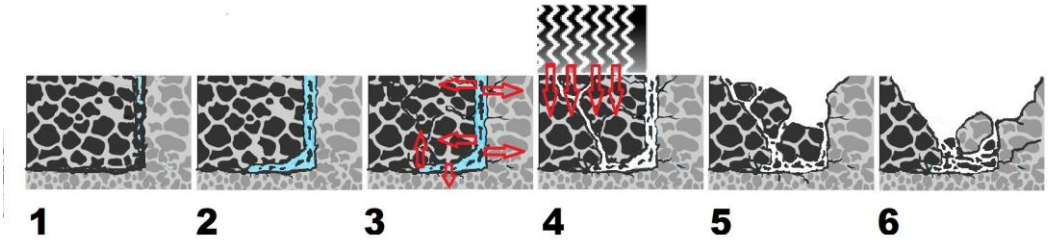

Fig. 1. The phases of the displacement of the seal starting with the perimeter areas.

Fig. 18. The neetans workgroup is the origin of the development of the plots adjacent to the seals.

Fig. 19. Poor repair of road infrastructure after utilities' interventions.

The ways in which IR technology helps eliminate the main impediments (Fig. 18 and Fig. 19), which can lead to poor bonding of the support material and the lack of tightness of the working joints, are:

- Remedy can also be done in cold weather;
- By heating the defective area, moisture is completely eliminated;
- The addition material is heated "in situ" to the optimal setting temperature;
- The heated defective area is scarified and added with a rejuvenating agent;

- The filler material and scarified substrate material interpenetrate, and by compaction a strong bond is created;
- There are no work joints, the perimeter areas are perfectly sealed (Fig. 20).

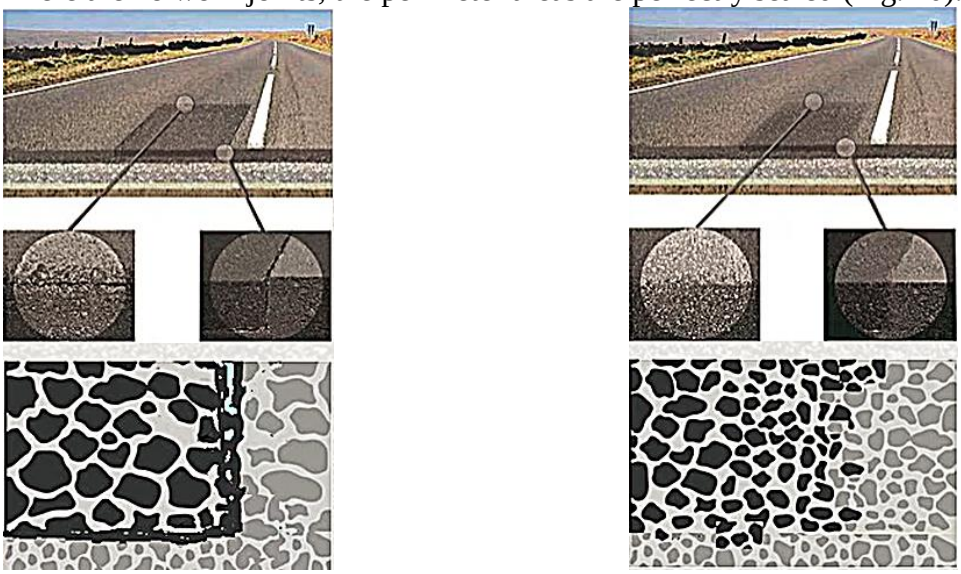

Fig. 20. Technology comparison.

a) classical technology (milling) unsealed joint – pasting

b) IR technology (infrared) sealed joint – welding

The SWOT Analysis

Strengths

- Advantages of technology provide exceptional quality of remediation work;

- Remedies are permanent and not temporary, work can be guaranteed for a period of at least 24 months;

- Annual costs are significantly reduced by preventive maintenance executed through rapid interventions that stop the deterioration of the degradation state and a high quality corrective maintenance;

- The innovative method (developed by Calorset SRL) allows the use of IR technology in cold weather.

Weaknesses

- The addition material must be storable (fresh briquetted mix or added milling mix) and it is necessary to prepare it;

- Gaseous fuel storage is required;

- Workers must be well trained in the operation of the machinery;

- SSM and PSI measures are required in terms of machine operation as well as handling and storage of LPG containers.

Opportunities

- IR technology allows what with classical technologies cannot be achieved optimally. By enabling quick interventions to solve isolated defects including cold weather, IR technology allows for preventive maintenance and emergency interventions with efficiency and effectiveness;

- The technology is included in Technical Regulation AND 547-2014 Annex 4;

- The technology has been successfully tested and implemented by C.N.A.D.N.R. (currently C.N.A.I.R.), the machines manufactured by Calorset SRL are currently included in the tool kit for emergency interventions from the C.N.A.I.R.

Threats

- Construction and road repair firms prefer that road maintenance and repairs be carried out by milling the existing layer, priming and asphalting asphalt mix;

- The IR Technology is not known, although it has been published in the Road Traffic Technical Bulletin AND 547/2013 with Annex 4;

- The IR technology is not provided in the tender documentation;

- Priority is given to the lowest price, to the detriment of the quality and durability of the repair and maintenance work;

- Workers must be properly trained to avoid compromising work.

R E F E R E N C E S

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