PAVEMENT LIFE EXTENSION THROUGH ULTRA HIGH-PRESSURE WATER RETEXTURING / RUBBER + PAINT MARKER REMOVAL METHOD

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ABSTRACT

Pavements, be they highways or airfield traffic surfaces like runways, play thee vital role in the economic development of our societies. They provide the necessary infrastructure for the transportation of people and goods. They allow an increase in trades and services, facilitating it through connecting a more and more diverse society. As the need for travel is continuously increasing, more emphasis is placed on optimising the usage of our current pavements and today's and future planning take into consideration environmental issues.

As a result, increasing attention is being given to protection of the environment and costs associated with constructing and maintaining pavements. It is imperative that more innovative methods are developed and employed to extend pavement life span in order to ensure the sustainability of new and existing pavements while decreasing costs of maintenance.

KEY WORDS: rubber removal, paint marker removal, road retexturing, and technology comparison

1. INTRODUCTION

Since the end of the 18th century, there has been a continuous increase in motor traffic and aircraft usage as the need for transportation of people and goods has increased (HOSKING, 1992). This has created the need for more roads and importantly raised the demand on airports while at the same time increasing maintenance demand on existing ones. As a result, the environment as well as cost consciousness has become most important issues, since roads and airports generally require large capital investment, raw materials and landscapes.

The surface sections of roads and runways are known as "pavements". The two most common types of pavements are concrete and asphalt.

To serve its purpose, a pavement must have adequate load-carrying capability, good rideability and must allow safe operation of vehicles on roads and aircraft on air traffic areas. (Marc Stet)

As with any physical structure after certain usage over time, pavements begin to wear and their physical properties alter. This alteration is normally evidenced in the appearance of various types of surface distress caused by a combination of environmental conditions, vehicle/aircraft loadings, mix design, materials and construction workmanship TRANSPORT CANADA, Civil Aviation, http://www.tc.gc.ca/CivilAviation/International/Technical/Pavement/management/maintenance.htm 12/04/05

This causes the pavement not to function as designed and results in safety hazards to its users if not repaired and maintained as alterations can become severe. This occurs whether on a Heathrow runway or on a European Highway. One major alteration of its physical properties is the reduction in roughness leading to reduced skid resistance.

Good roughness is based on several important characteristics of the road surface and the more frequent ones are (HOSKING, 1992):

1. adequate micro-texture,
2. good macro-texture of the surface, which is required to maintain skidding resistance at higher speeds,
3. adequate drainage of the water from the pavement.

Macro and Micro texture are major factors surrounding the friction value of a pavement and insufficient amounts of these two can result in reduced friction values. Each however serves different purposes and is discussed in more detail below in chapter 2.

Timely maintenance of pavements will lead to maintenance of adequate frictional value, increased pavement lifespan and has an effect on the safety of the user. There are two types
of pavement maintenance known: Structural and Operational maintenance. Each of these two types has a different functionality and as such contributes differently to the attributes of pavements. From this, different methods have been devised to retexture pavements. This paper looks at the importance and reasons for retexturing pavements and the different practices currently employed for pavement retexturing. Advantages and disadvantages are considered for each method. A comparative analysis is done taking into account critical factors such as method, cost, effectiveness and added lifespan to pavement. The TrackJet technology, which is most widely used by major airports in Europe, is also looked at, taking into account its technical properties and case studies to date.

2. PAVEMENT TEXTURE AND MAINTENANCE

Pavements are maintained as they gradually deteriorate with time due to usage, weathering, loading, design, materials and workmanship. In order to sustain the functionality of pavements for a longer time frame, it is necessary for them to be maintained. The two methods of maintenance pavements usually undergo are Structural and Operational maintenance.
Structural maintenance entails carrying out works that maintain the quality and safety characteristics of the pavement surface. Structural maintenance is vital as pavement break-up results in surface roughness and an increase in loose particles, which become a safety hazard to both aircraft and motor vehicle users. Examples of this type of work are crack and joint sealing, patching, paint marker removal, etc.
Operational maintenance entails activities that are necessary from time to time and are related to safety of daily operations. Examples of these types of work are rubber removal, sweeping
and cleaning, snow removal, wildlife and bird control, etc.

Of particular interest in structural maintenance is the removal of rubber and paint marker, oil

and loose particles from pavements to maintain an acceptable friction value. If this is not done on regular basis, skidding can occur when the coefficient of friction between the tyre and road/runway surface is inadequate to maintain full adhesion.
Pavement texture is broken into two components known as Macro and Micro texture.
The macro-texture of a pavement refers to the visible roughness of the pavement surface as a whole. The primary function of the macro-texture is to help maintain adequate skid resistance to aircraft/vehicles travelling at high speeds. It also provides paths for water to escape which helps

to prevent wheels of motor vehicles and aircraft hydroplaning. This is normally accomplished through cutting or forming grooves in existing or new pavements (see figure 1).

Micro-textures refer to the roughness of the surface of the pavement. It is the fine texture that occurs on chippings and other exposed parts of the surfacing. For concrete pavement this is usually the sand and fine aggregates present at the surface layer and for asphalt it is usually the type of aggregates used. Micro-texture creates frictional properties for vehicles and airplanes travelling at low speeds. The wet skidding of a road or taxiway is dependent on the interaction of the tyre and the micro-texture of the road surface.

References will be made to airport pavements, as structural damages are more evident and critical due to the extra precautions that are required and the cost of pavement investments to airports.

The FAA Advisory Circular 150/5320-12C explains the FAA view on Measurement, Construction and Maintenance of Skid-Resistant Airport Pavement surfaces

PAVEMENT MAINTENANCE MEASUREMENT TOOLS

This presentation is not focused on maintenance tools, however a short information seems valuable for future studies.
Roughness of a pavement can be measured by programs available through FAA or APRas.
Skid Measurements are recommended by ICAO Annex 14 to be done frequently, using different devices, each having unfortunately their own friction level. A harmonization process of these devices is under way but will still need time.
Structural conditions of in-service pavements are evaluated using Non-destructive Deflection Testing (NDT). Necessary to identify Classification Numbers like
Pavement Classification Numbers PCN (understanding pavement performance characteristics) or
Aircraft Classification Numbers ACN predicting pavement loading.
The Pavement condition survey and rating procedures are fully documented in FAA Advisory Circular 150/5380-6
See Marc Stet in Pavement Maintenance Management Tools *International Airport Review issue 4 2006*

3. PAVEMENT RETEXTURING

Retexturing of pavements can be understood as the mechanical modification of a sound runway/road surface to restore skidding resistance, texture depth or both. Determining if retexturing is required, is dependent on the road/runway conditions. Different treatment methods have different results. Dependent on the retexturing method and the road/runway surface conditions, results can range from

- an increase in both skid resistance and texture depth or
- an increase in skid resistance but reduce texture depth or
- an increase in texture depth and no effect on skid resistance.

Distinct advantages linked with pavement retexturing include:

- mostly more cost effective than resurfacing,
- usually able to be carried out at any time except extreme weather conditions,
- usually takes a short time to be completed versus resurfacing,
- conserves the earth's natural resources by not laying new surfaces.

Disadvantages include:

- not applicable on unsound roads where cracking or surface irregularities exist,
- certain road features such as ironwork, white lining and traffic detection loops may have to be avoided or protected,
- caution is needed with some treatments where joints exist within the concrete surface,
- retexturing is of limited value where coarse aggregates have been exposed and are easily polished,
- some technique may not be appropriate if the coarse aggregate is of very hard material and may not respond well to impact.

Various methods have been developed for pavement retexturing. Each of these methods has particular advantages and disadvantage to its usage. The decision of which method is employed depends on several factors. These factors vary from weather conditions, time taken to carry out work, cost, level of retexturing required and environment.

An Example for retexturing has been done on Damson Parkway in UK by Ringway Specialist Services Ltd using the TrackJet technology.

The road is a single carriageway with a slight gradient and appears to be heavily trafficked with a significant percentage of commercial vehicles. A SCRIM survey this year for the client gave satisfactory results (see below).

The current surface course is a 14 mm negative texture type laid in December 2005.

A visual assessment of the surface indicates loss of micro and macro-texture probably due to the trafficking intensity and a binder rich appearance in the wheel tracks giving a smooth and slick appearance.

The purpose of the treatment is to remove the binder film and restore the micro and macro texture to acceptable levels.

Site testing

A section of the northbound carriageway was selected as being representative and five points were tested on the nearside wheel track at approximately five metre intervals.

Summary of PTV results:

Location PTV	**before Average PTV**	**after Average % Increase**
Area 1 LC 21	Northbound	C/way ns wt.
47 PTV before	69 PTV after	46.8 % increase
45	66	46.7
50	70	40.0
48	66	37.5
46	69	37.5
47 Average	68	44.7

See Ringway test report Restoration of Surface Texture by Ultra High Water Pressure dated 13. Sep. 2006

These methods vary from mechanical to chemical methods and are generally classified as one
of the following. These are:

- Impact action: This involves stringing the road surface with hard tipped tools or particles. This method is effective when polishing is the cause of the loss of skid resistance. Examples of this are Bush Hammering and Shot Blasting.
- Cutting and flailing: This category is when cutting is combined with impact on the cutting heads. Examples are grinding and grooving.
- Fluid action: This method utilises high temperature or pressure. It does not involve mechanical retexturing of the road pavement to expose new aggregate to the surfaces. Examples are Hot Compressed Air and High Pressure Water Blasting.

The paper will focus on Impact and Fluid action as these two involve polishing and rubber and paint marker removal from pavements.

4. RUBBER REMOVAL TECHNIQUES

The most common methods of pavement retexturing are

1. High Water Pressure,
2. Ultra High Water Pressure (TrackJet),
3. Chemical,
4. Shot Blasting,
5. Mechanical Process.

Each of these methods is discussed in detail below, taking into account their various attributes.

4.1 High Pressure Water blasting (HPW)

Rubber is removed by means of rotary devices that move along the surface as it cleans. This is done utilising up to 30 gallons of water per minute at pressures of between 100 to 1,000 bar. The water that penetrates the surface effectively cleaning rubber deposits creates an hydraulic effect. This helps to increase the frictional values and surface texture of the pavement. A combined suction part or a sweeper that picks up the rubber debris during its operations usually accompanies it. This allows for the pavement to be easily and quickly returned to operations and is especially advantageous in airport operations where time constraints and short possession time is common.

Benefits of using this technique are:

- the speed at which rubber is removed (1,200 m² per hour are claimed),
- the cost efficiency of the process (water is generally provided),
- the improved friction characteristics of the pavement due to penetration of the water and the removal of rubber,
- the ease of getting off the runway in the event of an emergency,
- its usage is independent of weather and can be operated in cold, damp wintry conditions.

Disadvantages are:

- noise from the operation requires the wearing of hearing protection,
- eye protection should also be worn in the vicinity of the machine while in operation,
- appropriate disposal of waste material is required,
- does loosen surface matrix encouraging the loss of fine materials,
- cleaning rate is 70% with one run,
- heavily damages certain asphalt types like antiskid,
- damages grooves and pavement surfaces over time (8 years),
- damages sealing,
- cannot be used to clean AGL.

HPW is most effective on sprayed seals and asphalts that show loss of texture due to flushed bitumen. This results in safer operating conditions for pavements (SPEIDAL, 2002).

4.2 TrackJet (Ultra High-Pressure Water blasting)

The TrackJet, an Ultra High-Pressure Water blasting machine developed by Bernd Weigel in Germany, is widely used at BAA airports and other leading airports in Europe, as well as European highways for retexturing and paint marker removal. Through its modern technology of retexturing, this machine has consistently removed 100% of rubber build-up and pavement markings from pavements without touching the pavement micro or macro texture. It utilises a nozzle system that is truck mounted, applying very little water at very high pressure through a unique computer-controlled system. This enables an environmentally friendly and most effective maintenance for all kind of surfaces.
Cost savings through increasing rubber removal intervals without damaging or destroying the aggregates on the pavement surface result in an increased pavement life. (Ian Coats: *BAA Gatwick Field Study 2004/2005)*

Benefits of this technology are:

- optimum treatment with care of pavement surface,
- reduces direct and indirect renovation cost by prolonging cleaning and resurfacing cycles,
- applicable to all kinds of surfaces; for example asphalt, anti-skid, petro-grip and concrete,
- best possible friction values, therefore prolongs the time interval till next cleaning,
- high environmental compatibility is reached due to very low water consumption and very low eroded road/runway substance volume,
- no damage to grooving, runway lighting systems, marker paints and joint sealing,
- clearing out of expansion joints,
- only needs one personnel to operate,

- the ease of getting off the runway in the event of an emergency; runway can be evacuated in 3 minutes leaving the working area tidy and surface like new,
- its usage is independent of weather and can be operated in cold, damp wintry conditions or warm temperatures (2 to 40 degrees centigrade),
- high environmental care due to extremely low water and fuel consumption; the TrackJet works with clean water without chemical adhesives and requires only 10 to 20% of the water and 30% of the fuel HPW systems normally require,
- low expenses with waste removal, because no chemical is used to separate the rubber waste from waste water.

This system is also universally suitable for cleaning sealing joints, concrete renovation, cleaning of steel and concrete areas, apron areas and oil spill removal.

Disadvantage of systems:

- appropriate disposal of waste material is required,
- some airport staff claim that up to 800 m² per hour cleaning (but 100% rubber removed) is too little.

4.3 Chemicals

Environmentally friendly chemicals have been developed that are safe and effective in cleaning rubber from contaminated surfaces. This is done by spraying the chemicals onto the pavement surface and then scrubbing, brushing and working them into the rubber deposit over several hours. The chemicals break down the polymerised rubber into a soft jelly like substance. The substance is then flushed off the runway by water blasting when the process is completed. During this process, the runway cannot be reopened until the process is completed due to the runway surface being slippery. The debris cannot be swept up using conventional sweepers since the chemicals will react with the rubber seals within the sweeper. Even though the debris is considered to be biodegradable, the chemical is not and as a result, the usual method of clean up is: flush the soapy residue off the pavement surface onto the surrounding soil after completion of works.
Over time, the debris accumulates and may eventually cause an environmental problem requiring remediation. The cost of chemical removal is usually double the cost of HPW and TrackJet due to the cost of the chemicals ((SPEIDAL, 2002).

Benefits of this method are:

- rubber is cleaned at the same rate as HPW,
- Iit softens and removes polymerised rubber,
- the work can be accomplished using airfield staff and equipment.

Disadvantages are:

- once the process begins, the pavement/runway must remain closed until clean up is complete,
- it is expensive in comparison to HPW and TrackJet,
- poses an environmental problem due to chemicals not being biodegradable over time,
- time taken for process to be completed,
- requires more than one personal to carry out process,
- reacts with rubber seals in conventional sweepers and on runways,
- large amount of effluent needed to be disposed of.

4.4 High Velocity Impact Removal or Shot Blasting

Propelling abrasive particles onto the runway surface that blast the contaminant from the pavement surface using Shot-blasting. The operation is environmentally clean since it is self-

contained and the equipment can be adjusted to produce the desired surface texture result. On a non-grooved surface it collects the abrasive particles, loose contaminants and dust from the runway surface. The steel is then recycled for re-use. The primary reason using this method is for paint removal and the resurfacing and retexturing of pavement surfaces and not necessarily the removal of rubber deposits (SPEIDAL, 2002).

Benefits are:

- it retextures pavement and removes rubber deposit in excess of 1,000 m^2 per hour,
- retexturing is done by removing a thin layer of the pavement and coincidentally removing rubber deposits as well,
- the equipment is truck-mounted and can easily be removed from the runway (like HPW and TrackJet) in case of an emergency landing,
- the equipment cleans the surface while working.

Disadvantages are:

- expensive to mobilise,
- overall cost is expensive,
- noise and vision hazards due to operation process of machine,
- care is required to carry out machine operation,
- FOD hazard on airfields where steel shot becomes semi-embedded into the surface and then dislodged later in time.

4.5 Mechanical Removal (Grinding or Milling)

Mechanical Removal is generally carried out either by grinding or milling. Like shot blasting, the primary reason for the machine is not the removal of rubber from pavement surface. It is most effective in removing rough patches on highways and profiling high spots on pavements. It also removes rubber deposits as its process is carried out (SPEIDAL, 2002).

Benefits are:

- removes high areas such as bumps on pavement surfaces or at joints where slabs have shifted or faulted,
- mills asphalt surface for preparation of overlaying,
- improves pavement surface friction characteristics by removing a thin surface layer.

Disadvantages:

- can cause micro-cracking of the structure leading to accelerated aging of the surface,
- damages surface texture.

4.6 Comparative Analysis of Retexturing Methods

The table below is a comparative analysis of the different attributes associated with each type of retexturing method.

In comparing the different methods of retexturing against key operative variables it can be deduced that the specific requirements of the user will determine which method suites them best.

In table 1, HPW is used as the basic method from which the other methods were measured against using several different factors.

Table 1 Comparative analysis of Retexturing Methods

Technology	Cost per m^2	100 % Rubber Removal area	No. of staff used	Environment impact	Pavement Evacuation time	Pavement retexturing ability	Safety/Noise	Speed of 100 % Cleaning
Chemicals	+	-	+	+	-	-	-	-
HPW	=	-	+	+	=	-	=	-
Shot Blasting	+	-	+	=	-	-	-	-
Mechanical Removal	+	-	+	=	-	-	-	-
TrackJet Technology	=	=	=	=	=	=	=	=

Key to table: comparison of all technologies against TrackJet UHPW
= approximately the same like UHPW,
+ greater/more than UHPW
- less than UHPW

For cost, rubber removal, speed of cleaning, and pavement retexturing the TrackJet has a distinct advantage and equals HPW in the other factors. For pavement retexturing it should be noted that depending on the surface type whether asphalt or concrete there are advantages in using specific methods. Shot blasting is more effective on concrete than it is on asphalt pavements.
TrackJet is the only technology that removes paint markings without any damage to the texture below.

5. TRACKJET FRICTIONAL VALUES RESULTS

The TrackJet equipment is used at most of the major airports in the UK. These airports include the ones owned by BAA such as Heathrow, Gatwick and Stansted. Below is operational data on the performance of the HPW and TrackJet (PADE, 2005)

Before and after friction tester results Munich Airport/Germany

Figure 1 Conventional 700 Bar system - friction value increase was 0.23

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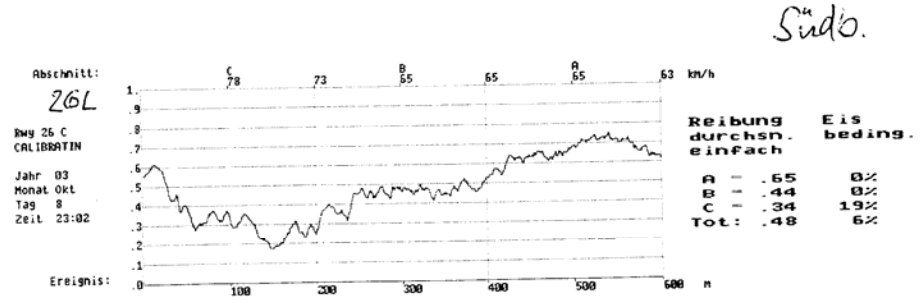

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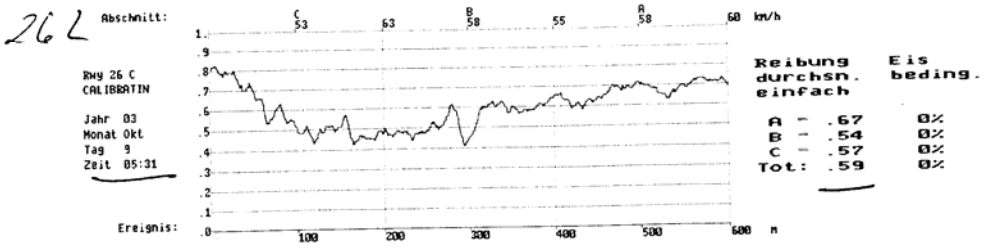

Figure 2 TrackJet 2500 Bar system - friction value increase was 0.45

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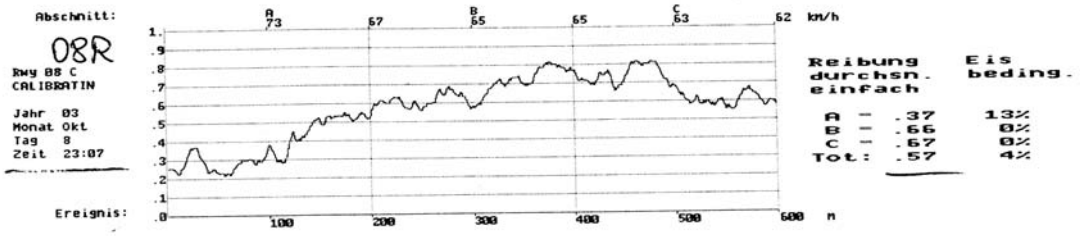

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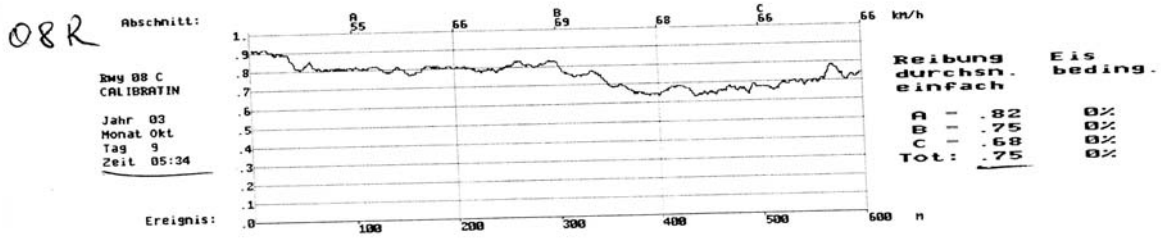


Figure 3 Visual Effect of Anti Skid coated runway treated by TrackJet

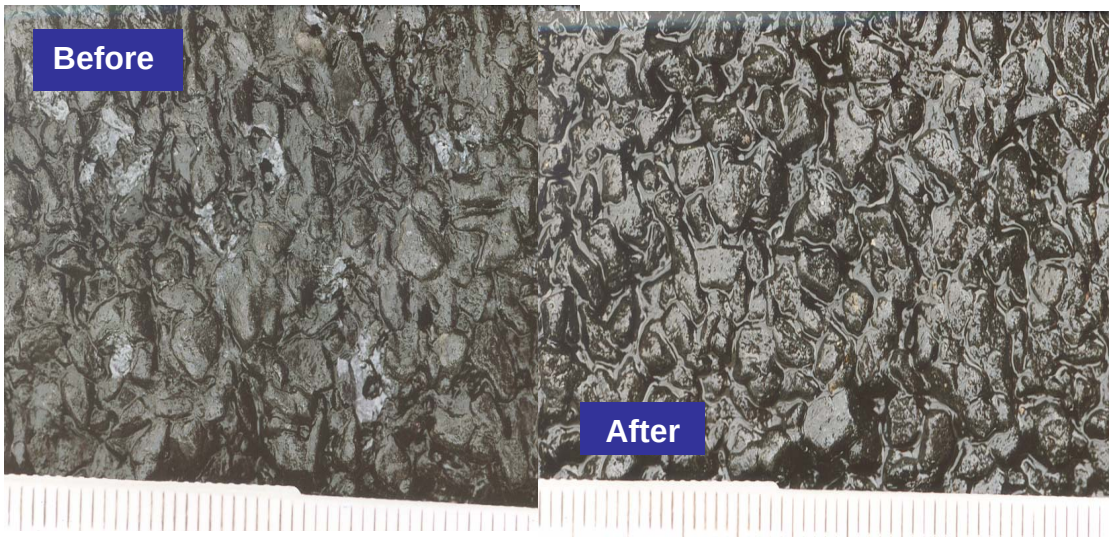
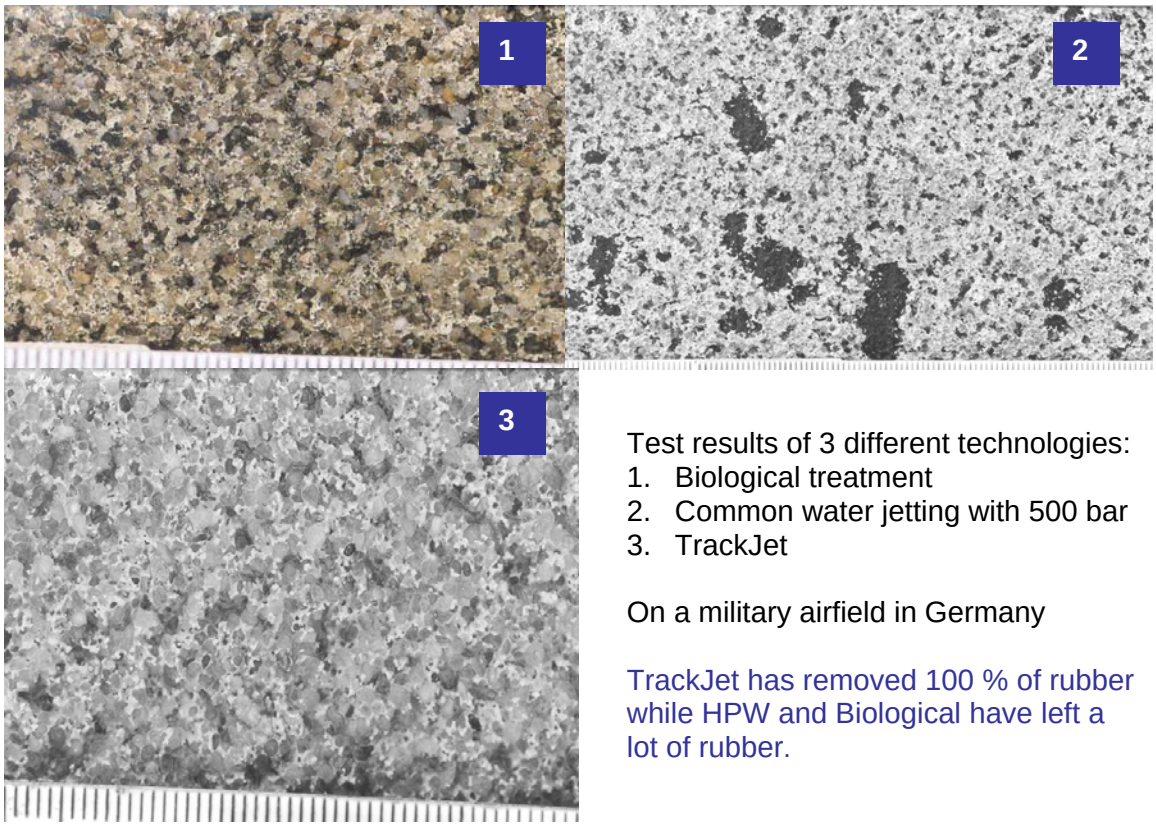


Figure 4 Picture of different treatment effects on antiskid surface



Test results of 3 different technologies:

1. Biological treatment
2. Common water jetting with 500 bar
3. TrackJet

On a military airfield in Germany

TrackJet has removed 100 % of rubber while HPW and Biological have left a lot of rubber.

5.1 BAA GATWICK AIRPORT FIELD STUDY: results from NOVEMBER 2004 to FEBRUARY 2005

TrackJet now operating for 3 years at Heathrow, Gatwick and Stansted Airport! Gatwick has in peak times up to 800 movements on a single runway system. Prior TJ, all kinds of rubber removal systems used including 600 bar Traditional H.P.W.

	THPW	TJ
m² Rubber Removed in 25 hrs	8,000	17,380 - 20,000
Friction value increased to	0.55	0.7 +
Water consumption (ltrs) in 5 hrs operation	75,000 -100,000	10,000
Rubber cleaning factor (%)	approx. 70	100
Waste removal from Runway	less 100%	100%
Actual Unit Costs (€ /m²)	3.00	less

BENEFITS:

- confidence in financial liability of cleaning process,
- confidence in output area level of 700m²/hr +,
- confidence in deep cleaning process,
- confidence in friction levels above 0,7+,
- confidence in low water consumption,
- confidence in 100% waste and water removal,
- confidence in NO damage to surface,
- confidence in NO damage to grooving.

RESULTS: Overall lifetime extension of Runway is expected to be:

For TDZ from 8 years to 12 years TDZ renewal costs are 3.1 mill €,
for RWY from 12 years to 18 years Rwy renewal costs are 27 mill €.

6. CONCLUSION

Similar to the maintenance of mechanical machinery, the maintenance of pavements also leads to an extended lifespan of pavements and increased safety to users. Undoubtedly this results in fewer costs for the project life cycle period and reduced usage of the earth's raw material to reconstruct pavements.
There are several different methods of pavement maintenance and the choice is dependent on the condition of the surface and what properties are required to be restored. One of the major physical disabilities of regular pavement usage is the loss of frictional value that is affected by the micro and macro texture of the pavement. This is of utmost importance especially to the airport and highway industry, as reduction in frictional values on runways and high-speed roads poses a great threat to aircrafts and other road users. There are five main techniques used for rubber removal that lead to a restoration of frictional values to pavements. Each method has its advantages and disadvantages and the choice of method may depend on the cost, pavement material, main reason for pavement restoration, environment, etc.

Based on the comparison analysis, the TrackJet equipment has a distinctive advantage against HPW and its other peers. It is used by BAA and other major airports and highway authorities across Europe because of its multiple usages, effectiveness and efficiency.

From its usage, BAA has seen the following advantages of the TrackJet technology compared with other systems:

- reduction in frequency of rubber removal required per annum (from 5 times to 2 times per year at Gatwick airport),
- frictional values after cleaning always more than 0.7,
- runway life time increase from 12 to 18 years (50% increase in lifespan),
- much lower water consumption,
- larger cleaned area within same time,
- no damage to grooving,
- no damage to surface,
- significant reduction in unit cost (below 3.00 € /m²),
- 100% removal of rubber and waste water,
- output level greater than 700m²/hr after first deep cleaning process.

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