RUNWAY RUBBER DEPOSITION, TEST AND REMOVAL TECHNIQUES

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ABSTRACT

One of the major operations involved in airport maintenance is to ensure the safe landing and takeoff of aircrafts, which is decided by the adequate runway pavement texture. Further the surface texture of airfield runway is decided by the quantum of rubber deposits on the runway during the landing and takeoff. Hence the removal of build-up rubber deposits play a major role in deciding the pavement skid resistance. In this paper, an effort has been made to revisit and discuss the various methodologies and its effectiveness for the removal of waste rubber from the airfield runway.

Key words: Safe Landing and Takeoff; Deposited Rubber; Adequate Runway Texture; Runway Skid Resistance Methodologies.


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1. INTRODUCTION

Safety and regularity of flights depends on considerable degree of runway surface conditions. The runway pavement skid resistance tends to degrade over certain period of time due to several factors out of which two primary factors are mechanical wear from aircraft tires on runway surface and the accumulation of contaminants on runway. Contaminants may reduce skid resistance on the runway texture. The most persistent contaminant problem is the rubber deposited caused by landing of aircraft, regardless of rubber deposition some other contaminants are dust particles, jet fuel, oil spillage, snow, ice and slush. The rate of rubber deposited are directly proportional to volume of aircraft landing, size and weight of aircraft, weather will also impact the rubber accumulation. (Aaron Pullen B. et all, 2015)

The most significant reason which needed to be concerned for the build-up of rubber on runway surface is safety. If you operate an airport with large jet aircraft, you will eventually
have deterioration with respect to pavement skid-resistance as well as reduction in friction coefficients, which is a major problem for aircraft tires to resist the aircraft speed. One of the main causes of ground based accidents is a runoff event. Aircraft skids off of the runway due to, the pilot is unable to brake soon enough upon landing or when having to abort a takeoff, the pavement surface will be carefully examined as a contributing factor. There are several another factors that contribute to surface deterioration, but the one that is easy to recognize, simple to correct and relatively inexpensive to do is airfield rubber removal. (CARC paper, 2010)

2. REASON FOR RUBBER DEPOSITION AND ITS INFLUENCE ON THE RUNWAY PAVEMENT.

During the landing, aircraft speed is been reduced, so that the aircraft will steadily descends towards the runway. When an aircraft is landing, the wheels are stationary with respect to the surface of touchdown area. Upon touchdown, the aircraft wheels will gain rotational speed so that it can match the speed of the aircraft. The tires are under very high pressure as the overall load of the aircraft is transferred from the wings keeping the aircraft flying to the landing gear reaction forces on the ground, this process is also called as spin up speed and it generates considerable heat and friction during this process (Resza Ashtiania S.). The heat and friction generated during the landing causes a reaction which polymerizes the aircraft tire, changing it from a soft load absorbing rubber into a hard dense rubber that is finely spread on the runway. The deposited rubber on the course layer will ultimately turn into a thin layer on the surface, which will eventually take over the surface texture of the runway pavement. This tire rubber build up obscures pavement macrotexture and ultimately compromises the safe take-off and landing operations. (Aaron Pullen B. et all, 2016)

2.1. Pavement Texture

Safe aircraft operations are generally influenced by the surface characteristics of the runway. Pavement textures are basically classified based on the magnitude of amplitudes and wavelengths deviating from a true planar surface.

<table>
<thead>
<tr>
<th>Table 1 Pavement Texture Classifications (After PIARC, 1987)</th>
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<tbody>
<tr>
<td><strong>WAVELENGTH(λ)</strong></td>
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<tr>
<td>Micro texture</td>
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<tr>
<td>Macrotecture</td>
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<tr>
<td>Mega texture</td>
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2.1.1. Microtexture

Micro texture is the roughness of the pavement. The fine scale particles on the pavement surface are not readily discernible to the eye, but are apparent to the touch, like the feel of fine sandpaper. In asphalt surfaces, the type of aggregate used will also help to increase and maintain the micro texture of the pavement. The presence of course grain and rocks high in silica which are most effective in providing long wear to the pavement and will constantly renew abrasive surface. (CARC, 2010)

2.1.2. Macrotexture

Macrotecture deals with the visible roughness of the pavement texture. The primary function of the macrotexture is to provide direction for water to escape from the surface so that the landing of aircraft will not be affected.
Micro texture of the pavement provides frictional properties for the aircraft which are operating at low speeds. Macrotexture provides frictional properties for aircraft which are operating at high speeds, combinedly they provide adequate frictional properties for the aircraft throughout their landing or take off speed range. (CARC, 2010)

2.2. HYDROPLANING
Hydroplaning of aircraft tires is often one of the major contributing factor in overrun and veer off accidents in the airports, therefore hydroplaning of aircraft tires has is studied for many years for a proper solution in order to prevent the hydroplaning. The majority of the current knowledge on hydroplaning was obtained mainly by NASA studies. Since then new tire types like radial tires are been introduced for civil aircraft. This paper will discuss the hydroplaning characteristics of these modern tires. Simple theoretical models in combination with empirical data will be used to analyse the hydroplaning characteristics. Hydroplaning will occur in situation when the aircraft runway surface zone is contaminated with water, snow or slush, these materials will seriously affect the controllability and braking of the aircraft. Basically there are 3 different types of hydroplaning which are categorised based on the amount of water deposited them are:

a) Dynamic hydroplaning.
b) Reverted hydroplaning.
c) Viscous hydroplaning.

One of these three can render an aircraft partially uncontrollable during landing or take off time.

2.2.1. Dynamic Hydroplaning
This is relatively a very high speed process that occurs when there is a film of water on the runway pavement that is at least one-tenth inch deep on the pavement surface. When the speed of the aircraft and the relative depth of the water increases, then the water which is built up on the surface will increase resistance to the displacement which will eventually result in formation of wedge of water beneath the aircraft tire.

2.2.2. Reverted Rubber Hydroplaning
This type of hydroplaning occurs during heavy breaking of aircraft which will results in a prolonged locked wheel skid on the surface texture. Thin film of water on the runway is required to facilitate this type of hydroplaning. Tire skidding on runway will generate enough heat which will cause the rubber in contact with the runway pavement to revert to its original uncured state. This reverted rubber will act as a seal coat between the aircraft tire and the runway texture, it will prevent water draining from the runway into drainage system. Reverted hydroplaning frequently follows dynamic hydroplaning, during which the pilot may have brakes locked in an attempt to slow the aircraft, through this way eventually the airplane will slow down the tire which make contact the runway surface and the aircraft begins to skid.

2.2.3. Viscous Hydroplaning
Viscous Hydroplaning is caused due to the various viscous properties of water. A thin film is formed on the runway surface which is of one thousandth of an inch in depth. This thin film layer on the surface will not allow the tire to penetrate through the thin film, which will occur at a lower speed than dynamic hydroplane, but require a smooth acting surface such as asphalt or a touchdown area which is been coated with the accumulated rubber of the previous landing.
3. TECHNIQUES USED FOR REMOVAL OF RUBBER DEPOSITS

The most common techniques for the removal of rubber from the runway pavements are as follows:

- Water Blasting Method
- Shot Blasting Method
- Chemical Removal Method
- Mechanical Method

3.1. Water Blasting Method

In this water blasting method deposited rubber on the runway surface is removed by means of rotary devices that move along the surface as it cleans. Horne and Griswold (1975) reported that water blasting to remove runway rubber deposited on U.S airports began in 1973. Michael Hammons I et all (2016) stated that this method is done by using around 30 gallons (113.362 litres) of water per minute at pressure which is between 100-1000 bars. The water which is been used during this process will penetrate the surface effectively by cleaning the rubber which is stored on the runway texture, this will also create a hydraulic effect on the pavement top layer. A combined suction part that picks up the rubber debris during this operations usually accompanies the same. This process will allows the runway pavement to get easily and quickly returned to operations which will ultimately help in continues flow of aircrafts in the airport. McKeen and Lenke (1984) reported that a maximum allowable water pressure is of 8000psi (55MPa).

Advantages of this techniques

1. The speed at which rubber is removed is 1200m² per hour.
2. The cost efficiency of the process is moderate.
3. The friction characteristics of the pavement texture due to the penetration of the water and the rubber removal will be improved.
4. The flexibility of getting off the runway in the event of any emergency.
5. The usage of this method is independent of the weather conditions and can also be operated in specified conditions like cold conditions.

Disadvantages

1. Noise pollution will be more so hearing protection are essential.
2. Small rubber fragments will be dispersed in the atmosphere so protection will be necessary.
3. The rubber removal is around 70%.
4. This will also damage the sea*ling.
5. Cannot be used to clean AGL (above ground level).
6. Heavily damages certain asphalt types of antiskid.
7. Appropriate disposal of waste material is to be done.

3.2. Shot Blasting Method

According to the Reza Ashtiani.S et all (August, 2016) stated in his paper that this process totally relies on a machine Propels some abrasion particles onto the runway surface will blast the contaminant from the runway pavement surface texture .That propels some form of abrasive particles, it also states that that there are different proprietary machines which are ranging pattern from roughly 0.15 to 1.8m in width. Lulu Edward et all (2013) coats that these operations are environmental safe because these are carried out by self-processes using
natural material like water. The containment and the equipment can also be adjusted for further producing the desired runway texture result. The primary reason for using this shot blasting method is for the removal of paint from the surface and resurfacing and retexturing of the runway pavement texture and not necessarily for the removal of the deposited rubber on runways in some main cases.

Horne and Griswold (1975), Jean (2006) concludes in their papers that the case study airports the content analysis in which texture tests are includes states that this method is used for the retexturing and not be selected for the rubber removal alone. The rubber removal is an incidental result of usage of shot blasting method to retexture runway pavement that has lost its skid resistance for reasons other than deposited rubber.

Advantages
1. It retextures pavement and will remove the rubber deposited in excess of 1000m$^2$ per hour.
2. Retexturing is done by removing a thin layer of the pavement and coincidentally removing rubber deposited.
3. By this method all the rubber can be removed while working.
4. The used equipment is truck mounted and can be easily be removed from the runway.

Disadvantage
1. Expensive for mobilisation.
2. Overall cost for this method is very expensive.
3. Noise and vision hazards due to operations process of machine.
4. Required care need to be taken during the operations on the runway.

3.3. Chemical Removal Method
In this method some environmentally friendly chemicals are used or developed artificially which are safe and which are very much effective in removal of the deposited rubber from the runway surface. The methodology is by spraying the chemicals on the deposited rubber surface area, later on we will be using the scrubbers, brush or can also be removed by technical persons manually. The mechanism in this method is the chemical used in the process will break down the deposited polymerized rubber into a soft jelly like substance or fluid, which can be removed easily with less effort.

As stated in the ACRP (JUNE 2008) the volatile and toxic nature of the chemical used dictates that extreme care need to be taken during and after the application of the chemical on the surface. If the chemical is allowed to remain on the runway surface for too long, there is a chance that the paint on the surface and the pavement strength can be damaged. Since the application process consists of spraying of the solvent solution on the deposited area, waiting a period of 1hr, the washing and sweeping is done in that area.

As it is stated in Thames Water Environment and Quality (2001) the two detergents in the formulation are widely used in a wide range of various applications, it also states that the surfactants are expected to be adequately biodegradable and there are no current adverse environmental implications with their use. Now coming to the final stage of the process which is after the application of the chemical on the surface, the deposited substance is then flushed off the runway pavement by using water blasting method if necessary. While this process is in progress the runway will be out of service due to the slippery conditions of the runway texture. It is likely that one touchdown zone 900m*24m could be treated in one eight hour shift.
Advantages

1. Rubber is cleaned at the same time as HPW.
2. Lit softens and removed the deposited polymerized rubber.
3. This method can also be accomplished by using airport staff and the airport equipment.

Disadvantage

1. Once the process is started the runway pavement will remain close until the process is done.
2. It is expensive in comparison to HPW and Track jet.
3. Possess an environmental problem due to the usage of the chemical which are not biodegradable over the time.
4. Requires more than one person for the completion of this process.
5. Large amount of effluent will be needed for the disposal.
6. Requires more attention while removing of rubber after spraying of chemical on it.

3.4. MECHANICAL REMOVAL

This mechanical removal method is generally carried out either by grinding or by milling. In Shot blasting process, the primary reason of the machine is not for the removal of rubber from the runway pavement surface. The main aim of this method is to remove the rough patches on the pavement and profiling high spots on the pavement surface. If this process is carried out for long time this will ultimately help in the removal of the deposited rubber on the runway surface. **Speidel (2002)** states in his paper that as most mechanical methods literally will remove a thin layer deposited rubber of 3mm to 5 mm along with the pavement surface, they are probably least friendly towards grooved runway texture and the grooves often have to redone to return to their design depth of 6mm to effectively drain the water deposited water on the runway surface due the rubber deposition.

Following are two different mechanical methods:

a) High Pressure Water Cleaner

**ICAO Part 2,4TH edition (2002)** states that the equipment ranges from a single, manually operated nozzle supplied by pump and water tends to sophisticated self-propelled semitrailer in corpora ting a pump, 22700L capacity water tank and oscillating high pressure water spray. The pressure is between 350kg/cm² and 700kg/cm² are common.

b) Hot Compressed Air Cleaner

The machine operates on an air/gas mixture fed in a combustion chamber where burning takes place. The resulting exhaust is emitted at about 400m/s from orifices at a temperature of approx 1200°C directly onto the surface these gases soften and share off the rubber particle. When a hot compressed air cleaner is used on concrete surfaces, a small amount of carbon deposit is produced, this can be brushed from the surface of the concrete using a normal tractor or any other brush machineries which are already present in the airport provinces.

Advantages

1. Removes high areas such as bumps on pavement surfaces or at joints where slabs have shifted or faulted.
2. Mills asphalt surface for preparations of overlaying.
3. Improves pavements surface friction characteristics by removing a thin surface layer.
Disadvantages

1. This can cause micro cracking of the structure leading to an accelerated ageing of the surface.
2. This will damage the runway surface texture.

4. VARIOUS METHODOLOGIES FOR RUNWAY FRICTION EVALUATION

Currently there are several types of friction measuring devices in operation in different airports in different countries. They adopt diverse principles and differ in their basic technical and operations characteristics. The results of several research programmes for correlating of various friction measuring equipment should have shown that the correlation between the friction values obtained from the devices which have satisfactory achieved on wetted surface pavements. However, consistent and reliable correlation between devices and the aircrafts stopping performance has not been achieved on wet pavement surfaces till now.

Measurements obtained by friction measuring devices on artificially wetted surfaces can also be used as an advisory information for maintenance and should not be totally relied upon to predict aircraft stopping performance. Following are the basic technical specifications for the friction measuring devices: (ICAO Part 2, 4TH edition 2002)

- Mode of measurement.
- Ability to maintain calibration.
- Mode of braking.
- Excessive vibrations.
- Stability.
- Friction coefficient range.
- Acceptable error.
- Allowable tire vibrations.

There are several friction-measuring devices in use today. Two decelerometer, the Tarpley Meter and Brakemeter-Dynometer, provide a spot check on compacted snow/ice-covered runway pavement friction related conditions. The seven devices described below will provide a permanent and continuous trace of friction values produced on a strip chart for the entire runway length surveyed. Although the operational modes of the continuous friction-measuring devices are different, certain components operate in a similar manner. When conducting a friction survey for the maintenance programme, they all use the same smooth tread friction-measuring tire, size 4.00 - 8 (16 × 4.0, 6 ply, RL2) made to ASTM E1551 specification, with the exception of the Grip Tester which uses a smooth tread tire, size 10 × 4.5-5 made to ASTM E1844 specification. Following are some of the most commonly used friction measuring devices:

4.1. MU-METER

The Mu-meter is a 245 kg trailer designed to measure side force friction generated between the friction measuring tires passing over the runway pavement surface at an included angle of 15 degrees. The trailer is been constructed with a triangular frame on which two friction-measuring wheels and a rear wheel are been mounted upon it. The rear wheel will help by providing stability to the trailer during the operation. A vertical load of 78 kg will be generated by ballast via a shock absorber on each of the friction-measuring wheels. These friction-measuring wheels will operate at an apparent slip ratio of 13.5 per cent. The Mu-
meter, being a trailer device, requires a tow vehicle; if in case the self-water system is required, then a water tank should be mounted on the tow vehicle to supply water for nozzles. The distance sensor is a sealed photo-electric shaft encoder mounted on the rear wheel of the trailer which can read digital pulses in increments of a thousand-per-wheel revolution, then the data will be transmitted to a signal conditioner to calculate the time taken by trailer for every one meter.

The load cell is an electronic transducer mounted between the fixed and movable members of the triangular frame. The load cell reads minute tension changes from the friction-measuring wheels. The signal conditioner is mounted on the frame and amplifies analog μ data received from the load cell and digital data from the distance sensor. The signals from the rear wheel distance sensor provide both distance measurement and, combined with increments of real time, speed measurement. Processor provides a continuous chart of friction values for the surveyed area.

ICAO Part 2,4TH edition (2002) states that Five chart scales are available to the operator: 25 mm equals approximately 20 m, 40 m, 85 m, 170 m and 340 m, these scales can be used to conduct a micro-investigation of areas where potential problems are suspected.

### 4.2. RUNWAY FRICTION TESTER

The Runway Friction Tester is a vehicular method which has a tire, made to ASTM E1551 specification, mounted as a fifth wheel connected to the rear axle to a van. The vehicular van will be equipped with front wheel and which supported by a powerful engine. The friction-measuring wheel is designed to operate at a fixed slip ratio of 13%. The test mode utilizes a two axis force transducer which measures both the drag force and the vertical load on the friction-measuring wheel. This method eliminates the need to filter the vehicle’s deflections and the effects of tire wear, thus giving instantaneous measurement of dynamic friction. ICAO Part 2,4TH edition (2002) states that a vertical load of 136 kg will be generated on the friction wheel. The Runway Friction Tester will be equipped by a self-water system and tank. Vehicle speed and distance travelled are been computed into a digital computer from pulses supplied by an optical encoder. The drag force and vertical load forces on the test wheel are sensed with the help of strain-gauged, two-axis force transducer and amplified for input into the digital computer. The digital computer samples values approximately five times for each metre of travel and computes the dynamic friction coefficient.

When conducting a friction survey, the data is been processed and will be sent to a printer which provides a continuous strip chart recording of μ and velocity values. Average μ values are printed alongside the chart. Transmission continues throughout the survey at appropriate intervals until the entire length has been surveyed. Three chart scales are available to the operator which are namely 25 mm equals approximately 30 m, 90 m and 300 m. (ICAO Part 2,4TH edition 2002)

### 4.3. SKIDDOMETER

The BV-11 Skiddometer is a trailer equipped with a friction-measuring wheel with a tire which is been designed to operate at a fixed slip ratio in between 15 and 17 per cent, depending upon test tire configuration. It consists of a four-sided welded frame supported by two independently sprung wheels. The equipped three wheels are connected together by roller chains and sprocket wheels, with a gear ratio to force the centre friction measuring wheel to rotate with a motion relative to the surface at the desired slip ratio. A vertical load of 105 kg is applied on the friction-measuring wheel by a weight via a spring and shock absorber. Since the Skiddometer is a trailer, it requires a tow vehicle. If a self-water system is required during
the process, a water tank must be mounted on the tow vehicle, along with a water supply line to the nozzle present on the BV-11 Skiddometer.

The torque applied upon friction-measuring wheel is measured with a special torque transducer. The speed of the trailer is measured by a tachometer generator, driven by one of the roller chains. A cable between the trailer and the towing vehicle converts the analog signals to a strip chart recorder located inside the tow vehicle. The data taken on a friction survey are processed by a digital computer and recorded on a strip chart as a continuous trace of friction values for the entire length surveyed. Basically four scales are available to the operator for measuring distance on the strip chart: 25 mm equals approximately 112 m, 225 m, 450 m and 900 m. *(ICAO Part 2,4TH edition, chapter 5, 2002)*

4.4. SURFACE FRICTION TESTER

The Surface Friction Tester is an automobile which uses a fifth wheel with a tire, made to ASTM E1551 specification, located in the trunk to measure the coefficient of friction. Figure 5-10 shows the configuration of the Surface Friction Tester. The automobile is equipped with Front-wheel drive; an optional turbo-charged engine is also available. *David Elton J. and Milton Harr E (2015)* states that the friction-measuring wheel is designed to operate at a fixed slip ratio of between 10 and 12 per cent, depending on the type of friction-measuring tire used in the survey. It is connected to the rear axle of the free rolling rear wheels by a chain transmission that is hydraulically retractable. *David Elton J. and Milton Harr E (2015)* also coats that a vertical load of 140 kg is generated by a weight via a spring and shock absorber on the friction measuring wheel. The Surface Friction Tester is equipped by a self-water system and tank mounted in the rear seat area of the vehicle. *(David Elton J. and Milton Harr E, 2015)*

The torque acting on the friction-measuring wheel and the distance travelled are been fed into a digital computer where the information will be converted into coefficient form. The electric current flowing through the strain gauges within the torque sensor located on the friction measuring wheel is affected by minute to minute changes in the tension of the chain transmission. Therefore, any variations in the frictional forces are monitored by the digital computer which measures these variations of the electric current and converts the analog signals into coefficient of friction data. The obtained \( p \) values are all continuously stored in the digital computer; upon completion of the survey, they are recorded on a strip chart as a continuous trace of \( p \) values for the entire length surveyed. The required speeds during the test, as well as data to identify the test, are also been recorded on the strip chart. The scale for measuring distance on the strip chart is 25 m which equals 100 m.

4.5. TATRA FRICTION TESTER

The Tatra Friction Tester is an automobile which has a hydraulically operated fifth wheel using an ASTM E1551 specification test tire, located in the rear seat area, to measure the coefficient of friction. The automobile is powered by an air-cooled, V-8 engine which is located above the rear-driven axle and produces 220 HP or, optionally, 300 HP. The vehicle is equipped with two internal water tanks and a water dispersal system. Vertical loading of the measuring wheel is adjustable from 25 kg to 145 kg.

The system can be programmed to perform continuous friction-measuring equipment (CFME) mode or variable slip-measuring mode, which can be operated either automatically or manually. In the CFME mode, the test tire can be slipped between 0 % - 60% of the forward speed. Aircraft wheel braking is simulated by using the variable slip measuring mode which has an adjustable increase of the slip per time (distance) and the value (steepness) from 0 per cent to the maximum required, up to 99 per cent. The coefficient of friction of the
surface to be tested is evaluated using the forward speed of the device, the distance measured, the surface characteristics and wheel slip. These data are measured and are been collected by the engine speed sensor, hydro generator speed induction sensor and sensor present on the left front wheel will measure the vehicle's forward speed and distance. Monitoring equipment comprises a computer, three microprocessors, a display screen and a printer, as well as automatic calibration and diagnostic systems.

4.6. RUNWAY ANALYSER AND RECORDER (RUNAR)
The standard RUNAR is a trailer equipped with the RUNAR basic friction-measuring unit. It is a hydraulically braked machine using an ASTM E1551 specification test tire. The basic unit measures 90 cm H x 45 cm W x 80 cm L and weighs approximately 100 kg. The trailer mounted configuration has a total weight of 400 kg. A version for side mounting on a maintenance truck has a total weight of approximately 150 kg. The measuring sensors are mounted on the hydraulic brake providing continuous data which are collected, processed, stored and displayed to the operator by the data-processing computer. The instrumentation in the vehicle consists of a touch-screen operation panel and a 10-cm graphic roll or A4 colour graphic printer. The RUNAR can be operated at speeds up to 130 km/hr. Measuring can take place above 20 Km/hr.

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4.7. DECELEROMETER
Decelerometer provides the most reliable information when pavement surfaces are covered by compacted snow and ice. Decelerometer should not be used on wet pavement surfaces, also tests should not be conducted when pavement surfaces are covered with loose or dry snow which have depth exceeding 51 mm or with slush exceeding depth 13 mm. Since decelerometer have to be mounted inside a vehicle, certain requirements for the vehicle have to be met to ensure that reliable and consistent measurements are obtained. Acceptable vehicles are large sedans, station wagons, intermediate or full-size automobiles, utility and passenger-cargo trucks, vehicles that have front wheel or four-wheel drive, and vehicles that have an ant locking braking system (ABS) on the rear axle.

The decelerometer should be installed in the vehicle according to the manufacturer’s instructions. It should be placed in the vehicle so that it is not displaced by any vehicle movement. The decelerometer should be maintained and calibrated according to the manufacturer’s recommendations. It is necessary to take a certain number of readings to obtain a reasonable appraisal of the runway surface condition. The total runway length is divided into three equal portions — the touchdown, mid-point and rollout zones. A minimum of three tests at the speed of 35 km/h should be conducted in each zone. An averaged μ number should be determined for each zone. The averaged μ numbers are always recorded in the same direction the aeroplane lands.
The following procedures should be used in conducting friction surveys.

a) Brakes should be applied sufficiently hard to lock all four wheels and then should be released immediately. The time during which the wheels are locked should not exceed one second.

b) The decelerometer which is used should record or should retain the maximum retardation braking force which occurs during the test.

c) Random figures that are very much high or very much low may be ignored while calculating the average values.

**Brakemeter-Dynometer**

The Brakemeter-Dynometer consists of a finely balanced pendulum free which will respond to any changes in speed and angle, while working through a quadrant gear train to rotate a needle around a dial gauge. The dial is been calibrated in percentage of “g”, which are accepted as standards for measuring acceleration and deceleration. For stopping all vibration, the instrument is filled with a fluid which is independent of changes in temperature. The meter, which requires a vehicle for transport, should always be used with a floor mounting stand. This device should be only used on runway surfaces which are covered with ice/snow compacted surfaces. This is device is not recommended for wet runway pavement surfaces.

**Tarpley Meter**

There are basically two versions of the Tarpley Meter which are available in the market: the original Tarpley (a standard mechanical decelerometer) and the Tarpley Electronic Airfield Friction Meter, these both require a vehicle for transport and are basically recommended only on compacted snow or ice covered runway surfaces pavements. They are not recommended for operation on wet runway pavement surfaces. . *(ICAO Part 2,4TH edition, Ch. 5, 2002)*

**Mechanical Decelerometer**

This mechanical decelerometer version is a small pendulum-based decelerometer which consist of a dynamically calibrated, oil-damped pendulum in a sealed housing. The pendulum in this decelerometer is magnetically linked to a lightweight gear mechanism. The pendulum is magnetically linked to a lightweight gear mechanism to which is attached a circumferential scale which will show values in percentage of “g”. A lightweight ratchet retains the maximum scale deflection reached upon completion of the test. The data collected has to be visually read and recorded by the operator during the process is going on and the average for each one – third segment of the runway mentally calculated and recorded.

**5. CONCLUSION**

After studying all the different types of methods used for the removal of the deposited rubber on the runway surface the best optimum method which can be used for the removal the rubber will be shot blasting method. This method is suggested by considering all the parameters like economy of airport, traffic of aircrafts, availability of equipment and the effectiveness of removal of the deposited rubber without damaging of the runway pavement texture. The selection of the friction measuring device depends on the type of airport and the number of aircrafts landing on the runway, airports having high traffic density will use the suitable device accordingly. This also depends upon the standards used by the respective.
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