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Pavement Surface Friction Management

ALACPA Short Course on Pavements Maintenance

Course Objective

- Principles of Pavement Friction
- Design & Construction Considerations
- Pavement Evaluation
  - Method
  - Equipment
- Friction Level Classification
- Maintaining High Skid-Resistance

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Pavement Roughness & Skid Resistance

- Pavement surface friction otherwise known as skid resistance or surface roughness is the main pavement surface characteristic that provides resistance between the aircraft tires and the ground to minimize uncontrolled aircraft movements and controlled stops
- Discussing the effects of pavement texture with respect to friction and hydroplaning; two common terms are used to describe the pavement surface roughness are Macrotexture and Microtexture
- This course will discuss these two components and how they interact with the whole dynamic system associated with the critical tire/ground contact area that provide safe skid resistance for the controlled stops of landing aircrafts on wet pavement

The Dynamic System

- The dynamic system is the process of the interaction between the airfield pavement, the aircraft, and the pilot, working together to prevent the aircraft from rolling, skidding or slipping across the pavement surface.
- The process envelopes the pavement friction characteristics, the aircrafts aerodynamics and braking capabilities, and the pilots ability to control the aircraft

The Dynamic System

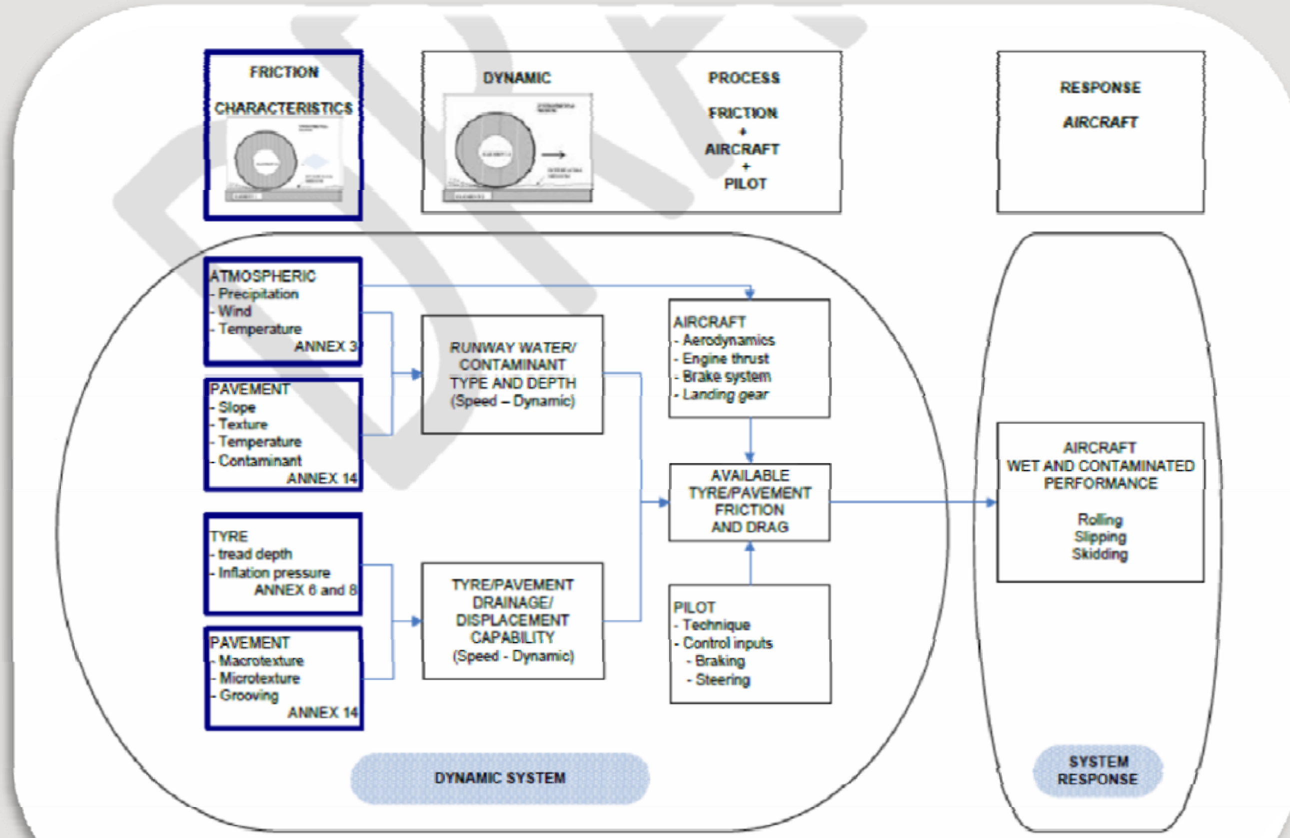

Figure 3.1 - Basic friction characteristics, the dynamic system and the system response.

The Dynamic System

- Although the dynamic system encompasses the pavement friction, the aircraft and the pilot, the aircraft response depends largely on the tire-pavement friction and the anti-skid system of the aircraft.
- The course will literally focus on “where the aircraft tires meet the ground”; the pavement friction system

Friction Basic Characteristics

- Basic friction properties belonging to the individual components of the friction component of the system:
  - Pavement surface (runway)
  - Tire (aircraft)
  - Contaminates (between the tire and the pavement)
  - Atmosphere (temperature, radiation; as effecting state of contamination)

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Pavement Friction System

- The basic friction characteristics of the critical tire/ground contact area, being part of the dynamic system, influences the available friction that can be utilized by an aircraft

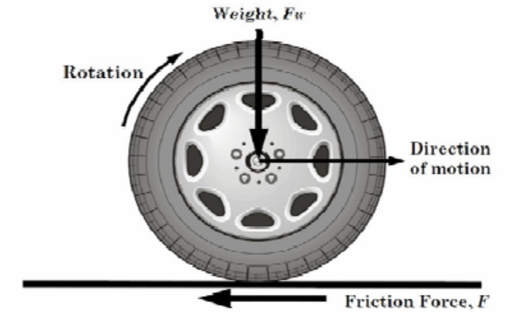


Figure 8. Simplified diagram of forces acting on a rotating wheel

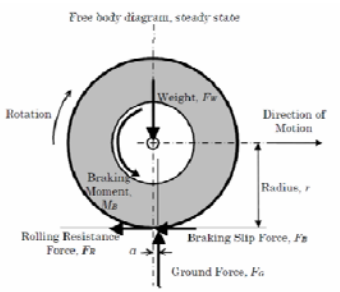


Figure 10. Forces and moments of a constant-braked wheel on a bare, dry paved surface (Andresen and Wambold, 1999).

System Main Components

- The three main components of the system:
  - Surface friction characteristics (static material properties)
  - Dynamic system (relative motion of aircraft/pavement)
  - System response (aircraft performance)

Airfield Pavement Basic Function

- Provide adequate bearing capacity
- Provide good riding qualities
- Provide good surface friction characteristics
- Other requirements
  - Longevity
  - Ease of maintenance

Key Definitions

- Dry pavement – pavement which is clear of contaminates and visible moisture within the required length and width being used
- Wet Pavement – pavement that is neither dry nor contaminated
- Contaminated Pavement – 25% or more of the pavement surface within the length and width being used is covered by:
  - Water, slush more than 3-mm deep
  - Loose snow more than 20-mm deep
  - Compacted snow or ice, including wet ice
  - Rubber deposits
  - Or other material which affects the pavement friction surface and its ability to quickly shed water off its surface

Dry Pavement

- When in a dry and clean state, the pavement provide operational insignificant differences in friction levels, regardless of the type of pavement and the configuration of the surface
- Friction levels available are unaffected by aircraft speed
- Operation on dry clean runways surfaces are satisfactorily consistent
- Provides best skid resistance

Wet Pavement

- Friction of pavement surface affected by water, can be expressed primarily as a general drainage problem consisting of three distinct criteria:
  - Surface drainage (surface shape, slopes)
  - Tire/ground interface drainage (Macrotexture)
  - Penetration drainage (Microtexture)
- These three criteria are significantly influenced by engineering measures, it is important that all three criteria are satisfied to achieve adequate friction in wet conditions

Contaminated Pavement

- Friction problems on pavement surfaces affected by contaminants can be expressed primarily as a generalized maintenance problem, most dominant being:
  - Ponding/flooded water (3-mm depth)
  - Rubber deposits
  - Snow, slush ice or frost, and
  - Other deposits such as sand, dust mud, oil, etc
- Issues can be significantly influenced by the level of maintenance provided

Pavement Surface Texture

- Surface Texture – most important aspect of pavement surface relative to its friction characteristics
- The effect of the surface material on the tire-to-ground coefficient of friction arises principally from the differences in surface texture
- Surface textures are normally designed with sufficient roughness to provide suitable water drainage rate at the tire/pavement interface
- Pavement texture is broken into two main components:
  – Microtexture, and
  – Macrotexture

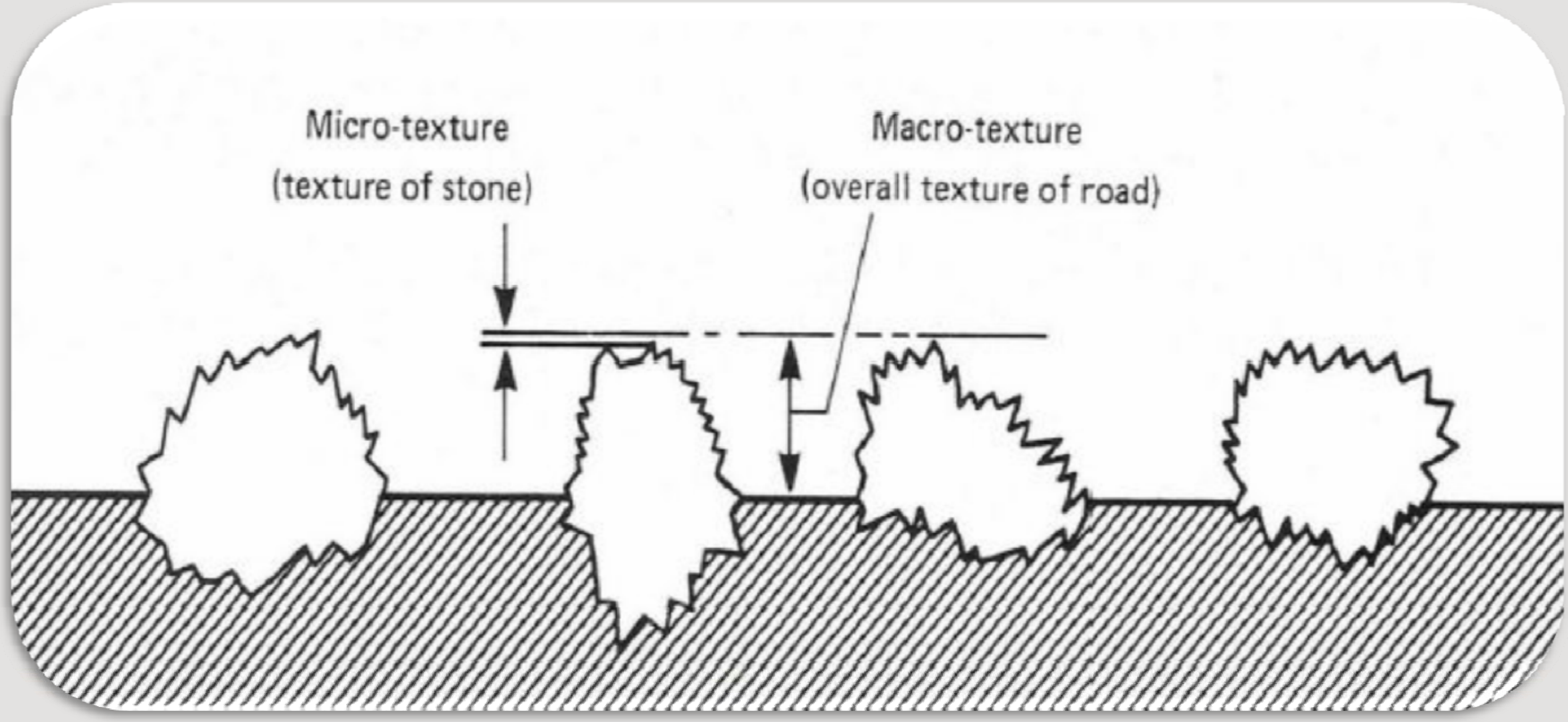
Microtexture

- The texture of the individual stone; hardly detectible by human eye
- Considered the primary component of skid resistance at slow speeds
- On wet surfaces at high speeds, water film may prevent direct contact between the surface roughness and the tire due to the lack of drainage between the contact areas
- Microtexture is built in quality of the pavement's aggregate
  - Crushed aggregate, which withstand Polishing
  - Microtexture and Drainage of thin water film are ensured for longer period of time
  - Resistance to polishing is expressed through the polish stone values (ASTM D3319, CEN EN 1097-8)
- Microtexture can change in a short time frame without easily being detected

Macrotexture

- The texture between the individual stone
- Created by the size of the aggregate used or by the surface treatment
- Grooving adds to the Macrotexture, although how much it adds depends on the width, depth and spacing.
- Macrotexture is a major factor influencing the tire/ground interface drainage capacity at high speeds

Microtexture/Macrotexture



Surface Drainage

- Surface drainage is a basic requirement of the utmost importance
- Objective to drain water off the pavement in the shortest possible path
- Average surface texture depth should provide adequate drainage in expected rainfall conditions
- Macro and micro texture should be taken into consideration in order to provide good surface friction characteristics
- Drainage capabilities can be enhanced by special treatments such as grooving or porous friction courses

Surface Drainage

- Note that special surface treatment is not a substitute for good pavement construction and maintenance practices
- Rapid drainage of surface water is a primary safety requirement that minimizes water depth across the pavement surface
- The objective is to drain water off the pavement in the shortest path possible and particularly out of the wheel path area; in effect there are two distinct drainage processes taking place:
  - Natural drainage of the surface water along top of pavement surface
  - Dynamic drainage, surface water trapped under moving tire until it reaches outside of tire/ground contact area

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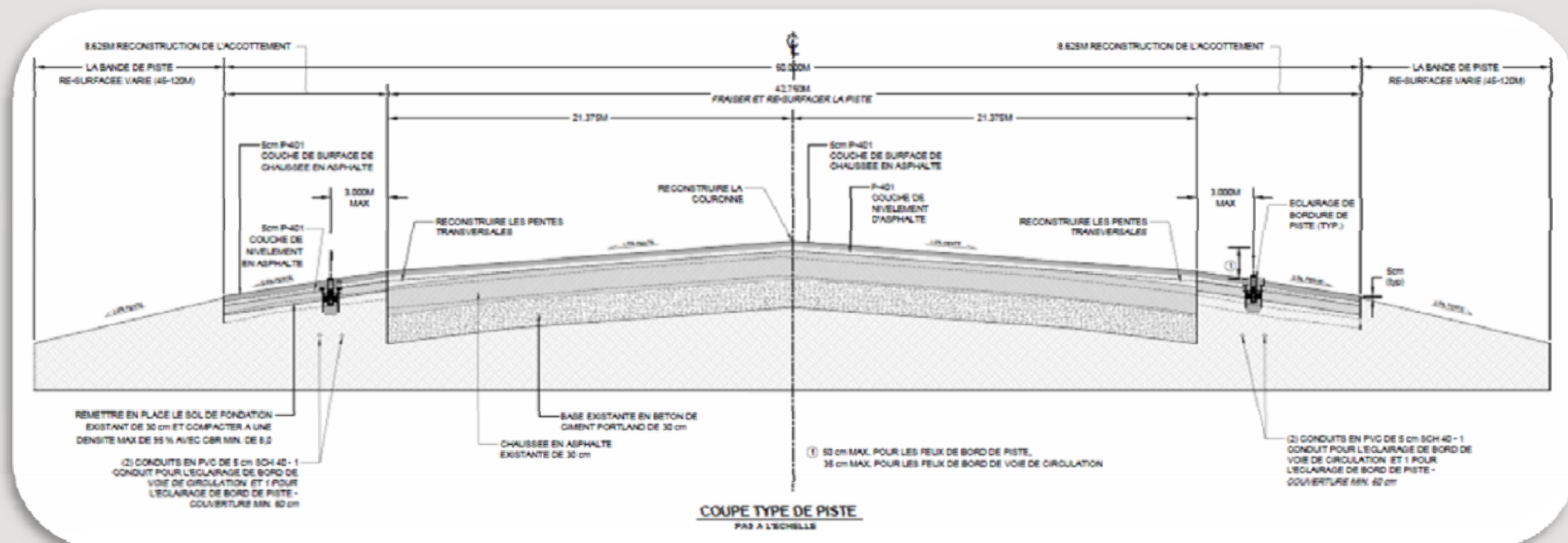
Natural Drainage

- Natural drainage is achieved through design of slopes allowing the surface water to flow away from the pavement.
- Resulting longitudinal and transverse slopes producing a natural runoff drainage path



Dynamic Drainage

- Achieved through providing texture in the pavement surface.
- Where the rolling tire builds up water pressure and squeezes the water out through escape channels provided by the pavement texture
- Dynamic drainage is improved with transverse grooves in the pavement

Surface Drainage Characteristics

- Natural drainage is achieved through the design and construction of sloped pavement sections. The combination of longitude and transverse slopes provides a natural gravitational drainage runoff path
- While dynamic drainage is achieved through the ability for surface water to be squeezed out from between the tire/pavement contact area through the texture of the pavement surface
- These surface drainage characteristics are built into the pavement as:
  - Longitudinal Slopes
  - Transverse Slopes
  - Pavement Textures
    - Microtexture, and
    - Macrotexture

Slopes

- Adequate surface drainage is provided primarily by appropriate longitudinal and transverse slopes and surface evenness.
- Maximum slopes allowed throughout the airfield are given in ICAO Annex 14
- Further slope guidance in the Airport Design Manual Part 1

Microtexture Drainage

- Objective to achieve high water discharge rates from under the tire with minimal dynamic pressure buildup
- Interface drainage between the individual aggregate and the tire dependent upon the fine texture on the surface of the aggregate
- At low speeds allows water escapes at tire/pavement contact area
- Utmost important to use crushed aggregate, which provides a harsh Microtexture surface that will withstand polishing (rough sandpaper)

Macrotexture Drainage

- Objective achieve high water discharge rate from under the tire with minimal dynamic pressure build up, this can only be achieved by providing a surface with an open Macrotexture
- Interface drainage is a dynamic process correlated to the square of speed; therefore Macrotexture is particularly important for the provision of adequate friction levels at high speed ranges
- From an operational perspective, this is most significant because it is at the high speed range where lack of adequate friction is most critical with respect to stopping distance and directional control
- Since Aircraft tires lack grooving such as car tires therefore the effective skid resistance of the tire is diminished by design
- ICAO Annex 14 recommends a Macrotexture of no less than 1-mm, MTD (Mean Texture Depth) (FAA 1.14-mm) for new pavement

Rainfall Impacts

- Rainfall brings moisture to the pavement surface, which will have an effect on the aircrafts performance, flight test data shows the smallest amount of water may have a significant effect on aircraft performance
- Damp pavement effectively reduces the braking action below that of a clean and dry pavement
- Rainfall on pavement that has good drainage characteristics has a lesser effect on an aircraft braking abilities; grooved and porous friction surfaces fall into this category
- At times when the pavement drainage capabilities are exposed to heavy or torrential rain, the system can be overwhelmed by water, especially when maintenance has been neglected
- Well maintained grooved runway pavements have been tested by NASA to provide adequate skid resistance with puddles or flooded pavemnets when the grooves are spaced no more than 30-mm (6x6 mm)

Surface Drainage

- In order to prevent the accumulation of surface water, both the natural and dynamic drainage process can be controlled through
  - Proper Design,
  - Good Construction, and
  - Constant Maintenance

Design & Construction Practices

- In building new airfield pavement, major reconstruction or rehabilitation, or adding overlays, the design engineer must choose either HMA or PCC as the basic paving component. The selection is typically based on economics, local preferences and other design factors
- The structural, surface condition and skid resistance durability of the pavement is dependent on the quality of the three primary material used in construction:
  - Aggregate
  - Portland Cement Concrete
  - Hot Mix Asphalt

Aggregate Properties

- The aggregate used in the construction of the airfield pavement should be of high quality and at a minimum encompass the following characteristics:
  - Crushed Rock, with a minimum of 70% with two fracture faces and 85% with one fracture face
  - Aggregates should be well blended if natural and synthetic aggregate are combined
  - The size and gradation should meet the pavement mix standards to produce the desired surface texture and strength
  - Exhibits Good Microtexture, resistance to polish and wear
  - Properties Values Meet FAA AC 150/5370-10 *Standards for Specifying Construction of Airport (P-401, P-402, P-403 & P-501)*

Hot-Mix Asphalt Friction Surfaces

- HMA must have good waterproofing & high structural performance
- Aggregate properties (size, shape, gradation resistance to polish and wear), are key Microtexture properties for good Macrotexture
- HMA mix design mechanical properties must have good adhesion of binder to aggregate, stiffness, resistant to permanent deformation, resistance to fatigue/crack initiation and resistance to abrasion
- Well graded Asphalt Mix design meeting the industry standards set by ICAO & FAA will produce an acceptable friction level after construction
- New HMA non-grooved pavement Macrotexture is typically 1.0-mm to 1.144-mm after construction
- Surface is usually quite smooth after construction, neverless several methods are available to improve the surface texture and friction
- Use of Porous Friction Course or Transverse Grooving improves friction characteristics

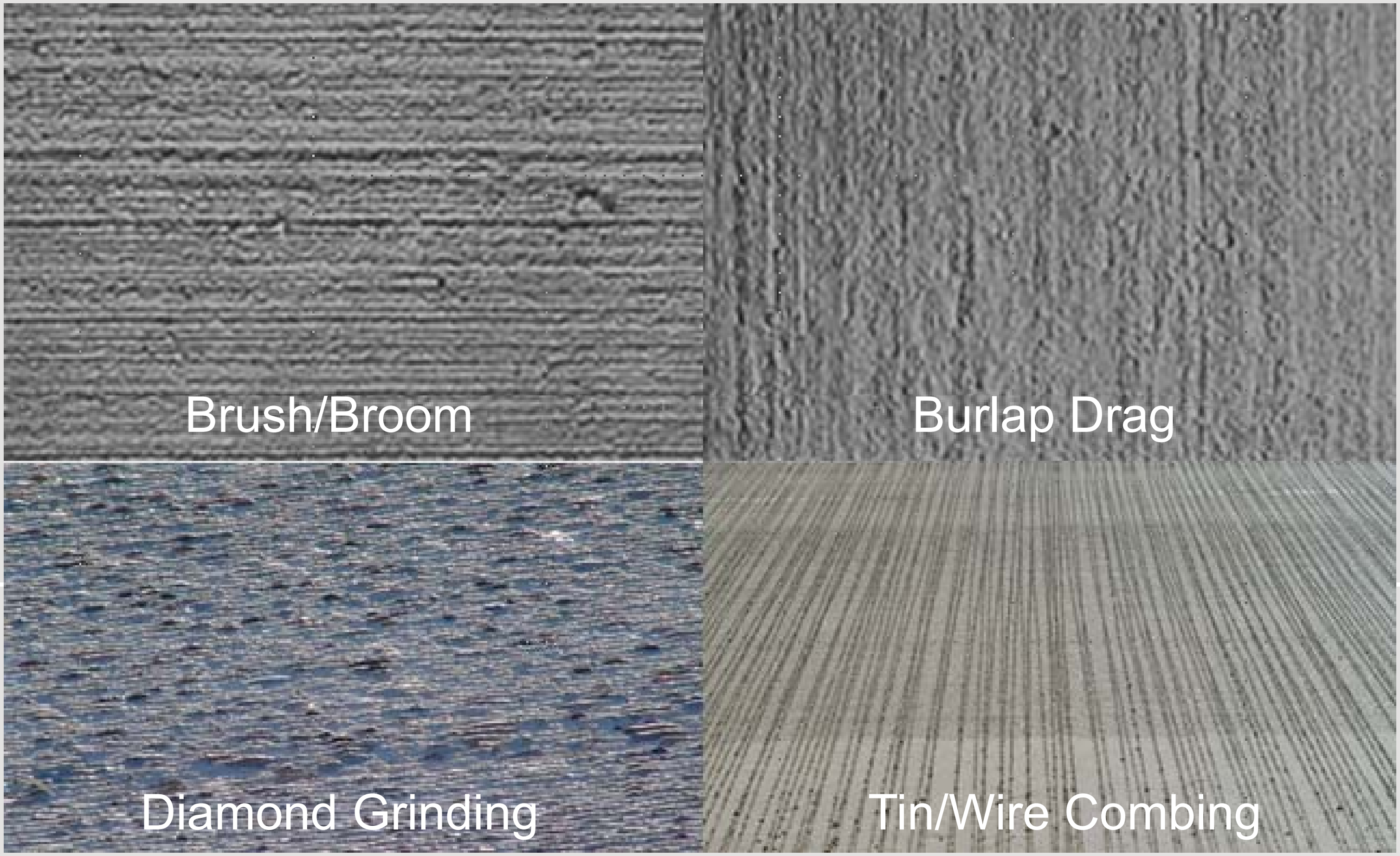
Porous Friction Course Pavement

- Open –Graded pavement course designed as a free draining wearing surface of uniform thickness placed on top of a sound structural pavement section
- Porosity adds to the pavement texture at the tire/ground interface and provides escape channels for dynamic drainage

Portland Cement Concrete Friction Surfaces

- PCC should have good waterproofing & high structural performance
- Friction characteristics of PCC are obtained by transversal texturing of the concrete surface under construction in the plastic physical state:
- Types of Finishes:
  - Broom or Brush,
  - Burlap drag,
  - Wire Comb/Wire Tinning and
  - Diamond Grinding

Portland Cement Concrete Friction Surfaces



Airfield Pavement Grooving

- Primary purpose, enhances runway drainage and tire/ground interface
- Natural drainage can be slowed down by the pavement texture, yet significantly improved by grooving
- Grooving adds to the pavement texture at the tire/ground interface and provides escape channels for dynamic drainage
- Reduces hydroplaning
- Enhances the Macrotexture
- Can be Used on HMA & PCC

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Airfield Pavement Grooving

- Grooving typically 6-mm x 6-mm with a 38-mm spacing.
- Spacing can be increased to 76-mm, yet 38-mm provides best performance
- Grooves are transverse and continuous across the pavement section ending 3-meters from edge
- Can be saw cut into the pavement for HMA & PCC
- Ribbed Rolled or Vibrating Plate Ribbed into the PCC when in the plastic state

Airfield Pavement Grooving

Typical Groove Geometry

Country	Condition	Groove Geometry			Macrotexture	
					Asphalt	
		Width (mm)	Depth (mm)	Spacing CL to CL (mm)	Un-grooved (mm)	Grooved (mm)
Australia USA	New	6		38	0.65	1.49
Norway	New	6		125	0.7 - 1.6	0.95 - 1.81
UK	New	4	4	25	0.65	1.19

Average grooved pavement Macrotexture equal to or greater 1.35 for new construction

Effect of Grooving on Macrotexture

$$M_g = \frac{WD + M_g\,(S-W)}{S}$$

where M_g grooved Macrotexture

W groove width

D groove depth

M_u un-grooved Macrotexture

S groove spacing

Skid Resistance

- Pavement friction characteristics are a dynamic system of an aircraft in motion
  - Surface Friction Characteristic (drainage, surface texture)
  - Dynamic system of the aircraft (tire/ground interface)
  - System response
- These three components when properly addressed will maximize skid resistance of the airfield pavement
- In order to ensure that wet pavement will provide the required skid resistance, the pavement friction characteristics should be frequently evaluated

Skid Resistance

- Factors that Cause the loss of skid resistance
  - Mechanical wear and polishing action from rolling, braking of tires or from equipment used for maintenance
  - Accumulation of contaminates
- Microtexture & Macrotexture directly relate to the two physical friction characteristics of the pavemnet that generate friction when in contact and relative motion with the aircraft tire

Skid Resistance

- Microtexture
  - Can be lost when exposed to mechanical wear of the aggregate (Polishing);
  - Polished Stone Value (PSV), the susceptibility of mechanical wear of aggregate
  - PSV is measured in accordance with (ASTM D3319, ASTM E303 and CEN EN 1097-8)
  - Microtexture is reduced by wear and polishing, which effect the skid resistance at low speeds

Skid Resistance

- Macrotexture
  - Affects the high speed tire braking characteristics, rough Macrotexture will provide a greater tire to ground friction when the pavement is wet
  - Macrotexture is reduced and lost when the voids between the aggregate are filled with contaminates, such as rubber, sand, snow, ice and slush
  - Preferred to develop pavement management programs aimed at improving surface texture and drainage, such that safety is improved

Pavement Surface Friction Evaluation

- It's erroneous to believe that the coefficient of friction is a property belonging to the pavement surface….this is not the case as described earlier. It is a system response generated by the dynamic components system consisting of:
  - Pavement surface
  - Tire
  - Contaminants, and
  - Atmosphere

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Pavement Surface Friction Evaluation

- As the airfield pavement is utilized, it becomes worn, weathered and contaminated
- Over time the skid resistance deteriorates, due to the mechanical wear and polishing actions of braking and the accumulation of contaminates such as rubber and sand, but mainly rubber
- In the efforts to assure that the runway pavement skid resistance is adequate, the pavement surface should be evaluated frequently as required by the FAA or ICAO to determine the friction levels and how they relate to the safe operations at the airport

Pavement Surface Friction Evaluation

- The evaluation should address the following:
  - Verify friction characteristics of new and existing pavements
  - Periodically assess the slipperiness of the wet runway pavement
  - Determine pavement friction when drainage characteristics are poor
  - Determine pavement friction under unusual conditions
  - Periodic friction evaluation should be performed on each runway that accommodates jet aircraft
- Evaluations should be carried out in accordance with the FAA AC 150/5320-12
- Evaluations should be scheduled at least once a year, yet is dependent to the number of daily jet landings per end of runway
- Friction measuring is a tool used maintenance planning and minimum friction level

Pavement Surface Friction Evaluation

Pavement Surface Friction Evaluation Frequency

Number of Daily Turbojet Aircraft Landing per Runway End	Minimum Friction Survey Frequency
Less than 15	1-Year
16 to 30	6-Months
30 to 90	3-Months
91 to 150	1-Month
151 to 210	2-Weeks
Greater than 210	Every Week

Pavement Surface Friction Evaluation

- Visual Survey – although visual inspection are essential for determining surface defects, yet the micro/macro friction characteristic cannot not be measured by the naked eye
- Friction Evaluation should be performed with a Continuous Friction Measuring Equipment (CFME)
- Texture depth should be performed with pavement texture depth testing tools

Pavement Surface Friction Evaluation

- Minimum Friction Evaluation consists of:
  - Friction Characteristic along the length of the runway, collected with a CFME (note all friction measurements to be performed on wet pavement)
  - Visual Inspection of surface inadequacies, such as drainage problems, ponding, groove deteriorations and structural deficiencies
  - Pavement Surface Texture Measurements

Friction Measurement Using CFME

- Friction measurement should be proceed by a thorough visual surface inspection
- CFME can be a vehicular mounted or trailer pulled
- Operator is trained and certified for the specific equipment

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Friction Measurement Using CFME

- CFME should be a self wetting system, capable of delivering a water depth of 1-mm in front of the friction measuring tire
- CFME shall have an electronic data logger which is capable of providing continuous, accurate and reliable friction measurements along the entire length of the runway
- Capable of automatically providing the operator with a section average friction value for both 150-meters and one-third segments

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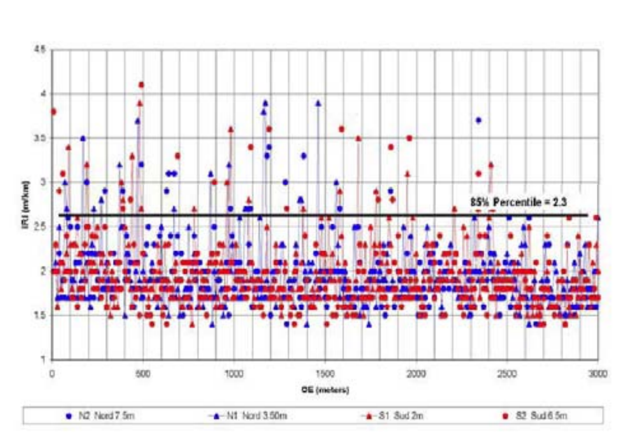
Friction Measurement Using CFME

- Capable of producing a permanent trace of friction measurement versus pavement length
- Capable of providing friction survey at 65 and 95 km/h
- Have electronic instrumentation including keyboard, internal microprocessor, and readily visible to the operator of the vehicle



Friction Measurement Using CFME

- Friction surveys should be performed at both 65 km/h and 95 km/h
  - The lower speed determines the overall Macrotexture of the pavement while the higher speed provides an indication of the Microtexture
- Lateral location is based on the type and mix of aircraft operating at the airport:
  - Survey should be conducted at 3-meters and 6 meters for wide bodies from the centerline of the runway for narrow body and wide body aircrafts respectively

Friction Level Classification

- Friction Values (Mu) measured by the CFME can be used as guidelines for evaluating the pavement surface friction deterioration of the pavement, and current maintenance needs
- By comparing historical data, the friction deterioration rate of the pavement can be forecasted and preventative maintenance can be scheduled
- Results should be recorded in the Pavement Management Program

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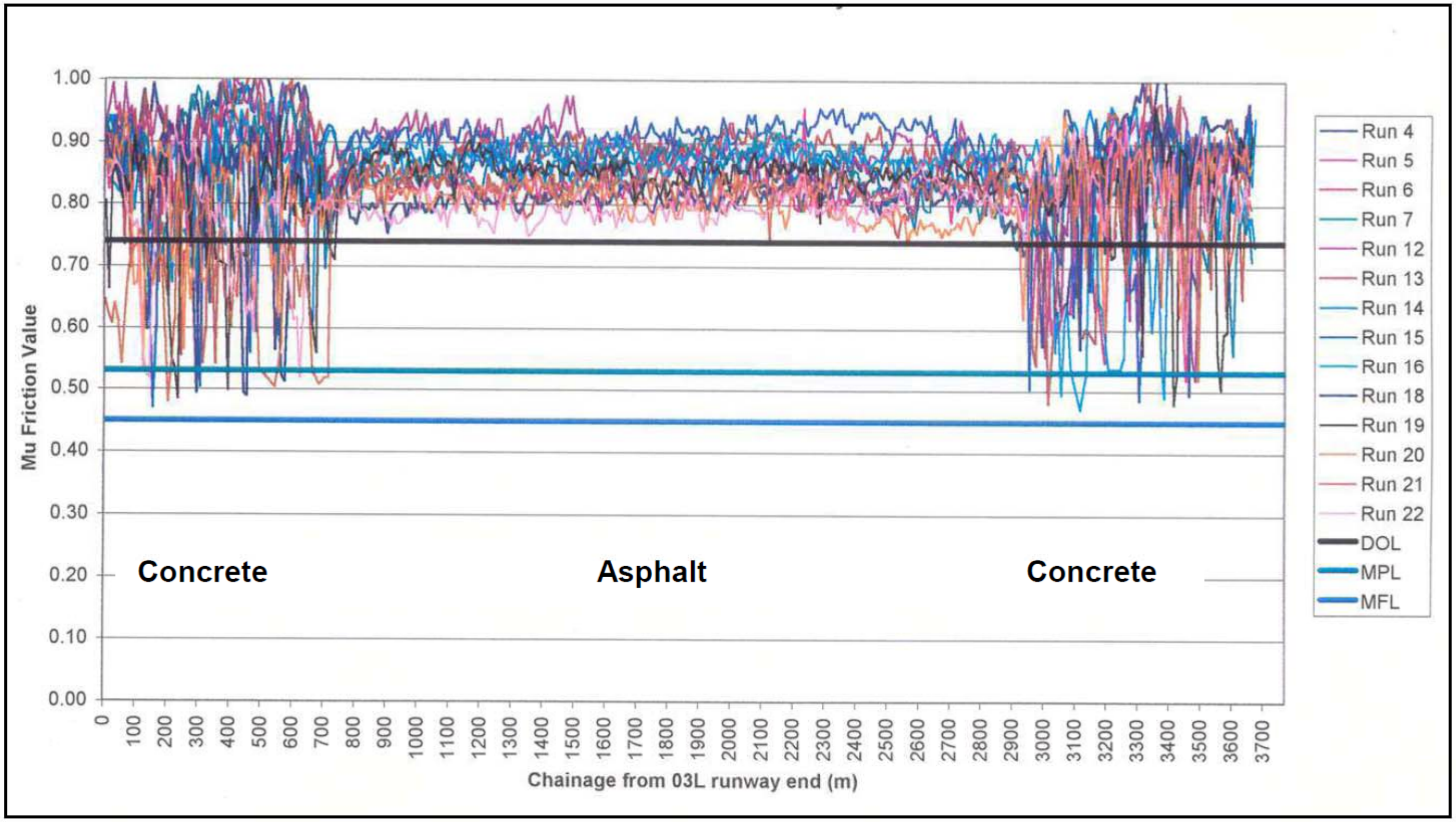
Friction Level Classification



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ICAO Friction Level Classification

Test Equipment	Tire Test		Test Speed (km/h)	Test Water Depth (mm)	New Construction	Maintenance Planning	Minimum Level
	Type	Pressure (kPa)					
Mu Meter	A A	70 70	65 95	1 1	0.72 0.66	0.52 0.38	0.42 0.26
Airport Equipment Co Skiddometer	B B	210 210	65 95	1 1	0.82 0.74	0.60 0.47	0.50 0.34
Airport Surface Friction Tester	B B	210 210	65 95	1 1	0.82 0.74	0.60 0.47	0.50 0.34
Runway Friction Tester Vehicle	B B	210 210	65 95	1 1	0.82 0.74	0.60 0.47	0.50 0.34
Tatra Friction Tester	B B	210 210	65 95	1 1	0.76 0.67	0.57 0.52	0.48 0.42
Findlay, Irvine LTD Griptester Friction Meter	C C	140 140	65 95	1 1	0.74 0.64	0.53 0.36	0.43 0.24

Values depicted are for non-grooved pavement surfaces

FAA Friction Level Classification

Test Equipment	65 km/h			95 km/h		
	Minimum	Maintenance Planning	New Construction	Minimum	Maintenance Planning	New Construction
Mu Meter	0.42	0.52	0.72	0.26	0.38	0.66
Dynatest Consulting, Inc Runway Friction Tester	0.50	0.60	0.82	0.41	0.54	0.72
Airport Equipment Co Skiddometer	0.50	0.60	0.82	0.34	0.47	0.74
Airport Surface Friction Tester	0.50	0.60	0.82	0.34	0.47	0.74
Airport Technology USA Safegate Friction Tester	0.50	0.60	0.82	0.34	0.47	0.74
Findlay, Irvine LTD Griptester Friction Meter	0.43	0.53	0.74	0.24	0.36	0.64
Tatra Friction Tester	0.48	0.57	0.76	0.42	0.52	0.67
Norsemeter RUNAR (operated at 16% slip)	0.45	0.52	0.69	0.32	0.42	0.63

Values depicted are for non-grooved pavement surfaces

Evaluation & Maintenance Guidelines

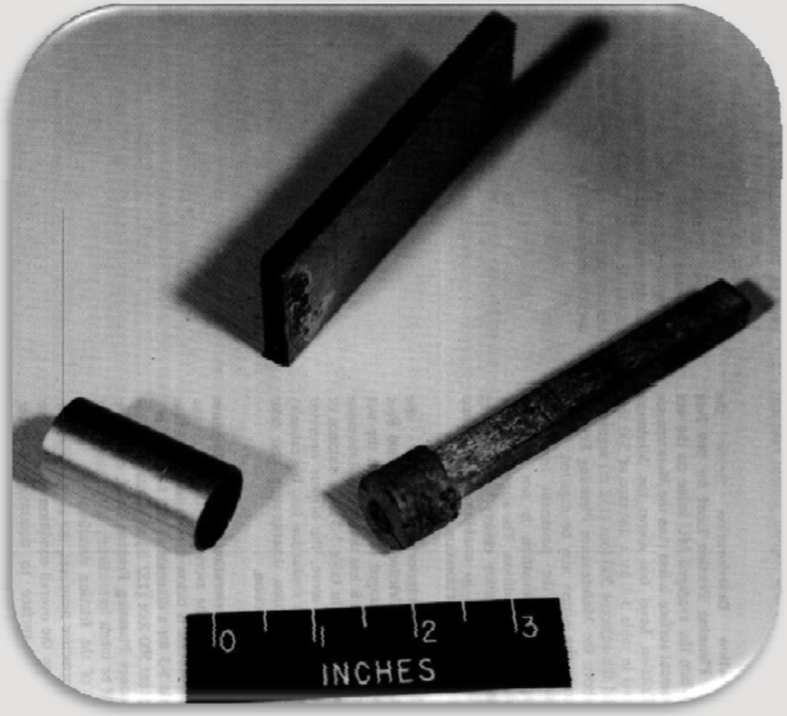
Friction Deterioration	Action
Below maintenance planning level yet above minimum level for a distance of 152-meters and the adjacent 152-meter segments are above maintenance planning level	No Action Required, within acceptable level, yet determination of deterioration rate and monitoring of friction surface required
Below maintenance planning level yet above minimum level for a distance more than 305-meters	Conduct extensive evaluation in determining the cause(s) and extent of the friction deterioration and take appropriate corrective action
Below minimum level for a distance of 152-meters and the adjacent 152-meter segments are below maintenance planning level	Corrective action should be taken immediately after determining the cause(s) of the friction deterioration, in addition overall surface condition should be evaluated
Newly constructed pavement surfaces, that are either saw cut or grooved	New constructed grooved pavement Mu values should be no less than those values specified in the aforementioned tables for new construction for each 152-meter segments

Visual Inspections

- Pavement visual inspection should be performed in accordance with FAA AC 150/5320-7, as discussed in the previous session
- Visual inspection should occur prior to the execution of the friction measurements
- Results should be implemented into the Pavement Management Program along with the friction values obtained

Texture Depth Measurements

- When the friction values are below acceptable values and it is obvious that contaminates are the cause of the reduction of friction, a Texture Depth Measurement should be performed
- Texture Depth Measurements verifies the Macrotexture characteristics



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Texture Depth Measurements

- Groove depths are never included in texture depth measurements
- Measurements should be taken in the non-grooved areas within the heavily trafficked areas
- Minimum of three measurements should be taken within areas noted as friction deficient
- More tests should be taken when obvious texture changes are noticed in the pavement surface
- FAA AC 150/5320-12 Provides guidance on how to perform the test

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FAA Recommended Texture Depth

Texture Condition	Action
Newly constructed pavement's average texture depth for HMA & PCC not lower than 1.14-mm	A lower value indicates a deficiency in the Macrotexture construction that will require corrective action as the surface deteriorates
Existing pavement's average texture depth for HMA & PCC lower than 1.14-mm	Texture depth measurements should be conducted every time a runway friction survey is performed
Existing pavement's average texture depth for HMA & PCC lower than 0.76-mm but above 0.40-mm	Initiate plans to correct the pavement texture deficiency within ONE YEAR
Existing pavement's average texture depth for HMA & PCC lower than 0.25-mm	Initiate plans to correct the pavement texture deficiency within TWO MONTHS
Retexturing	Retexturing of pavement surface should improve the average texture depth to a minimum of 0.76-mm

ESDU 71026 Runway Texture Classification

- ESDU 71026 groups runways into five classifications, based on the surface texture of the pavement.
- Classification are labeled “A” through “E” with “A” being the smoothest and “D” being the petered operation surface Macrotexture value

Runway Classification	Macrotexture/Texture Depths
A	0.10 – 0.14
B	0.15 – 0.24
C	0.25 – 0.50
D	0.51 – 1.00
E	1.01 – 2.54

Note that excess roughness may damage aircraft tires.

Analyzing and Logging Friction Surveys

- Friction and Texture Evaluation data collected from the respective surveys should be logged into the Airport's Pavement Management Program (PMP) for comparison
- Average friction and texture depth should be mapped onto the PMP at 152-meter intervals
- Areas with poor friction and surface roughness values should be identified

Analyzing and Logging Friction Surveys

- Utilizing past survey deterioration rates should be calculated for each survey
- A correction plan should be developed for those surface sections which do not meet the minimum levels specified by ICAO or FAA
- For those areas that are within specifications; using the historic survey data and the deterioration rates, a maintenance plan should be created based on forecasted deterioration

Pavement Friction Maintenance

- Pavement surface basic friction characteristics are:
  - Pavement surface
  - Aircraft Tire
  - Contaminates
  - Atmosphere
- In this section, all we will be discussing are the pavement surface and how contaminates impact it

Pavement Friction Maintenance

- Pavement friction or roughness is composed the static material properties which assist in the draining of water from underneath the aircraft wheel :
  - Macrotexture, and
  - Microtexture

Pavement Friction Maintenance

- When either of these two components deteriorate below the maintenance planning level, the skid resistance of the runway is decreased such that the safe landing on wet pavements may be jeopardized
- Normal wear and tear along with contaminates can reduce the surface roughness of the pavement and reduce skid resistance

Pavement Friction Maintenance

- Typical Pavement Contaminates
  - Rubber deposit
  - Dust particles
  - Jet fuel
  - Oil spill
  - Water
  - Snow ice
  - Ice slush

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Methods for Removing Contaminates

- Water Blasting
- Chemical removal
- Shot Blasting
- Mechanical means, such as:
  - Grinding
  - Plowing
  - Sweeping

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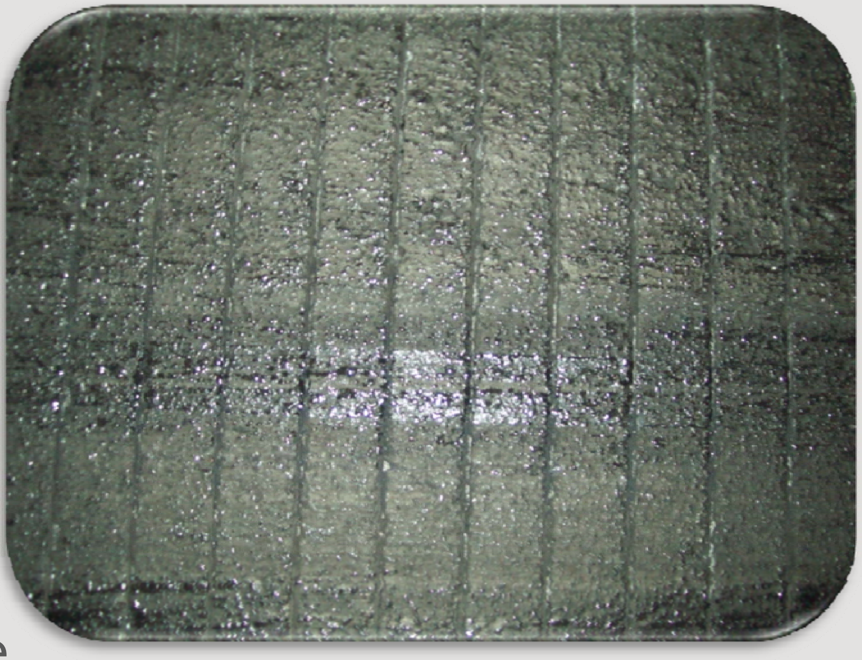
Rubber Buildup Removal

- The most common containment that effects pavement skid resistance is rubber buildup along the touch down zones
- Rubber buildup is typically removed by:
  - High pressure water blasting
  - Chemical removal
  - Shot Blasting
  - Mechanical means

Rubber Buildup Removal

- High pressure water blasting is the most common method used to remove rubber from the pavement surface
- Technique is economical, environmentally friendly, and effective in removing rubber with minimal down time to the runway
- Equipment can be easily removed from runway
- Loose rubber can be swept to the runway edge or collected by a pavement sweeper



Rubber Buildup Removal

- Removal of rubber by chemical means is another alternative
- Chemical solvents must meet national, state and local environmental requirements
- For PCC, the chemicals are typically a cresylic acid blend of benzene with a synthetic detergent as a wetting agent
- For HMA an alkaline base chemical is used
- Caution should be taken using chemicals if left too long it may damage the pavement surface, and markings
- Chemical requires a reaction period which may be several hours, runway/pavement cannot be utilized during the removal process due to the slipperiness of the removal process

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Rubber Buildup Removal

- Shot blasting rubber removal method that produces an acceptable surface texture
- The method is self contained and environmentally friendly
- Abrasive material is recycled
- Equipment can rabidly be removed from the runway
- Shot blasting has been used to restored the texture in polished pavement surfaces

Rubber Buildup Removal

- Mechanical Removal of rubber buildup employs the corrugating technique to grind away a 3 to 5 mm depth of pavement, thereby retexturing the surface and removing all contaminates
- Milling 3 to 5 mm off the top of the pavement can assist in the removal of high spots “bumps”
- Note that milling of the pavement surface may cause the roughness value to exceed the aircraft tire capacity and cause damage to the aircraft tire and/or a “tire blowout”

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Rubber Buildup Removal

- No single method works best for rubber removal
- Caution should be taken with which method used that the pavement surface is not damaged during the removal process

Dust & Snow Removal

- Dust/Dirt removal is typically performed with vacuum style or broom sweeper
- Advantage of utilizing a wire broom sweeper to remove FOD and dust from the runway surface is that the sweeper will also remove loose rubber from the surface
- The combination of a plow and broom sweeper along with chemicals are typically used to remove snow, slush, ice or wet ice from the pavement

Surface Restoration

- Once the pavement surface texture falls to such a level were common maintenance practices will not restore the surface roughness to acceptable levels, the following options may be considered:
  - Surface dressing
  - Retexturing by milling 3 to 5 mm off the surface
  - Grooving the pavement (if pavement not grooves)
  - Mill and overlay of HMA

Surface Dressing

- Skid resistance can be improved by surface dressing the pavement with high quality crushed aggregate and modified polymer binder
- This product has a high texture depth and can damage aircraft tires
- Airport's Engineer need to verify final depth and ensure that the new texture will not cause damage to aircraft tire
- If the pavement structure and surface properties are sound, retexturing the pavement by either shot blasting or milling 3 to 5 mm off of the pavement surface is a variable option

Surface Grooving

- If the pavement structure and surface properties are sound and is not grooved, grooving of the runway pavement may be an option if the roughness values are above the maintenance level
- Recommend a 38-mm groove spacing for optimal effectiveness

Pavement Overlay

- If the HMA pavement shows considerable amount of distress along with polishing and wear it maybe most economical and efficient to rehabilitate the pavement surface with an asphalt overlay.
- The overlay should consider a PFC or grooving

Summary on Pavement Texture Evaluation

- Pavement texture consists of two key components, the microtexture and the macrotexture
- Both components interact and provide a suitable pavement friction
- Pavement texture needs to be verified constantly to ensure safe airfield operations, evaluation should not be limited to the runway, high speed exists, taxiways and other heavily trafficked areas must be checked
- Friction survey results should be logged and inputted into the PMP
- Sound construction methods along with proper maintenance will provide pavement friction durability
- Overall the pavement texture during wet conditions is critical for the safe operation of the airfield

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Survey Results and the PMP

- The pavement friction field survey, surface friction levels, macrotexture depths, along with the field notes and sketches should all be inputted into the airport's Pavement Management Program (PMP).
- By inputting such data, a historic log of each survey and deterioration rates can be easily accessible for future reference

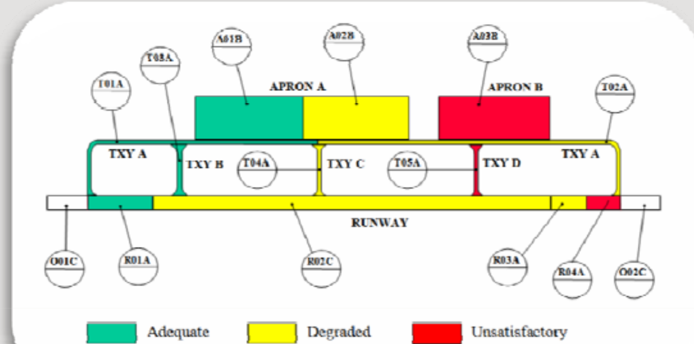
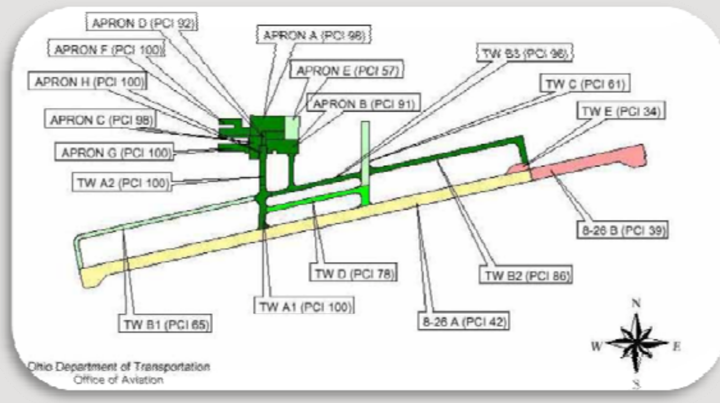


Figure 8: Sample Airfield Layout Plan



In Closing

- Sufficient pavement roughness is critical for the safe operation of aircrafts within the airfield
- Pavement friction plays a key role for the controlled braking of landing aircrafts and provides critical skid resistance on wet pavement
- It is the airport's operator responsibility to ensure that the pavement is structurally sound, the surface is free of defects and debris, and the surface texture provides adequate friction (stopping capabilities)
- By documentation and inputting the data collected during the friction evaluation process into the pavement management program a more comprehensive and effective pavement maintenance program can be generated to ensure a safe airfield

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Forum for Open Discussion