Problem: The Water Covered Runway

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Runway Grooving

- Misconceptions Have Developed Relative to Its Purpose During Its More Than 40 Years of Application.
Runway Grooving

- Prudent to Stress Reasons for Which It Is Not Used
Runway Grooving

- Not Used to Provide Drainage of Water from the Pavement Surface
Drainage

- Provided by the Transverse Slope of the Pavement Surface
- Grooves Are Cut in the Runway Surface Transversely to the Pavement Centerline and Make a Secondary Contribution to Drainage.
Runway Grooving

- Not Used to Provide an Increase in the Friction Capability of the Pavement Surface
Friction

- Friction Capability of the Pavement Surface Provided by the Quality of the Microtexture - Macrotexture Combination

Friction Provides the Skid Resistance
Skid Resistance by Other Names

- Friction
- Friction Coefficient
- Braking Coefficient
Runway Grooving

- Provides Forced Water Escape from the Pavement Surface under Aircraft Tires Traveling at High Speed
Runway Grooving

- Does Not Eliminate Hydroplaning
- Reduces Hydroplaning to a Manageable Level
- A Higher Degree of Contact is Maintained Between Aircraft Tires and the Pavement Surface under the Condition of Standing Water.
Runway Grooving

- Enables Pavement Surface Microtexture - Macrotexture Combination to Provide Sufficient Braking and Directional Control to Aircraft
- Slight to Significant as Speed of Aircraft or Water Depth on Pavement is Reduced
Runway Grooving

- Reduces Dynamic Hydroplaning (Standing Water)
- Reduces Viscous Hydroplaning (Wet Pavement with Little to No Standing Water)
Functions of Runway Surface Characteristics in the Presence of Water

- Transverse Slope Provides Drainage.
- Texture of Pavement Provides Friction.
- Grooving Enables Aircraft Tires to Contact the Pavement.
Runway Grooving

- In the Presence of Water, Totally Worn Aircraft Tires Experience Better Braking on a Grooved Pavement than Newly Treaded Tires on a Nongrooved Pavement.
Porous Friction Course
Substitutes for Runway Grooving

- Provides **Drainage** of Water from the Pavement Surface (Primary)
- Provides **Forced Water Escape** from the Pavement Surface under Aircraft Tires Traveling at High Speed Similar to Grooving (Secondary)
- Application Limited Relative to Density of Aircraft Operations
Not Substitutes for Runway Grooving

- Tire Tread
  (Demonstrated in Full Scale Tests)

- Coarse Pavement Surface Macrotexture
  (Demonstrated to a Limited Degree in Full Scale Tests)
Grooving vs. Macrotecture

- **Grooving** Lies Below the Pavement Surface. **Flexibility of Tire Cannot Seal the Path of Water Escape.**

- **Macrotecture** Is the Pavement Surface. **Flexibility of Tire Can Seal the Path of Water Escape.**
Grooving vs. Macrotexture
FAA Full Scale Test Program
Braking/Hydroplaning

- 1975 to 1983
- 600 Full Scale Tests
- Dynamic Test Track
- Asphalt and Portland Cement Concrete
- Variety of Pavement Surface Treatments
- Wet to Flooded Conditions
- Speeds of 30 to 150 Knots
FAA Full Scale Test Program
Braking/Hydroplaning

- Aircraft Tire, 49 by 17, 26 ply, type VII (Boeing 727 and 747)
- Tire Pressure, 140 psi
- Wheel Load, 35,000 lbs
- Maximum Braking Data Base
- Test Facility, NAEC (Navy), Lakehurst, New Jersey
FAA Full Scale Test Program
Braking/Hydroplaning
Water Depth Conditions on Pavement

- Wet 0.00 in. Standing Water
- Puddled 0.10 in. Standing Water
  2.54 mm
- Flooded 0.25 in. Standing Water
  6.35 mm
Launch End of Test Track
Launch End of Test Track
Dynamometer with Tire-Wheel Assembly
New and Worn Tire Tread
Saw Cutting Grooves in the Test Pavement
Test Pavement at the Recovery End of the Test Track
1/4 x 1/4 in. Grooves Spaced at 1 1/4, 2, and 3 ins.
1/8 x 1/8 in. Grooves Spaced at 1/2 in. and Porous Friction Course
Experimental Percussive Grooves at 3 in. Spacing
Grooved Pavement

- FAA Standard 1/4 x 1/4 Saw-Cut Grooves Spaced at 1 1/2 inches
- Represented by Curve Fits between Data Points for 1 1/4 inch and 2 inch Spacing
- FAA Standard in Metric 6mm x 6mm Grooves Spaced at 38 mm
Braking on a Wet Asphalt Pavement

- Worn Tire, Grooved Pavement
- New Tire, Non-Grooved Pavement
- Worn Tire, Non-Grooved Pavement
- Hydroplaning
Braking on a Puddled Asphalt Pavement

- Worn Tire, Grooved Pavement
- New Tire, Non-Grooved Pavement
- Worn Tire, Non-Grooved Pavement
- Hydroplaning
Braking on Flooded Asphalt Pavement

![Graph showing braking coefficient vs. speed for different tire conditions and pavement types. The graph includes lines for Worn Tire, Grooved Pavement, New Tire, Non-Grooved Pavement, Worn Tire, Non-Grooved Pavement, and Hydroplaning. The data points are scattered along the lines, indicating varying braking coefficients at different speeds.]
Essentials of an Aircraft Braking/Hydroplaning Test System

- Full Scale
- High Speed
- Standing Water
- Uniformity of Water Depths
- Close Control of Variables
Aircraft Braking/Hydroplaning Test System Scenarios

- Full Scale Tire-Wheel Assembly on a Dynamic Test Track (Best Control of Variables)
- Aircraft on a Runway
FAA Standard and Proposed Saw-Cut Groove Patterns

Standard

Proposed
Grooving vs. Macrotexture - New Tire on a Puddled PCC Pavement

- 0.97 mm Surface Cavity, Macrotexture 0.18 mm, Groove Spacing at 51 mm
- 0.57 mm Surface Cavity, Macrotexture 0.18 mm, Groove Spacing at 102 mm
- 0.53 mm Surface Cavity, Macrotexture 0.53 mm (Broomed 0.18 mm, Percussive Treatment 0.35 mm)

Hydroplaning
Relationship between Results on the Test Track and Performance of the Aircraft on a Runway
Braking on a Wet Asphalt Pavement

**Graph**

- **Y-axis**: Braking Coefficient (Track)
- **X-axis**: Ground Speed (knots)

- **Legend**:
  - Worn Tire, Grooved Pavement (Track)
  - In-Service Tires, Grooved Pavement (B727 ACY)
  - Worn Tire, Non-Grooved pavement (Track)
  - In-Service Tires, Non-Grooved Pavement (B727 ACY)

**Data Points**

- Worn Tire, Grooved Pavement (Track)
- In-Service Tires, Grooved Pavement (B727 ACY)
- Worn Tire, Non-Grooved pavement (Track)
- In-Service Tires, Non-Grooved Pavement (B727 ACY)
Braking on a Wet Asphalt Pavement

- Worn Tire, Grooved Pavement 1 1/2 in. Spacing (Track)
- In-Service Tires, Grooved Pavement 1 1/2 in. Spacing (B727 ACY)
- Worn Tire, Grooved Pavement 3 in. Spacing (Track)
- In-Service Tires, Grooved Pavement 3 in. Spacing (B727 ACY)
Braking on Wet Porous Friction Course

- Braking Coefficient (Track)
- Effective Braking Coefficient (B727)

Ground Speed (knots):
- Worn Tire (Track)
- In-Service Tires (B727 - Pease AFB)
- Hydroplaning

- 30
- 50
- 70
- 90
- 110
- 130
- 150
- 170
Dynamic Test Track Data Can Be Used to Simulate Tire-Pavement Interaction During the Landing and Takeoff of a Jet Transport Aircraft with Worn Tires on a Runway under Rainfall Conditions.
Inference Drawn from Simulation on Asphalt Pavement

- **Runway Grooving** Offers the Potential to **Double** The Magnitude of **Tire-Pavement Interaction** for Jet Transport Aircraft Operating on Water Covered Runways.
Landing
Fast Touchdown at 150 Knots

![Graph showing braking coefficient versus water depth for different pavement conditions.](Image)
Touchdown at 130 Knots

![Graph showing braking coefficient vs. water depth for grooved and non-grooved pavement, as well as hydroplaning. The graph indicates a significant decrease in braking coefficient with increasing water depth.](image-url)
Braking at 110 Knots

- Grooved Pavement
- Non-Grooved Pavement
- Hydroplaning

Braking Coefficient vs. Water Depth (Inches)
Braking at 90 Knots

Braking Coefficient vs. Water Depth (Inches)

- Grooved Pavement
- Non-Grooved Pavement
- Hydroplaning
Braking at 70 Knots, Approaching High Speed Turnoff

![Graph showing braking coefficient vs water depth for grooved pavement, non-grooved pavement, and hydroplaning.]

- Grooved Pavement
- Non-Grooved Pavement
- Hydroplaning

Water Depth (Inches)

Braking Coefficient
Takeoff
Takeoff Roll at 70 Knots
Takeoff Roll at 90 Knots

- Grooved Pavement
- Non-Grooved Pavement
- Hydroplaning

Braking Coefficient vs. Water Depth (Inches)
Takeoff Roll at 110 Knots

![Graph showing braking coefficient vs. water depth for grooved pavement, non-grooved pavement, and hydroplaning.]
Decision Point at 130 Knots
Takeoff or Abort

![Graph showing braking coefficient against water depth with data points for Grooved Pavement and Non-Grooved Pavement compared to Hydroplaning.]

- Grooved Pavement
- Non-Grooved Pavement
- Hydroplaning
FAA Full Scale Test Program
Braking/Hydroplaning
Technical Advances Achieved

- Maximum Braking Data Base
- Asphalt as well as Portland Cement
- Porous Friction Course as well as Grooving
- Benefit of Grooving versus Tire Tread
- Uniformly Puddled Condition
- Groove Spacing up to 4 inches
- Speeds up to 150 Knots
FAA Full Scale Test Program
Braking/Hydroplaning
Products of the Effort

- Supports Current FAA Grooving Standards.
- Spacing of 1/4 x 1/4 in. Saw-Cut Grooves Extended from 1¼ ins. to 1½ ins.
- Grooving Costs Reduced by an Estimated 7%.
- More Significant Cost Savings Possible with Slightly Greater Increases in Spacing.
Data Base Can Be Useful to Foreign Aviation Authorities in Supporting the Grooving of Runways in their Respective Countries.

Data Base Can Support the Establishment of International Guidelines for the Grooving of Runways.
FAA Full Scale Test Program
Braking/Hydroplaning

- Briefing and DOT/FAA Technical Reports Available for Download from NAPTF Website
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- Menu on left
- Located under “Downloads”, “Safety”
Dynamic Test Track

- Naval Air Engineering Center (NAEC)
- Lakehurst, New Jersey
- High Speed Films of Tests Follow: