Preventing Slippage Failures of Airfield Pavements

Research Team: Rutgers University, National Center for Asphalt Technology, and Arizona State University
Sponsored by: AAPTP, in partnership with FAA and NAPA

Runway pavements in the vicinity of high-speed exit taxiways, which allow aircraft to leave runways quickly without decelerating to typical taxi speeds, can experience slippage failures on asphalt surfaces, particularly where aircraft brake or turn. Surface shoving is an early sign of this type of pavement distress, and it can progress to full slippage cracking — increasing the risks of foreign object damage.

Source: Federal Aviation Administration

Slippage failures can lead to cracking in airport asphalt pavement.

Slippage failure can result from unstable asphalt mixtures or weak bonding between pavement layers, with temperature, mixture properties, and construction practices all influencing failure potential. The current airport pavement design primarily considers vertical loading from aircraft weight, but the braking and turning common at high-speed exits impose multi-axial stresses (compression, shear, and tension). Addressing slippage failure of runway pavements in the vicinity of high-speed exits therefore requires evaluating material properties and multi-axial stress conditions.

The Airport Asphalt Pavement Technology Program (AAPTP) initiated this study to identify the mechanisms behind slippage failures, develop material and construction specifications for inclusion in FAA Advisory Circular 150/5370-10H, and propose minimum asphalt overlay thickness requirements to prevent slippage failures.

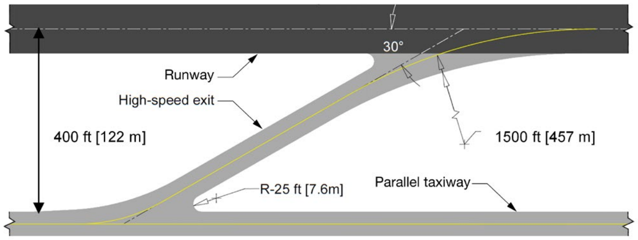
Benefits

- Improves understanding of runway pavement slippage mechanisms near high-speed exit taxiways, identifying interface delamination as the dominant failure mode.
- Defines critical shear stress ratio (SSR) thresholds to prevent surface shear flow and interface delamination under realistic aircraft loading conditions.
- Offers guidance for overlay thickness to minimize interface shear stresses and extend pavement life.
- Offers a mechanistic–empirical framework that links aircraft braking loads, temperature, and material properties to predicted failure risk.
- Supports performance-based specifications that complement FAA's rut depth and tack coat requirements.

Approach

The research combined laboratory testing and mechanistic modeling to analyze shear failure potential in asphalt mixtures and layer interfaces of airfield pavements. The cohesion and friction parameters of various airfield asphalt mixes and their interface shear strength (ISS) were measured across temperature, loading rate, air-void content, surface type, and tack coat rate.

These data were incorporated into finite element models simulating pavement stress responses under moving aircraft tires during braking at different load and tire pressure levels. A multi-axial stress criterion was used to calculate shear stress ratios (SSR) at the pavement surface and layer interface. Tests measured dynamic modulus, triaxial shear strength, flow number, repeated load permanent deformation, indirect tensile strength, interface shear strength, and interface shear fatigue life to provide inputs for numerical modeling and determine the SSR thresholds corresponding to failure. In addition, machine learning models were developed to predict pavement temperature profiles using climate data, providing more accurate estimates of in-service conditions than traditional empirical methods.



Source: Federal Aviation Administration

Schematic diagram of a high-speed exit taxiway.

Results

Laboratory and modeling results confirmed that slippage failure is primarily caused by interface delamination, with shear stress ratios at the interface exceeding those in the surface layer. Temperature was identified as the most critical factor influencing mixture stability and bond strength. Higher temperatures greatly reduced shear resistance.

Performance testing established SSR thresholds of approximately 0.70 for asphalt mixtures (to prevent surface shear flow) and 0.76 for interfaces (to prevent delamination). These thresholds were translated into the following performance criteria of asphalt mixture and layer interface below surface tested at the representative high temperature experienced in the airfield pavement: a minimum high-temperature indirect tension test (HT-IDT) strength of 45 psi for P-404 mixtures and 29 psi for P-401 mixtures, and a minimum ISS of 17 psi without confinement. Also, in terms of overlay thickness, thicker surface layers (no less than 2 inches) reduce interface shear stresses and lower delamination risk.

Implementation

Airport engineers can use the study's results during design and construction, where SSR thresholds and the corresponding HT-IDT and ISS values can be applied to select materials and layer configurations that resist plastic flow and delamination under site-specific temperature and loading conditions. Machine learning temperature models can help define critical design temperatures for each airport, allowing designers to verify mix performance under realistic conditions. While these recommendations are based on laboratory and modeling studies, full-scale testing is needed to validate the proposed material specification thresholds and refine future airport pavement design standards.

Download the ***Mitigation of Plastic Flow and Delamination of Runway Pavements at High-Speed Exits*** report for free at https://go.asphaltpavement.org/air-009.

For more details, visit:

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For more information, contact:

Richard Willis, PhD
Vice President for Engineering, Research, and Technology, NAPA
rwillis@asphaltpavement.org

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About AAPTP

The Airport Asphalt Pavement Technology Program (AAPTP) is a cooperative agreement effort between the National Asphalt Pavement Association (NAPA) and the Federal Aviation Administration (FAA) to advance asphalt pavements and pavement materials. The AAPTP advances solutions for asphalt pavement design, construction, and materials deemed important to airfield reliability, efficiency, and safety. The program leverages NAPA's unique technology implementation capabilities with assistance from the FAA and industry to advance deployment and adoption of innovative asphalt material technologies.

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