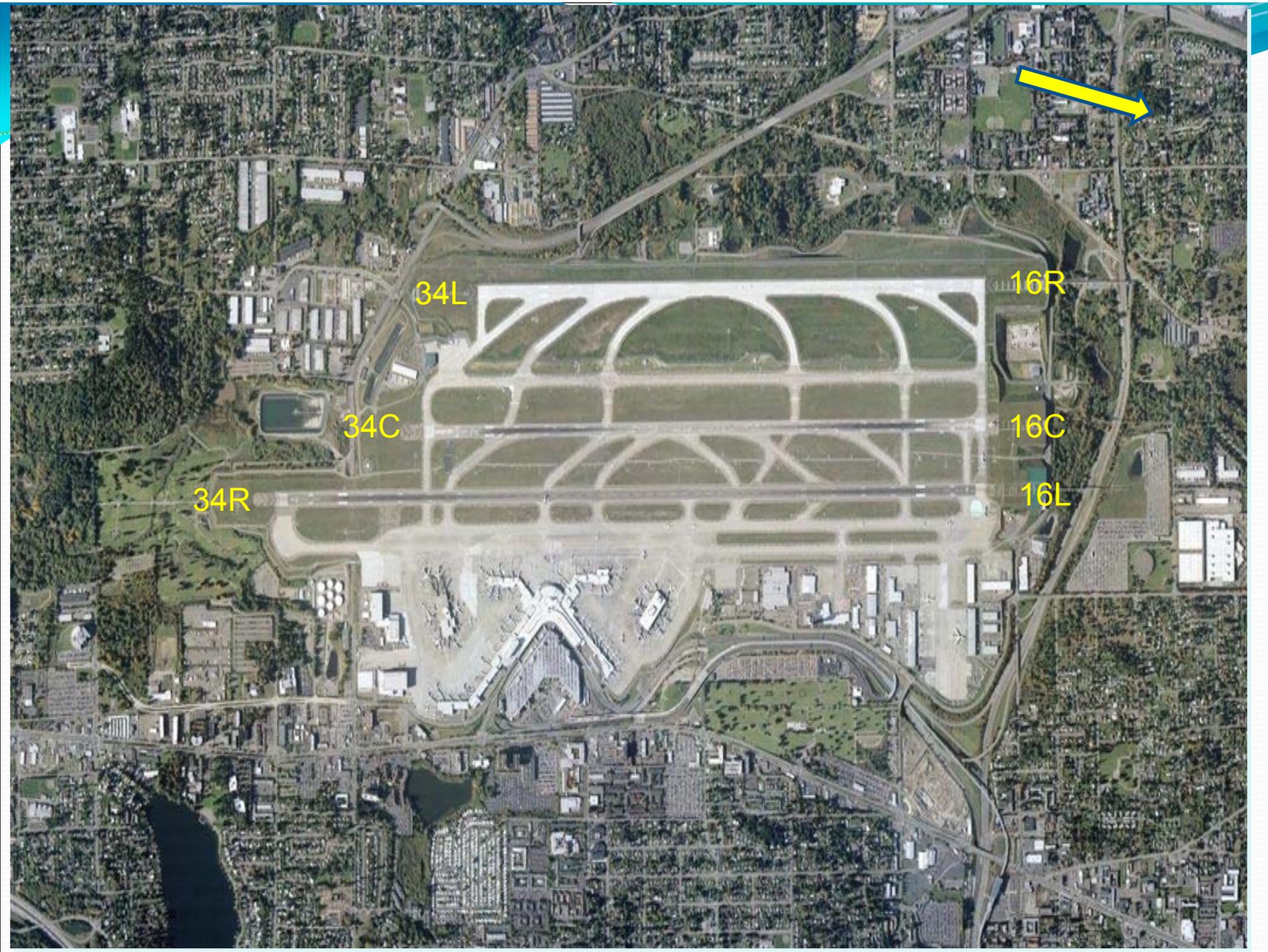
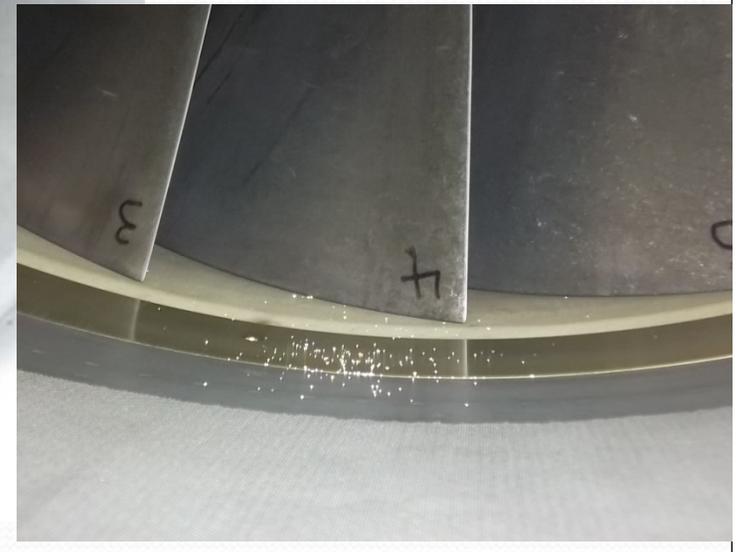


# Federal Aviation Administration Airfield Pavement Working Group

Airport Authority Pavement Perspective  
Seattle-Tacoma International Airport  
Ralph L. Wessels, PE



# Airline's Definition of FOD



Type 3 Glass Beads

# #1 Runway Pavement Pop-Outs

- STIA has added one runway and replaced another.
- Aggregate loss occurred on new RW 16R/34L completed in 2008.
- No noticeable aggregate loss on replaced RW 16L/34R completed in 2010.
- Pavement with saw-cut, grooved finish has more pop-outs than pavement with broom finish (outer 10' and around lights)

# Potential Research on Runway Pop-Outs

- What is the scope of the issue?
- What is the risk of FOD created by pop-outs?
- What is the acceptable limit of pop-outs?
- Can pop-outs be managed by a prescriptive specification?
- Can a performance-based specification be developed?
- What should be the definition of a pop-out and how to measure and quantify?
- What modification to AC 150/5370-10F may be warranted?

# Evaluation of RW 16R/34L

- Forensic evaluation of records.
- Literature and case study review.
- Limitations on availability of project personnel.
- Two visual surveys.
- Samples taken for petrographic examination, scanning electron microscope, and chemical analysis.



# Testing Results

- Elevated level of sulfur and iron in dark, soft aggregate.
- Mostly granitic and siliceous metamorphic rock.
- Some coal throughout slab with higher concentration near the surface.
- No alkali-silica reaction.
- Visit to fly ash plant revealed that there was no opportunity for coal to be introduced there.



# Visual Surveys

Mix Design #	Aggregates used for construction			Pop-outs		Rust Stain without Pop-out		Black Stain without Pop-out	
	Fine (3/8" minus)	3/4"-#4	1&1/2"-3/4"	Survey conducted in Nov.08	Survey conducted in Sep.11	Survey conducted in Nov.08	Survey conducted in Sep.11	Survey conducted in Nov.08	Survey conducted in Sep.11
Mix #1	Icon	Icon	Glacier	0.72	36.31	2.23	1.03	4.10	0.71
Mix #2	Icon	Icon	Washington	0.46	22.42	1.54	0.85	2.97	0.47
Mix #3	Washington	Washington	Washington	0.28		0.34		0.47	

# Mix Design Test Results

Mix Design #	Deleterious Materials (lbs)	Fine Aggregates	Coarse Aggregates	Total (lbs)
Mix #1	Clay lumps & Friable particles (lbs)	301.63	24.56	326.19
	Lightweight pieces (lbs)	Nil	Nil	
Mix #2	Clay lumps & Friable particles (lbs)	301.63	62.34	363.97
	Lightweight pieces (lbs)	Nil	Nil	
Mix #3	Clay lumps & Friable particles (lbs)	Nil	132.23	132.23
	Lightweight pieces (lbs)	Nil	3.78	

# Determine Causation

- Loss specific to pavement that used mix design #1 or #2
- Minimal loss where mix design #3 used.
- The source of aggregate is different for the three mixes.
- Other concrete components not changed between mixes.
- Logic and examination of concrete indicate that aggregate is the issue!
- Confirmation glaciation resulted in some coal being distributed in the pit.

# What Are We Talking About?



# Pavement View #2



# Typical Size



# Black Indicates Coal



# Clay Dislodged in Small Pieces



# Pop-out Size $\neq$ FOD Size



# Small Rust Stain



# Recent Pop-out



# Rust Remnant



# Larger Area Affected



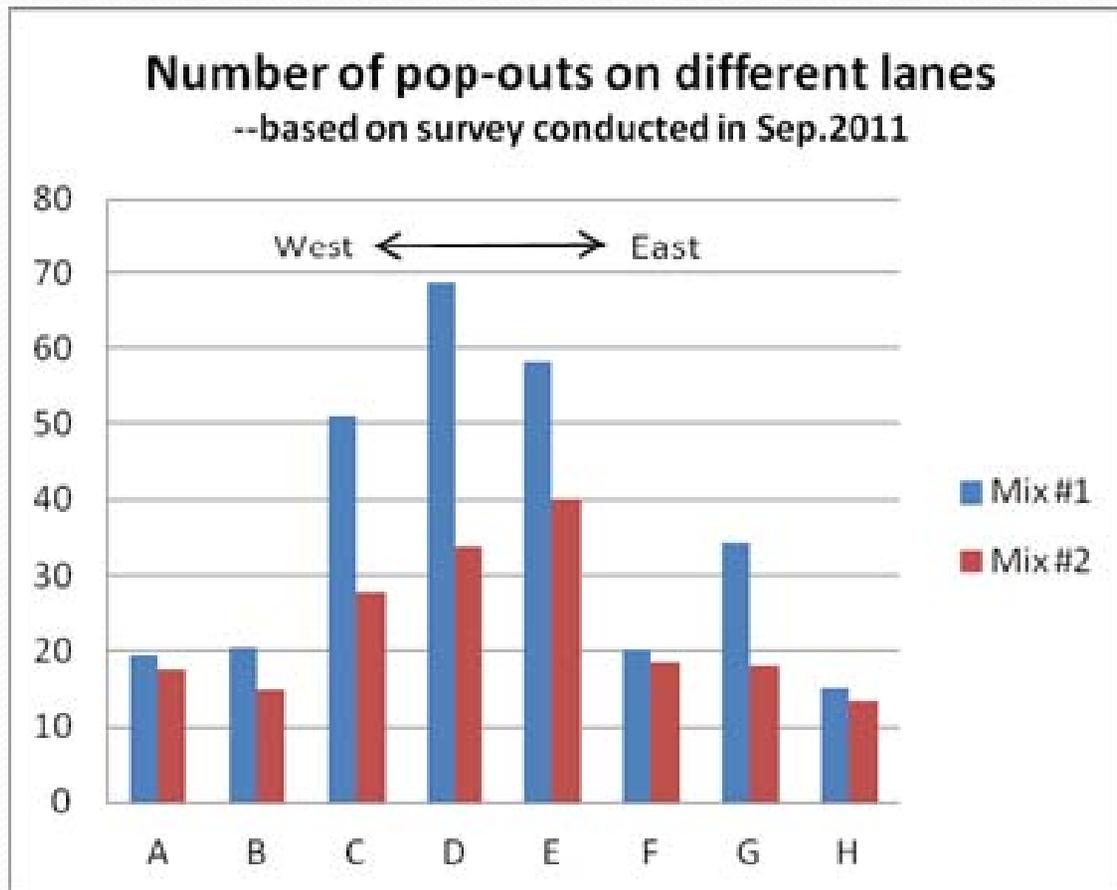
# Definite FOD



# FOD Waiting to Happen



# Location of Pop-outs



# A More Restrictive Specification?

Reference Amount Per Slab	Clay	Coal & Lignite
3RW - Fine aggregate (assume Class 4M)	646 lbs.	108 lbs
3RW – Course aggregate (assume Class 4M)	1889 lbs	189 lbs
FAA – Fine aggregate per memo issued in April 2011 (superseded)	215 lbs.	108 lbs
FAA – Course aggregate per memo issued in April 2011 (superseded)	76 lbs	76 lbs
Theoretical amount needed to create 100 pop-outs (0.5 cubic inch) with homogenous distribution	12 lbs	
Theoretical amount needed to create 100 pop-outs (0.5 cubic inch) with heterogenous distribution (upper 2” of slab)	0.7 lbs	

# Pop-outs at Other Runways

- In the 1960's, several military airports experienced severe pop-outs.
- Related to type of aggregate specified.
- Estimated 800,000 pop-outs up to 3" in size.
- Congressional hearings.
- Determination
  - Inadequate specifications
  - Poor material testing standards
  - Severe lack of engineering judgment

# Findings and Conclusions

1. The amount and size of pop-outs on RW 16R/34L is relatively low compared to previous documented instances elsewhere and is not a structural issue.
2. Pop-outs limited to areas where mix design 1 or 2 used.
3. The size is generally 1" or less.
4. Pop-outs are likely due to coal and deleterious material within the course aggregate from the pit.
5. Other concrete components do not appear to be factors.
6. Some test records missing from contract records, not all tests performed or performed at correct frequency.



# Findings and Conclusions

7. It appears that test info not conveyed from QC/QA to inspectors. Records do not show systematic communication between contractor, testing lab, and CM team.
8. Specifications unclear as to weather severity that establishes the allowable amount of coal and deleterious materials. Criteria used for density testing unclear.
9. There is no evidence that the Contractor failed to comply with specifications and documentation which supports the contractor not being contractually responsible for pop-outs.

# Findings and Conclusions

10. More pop-outs occurred between 2008 and 2011. A trend cannot be established with only two data points.
11. In the 1960s, the DoD revised their specs due to severe pop-outs at military airports.
12. In April 2011, the FAA NW Mtn. Region issued a memo to reduce the amount of coal and deleterious material matching DoD.
13. AC 150/5370-10F effective September 2011 does not tighten the requirements regarding coal and deleterious material.

## #2 Automated Data Collection

- Seamless collection that feeds into pavement management system.
- Ongoing, monthly evaluation of pavements.
- Ability to use for pavement imperfections resulting from construction.
- Concise, accurate, repeatable.

# #3 Pavement Friction Factors

- What were requirements based on?
- Has requirements kept pace with current materials and aircraft?
- Additives and aggregates effect upon friction?
- Tire interaction with pavement?



# Questions and Discussion