Accelerated Pavement Testing
at the
Geotechnical and Structures Laboratory,
U.S. Army Corps of Engineers

Vicksburg, MS U.S.A.

Background

- Started HVS operation in 1999.
- One airfield study completed and one roadway study underway with the HVS.
- Complements the use of military trucks and aircraft load carts in APT.

Outline

- Load Carts versus HVS
- Achievements in APT
- Implementation
- Costs
- Problems/Issues
- Potential Collaborations

When Trucks/Load Carts are Necessary

Difficult Terrain

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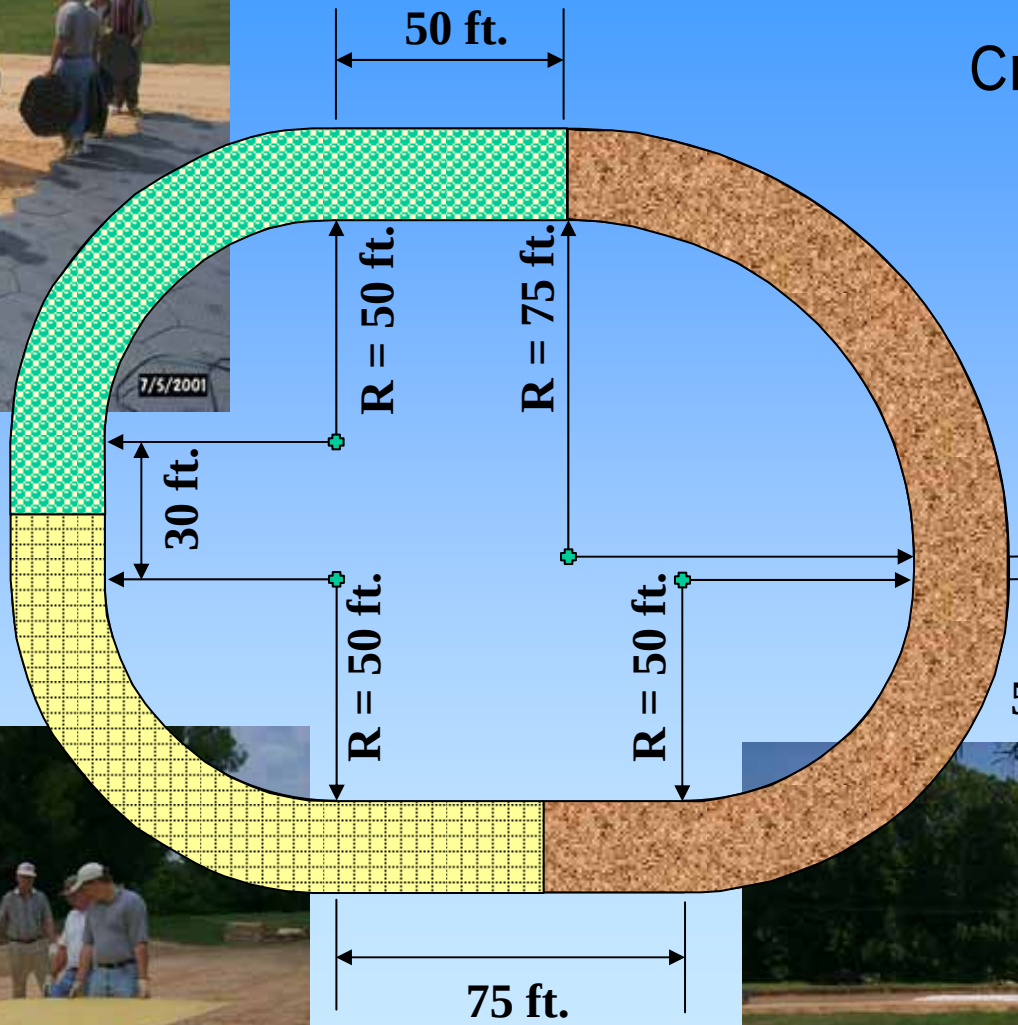
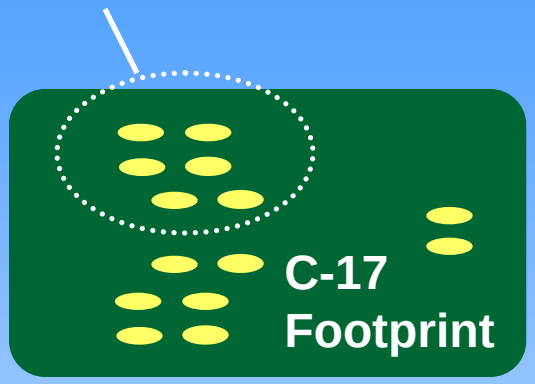
When Trucks/Load Carts are Necessary



Critical Load Involves Turning

When Trucks/Load Carts are Necessary

930 kN (210,000 lb)



Simulating aircraft gear

Advantages of HVS Relative to Load Carts

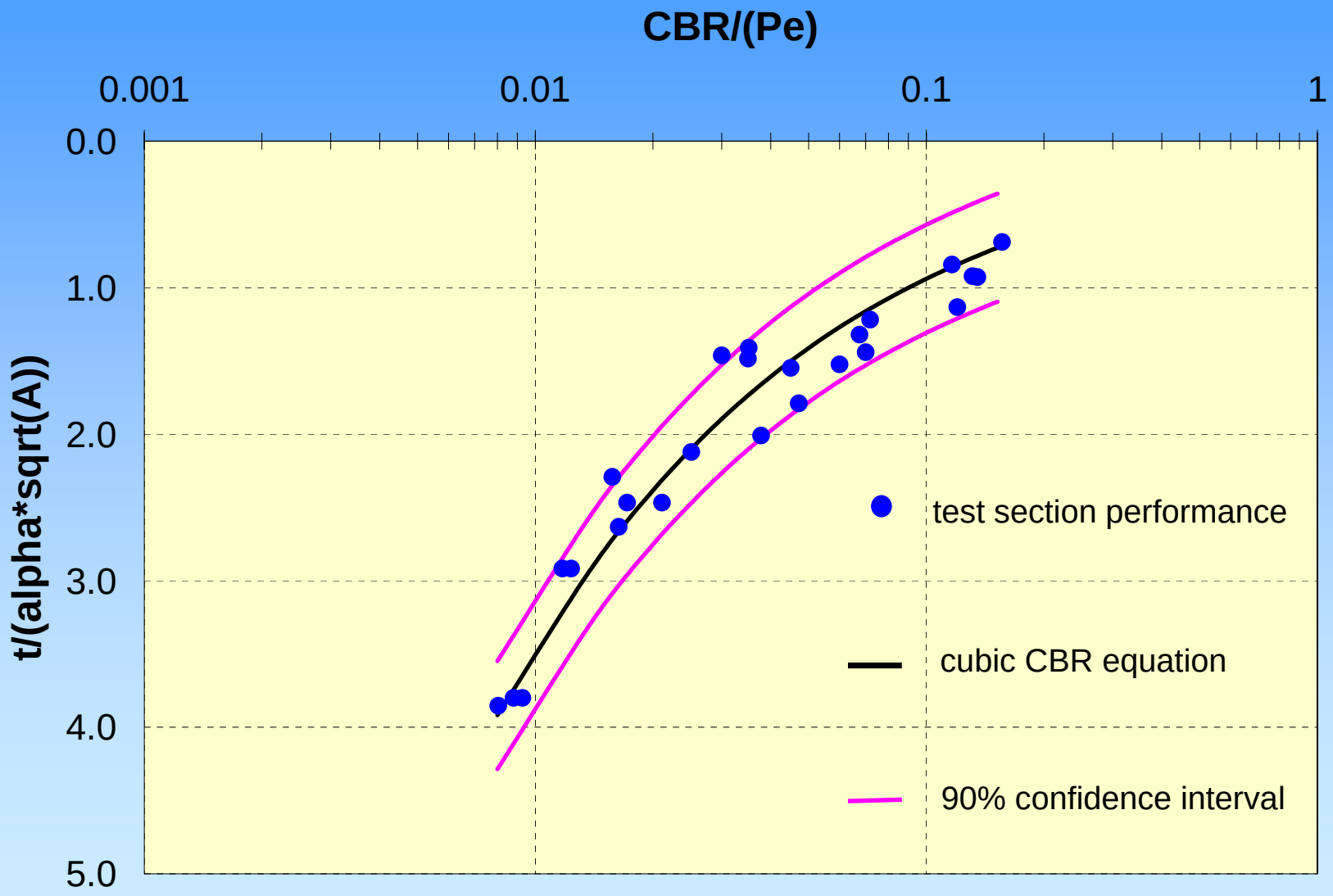
- Trafficking is faster (of course) ... but it's also cheaper.
- Accurate knowledge of load positions for response testing
- More realistic wander patterns
- Safer

rutting under C17 load cart

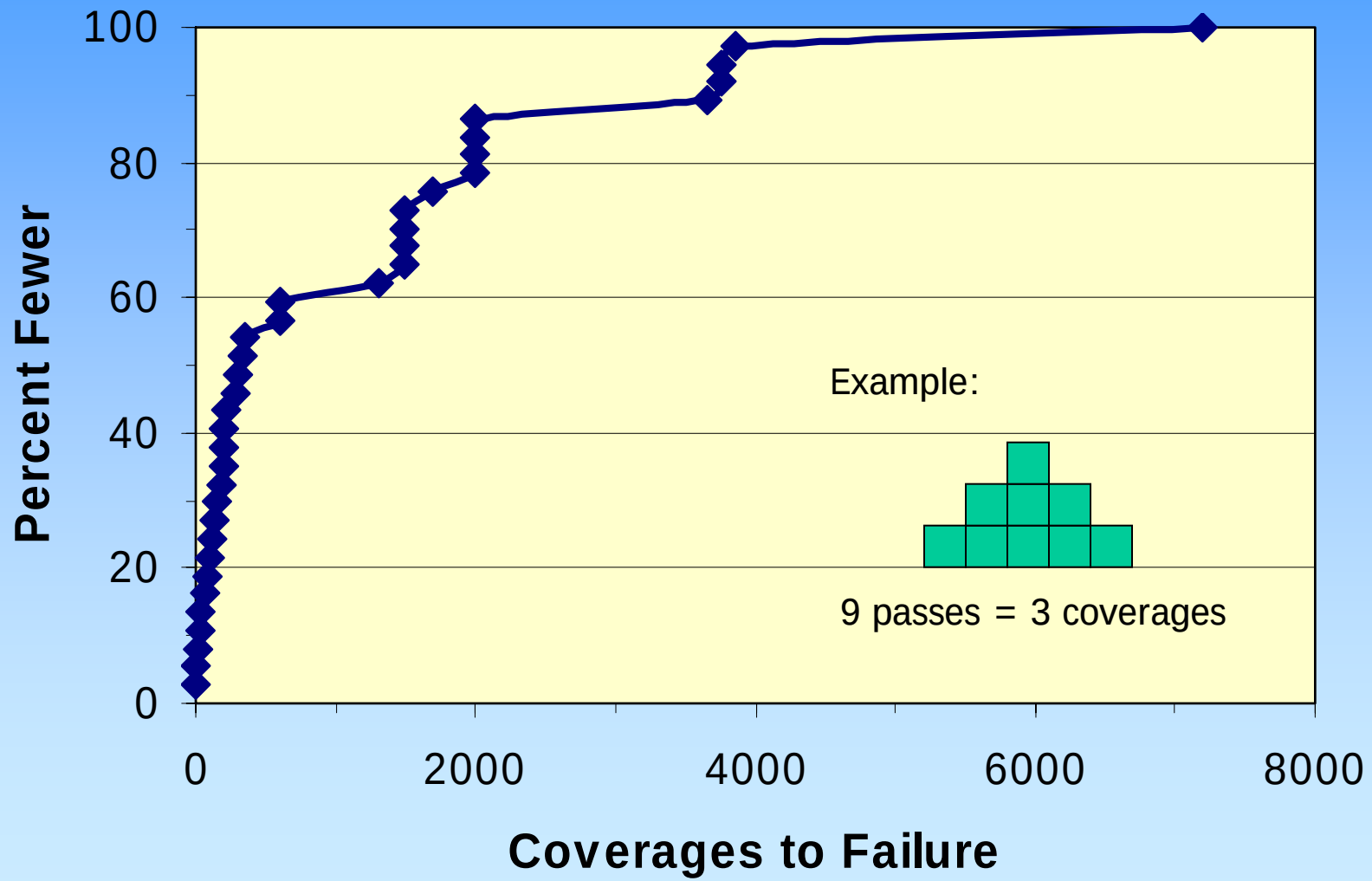
Achievements

- Validated current USACE airfield design methods for high repetitions of traffic.

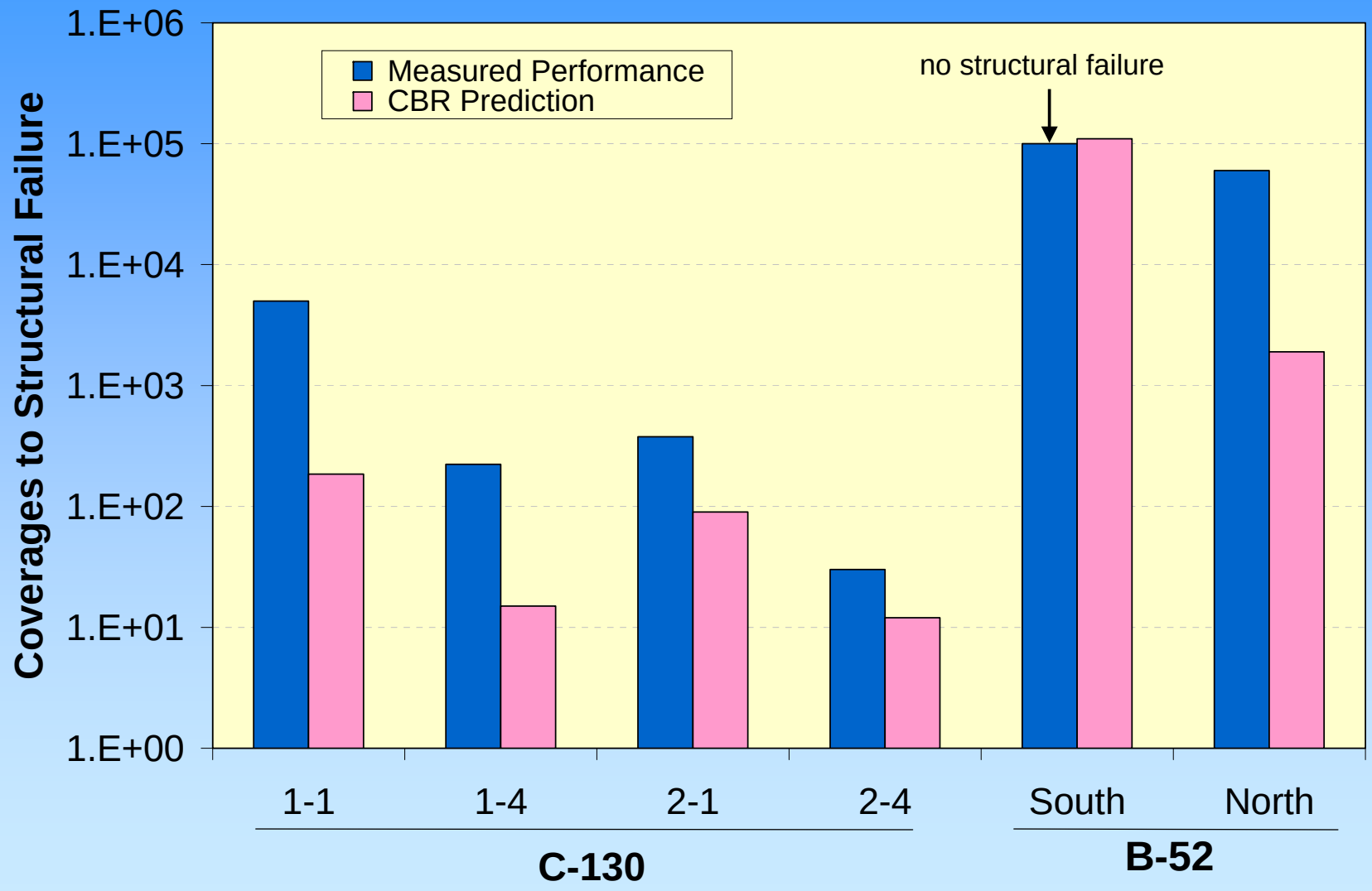
Historical Test Sections



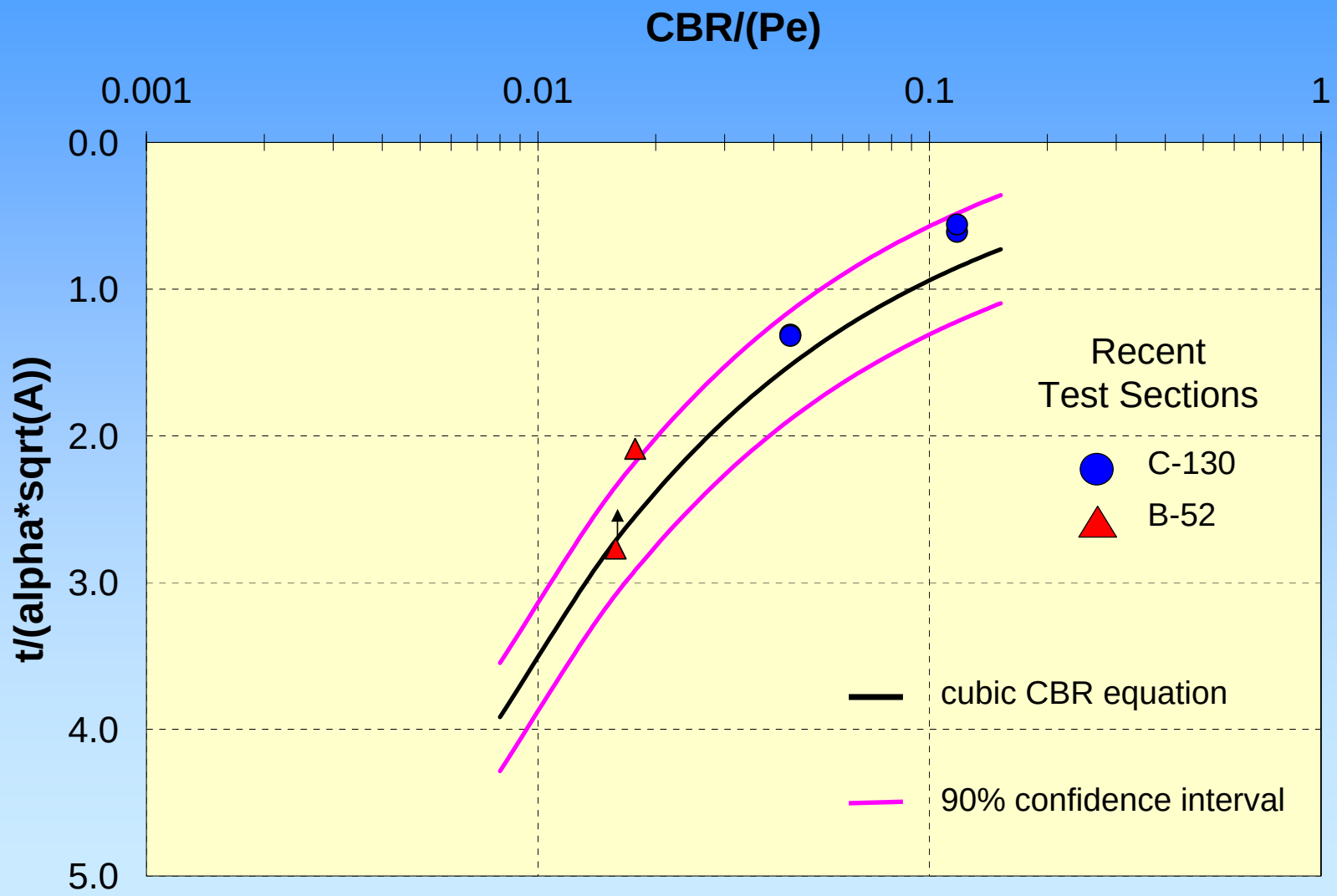
Historical Test Sections



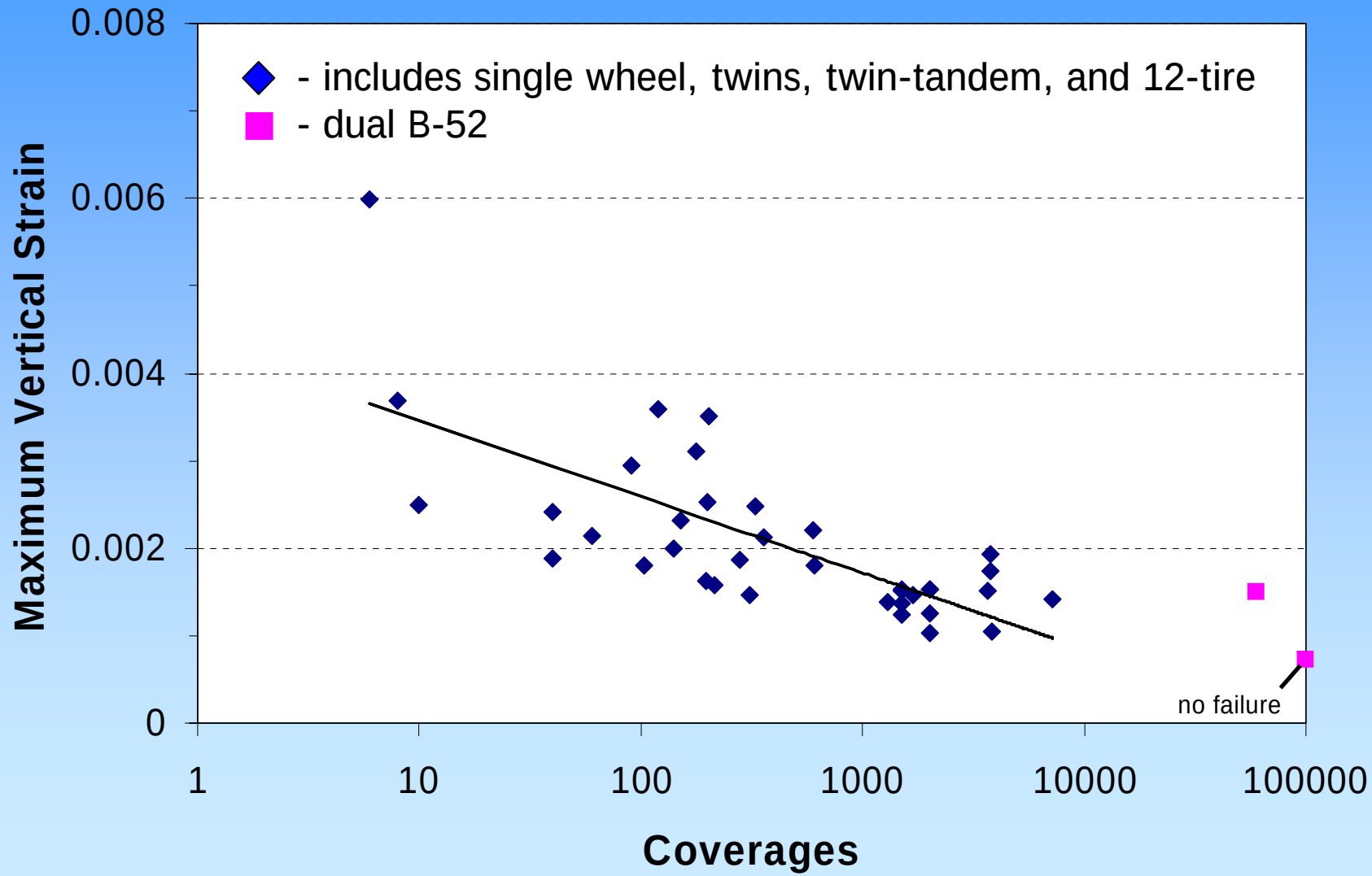
Recent Test Sections



Matching High Reps With CBR Criteria

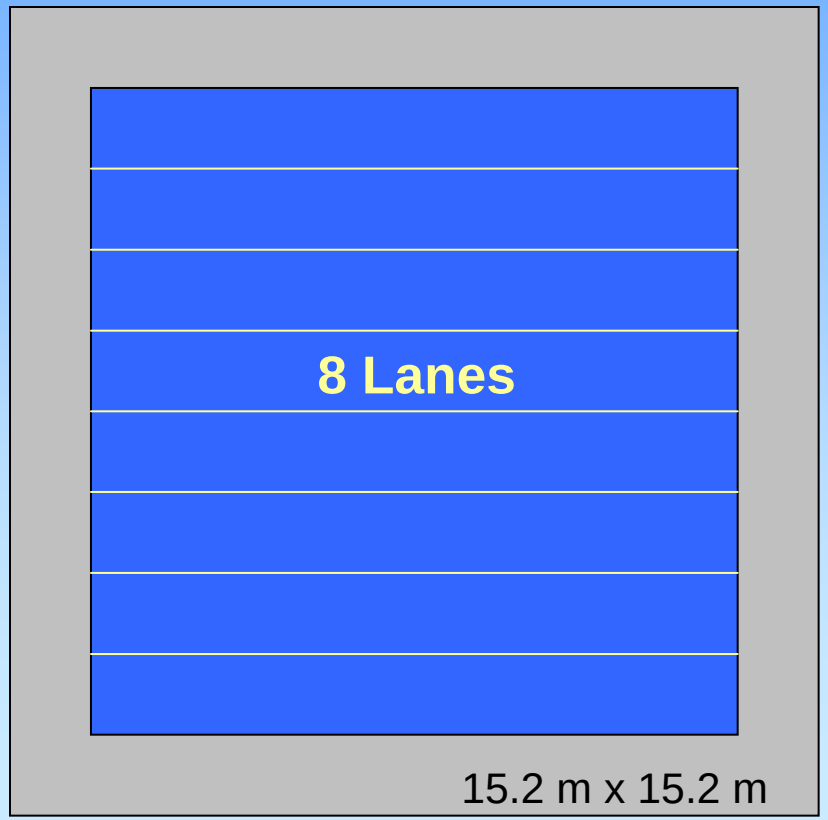


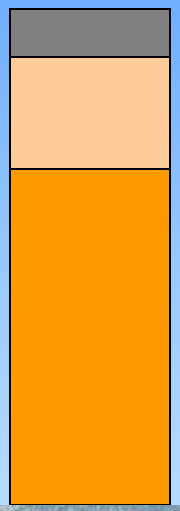
High Repetition Data for LE Development



Achievements

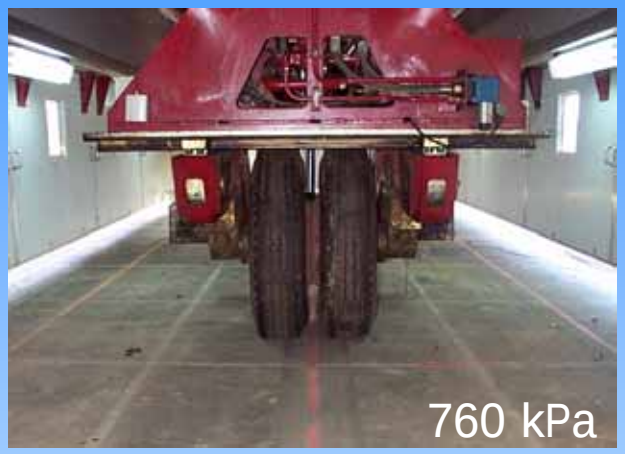
- Performance predictions for roadways built with marginal materials.





Performance Predictions for Low-Quality Roads

duals



super single

military truck

F-15

Performance Predictions for Low-Quality Roads

- Status
  - need to improve our ability to predict performance of pavements with marginal materials
  - dry clayey gravel is not bad
  - super single damage rate > dual tire damage rate
    - 67 kN per ½ axle
  - don’t land F-15s on secondary roads

“Achievements”

- Ongoing efforts that depend heavily on the APT program due to ...
  - Instrumentation
  - Thorough materials testing
  - Known construction
  - Accurate control over loading

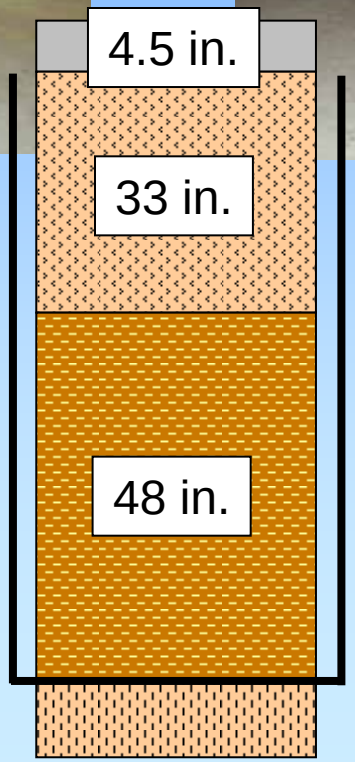
“Achievements”

- Development of stress-based criteria

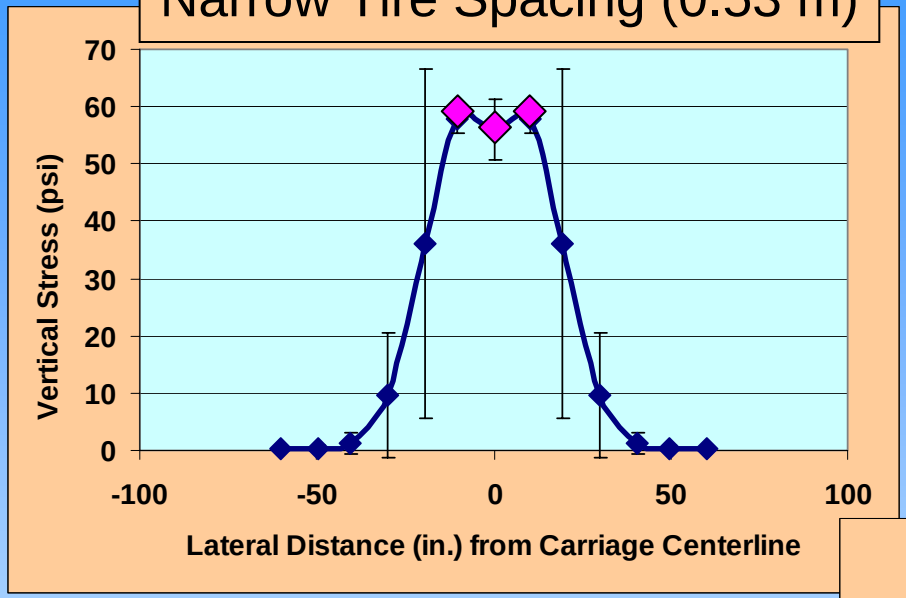
Stress-Based Criteria

B-52 Narrow Spacing

B-52 Wide Spacing



Narrow Tire Spacing (0.53 m)

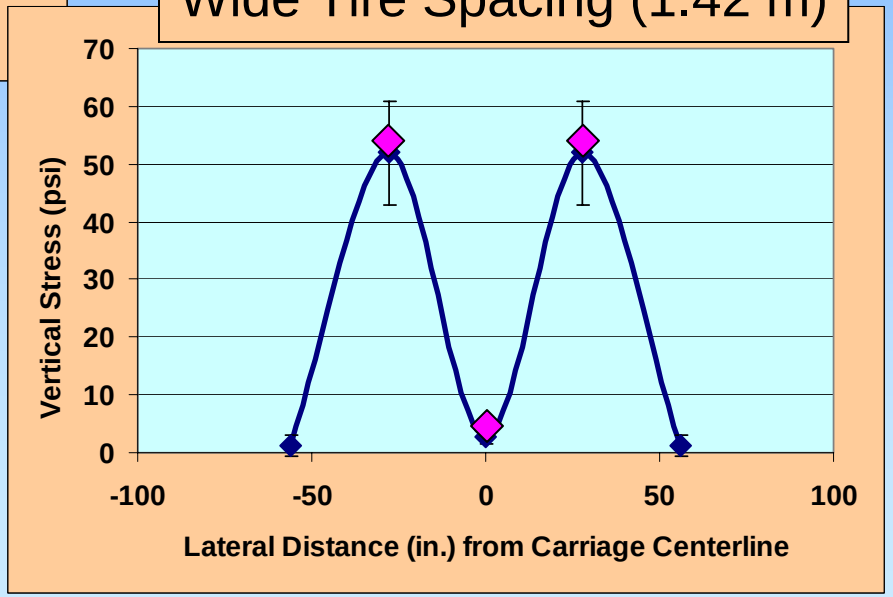


South Test Item

Carriage Load = 335 kN

Depth = 0.42 m

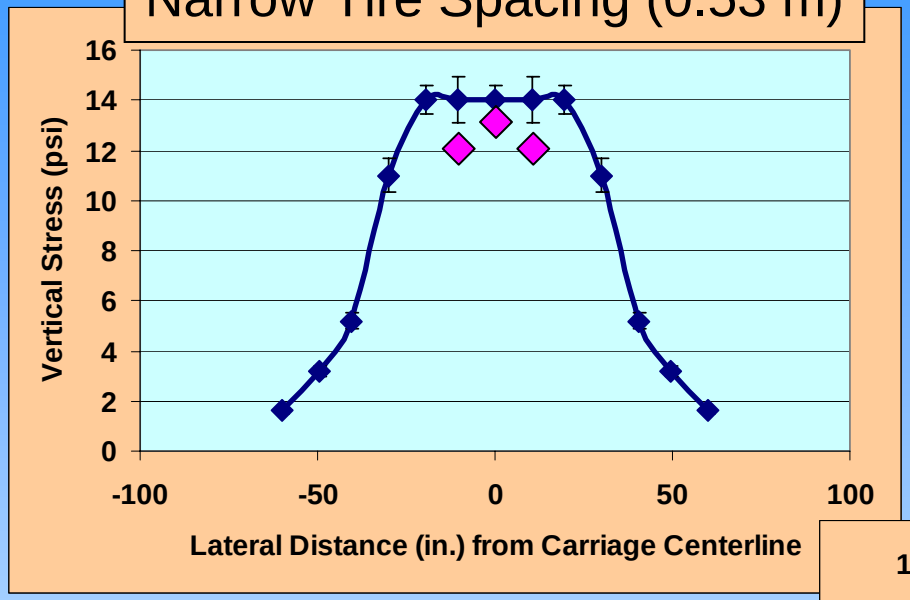
Wide Tire Spacing (1.42 m)



◆ Boussinesq predictions

1 psi = 6.9 kPa

Narrow Tire Spacing (0.53 m)

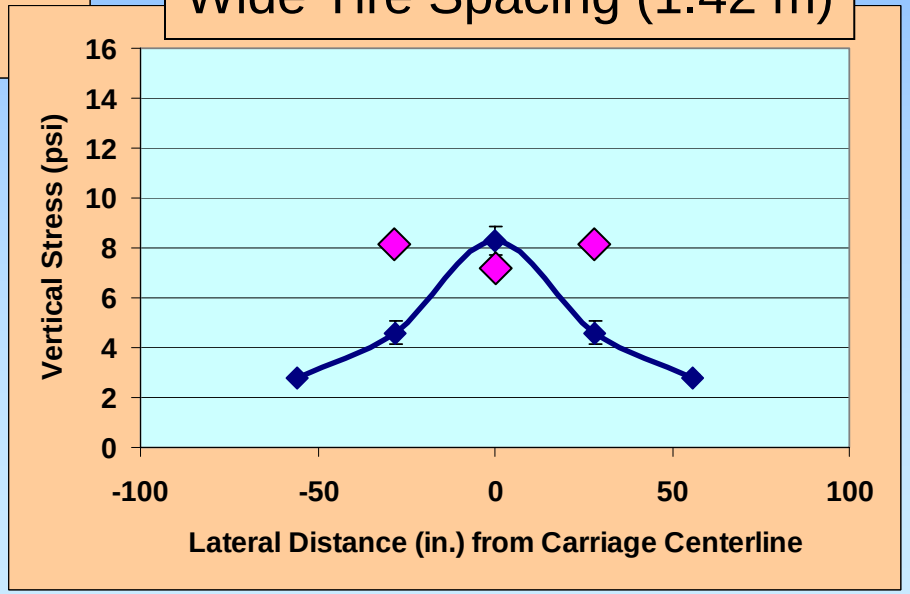


South Test Item

Carriage Load = 335 kN

Depth = 1.26 m

Wide Tire Spacing (1.42 m)



◆ Boussinesq predictions

1 psi = 6.9 kPa

Stress-Based Criteria

- Probabilistic methods for predicting stress
  - Harr (1977)
  - One material parameter = coefficient of lateral stress, ν

$$\nu = \frac{\text{horizontal stress}}{\text{vertical stress}}$$

  - Harr recently extended the method to predict full stress state

Stress-Based Criteria

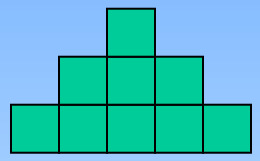
- Currently:
  - Ensuring adequate stress measurements in test sections
  - Using historical and new stress measurements to build database of ν values for different materials
  - Using historical test sections to develop criteria

“Achievements”

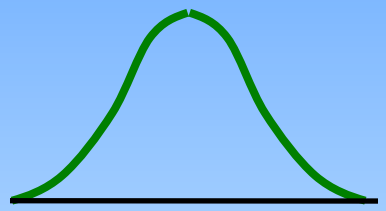
- Test section simulation software tool for reliability-based design/evaluations

Simulation Software

- Traffic input
  - single or multiple vehicles
  - discrete or continuous wander



cart



HVS

- Materials and thickness input
  - single value or
  - uniform, triangular, or normal distribution

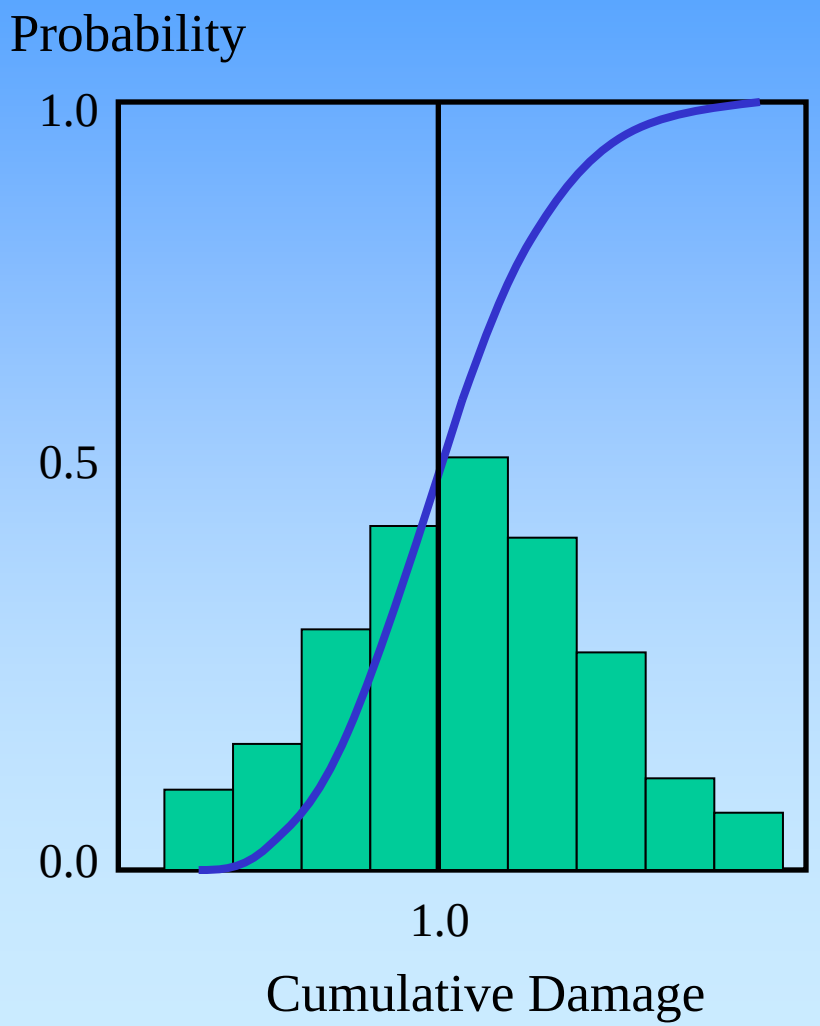
Simulation Software

- Input for type of analysis
  - road or airfield
  - type of criterion
    - LE with strain
    - stress-based Boussinesq
    - stress-based probabilistic
  - criterion constants
    - example → $\text{Damage} = A \cdot e^{-BR}$ where

      $R = \frac{\text{strength}}{\text{stress}}$
  - number of simulations

Simulation Software

- Output



“Achievements”

- Use test sections for developing procedures for NDT
  - Radar
  - Scanning laser
  - PSPA
  - Photograph profilometry
  - Embedded geophones

Implementation of APT Results

- Method
  - Short courses offered to USACE personnel
  - Answering “TeleEngineering” requests for information
  - Engineering technical letters
  - USACE guide specifications
  - Design/assessment manuals and software
- Measurement
  - Did the results of your study affect anything above?

Operation Costs

- Continuous HVS Operation ($400k/year including indirect costs)
  - 3 men full-time = $290k/year
    - 1 operator, 1 mechanic, and 1 electronics technician
  - $75k/year for parts and facility upkeep
  - $30k/year for instrumentation sensors
  - $5k/year for periodic upgrading software and hardware infrastructure
  - Does not include additional costs of test section construction
  - Does not include engineer time for designing experiments and analyzing data

Problems/Issues

- Overall, APT personnel are “extremely happy with how the HVS is running.”

Problems/Issues

- Getting SI parts for small repairs
- We got greedy with our desire for high loads
  - Sacrificed precise control over loads < 44 kN (10 kips)
- HVS management
  - WHAT DIDN'T WORK – HVS was treated as a test section tool under control of each individual engineer
  - NOW TRYING – One person stays in charge of accelerated load testing

Problems/Issues

- USACE environment is different today than during the days of the MWHGL study
  - Funding pools are smaller
  - Need quick turnaround on products
- Recent pure empiricism has taken the spotlight
  - Quick products
  - “Helping the troops”
- Better ways to market APT to the military?
  - Complement materials and structures research

Problems/Issues

- Getting asphalt concrete that meets airfield specifications
- Not much success with MDDs
- Calibration and accuracy of pressure cells
- Measuring horizontal stress
- Uniformity of the definition of “failure” over the years

Problems/Issues

- Using the HVS on pavements with stabilized surfaces

Problems/Issues

- Improved communication between operators/instrumentation personnel from different agencies
- Information management / APT database
- Materials processing warehouse

Problems/Issues

- Improved control over loading/response tests
  - Both “rolling load” and static tests
    - need to capture longitudinal position and load data
    - currently using peak responses only
- Profiling laser on carriage similar to Florida
- Instrumentation for recording pressure distributions under tires

Potential Collaborations

- What we offer
  - Space and full-size construction equipment
  - High load with high rate of accumulating passes
  - “Good” instrumentation and NDT capabilities
  - “Good” modeling capabilities
- What we lack
  - Precipitation and subsurface moisture control
  - Complete temperature control
  - SHRP shear tester in laboratory
  - High speed trafficking