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U.S. ARMY ENGINEER RESEARCH AND DEVELOPMENT CENTER

APT Monthly Webinar Update
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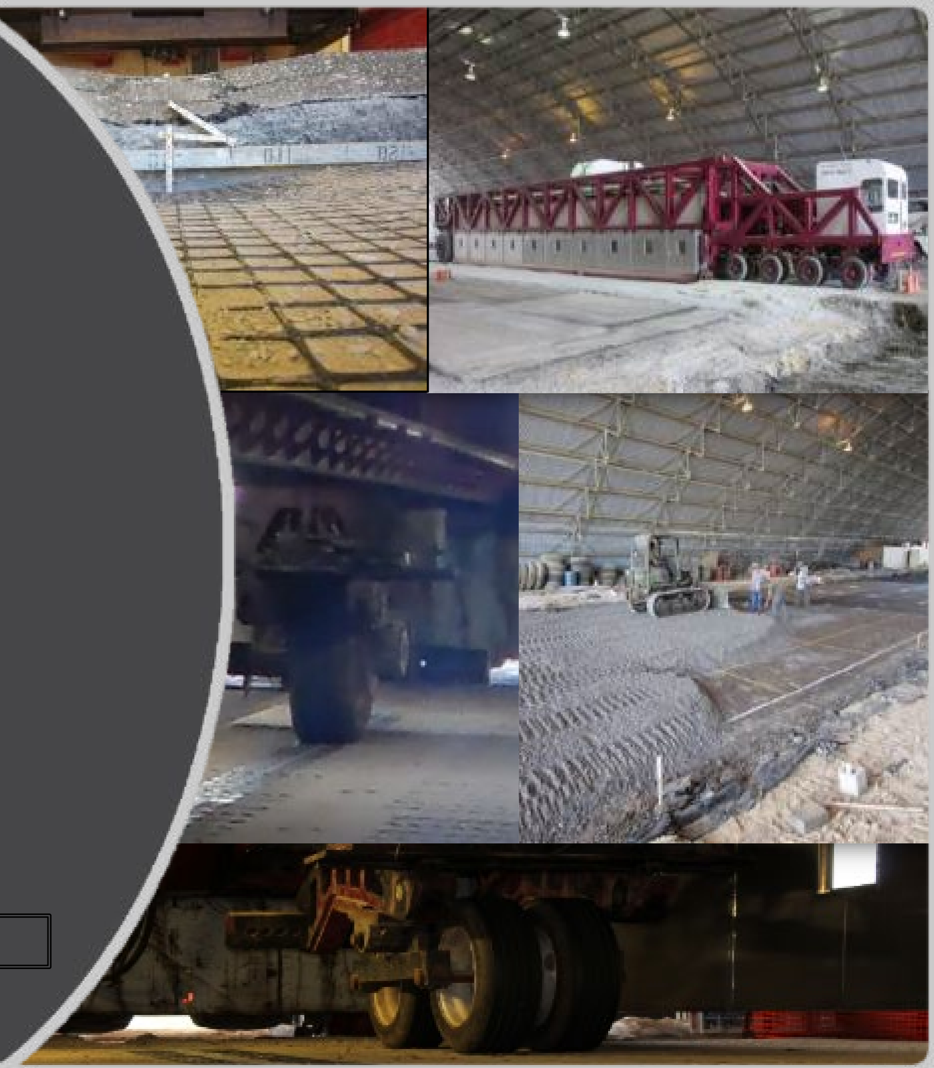


US Army Corps of Engineers®

ERDC
ENGINEER RESEARCH & DEVELOPMENT CENTER

DISCOVER | DEVELOP | DELIVER

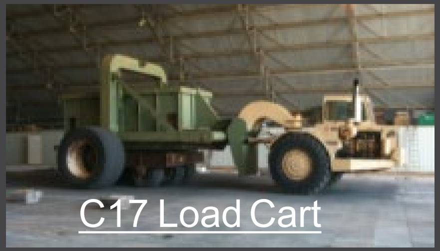
US ARMY ERDC – FACILITIES

Hangar 2 Pavement Testing Facility

127,000 ft² of covered testing area

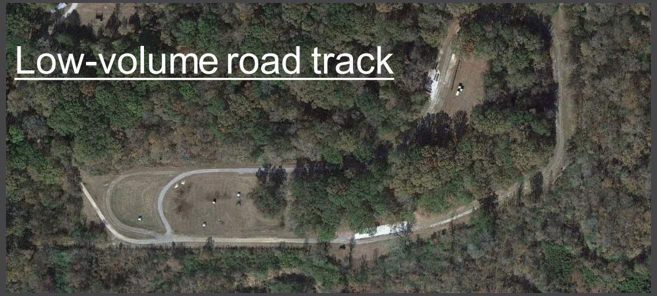
HVS-A (Bigfoot)

HVS-T (Titan)



C17 Load Cart

Load Cart



Low-volume road track

Pavement Box Testing

Outdoor Testing Facility

“Snake Pit”

US ARMY ERDC – CURRENT EQUIPMENT

- **HVS-A (Bigfoot)**
  - Length: 119.2 ft
  - Width: 16.4 ft
  - Mass: 227,000 lbs
  - Tracking length: 40 ft
  - Wander: 5 ft
  - Load: 10,000 – 100,000 lbs
  - Speed: 4 – 10 mph
  - Environmental: 23°F - 109°F

US ARMY ERDC – CURRENT EQUIPMENT

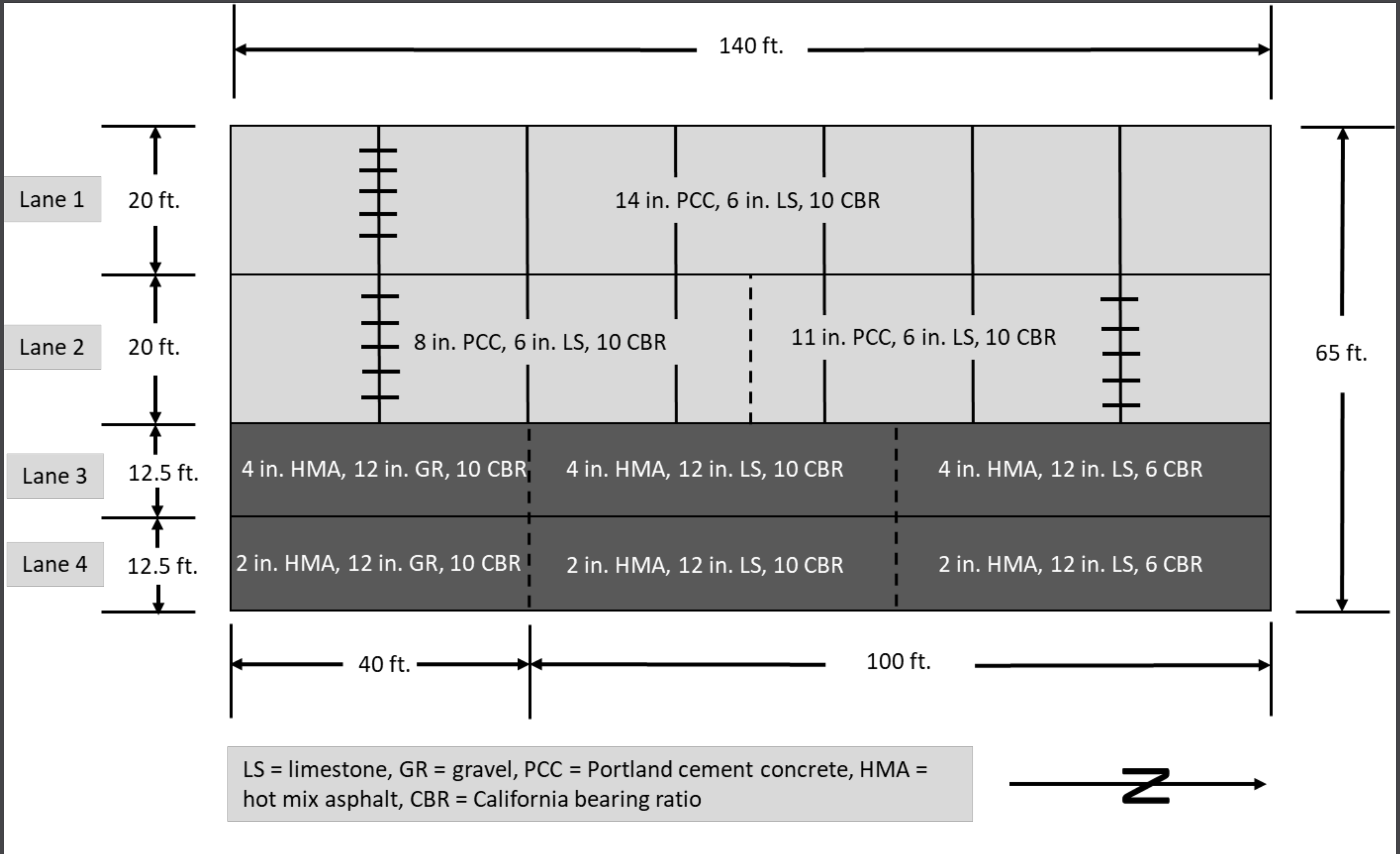
- HVS-T (Titan)
  - Wheel load: 9,000 – 120,000 lbs.
  - Testing length: 70 ft
  - Wander: 6 ft
  - Laser profiler
  - Environmental chamber
    0° F – 110° F
  - Carriage:
    - Highway
    - Aircraft
    - Rail
  - Programmable sink rate
    - Simulate aircraft touchdown

Structural evaluation for the P-8 Poseidon aircraft

- Rigid pavement
  - 8 in., 11 in, 14 in. thick
  - Dowel and undowelled joints
  - Standard PCC mix (650 psi flex)
- Flexible pavement
  - 2 in. and 4 in. thick HMA
  - Weak and strong base course
  - 6 and 10 CBR clay subgrade
- AM-2 matting
- Airfield Damage Repair (ADR)

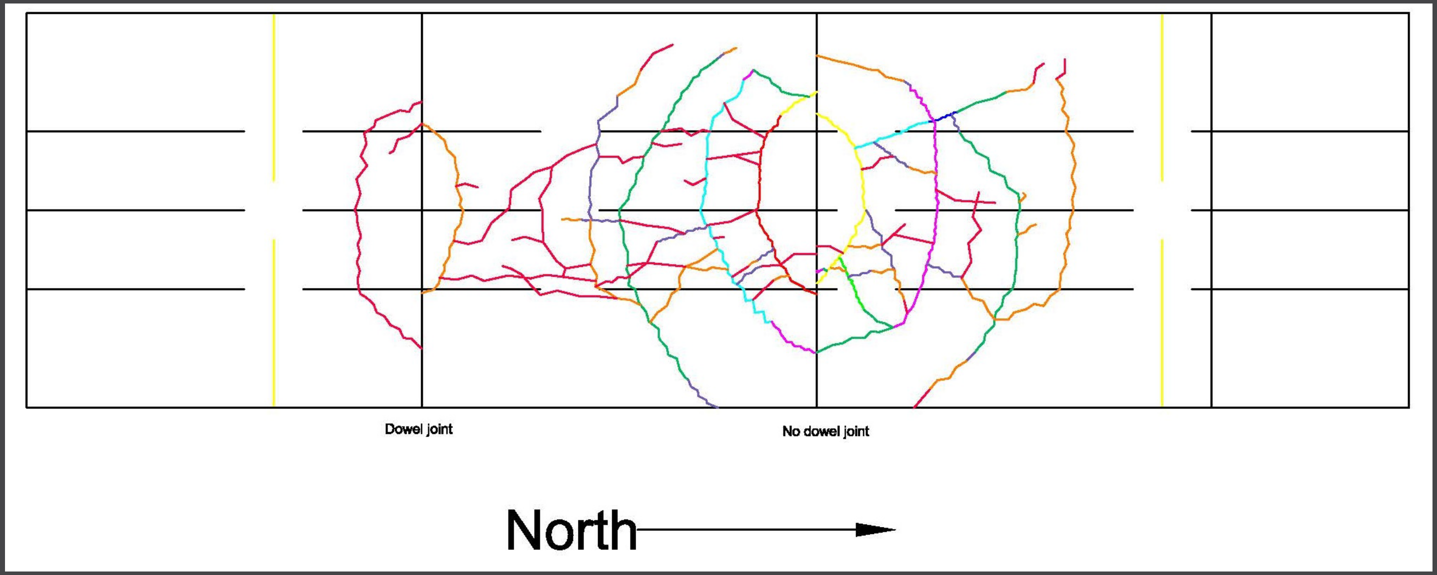
- 89,000 lb total load
- 220 psi inflation pressure
- 8-ft wide wander (outside to outside)

Structural evaluation for the P-8 Poseidon aircraft

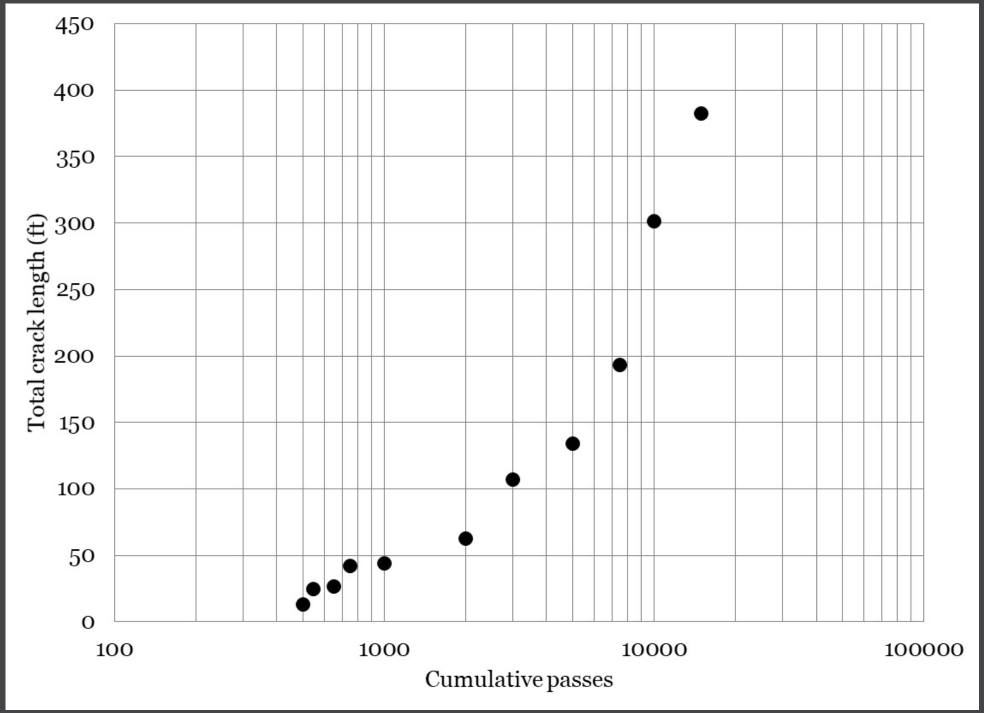


Structural evaluation for the P-8 Poseidon aircraft

8-in. PCC crack development

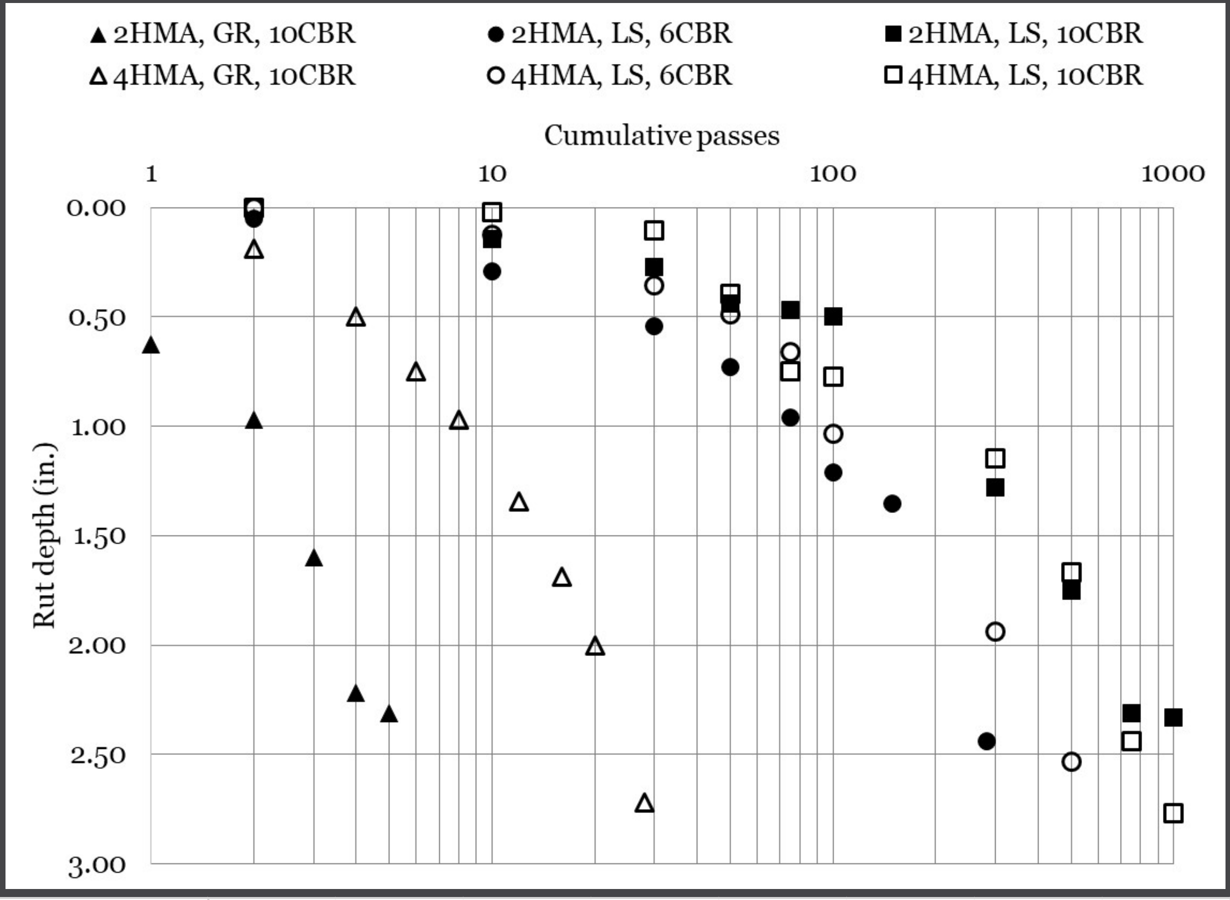


11-in PCC achieved 50,000 passes with no cracking



Flexible pavement testing

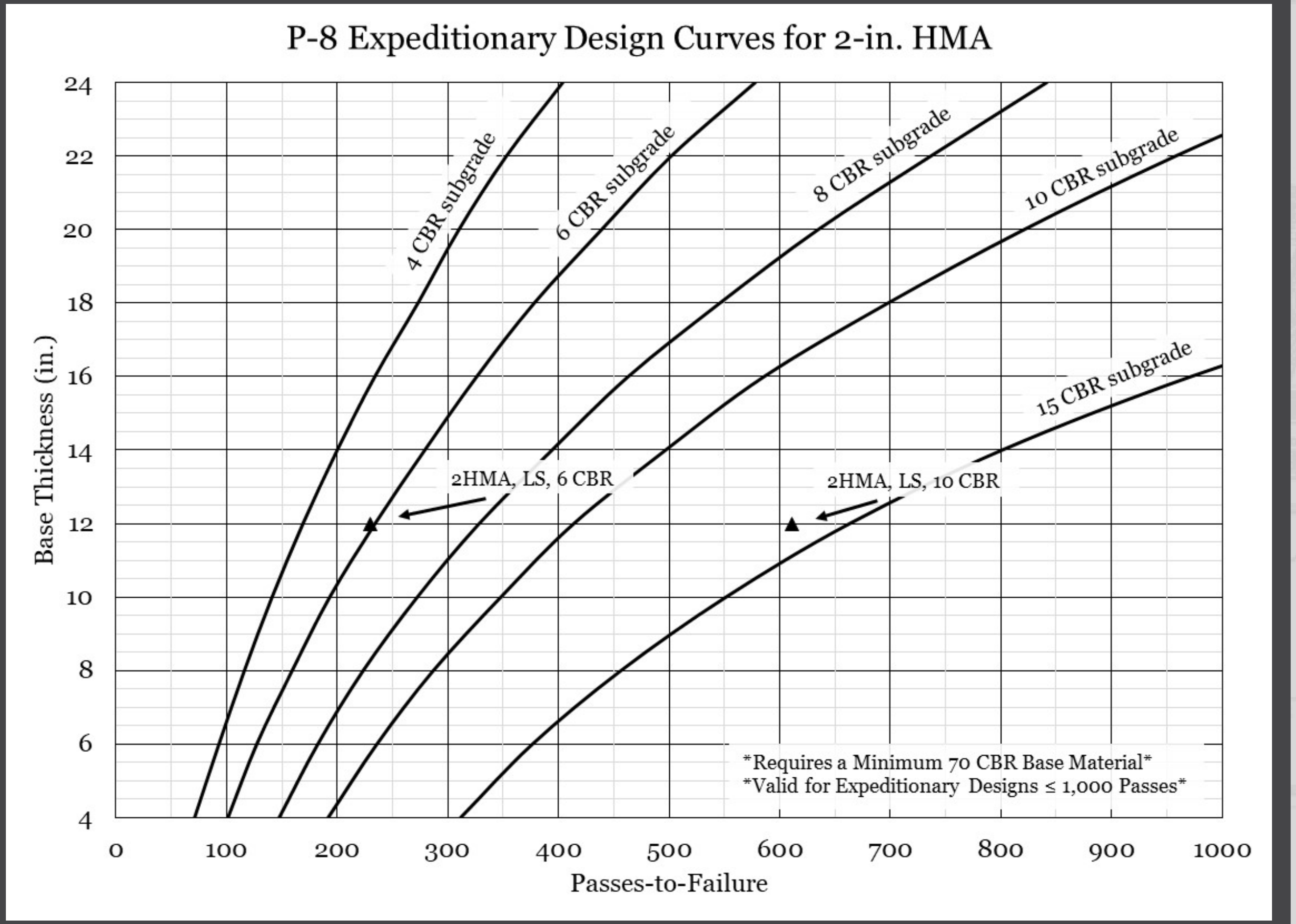
- HMA Thickness
  - Increase in HMA thickness improved rutting performance on weaker subgrade
  - Not meaningful on firm subgrade
- Base Course Strength
  - Increase in base course strength significantly improved rutting performance
  - Highlighted importance of competent base layer
- Subgrade Strength
  - Increase in subgrade strength improved rutting performance



	Rut depth (in.)							
Passes to rut	0.25	0.5	0.75	1	1.25	1.5	2	2.5
2HMA, GR, 10CBR	1	1	1	2	3	3	4	7
4HMA, GR, 10CBR	2	4	6	8	11	14	20	26
2HMA, LS, 6CBR	9	27	52	79	114	168	230	290
4HMA, LS, 6CBR	21	52	81	99	148	203	321	489
2HMA, LS, 10CBR	27	100	180	260	292	356	611	833
4HMA, LS, 10CBR	40	57	75	222	340	436	608	797

Flexible pavement contingency design curves

- Developed design curves based on APT observations and analytical effort
- Leveraged MEPDG deformation model
  - Added a modulus deterioration model
  - Added a non-uniform tire loading model
  - Incorporated aircraft wander
- Calibrated model using rutting data, instrumentation response, and NDT data



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P-8 Work Continued (Leveraging existing test section)

- Saltwater concrete
  - Replaced Lane 2 (8 in. and 11 in.) PCC with saltwater concrete
  - Same PCC mix design with the exception of saltwater replacement for potable water
  - No meaningful difference was observed in short-term trafficking performance
    - Long-term slabs were placed to monitor with NDT test equipment (non-trafficked)
  - Similar crack development in the 8-in.-thick PCC and no cracking observed in the 11-in.-thick PCC

- Full-depth reclamation
  - Reclaimed both HMA test lanes
  - 3% engineered emulsion (CRS-2P) and 2% cement
  - Reclamation depth of 14-in.
  - 2-in. and 4-in.-thick HMA surface

- Low strength PCC
  - Replace saltwater concrete test lane with a low flexural strength PCC
  - Simulate remote locations (poor materials, poor construction)

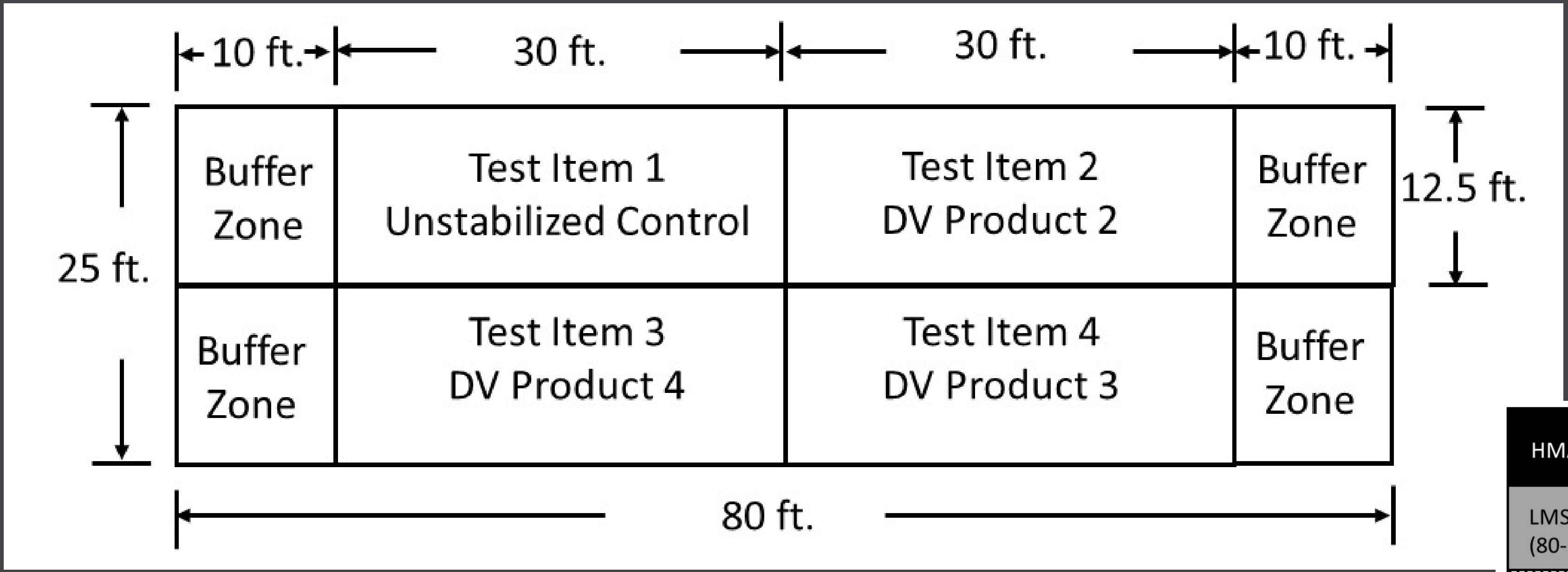
Evaluation of Hexagonal Multi-shape, Multi-axial Geogrids in Road Applications

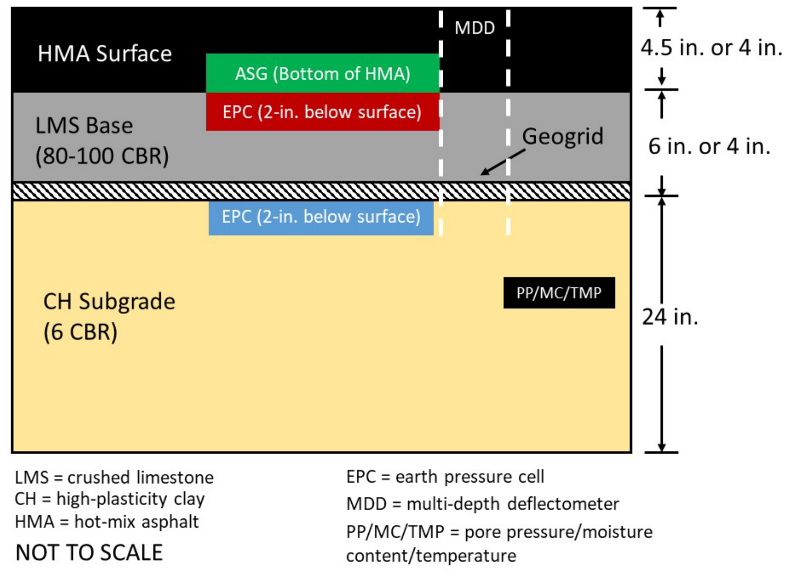
- Full-scale flexible pavement test section
  - 4-in. and 4.5-in.-thick asphalt layer
  - 4-in. and 6-in.-thick crushed limestone aggregate layer
  - 6 California Bearing Ratio clay subgrade

- Three recently developed innovative geogrids
  - Combination of hexagonal, trapezoidal, and triangular aperture shapes
  - Coextruded, composite polymer sheet
  - Punched and oriented

- Geogrids placed at aggregate/subgrade interface

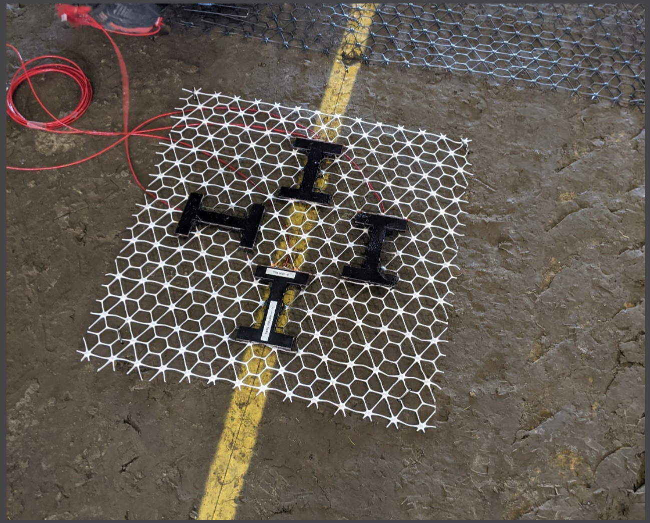
Evaluation of Hexagonal Multi-shape, Multi-axial Geogrids in Road Applications

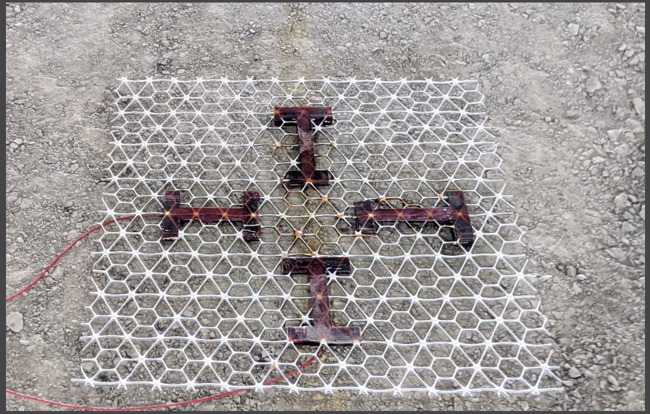




Evaluation of Hexagonal Multi-shape, Multi-axial Geogrids in Road Applications

Evaluation of Hexagonal Multi-shape, Multi-axial Geogrids in Road Applications





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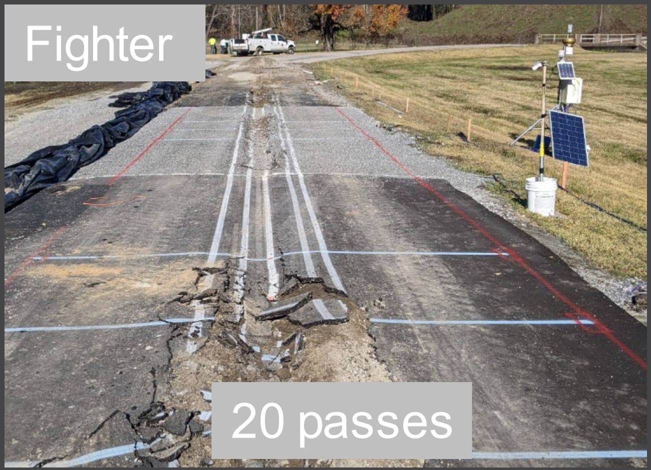
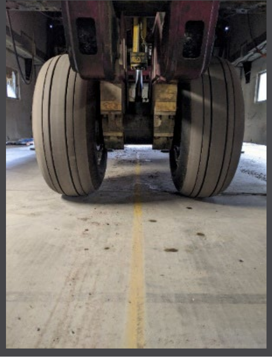
FDR Pavement Research Projects

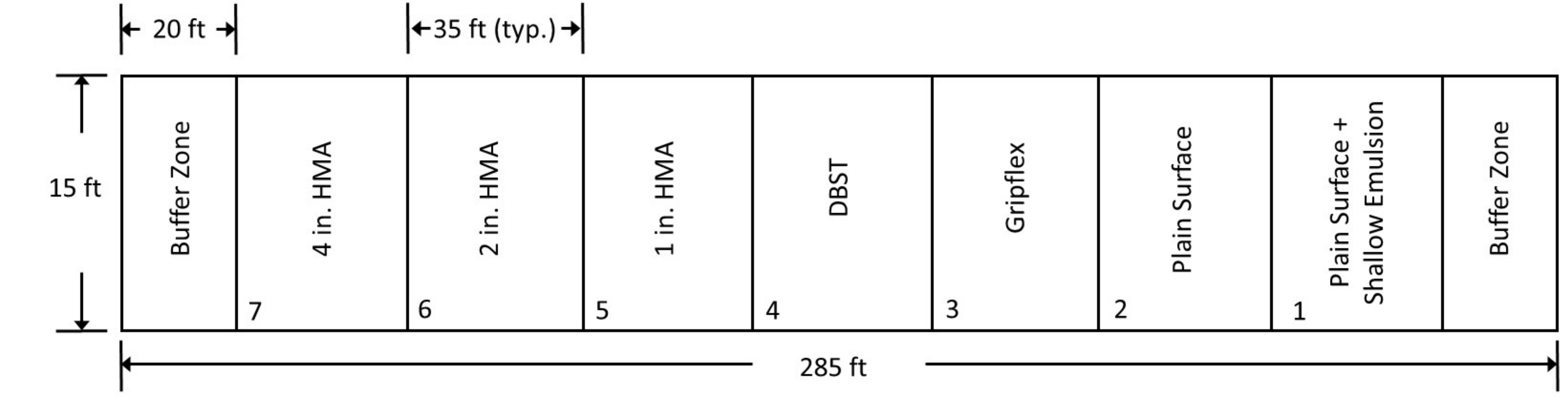
- **FDR for Sustainment Operations:**
  - C-17 loading conditions (45 kips/142 psi)
  - Cement and cement/emulsion additive
  - 12-in.-thick reclaimed layer
  - 2.5-in.-thick HMA surface
  - Trafficked to 100,000 passes with <1 in. rutting
- **Minimum Surface Thickness for Fighter Aircraft:**
  - F-15 loading conditions (35 kips/325 psi)
  - Cement additive
  - 10-in.-thick reclaimed layer
  - Multiple surfaces
    - 4 in., 2 in., and 1 in. HMA layer
    - Double bituminous surface treatment
    - Microsurfacing
    - Unpaved
    - Emulsion treatment
- **Evaluation of FDR under P-8 Poseidon Aircraft:**
  - P-8 loading conditions (45 kips/220 psi)
  - Emulsion/cement additive
  - 14-in.-thick reclaimed layer
  - 2-in. and 4-in.-thick HMA surface; unpaved test item
- **FDR for Landing Zones:**
  - C-17 (45 kips/142 psi) & C-130 (35 kips/100 psi) loading conditions
  - Two material types
    - Silty sand
    - Gravel
  - 12-in.-thick reclaimed layer
  - Unpaved surface





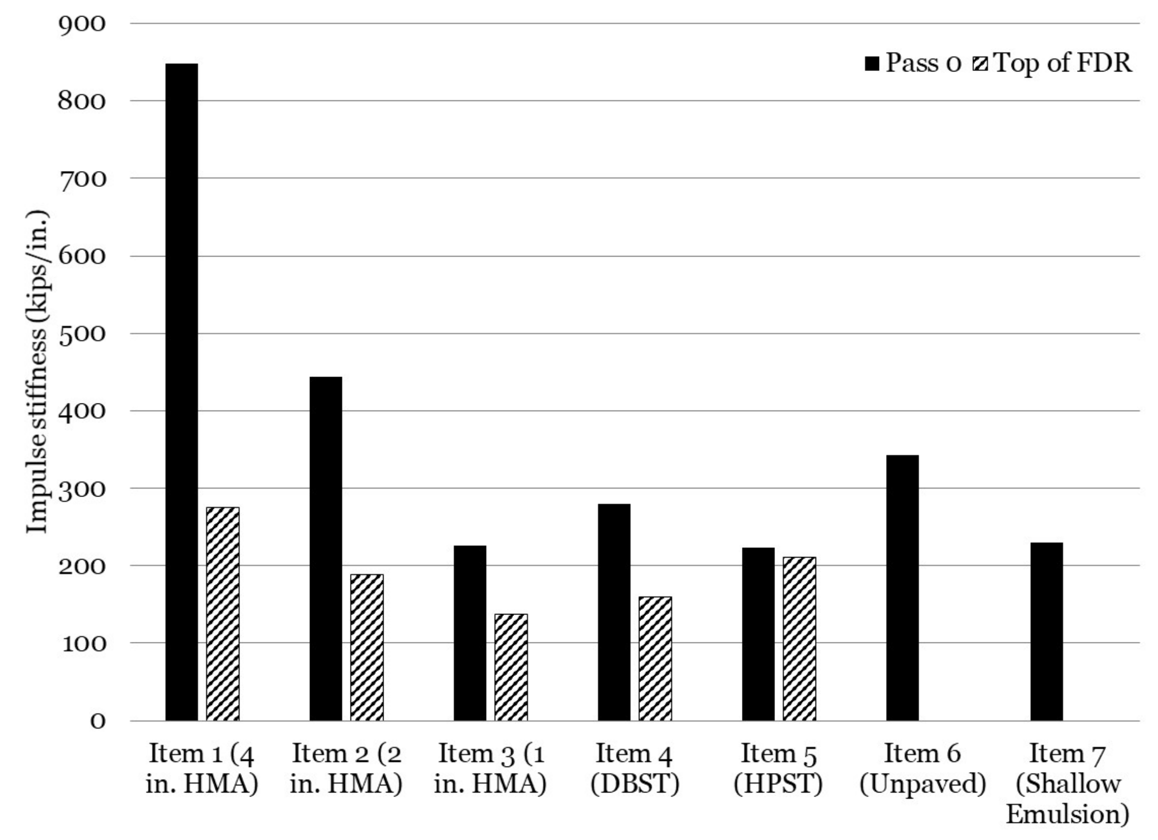
Effect of Fighter Aircraft Traffic on Full-Depth Reclamation with Thin Surface Treatments

- Assess structural capacity of FDR base layer with a variety of thin surface treatments
  - Cement treatment only (5% cement)
  - Section was trafficked with single-wheel F-15 load cart
    - 35,000 lb total load
    - 325 psi tire inflation pressure

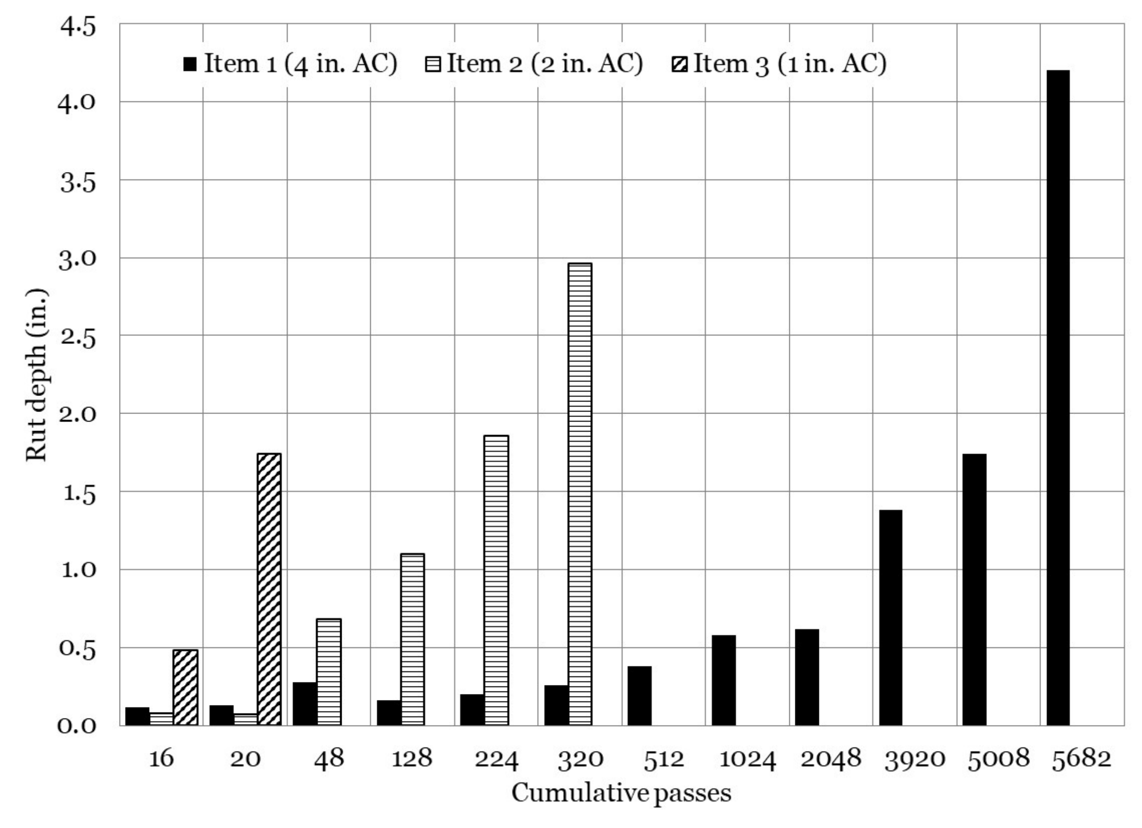


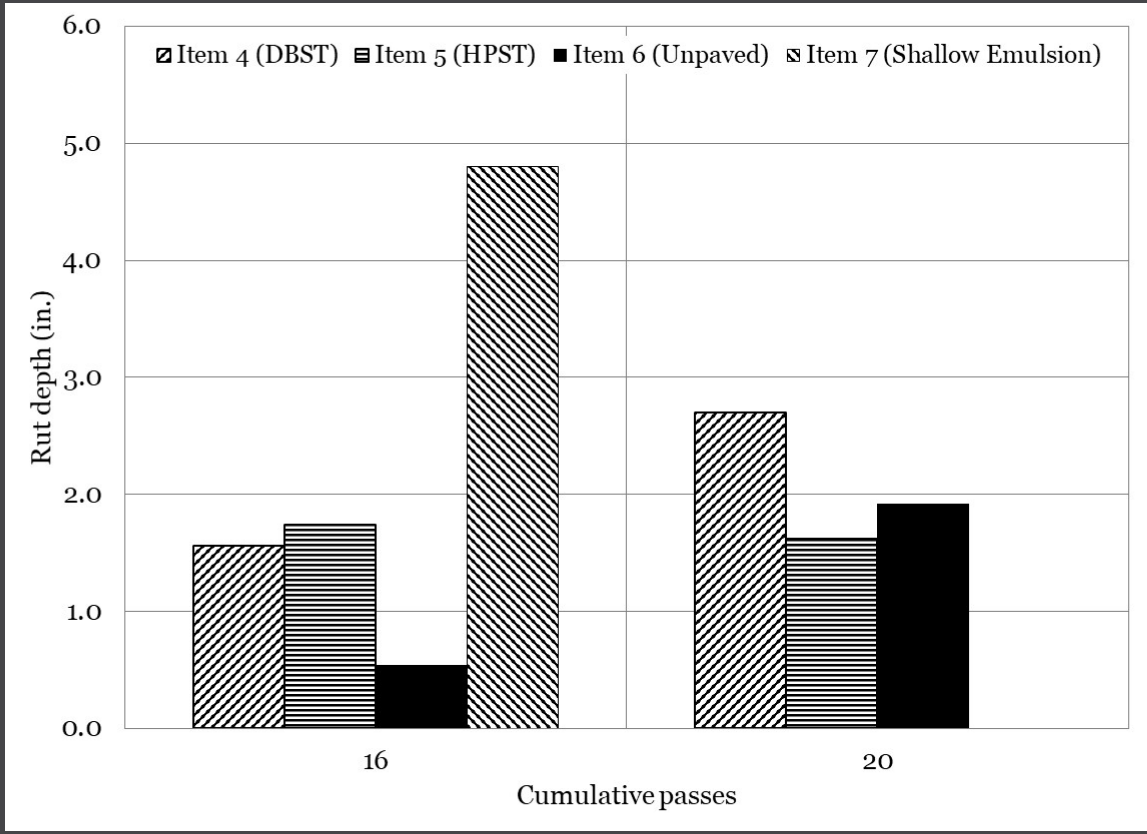
Effect of Fighter Aircraft Traffic on Full-Depth Reclamation with Thin Surface Treatments

- FWD data were collected at the top of the FDR layer and after surfacing
- Observed trends were reasonable
  - Increase in asphalt thickness resulted in an increase in ISM
- Leverage data for analytical effort



Effect of Fighter Aircraft Traffic on Full-Depth Reclamation with Thin Surface Treatments





Effect of Fighter Aircraft Traffic on Full-Depth Reclamation with Thin Surface Treatments

1 in.-thick HMA @ 20 passes

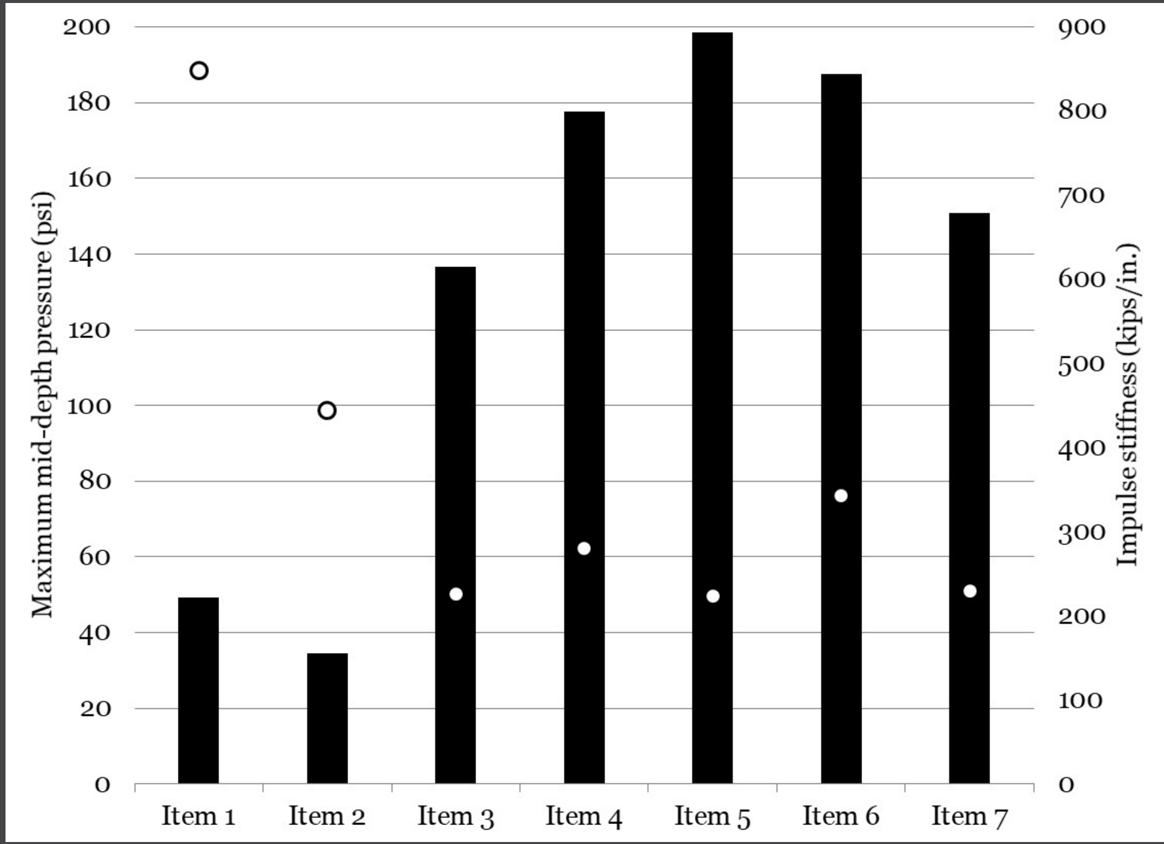
4 in.-thick HMA @ 2,048 passes

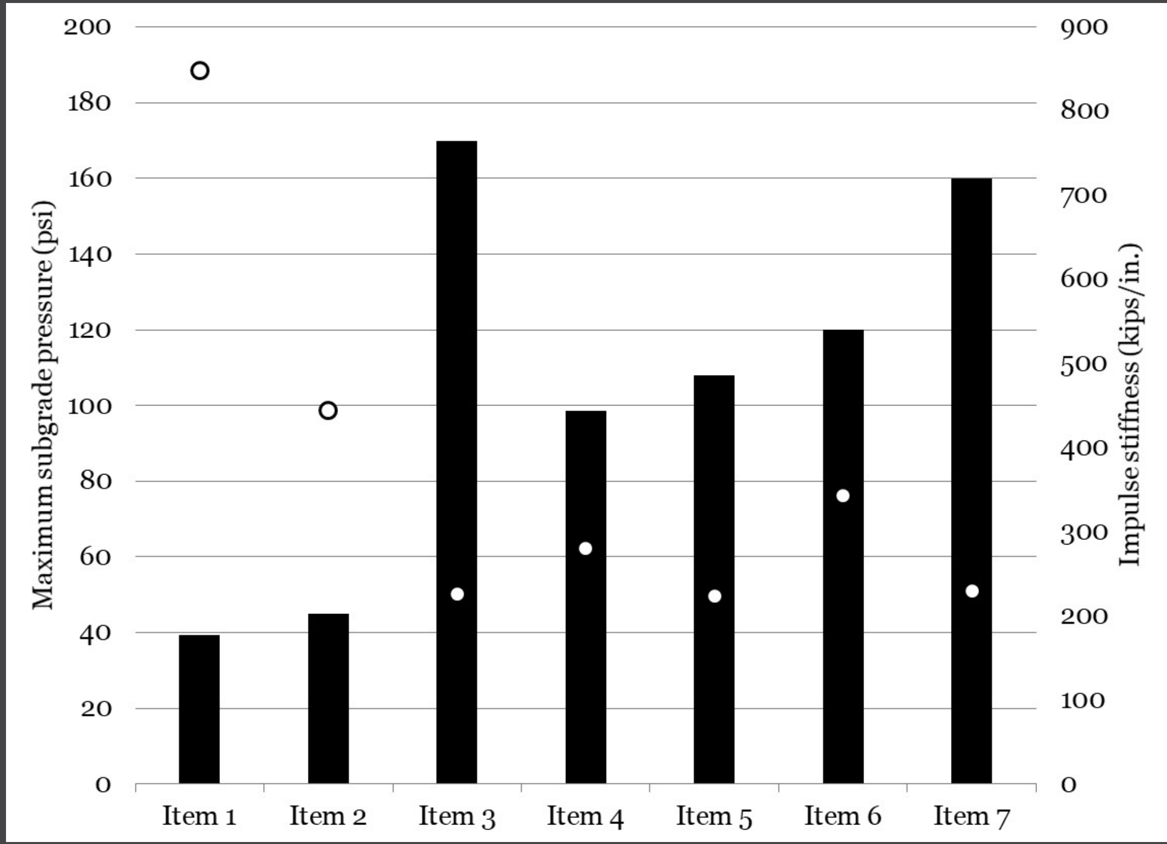
Effect of Fighter Aircraft Traffic on Full-Depth Reclamation with Thin Surface Treatments

DBST @ 20 passes

Unpaved @ 20 passes

Effect of Fighter Aircraft Traffic on Full-Depth Reclamation with Thin Surface Treatments





Evaluation Methods for Non-Traditional Pavement

- Develop pavement performance models for cargo aircraft operation on non-traditional pavements
  - Follow up to Thin Asphalt study conducted in Hangar 2 Test Facility
  - Identify existing field sections meeting the following:
    - Asphalt < 4-in.-thick; aged and/or non-traditional (sand asphalt)
    - Subgrade CBR < 8
    - Pavement Condition Index < 55
- Traffic with single-wheel cargo load cart
  - C-17 (max load with normal and reduced tire pressure)
  - C-130 (max load with normal and reduced tire pressure)

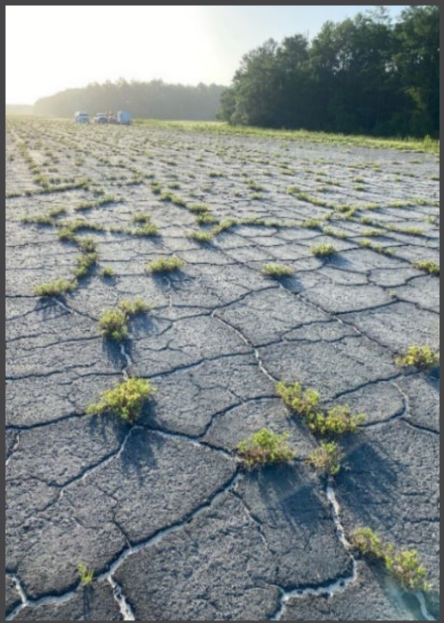
Evaluation Methods for Non-Traditional Pavement

- Site 1: Tyndall Air Force Base, Florida
  - 2-in.-HMA, 6 to 8-in. base, silty sand subgrade (severely oxidized and block cracked)
- Site 2: ERDC, Mississippi
  - 1 to 2-in.-HMA, variable base course, CL subgrade
- Site 3: Eglin, Florida
  - 7-in.-thick sand asphalt, sand subgrade
- Site 4: Eglin, Florida
  - 3.5 to 4-in. HMA, variable base course, sand subgrade
- Site 5: Malmstrom, Montana
  - DBST surface, 4-in.-thick base, 58-in. thick subbase, clay subgrade
- Site 6: Malmstrom, Montana
  - 3.5-in. HMA, 4 to 6-in. base 58-in. thick subbase, clay subgrade

Evaluation Methods for Non-Traditional Pavement

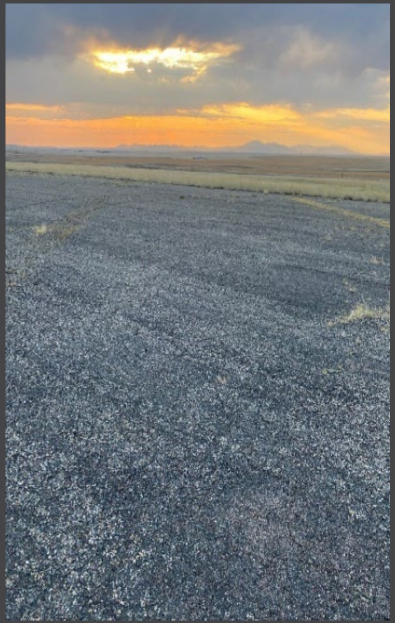
Site 1

Site 2



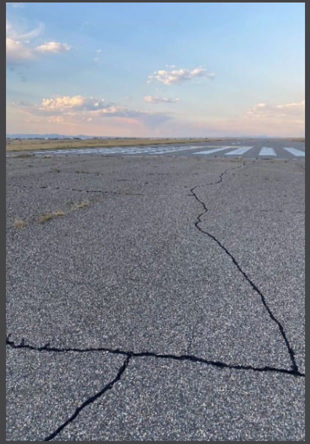
Site 3

Site 4



Site 5

- **Most sites were non-aircraft traffic, i.e. training sites or overruns, thus deterioration was primarily environmental.**

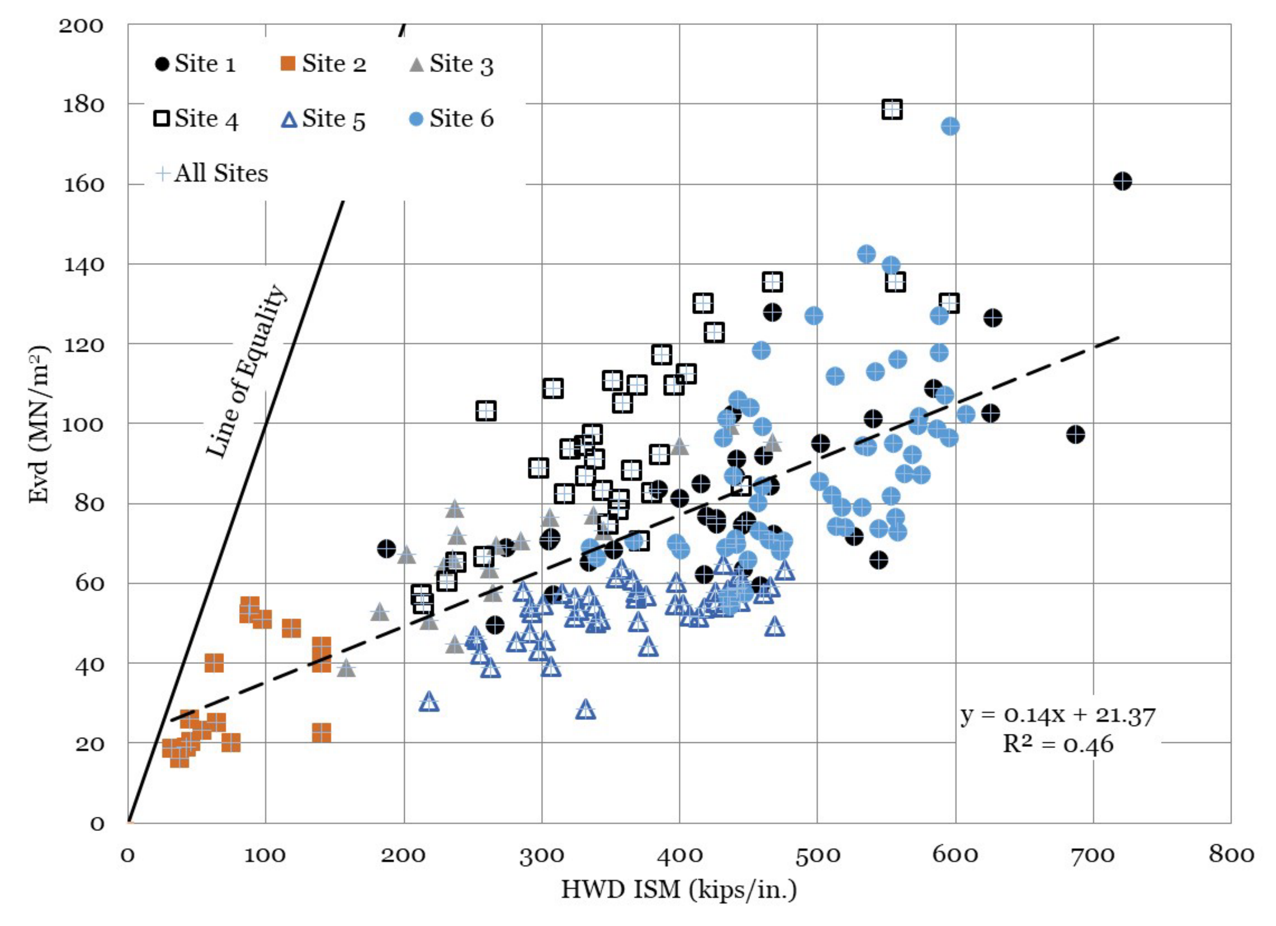


Site 6

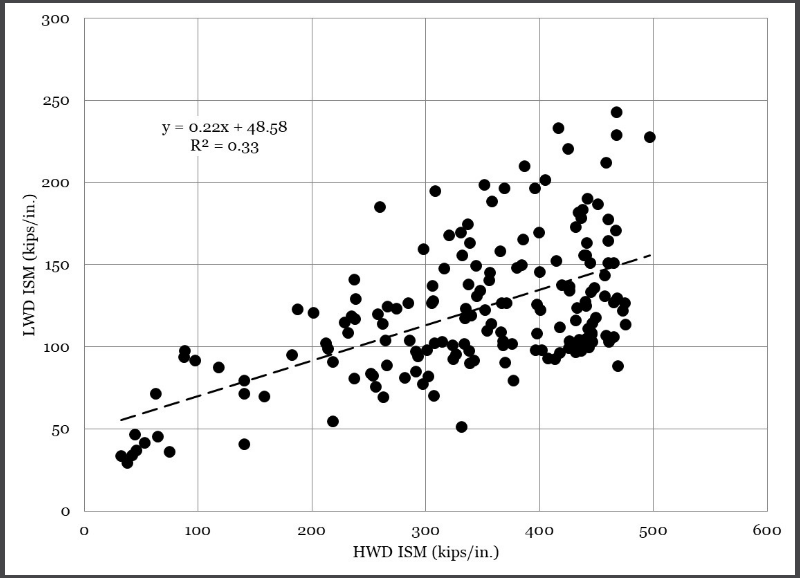
Evaluation Methods for Non-Traditional Pavement

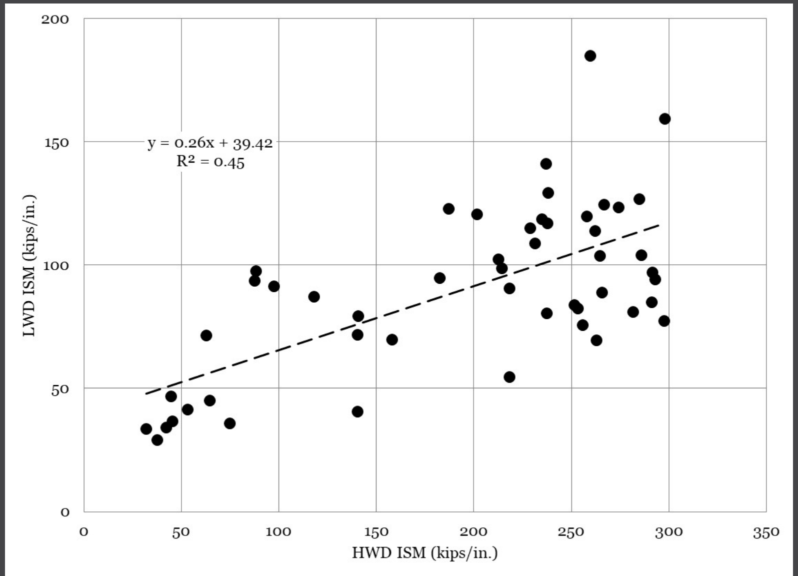
- Lightweight deflectometer and FWD measurements were made at the same location at the same traffic interval

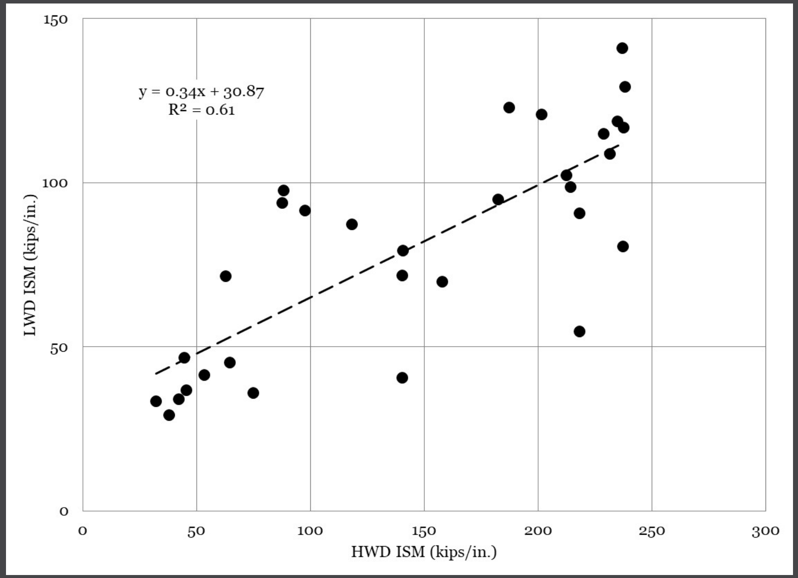
- Data were paired to determine if the LWD could be a suitable alternative to an FWD for contingency evaluation



Evaluation Methods for Non-Traditional Pavement







- LWD deflections were used to convert to ISM (note LWD used in this study does not have load measuring capabilities; thus constant force was assumed.
- Correlation tended to improve with lower HWD ISM (i.e., weaker pavements)

Evaluation of low volume road structural deterioration

Problem Statement:

- Low Volume Road (LVR) emphasis on structural capacity is minimal since deterioration typically results from environmental factors.
- Cases where structural condition of LVR becomes important due to rapidly increased traffic loading include:
  - Detouring traffic due to rehabilitation/replacement
  - Opening new industrial facility near LVR (e.g., oil and gas exploration)
  - Emergency response to extreme weather events
  - Transporting military cargo in contingency environments

Objective:

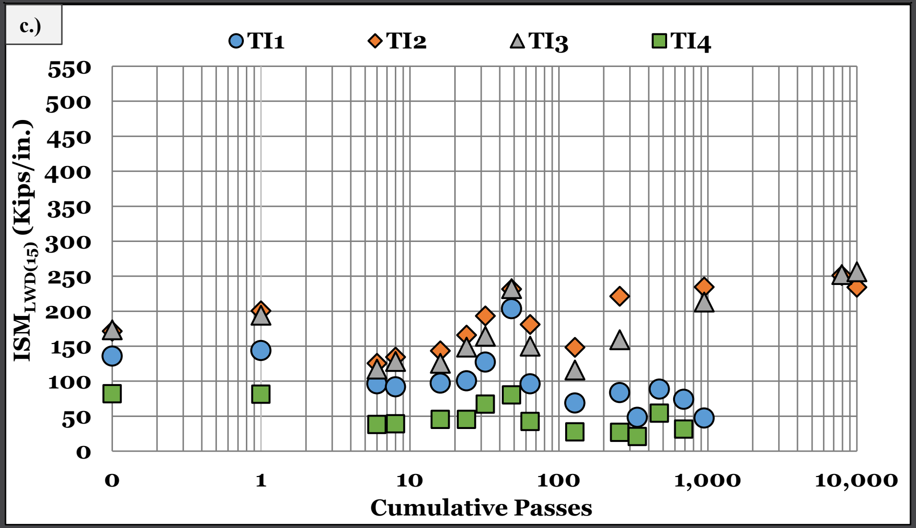
- Determine suitability of Light Weight Deflectometer (LWD) as a structural evaluation tool for LVRs.
- Explore the capability of LWD equipment in evaluating:
  - Load induced deterioration
  - Soil moisture
  - Flexible pavement temperature

Impact

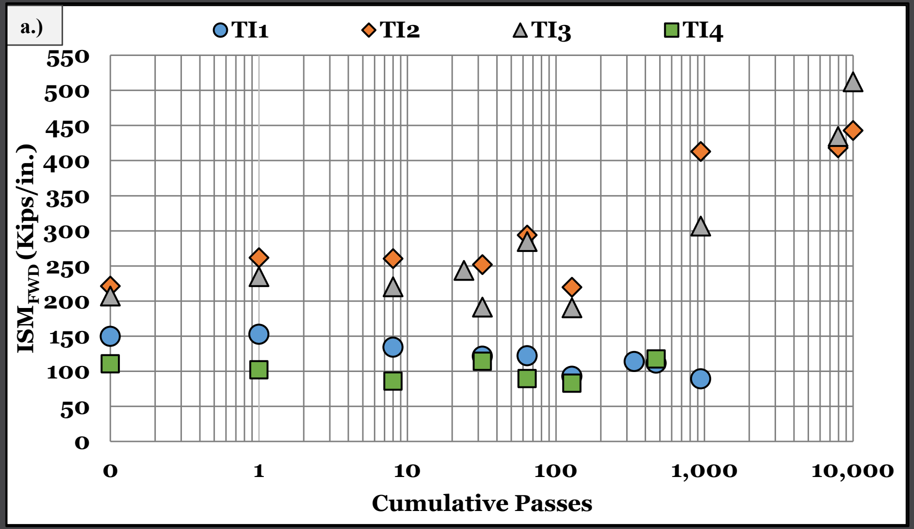
- Provide a quick cost-effective way to indicate structural capacity for LVRs.
- Provide project managers with pavement structural condition for decision making when traffic rapidly increases, and structural deterioration becomes the dominant distress mechanism.
- Develop criteria for prioritizing pavement maintenance/rehabilitation.

Results

- LWD was compared to FWD using Impulse Stiffness Modulus (ISM) to assess ability to track pavement structural condition.
- LWD was successful in tracking pavement structural condition over the duration of 10,000 vehicle passes (using a 4-axle, 58,000 lb truck) similar to the trends of the FWD.



LWD- 15kg hammer, 150 mm plate diameter



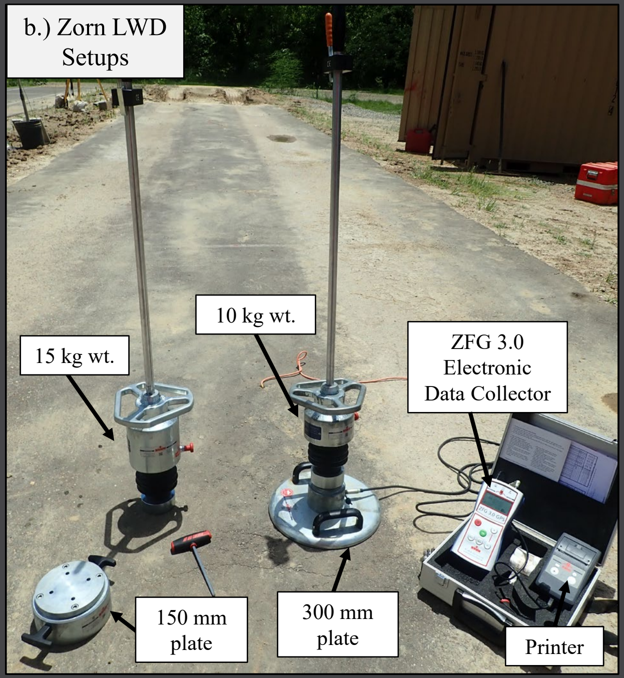
FWD

Results

- The LWD was successful in evaluating the effects of load induced deterioration on relatively weak pavement structures.

<u>Benchmarks for Criteria Development</u>

- ISMs > 150 kips/in. corresponded to good pavement performance and sustained 10,000 passes or more.
- ISMs ≤ 125 kips/in. corresponded to poor pavement performance and sustained less than 1000 passes.
- LWD provided useful information for ISMs < 250 kips/in. The LWD is not suitable for evaluating pavements stiffer than this.



Other APT work

- Biostabilization – cementation of sand using microorganisms
  - Response to military truck traffic and aircraft traffic
- Airfield matting
  - Lighter weight airfield matting solutions (multiple test sections)
- Airfield damage repair

Questions?