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CALTRANS DIVISION OF RESEARCH, INNOVATION AND SYSTEM INFORMATION
TRANSFORMING IDEAS INTO SOLUTIONS

Research Results

PAV TPF: Improving the Foundation Layers for Concrete Pavements TPF-5(183)

Field testing, numerical modeling, and design reviews were conducted to develop performance-based specifications to improve pavement foundation construction.

Pavement

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Project Title: PAV TPF-5(183): Improving the Foundation Layers for Concrete Pavements

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WHAT WAS THE NEED?

This research addressed longstanding limitations in how pavement foundation layers are designed, constructed, and inspected. Traditionally, the construction of these layers relied on empirical specifications with limited geotechnical testing, which could not ensure that the as-built conditions matched design assumptions. Poor support conditions in foundation layers – especially those that are spatially nonuniform or prone to permanent deformation – have been shown to reduce pavement life and performance. Despite their critical role, no mechanistic parameter measurements (such as resilient modulus) were used for in situ quality assurance during construction. This lack of mechanistic measurement reduces reliability and contributes to early pavement failures. There was a need for better measurement tools, verification practices, and performance-based construction specifications that could support longer-lasting pavement systems.

WHAT WAS OUR GOAL?

The goal of this research was to improve pavement foundation construction and inspection practices by identifying mechanistic parameters to be measured in situ measurements and developing a performance-based specification framework to support long-life pavement systems.

WHAT DID WE DO?

- Conducted an extensive field-testing program across multiple sites and geomaterial types, including freeze-thaw conditions in collaboration with several state DOTs.
- Performed advanced numerical modeling (e.g., finite

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element analysis) to evaluate the effects of foundation variability and deformation on pavement performance.
- Reviewed existing engineering parameters and design inputs for pavement foundation layers.
- Identified gaps in current testing methods, construction practices, and quality verification techniques.
- Developed a new performance-based specification workflow, emphasizing spatial uniformity and mechanistic measurements.
- Proposed measurement technologies and protocols that enable near-complete coverage and improved field control.

WHAT WAS THE OUTCOME?

- Identified major challenges with current practices, including limited field verification, non-uniform foundation layers, and lack of mechanistic testing.
- Confirmed that spatial variability and permanent deformation in foundation layers negatively affect pavement fatigue life.
- Demonstrated that compaction-based inspection methods are insufficient and correlate poorly with mechanistic design inputs.
- Developed a new performance-based specification approach centered on measuring resilient modulus and ensuring uniformity.
- Outlined a workflow to improve communication among designers, contractors, and inspectors.
- Documented data and lessons learned in site-specific reports and peer-reviewed publications.

WHAT IS THE BENEFIT?

This research benefits Caltrans, other DOTs, and the public by enabling the construction of more durable and reliable pavements. It introduces a modern, mechanistic approach to quality inspection that reduces early pavement failures, extends pavement life, and lowers long-term maintenance costs. By measuring key engineering properties directly in the field and enforcing uniformity, construction quality can be verified and deficiencies corrected before paving begins.

LEARN MORE

https://statics.teams.cdn.office.net/evergreen-assets/safelinks/2/atp-safelinks.html