CALIFORNIA DEPARTMENT OF TRANSPORTATION

DIVISION OF ENGINEERING SERVICES

Portland Limestone Cement: Lessons Learned and Ongoing Efforts to Support Net-Zero Emissions

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Caltrans Vision and Mission

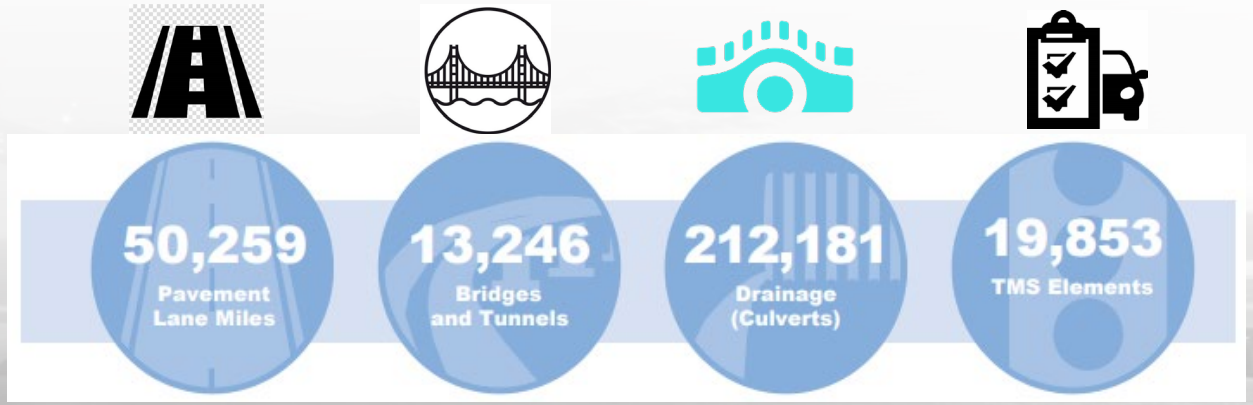
VISION

A brighter future for all through a world-class transportation network

MISSION

Provide a safe and reliable transportation network that serves all people and respects the environment

ASSETS



2019 CT Asset Management Data

Outline

- **Sustainability Strategies**
  - *Blended Cements/PLC in California Transportation*
    - Motivations and Concerns
    - Stakeholder Engagement
    - Current Status/Lessons Leaned
  - *Other Low Carbon Cement/Concrete Strategies*
    - Blended Supplementary Cementitious Materials (SCMs)
    - Alternative SCMs
    - Products In-Development (Product Evaluation Program)
    - Sustainability and Performance Specification Roadmap
- **Takeaways and Resources**

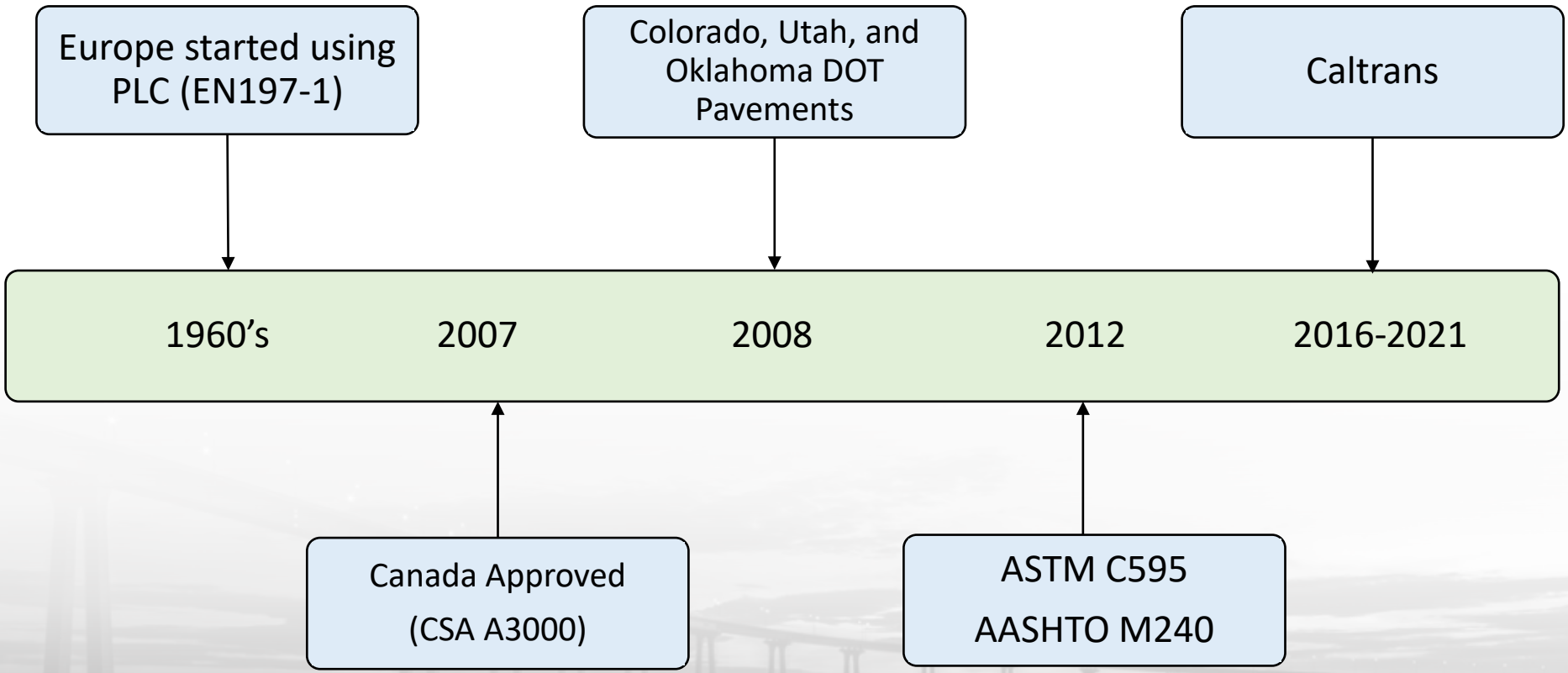
Sustainability Strategies

- Blended Cements, PLC
- Blended SCMs
- Alternative SCMs
- Products In-Development (Product Evaluation Program-PEP)
- Sustainability and Performance-Based Concrete Specifications

Sustainability Strategies

- **Blended Cements, PLC *(Completed Oct. 2021)***
- Blended SCMs
- Alternative SCMs
- Products In-Development (Product Evaluation Program-PEP)
- Sustainability and Performance-Based Concrete Specifications

PLC In Transportation



PLC In California

Motivations

- National Standards exists
- Ongoing positive research outcomes in North America
- Sustainability, Lower GHG

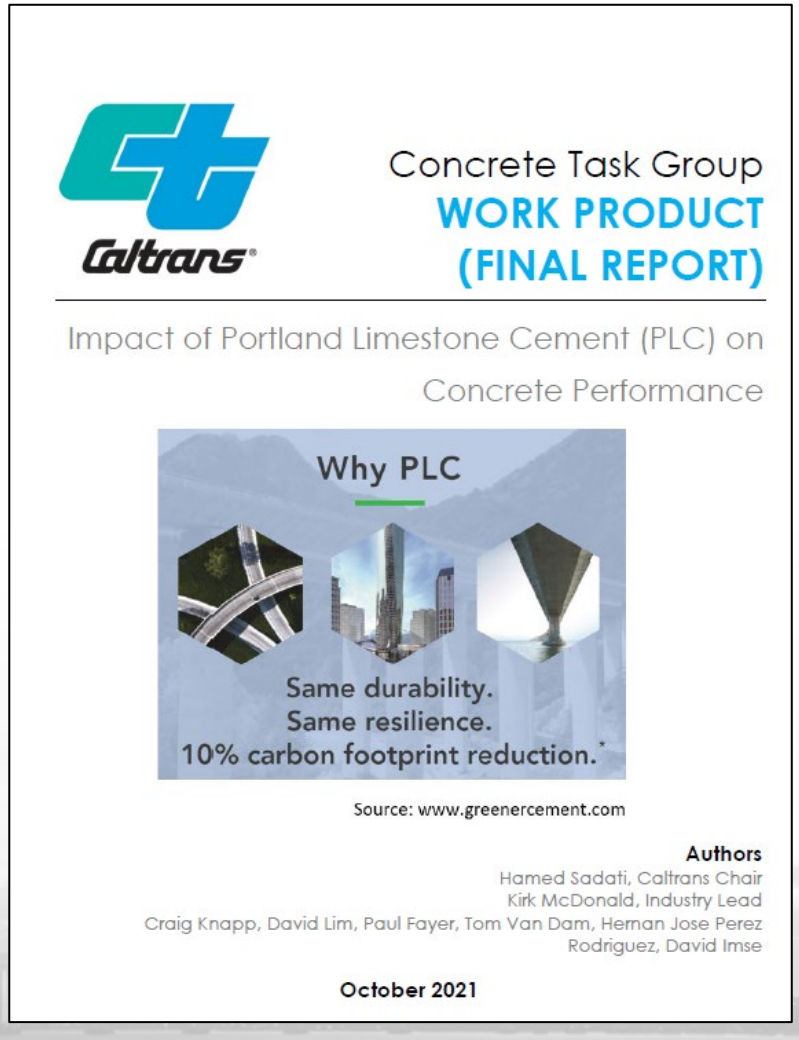
Concerns

- Local materials and distress mechanisms
- Different climates
- Impacts to Stakeholders

Pavement Deterioration due to Alkali-Silica Reaction (ASR), Caltrans Simi Valley

PLC In California (continued)

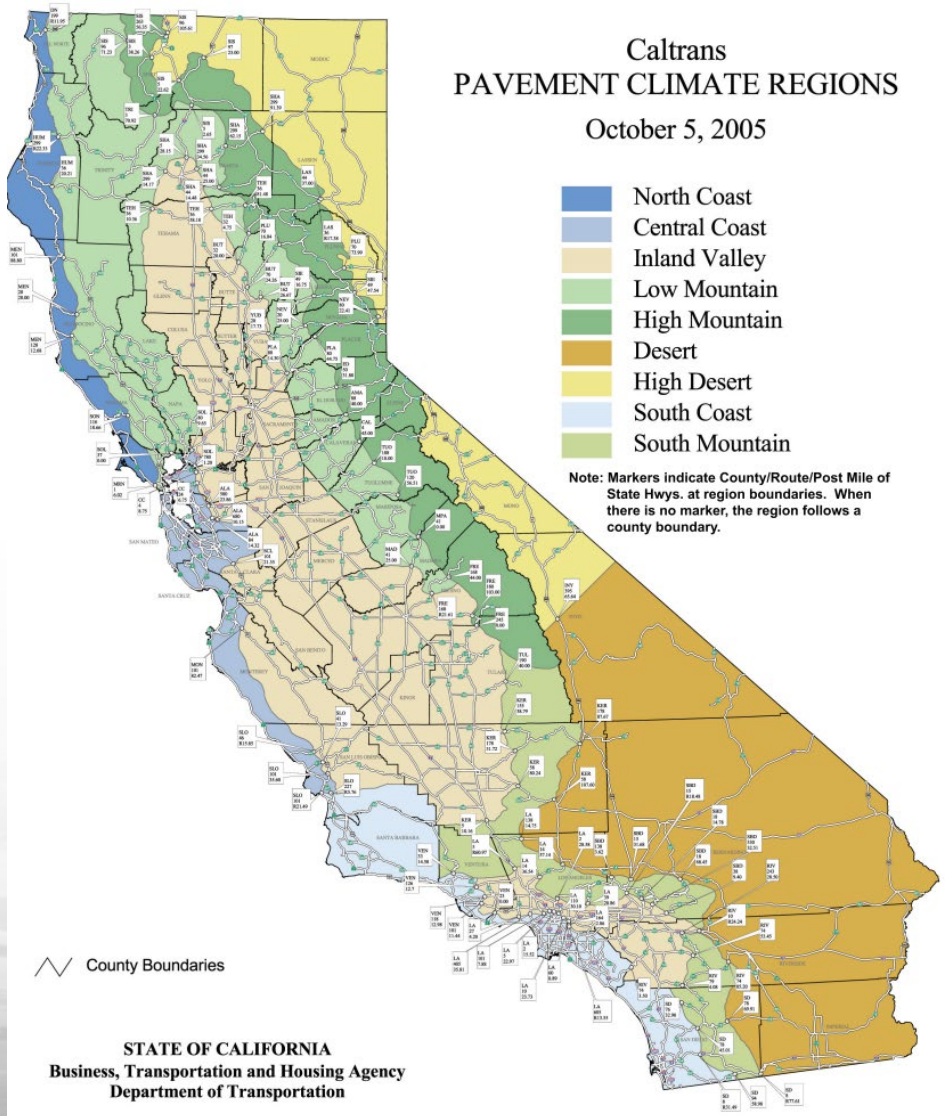
- **Caltrans 2016-2021**
  - *2016*: Research RFP developed
  - *2018*: OSU Study Started
  - *June 2021*: Completed 3-yr study with CA materials
  - *October 2021*: Revised Standard Specification includes PLC as a standard material (blended cement)



Now permitted in in FAA P-501; AIA Masterspec; UFGS 03 30 00; ACI and ICC building codes

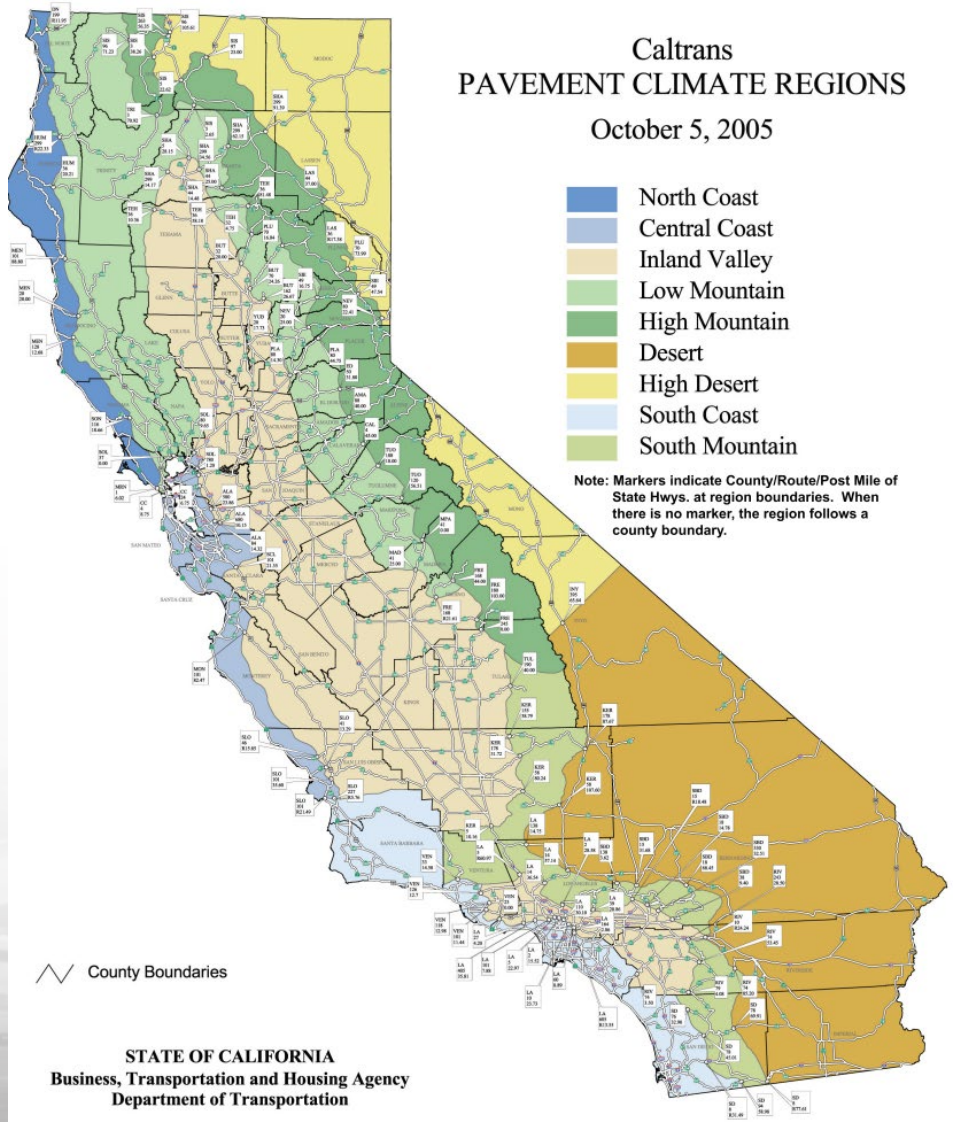
Approach

- New materials technology is context-sensitive, CA is no exception
- Existing Specifications
- Many participants and many moving parts
- Comprehensive plan developed
- Use of data to make informed decisions



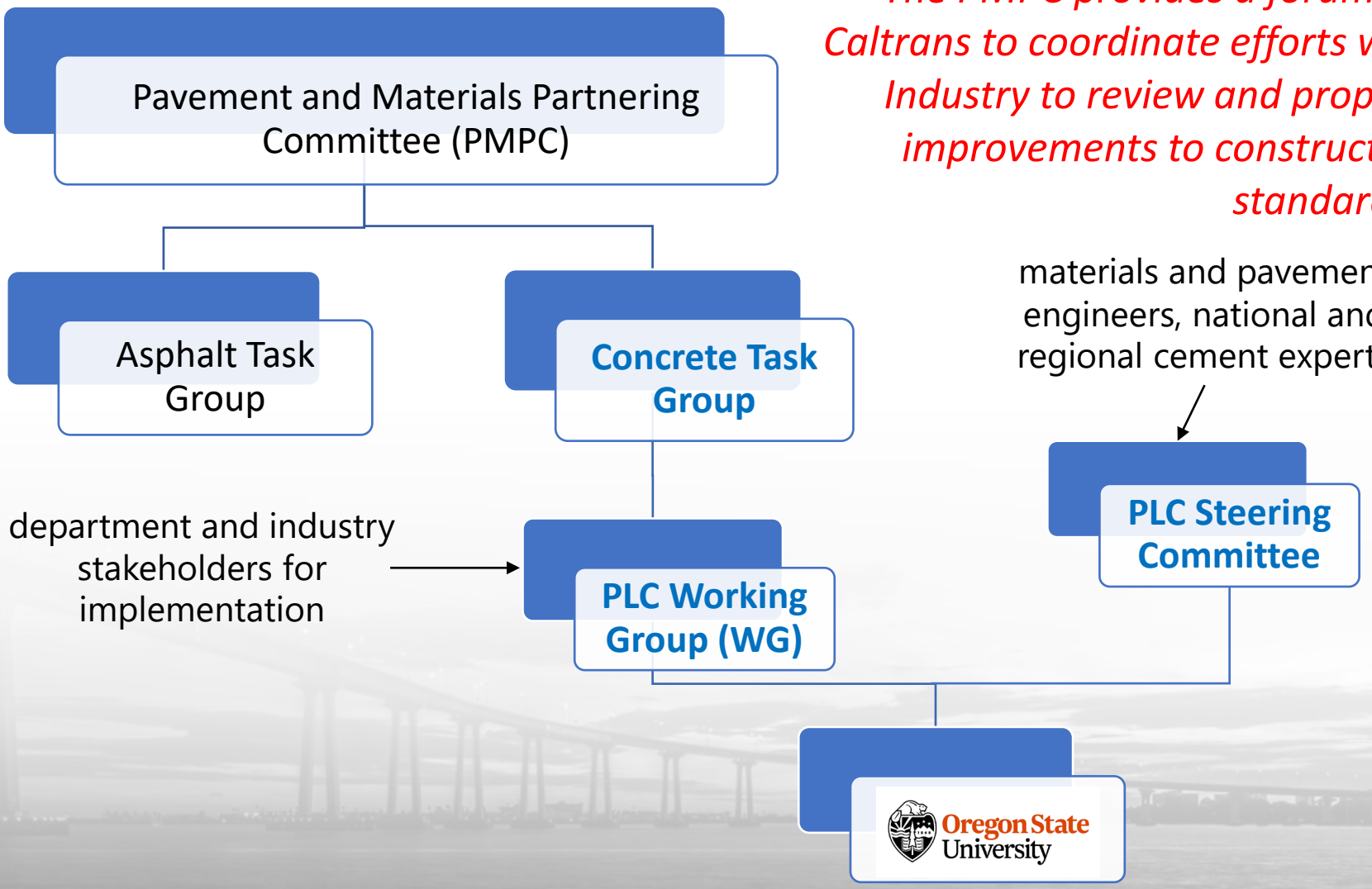
13 Performance Characteristics Evaluated

- Constituent material characterization
- Alkali-silica reactivity
- Shrinkage and restrained shrinkage
- Mechanical properties
- Transport properties
- Chloride binding
- Resistance to Chloride Ingression
- Corrosion of reinforcing steel
- Air entrainment
- External sulfate attack
- Construction schedule
- Environmental impact
- Thermodynamic simulations



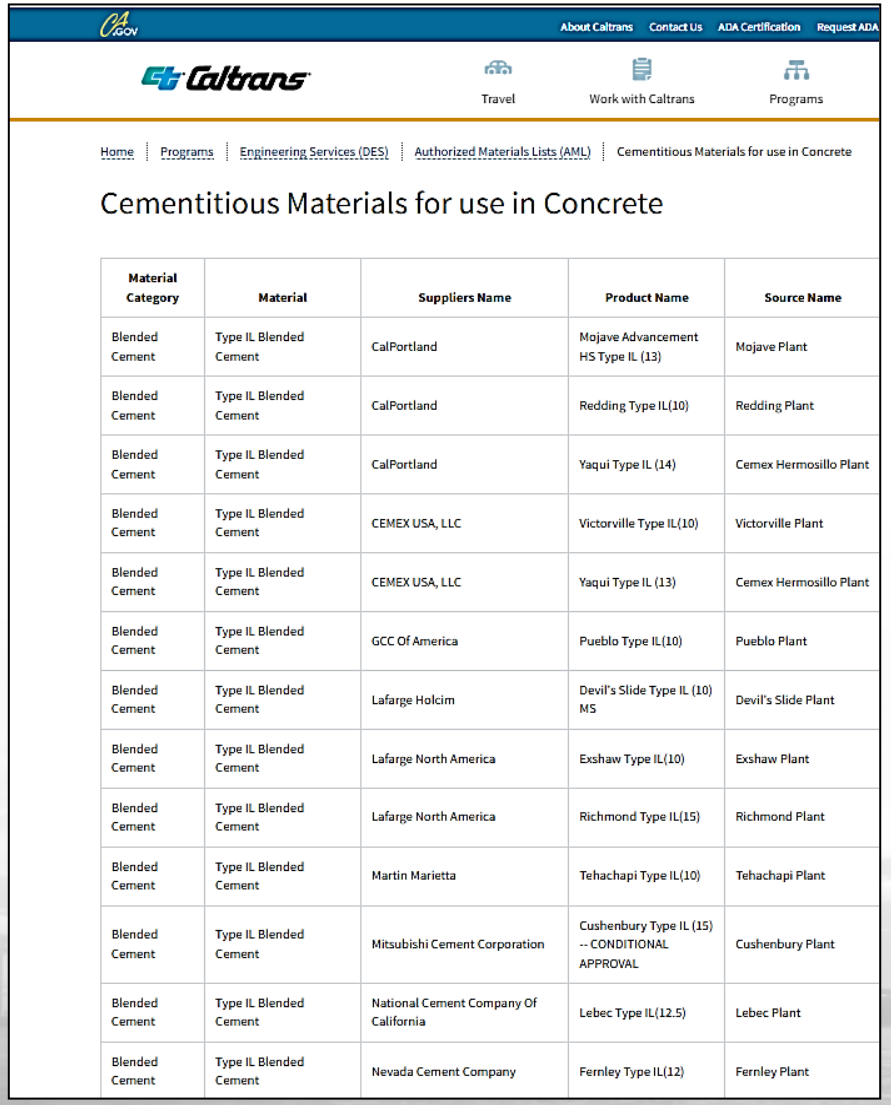
Stakeholder Engagement

"The PMPC provides a forum for Caltrans to coordinate efforts with Industry to review and propose improvements to construction standards."



Current Status

- Adopted into Standard Specifications, October 2021
- Utilizing AASHTO M240
- As of May 2023:
  - 14 sources of PLC on AML
  - 1 source of IT (ternary blended cement) on AML
  - Door open for more materials like a LC3 cement



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Home | Programs | Engineering Services (DES) | Authorized Materials Lists (AML) | Cementitious Materials for use in Concrete

Cementitious Materials for use in Concrete

Material Category	Material	Suppliers Name	Product Name	Source Name
Blended Cement	Type IL Blended Cement	CalPortland	Mojave Advancement HS Type IL (13)	Mojave Plant
Blended Cement	Type IL Blended Cement	CalPortland	Redding Type IL(10)	Redding Plant
Blended Cement	Type IL Blended Cement	CalPortland	Yaqui Type IL (14)	Cemex Hermosillo Plant
Blended Cement	Type IL Blended Cement	CEMEX USA, LLC	Victorville Type IL(10)	Victorville Plant
Blended Cement	Type IL Blended Cement	CEMEX USA, LLC	Yaqui Type IL (13)	Cemex Hermosillo Plant
Blended Cement	Type IL Blended Cement	GCC Of America	Pueblo Type IL(10)	Pueblo Plant
Blended Cement	Type IL Blended Cement	Lafarge Holcim	Devil's Slide Type IL (10) MS	Devil's Slide Plant
Blended Cement	Type IL Blended Cement	Lafarge North America	Exshaw Type IL(10)	Exshaw Plant
Blended Cement	Type IL Blended Cement	Lafarge North America	Richmond Type IL(15)	Richmond Plant
Blended Cement	Type IL Blended Cement	Martin Marietta	Tehachapi Type IL(10)	Tehachapi Plant
Blended Cement	Type IL Blended Cement	Mitsubishi Cement Corporation	Cushenbury Type IL (15) -- CONDITIONAL APPROVAL	Cushenbury Plant
Blended Cement	Type IL Blended Cement	National Cement Company Of California	Lebec Type IL(12.5)	Lebec Plant
Blended Cement	Type IL Blended Cement	Nevada Cement Company	Fernley Type IL(12)	Fernley Plant

PLC Lessons Learned

- Understand motivations and perform needs assessment early
- Collaboration with impacted stakeholders was a key to success, PLC simpler than current efforts
- Data-driven research outcomes needed to demonstrate suitability of PLC as a replacement for OPC
- Continued focus on the intended outcome helped steer and course-correct along the way
- A similar approach and research mechanisms are underway for adoption of alternative SCMs

Sustainability Strategies

- Blended Cements, PLC
- **Blended SCMs**
- Alternative SCMs
- Products In-Development (Product Evaluation Program-PEP)
- Sustainability and Performance-Based Concrete Specifications

Blended SCMs-PMPC WG (In-Progress)

Motivations

- Increasing overall SCM supply
- Use one SCM's positive attribute to compensate for another SCM's properties.
- Custom blended for local markets and environmental conditions.
- Potential to bridge the fly ash supply over time.

Goal: *Allow the use of blended SCMs via ASTM C1697*

Blended SCMs-PMPC WG (In-Progress)

Current Effort:

- Pre-blending and storage of blended SCMs

ASTM C1697 – 21

TABLE 1 Classification of Supplementary Cementitious Materials

Type	Name
N	Class N Pozzolan meeting Specification C618
F	Class F fly ash meeting Specification C618
C	Class C fly ash meeting Specification C618
SF	Silica Fume meeting Specification C1240
S	Slag cement meeting Specification C989/C989M

- Potential modifications to the Standard Specifications
  - Proposed direction:
    - Blended SCMs according to ASTM C1697
    - Blending FA & NP to meet AASHTO M295 & Spec criteria

Sustainability Strategies

- Blended Cements, PLC (Oct. 2021)
- Blended SCMs
- **Alternative SCMs**
- Products In-Development (Product Evaluation Program-PEP)
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Alternative SCMs

Motivations

- Reduce greenhouse gas (GHG) emissions
- Potential to bridge the fly ash supply over time.
- Identify alternative SCMs that come from local (i.e. California) and regional sustainable sources

Goal: *Consider viable alternative local materials that lower GHG impact*

Reclaimed Fly Ash

https://www.fayobserver.com/story/news/2019/04/01/state-orders-duke-energy-to-excavate-all-coal-ash/5563588007/

Alternative SCMs

Project #1

Material	Material Group
Ashes from combustion of forest byproducts and waste	SCMs
Ashes from combustion of straw ash	SCMs
Ashes from municipal solid waste incinerators	SCMs
Natural pozzolans - volcanic and sedimentary deposits	SCMs
Natural pozzolans - calcined clays	SCMs
Seafood waste (oyster shells, urchins, etc.)	Fillers
Cellulose nanomaterials	Nanomaterials
Chitin nanomaterials	Nanomaterials
Construction demolition waste powder	Fillers / SCMs
Asphalt plant baghouse fines	Fillers / SCMs
Dust from lightweight aggregate production	Fillers / SCMs
Carpet backing	Fillers
Returned plastic concrete	Fillers / SCMs





Alternative SCM Potentials

Project #2

- Focus on Reclaimed FA, FA-C, Glass Powder
- Communication with potential material suppliers to identify potential alternative SCMs
- Roughly 29 products have been identified (CA, NV, AZ, UT,…)
- Experimental work starting

Ground Glass Pozzolan

https://www.buildinggreen.com/newsbrief/new-standard-replacing-cement-recycled-glass

Sustainability Strategies

- Blended Cements, PLC (Oct. 2021)
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- Alternative SCMs
- **Products In-Development (Product Evaluation Program-PEP)**
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Product Evaluation Program-PEP

- Dedicated to the objective, impartial, consistent and timely evaluation of products
- Eligible products must be fully developed, commercially available, and ready for use
  1. Vendor has a product for Caltrans to adopt.
     Does the product meet the existing specifications? If not,
  2. Vendor completes and submits the New Product evaluation Submittal Form (TL 9501) and supporting documentation.
  3. Subject matter Technical Committee assigned and performs evaluation.
  4. Technical Committee Rejects or Accepts product with a work plan for further implementation.

Sustainability Strategies

- Blended Cements, PLC (Oct. 2021)
- Blended SCMs
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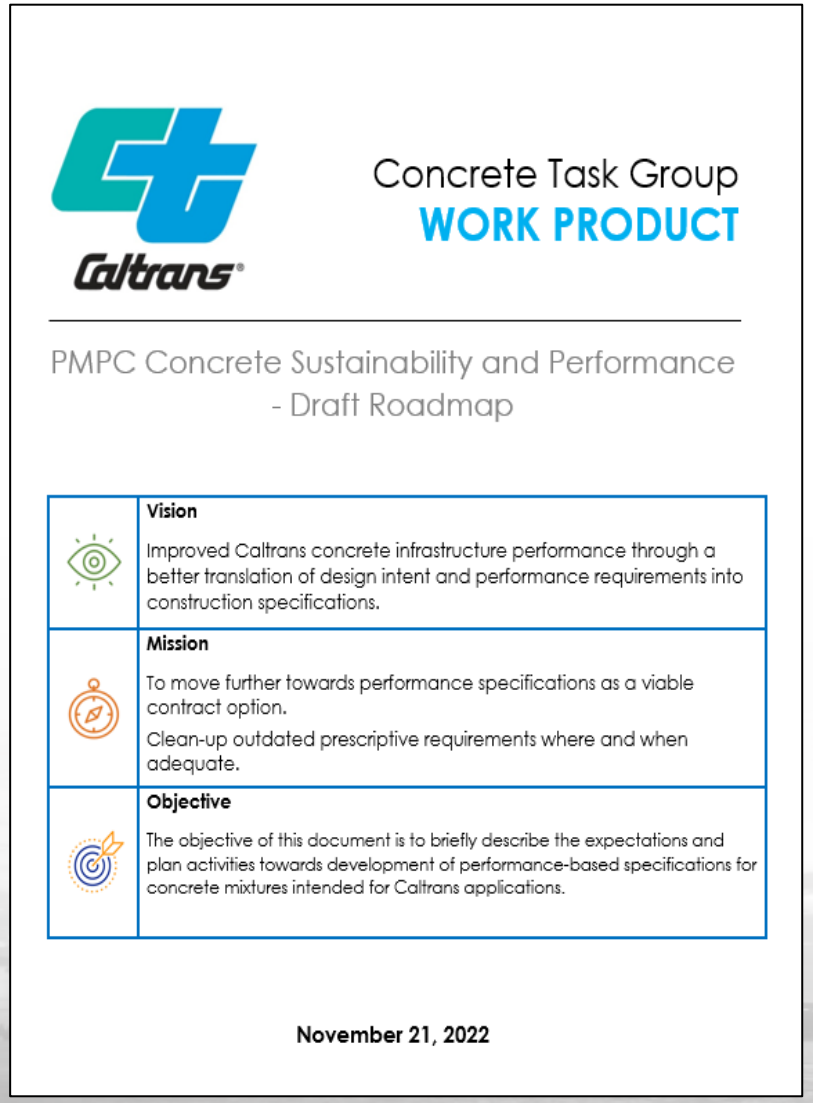
- **Sustainability and Performance-Based Concrete Specifications**

Concrete Performance Workplan

- **The Vision** (***What is our end state?***)
  - Improved Caltrans concrete infrastructure performance
- **The Mission** (***Why are we doing this?***)
  - Viable contract option.
  - Clean-up outdated prescriptive requirements
- **The Purpose**
  - Align all concrete sustainability efforts



Concrete Task Group
WORK PRODUCT

PMPC Concrete Sustainability and Performance - Draft Roadmap

	Vision Improved Caltrans concrete infrastructure performance through a better translation of design intent and performance requirements into construction specifications.
	Mission To move further towards performance specifications as a viable contract option. Clean-up outdated prescriptive requirements where and when adequate.
	Objective The objective of this document is to briefly describe the expectations and plan activities towards development of performance-based specifications for concrete mixtures intended for Caltrans applications.

November 21, 2022

Caltrans; Cement and Concrete Related Efforts

Pavement Program

- EPD Constituent Materials & Proportions
- Div. of Sustainability Roadmap
- Tracking GHG #s
- eLCAP
- Life Cycle Assessment (LCA)

Materials Engineering Testing Services (METS)

- FHWA Climate Challenge
- EPD Pilot Projects
- Sustainable Pavement EPD Implementation Asphalt & Concrete

Pavement and Materials Partnering Committee (PMPC)

- Concrete Sustainability Roadmap Initiate LCA for Concrete
- PLC Implementation
- EPD collection

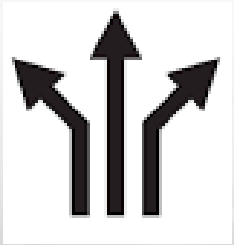
Ongoing Academic Research

- In-Place Recycling
- CIR concrete pavement bases
- LCA eLCAP Data & Models
- Multi-Criteria Decision Making
- Implementation of likely SCMs
- Recycled fibers
- Tech. Eval. of street assets

Takeaways

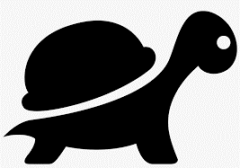
- Identification of risks and engagement with impacted stakeholders

- Support from academia towards data-driven decision making is crucial



- Different climates and local materials requires specific evaluation of distress mechanisms and performance impacts

Takeaways



- Not a fast process

- Milestones should be driven by the intended end state

- Communication and collaboration with partners is the key to success

Resources

- Pavement and Materials Partnering Committee
  - https://dot.ca.gov/programs/maintenance/pavement/pavement-materials-partnering-committee
- Product Evaluation Program (PEP)
  - https://dot.ca.gov/programs/engineering-services/product-evaluation-program
- Concrete Task Group and Technical Reports
  - https://dot.ca.gov/programs/maintenance/pavement/pavement-materials-partnering-committee/concrete-task-group
- Portland Limestone Cement Scoping Document (ca.gov)
  - https://dot.ca.gov/-/media/dot-media/programs/maintenance/documents/pmpc/ctg/pmpc-ctg-sd-portland-limestone-cement-a11y.pdf
- Article | CALTRANS: Impact of the Use of Portland-Limestone Cement on Concrete Performance as Plain or Reinforced Material - Final Report
  - https://ir.library.oregonstate.edu/concern/articles/7h149x67f?locale=en



DIVISION OF ENGINEERING SERVICES

Thank You!

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