



20 a 22 de Junho de 2016 - São Paulo/SP

# ***The Role of Concrete in Sustainable Building***

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**Portland Cement Association**

Realização




## MIT Concrete Sustainability Hub: Changing the Rules of the Game




CHANGING THE RULES OF THE GAME

In the past... research focused on  
changing the properties of concrete



Now, the CSHub is changing the way  
concrete is evaluated & implemented  
in infrastructure projects



## CSHub Mission

Develop breakthroughs that will lead to more sustainable and durable infrastructure, buildings, and homes



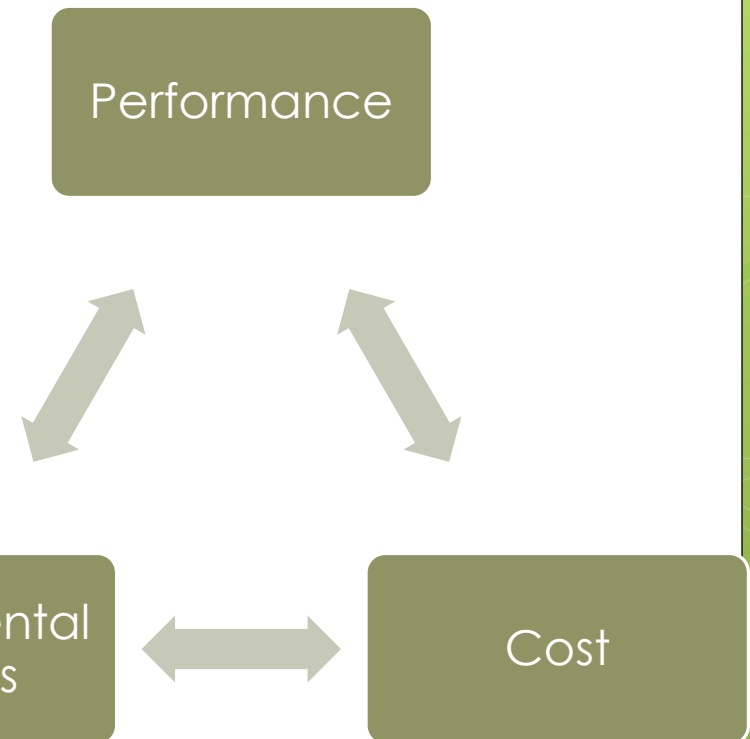
1. Provide scientific basis for informed decisions

2. Demonstrate the benefits of a life-cycle perspective

3. Transfer research into practice



MIT is trying to open people's eyes to the benefits of concrete--...using a life cycle perspective



# CSHub approach is holistic and multidisciplinary



Science



Engineering



Economics

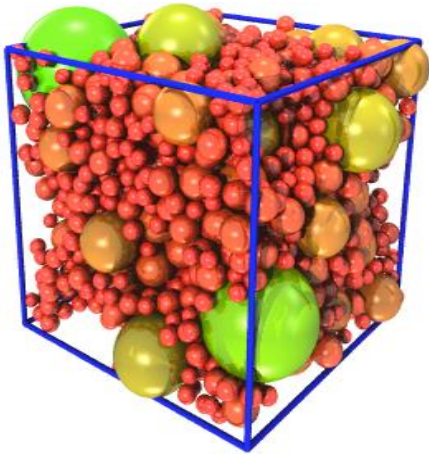


Environment

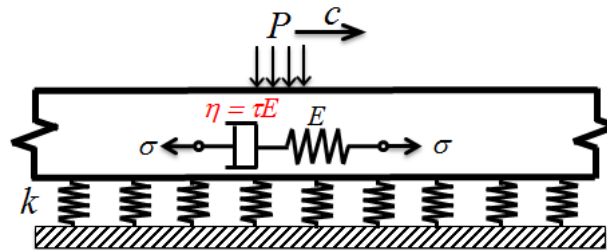


# 1. Provide scientific basis for informed decisions

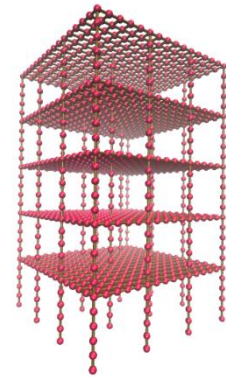
Concrete science



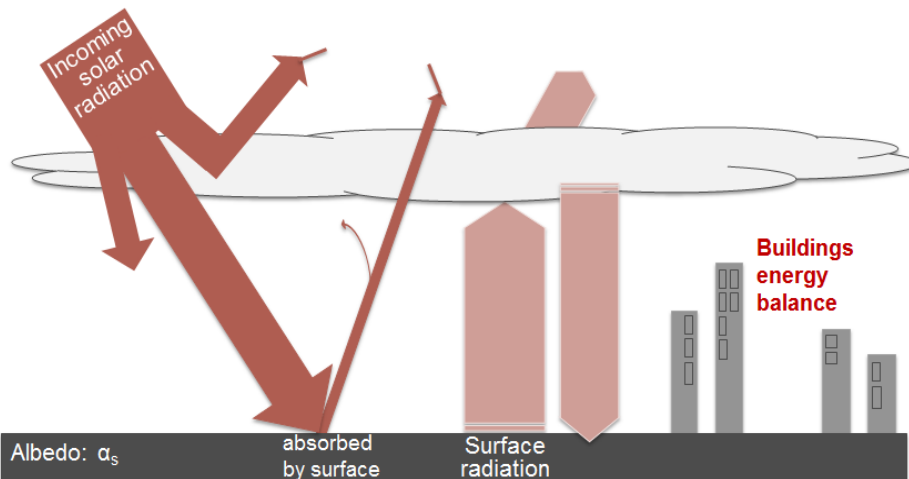
Pavement-vehicle interaction



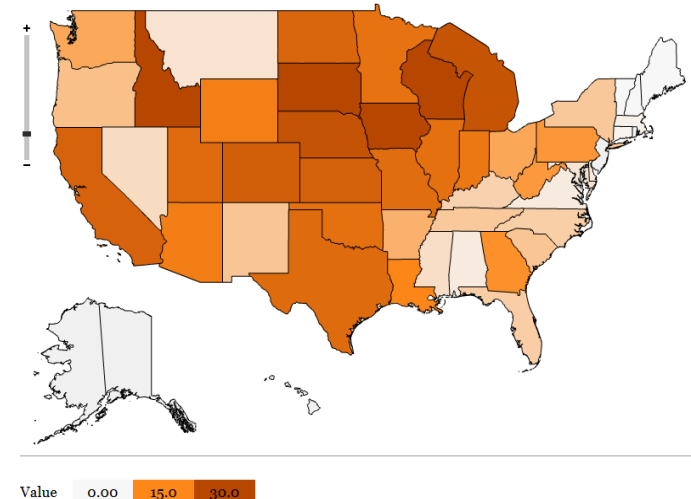
Building resilience



Albedo

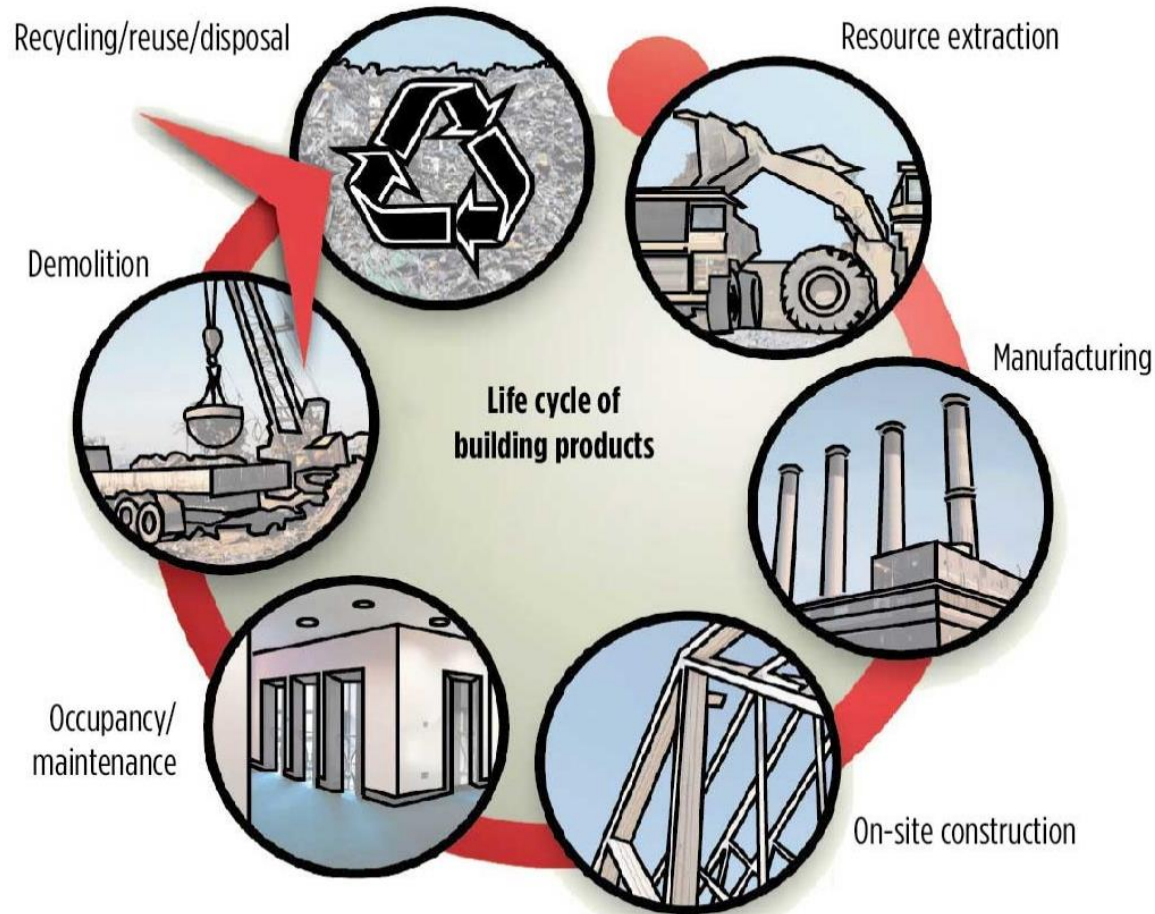


Paving competition



## 2. Demonstrate the benefits of a life-cycle perspective

Pavements



Buildings





# An integral part of communities

Concrete science

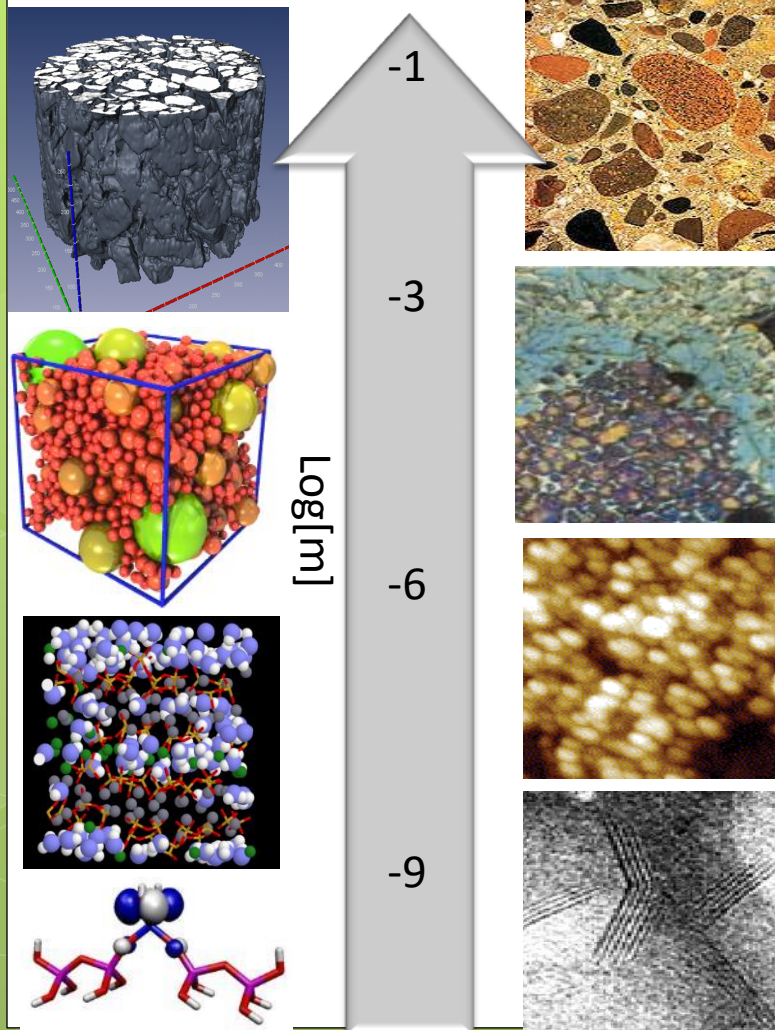
Pavements



Transportation  
Research  
Board



Buildings



CSHub research has received  
extensive media attention

**ENR**  
Engineering News-Record

**B B C**

The Boston Globe

**25** **THE TOP 25 NEWSMAKERS**

 **MARKETPLACE**<sup>®</sup> Sustainability

The  
**Concrete  
Producer**

**nature** International weekly journal of science  
**SCIENTIFIC  
AMERICAN**<sup>™</sup>

# CSHub research has had impact



U.S. Department  
of Transportation  
Federal Highway  
Administration

## Towards Sustainable Pavement Systems: A Reference Document

FHWA-HIF-15-002



South  
Dakota  
DOT

## MOUNTAIN-PLAINS CONSORTIUM

MPC 14-275 | Xiao Qin, Kai Wang, and Zhiguang Wang

Selection of Interest and Inflation Rates for Infrastructure  
Investment Analyses



UNIVERSITY of CALIFORNIA | PAVEMENT RESEARCH  
Davis • Berkeley | CENTER



**Athena**  
**Pavement**  
LCA

CSHub researchers are sought for  
their expertise



**MICHELIN**

**MeritageHomes®**



**USTDA**

U.S. TRADE AND DEVELOPMENT AGENCY





### 3. Transfer research into practice

Technology transfer spectrum

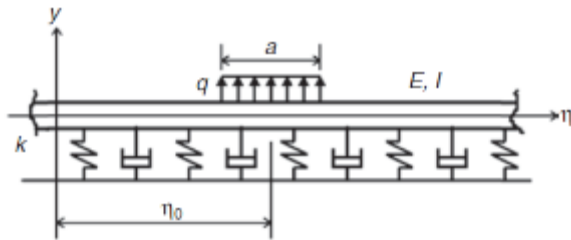


Innovation      Incubation      Implementation

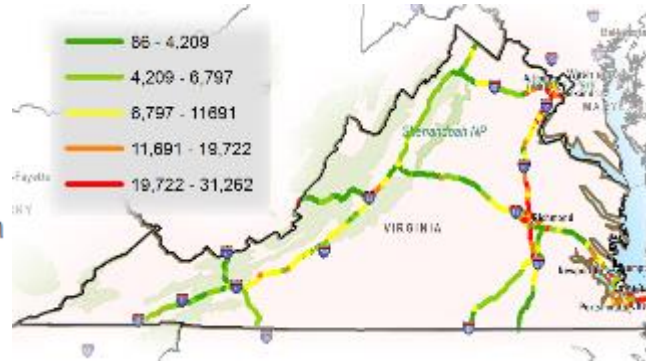
# PVI research: clear success in transition of innovation to implementation

**2010**

$$\delta E = -P \frac{dw}{dx} \approx P \frac{w_{max}}{\ell_s/2}$$



**2014**



**2016?**



Innovation Incubation Implementation

# Durability Research

- Alkali-Silica Reactivity—Mike Thomas, University of New Brunswick
- Freeze-thaw and deicer—Jason Weiss, Oregon State University
- Modeling interaction—MIT

# Durability: the ability of concrete to survive the environment to which it is exposed

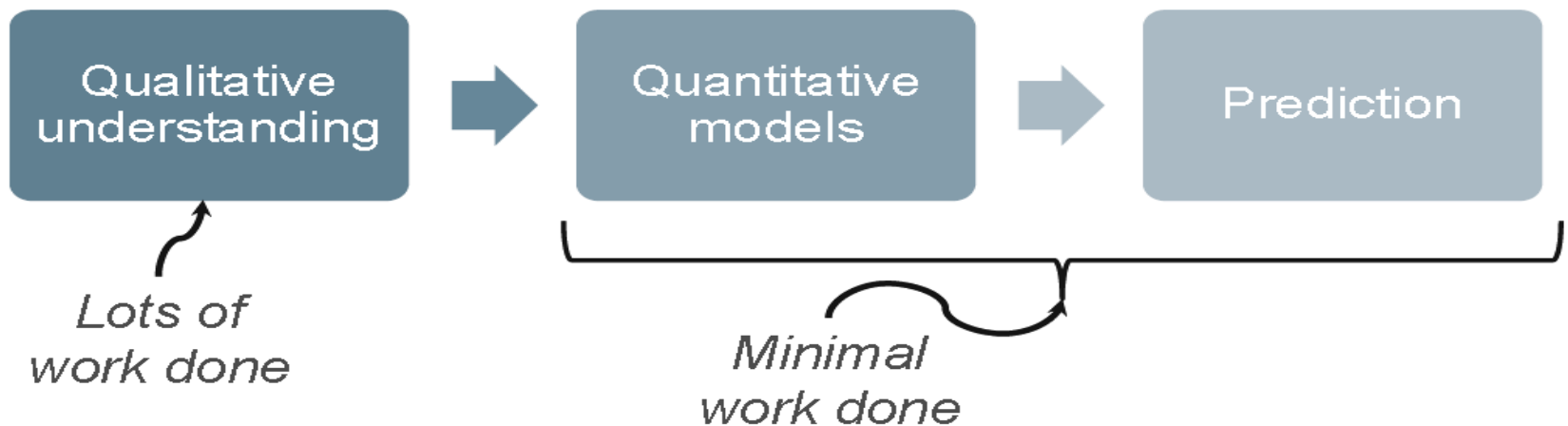
## Concrete distress mechanisms\*



\*P. Taylor, "Long-Life Concrete: How Long Will My Concrete Last?", National Concrete Pavement Technology Center, 2013



## Distress mechanisms understood, but quantification is a challenge



Current experimental methods do not adequately predict pavement durability

Pavement durability models do not directly account for material properties

# Objective: improve concrete pavement durability & demonstrate benefits

- Improve scientific understanding of pavement distresses
- Translate knowledge into pavement design & maintenance
- Demonstrate cost and environmental benefits of durable pavements and pavement networks

# Vision: connect pavement materials and performance prediction

Pavement  
Material  
Composition



Pavement  
Durability  
Performance

- For a given material composition and context:
  - What is the potential for ASR/FT damage?
  - What is the rate at which it would happen?
- Which conditions lead to ASR/FT damage?

There have been several pavement implementation projects

**CO:** LCCA case studies

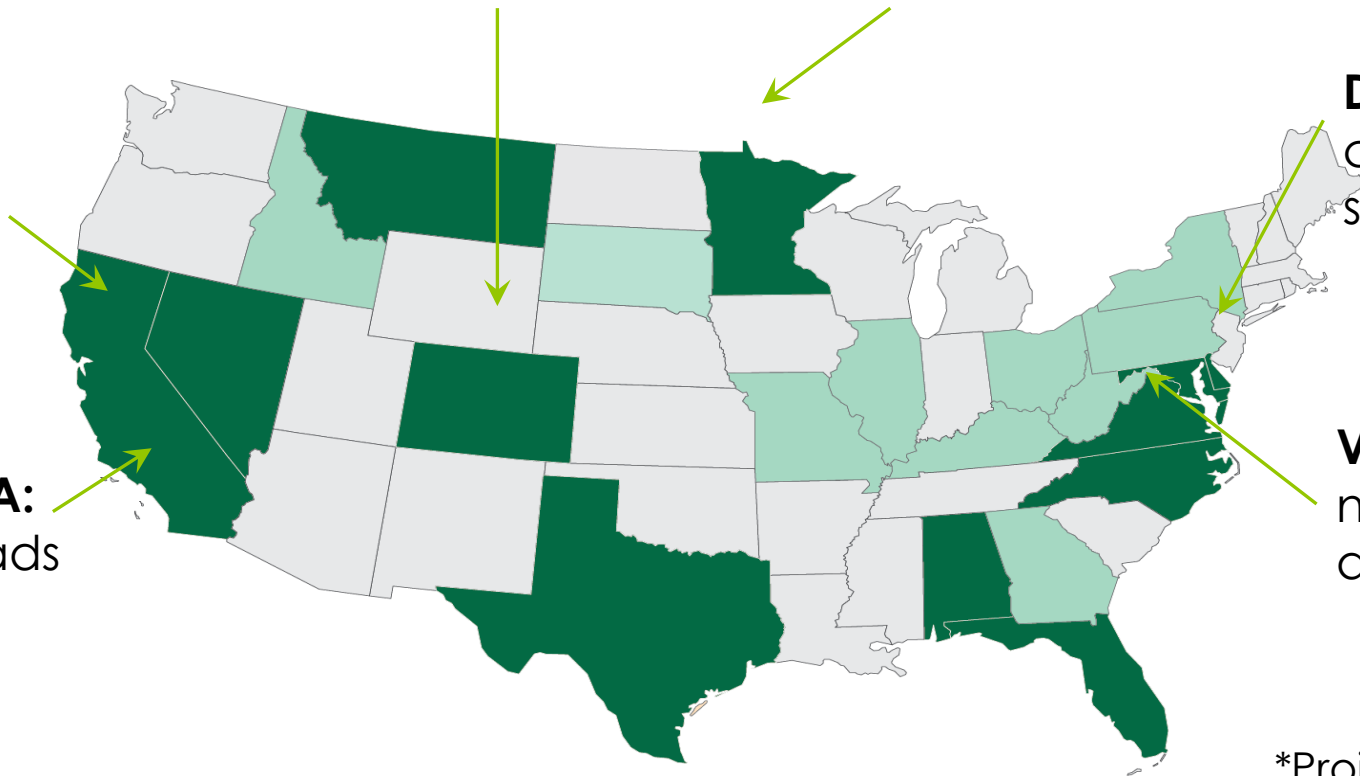
**MN:** LCCA case studies\*

**DE:** LCA case studies\*

**VA:** PVI network analysis

**CA:** PVI network analysis

**City of LA:** local roads LCA



\*Projects underway

**Advisory support in LCCA legislation:** AL, MD, NC

**Interactions with DOTs and Federal Agencies:**

AASHTO, FHWA, GAO, OMB, FL, MD, MN, MT, NC, NV, TX



# MIT research has influenced pavement projects in several states

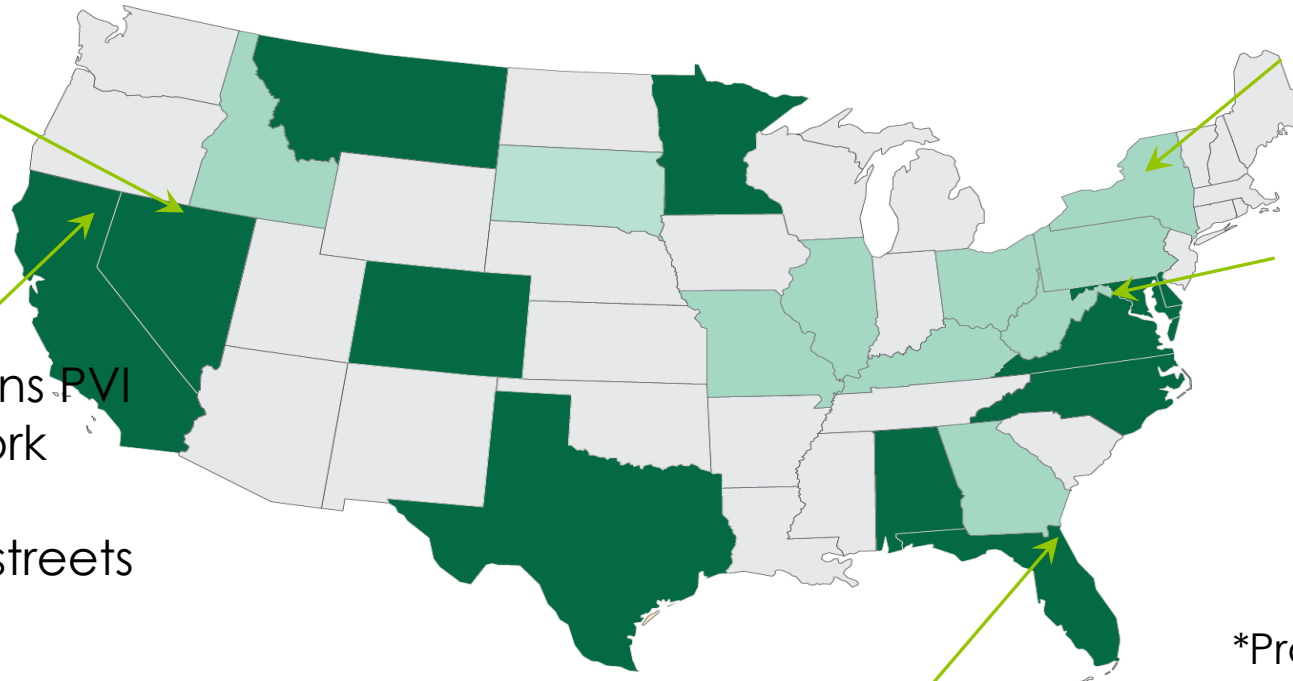
**NV:** Major  
bypass  
outside Las  
Vegas

**CA:** Caltrans PVI  
and network  
analyses  
City of LA streets

**MD:**  
mainline  
paving &  
RMC in  
parking lots  
**NC:** mainline  
paving &  
RMC in  
parking lots

**FL:** RCC  
at a  
port

\*Projects underway



Buildings implementation projects on streamlined LCA are beginning now



**BUILD WITH STRENGTH**

# Implementation evolution

2010

PCA & NRMCA manage implementation



2013

A few industry partners facilitate projects with MIT



2016

Industry and MIT develop implementation plans



# What did it take to achieve success in California?

## Local effort

Objectives

Strategy

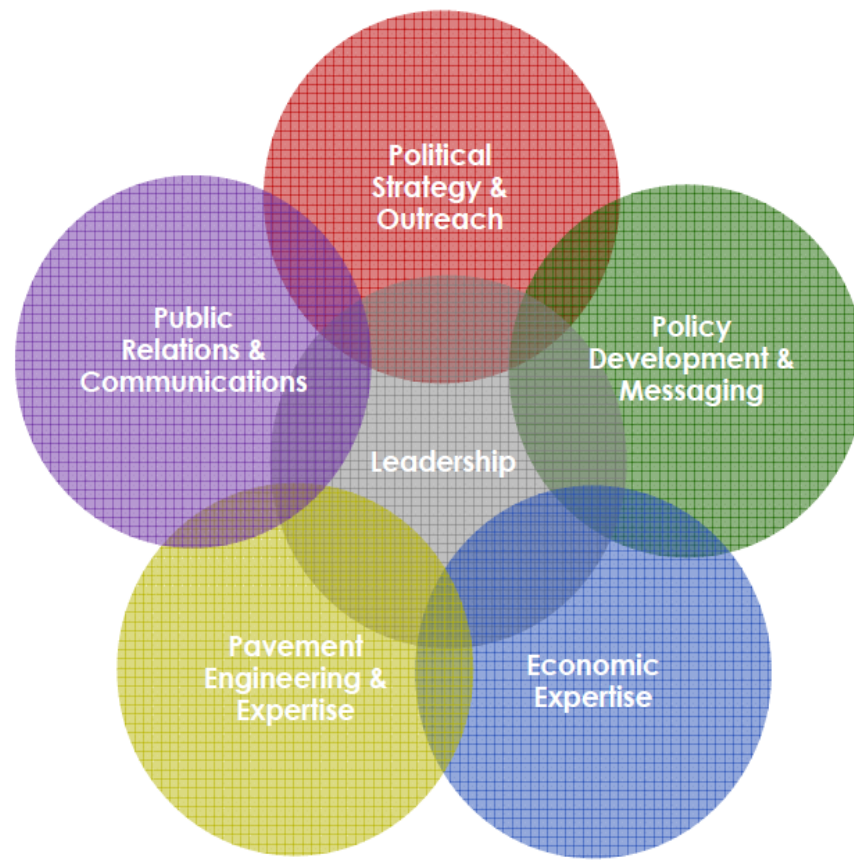
Understanding of social system

Dedication

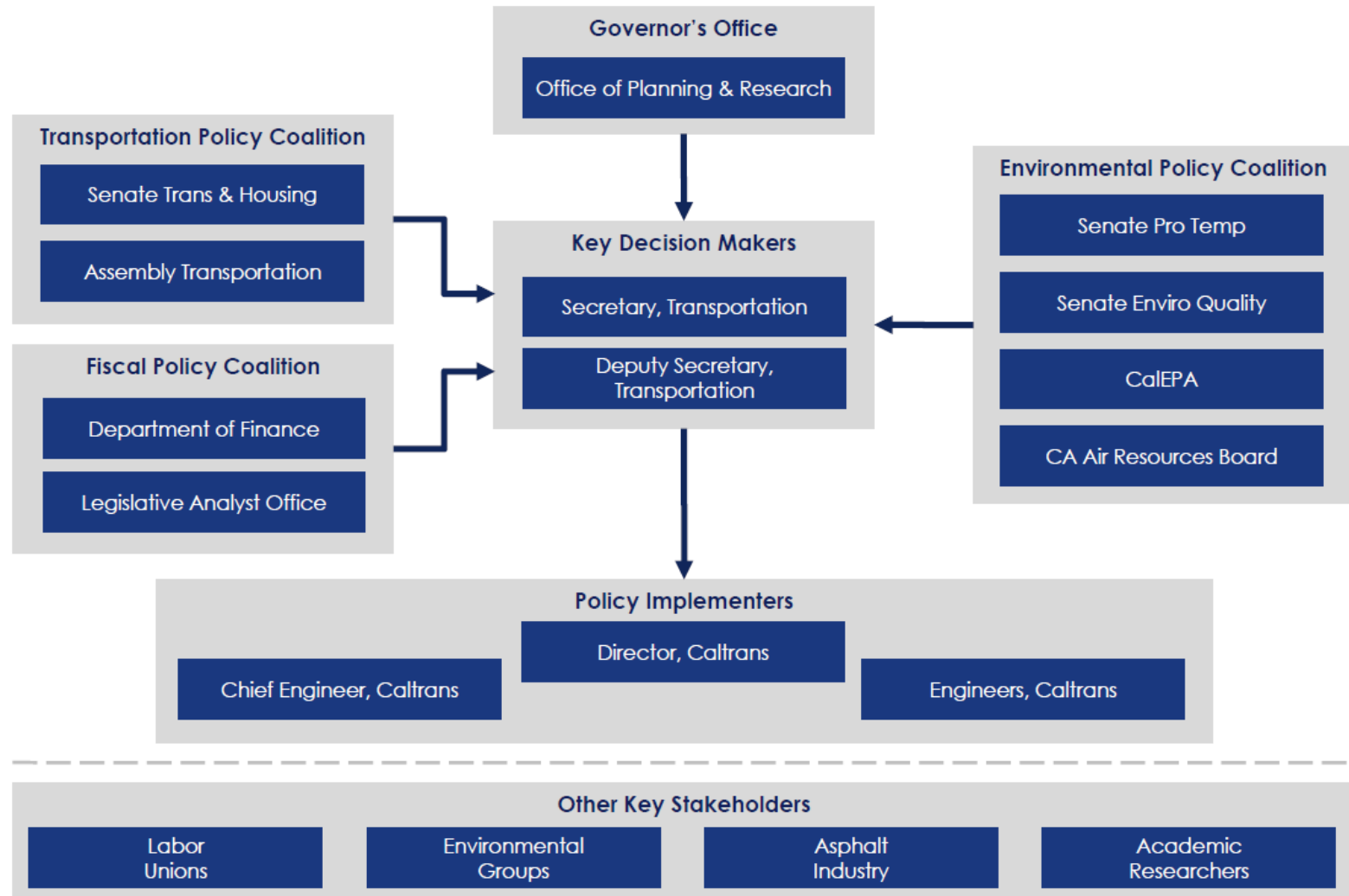
Patience



A diverse and well-integrated team of experts is critical to designing, building, and implementing an effective strategy.



Detailed analysis identified the “eco-system” of key decision makers, opinion leaders, and other stakeholders.



# Key factors that determine rate of adoption of innovations

Perceived attributes of innovations

Types of innovation-decisions

Communication channels

Nature of the social system

Extent of promotion efforts

# New paradigms require new promotion methods

***Collaborative communication & implementation plans should consider these elements***

Perceived attributes of innovations

Types of innovation-decisions

Communication channels

Nature of the social system

Extent of promotion efforts

MIT	Industry
✓	✓
	✓
✓	✓
	✓
✓	✓

# CSHub and industry joint communication efforts support implementation



## Quantifying C

### Research Briefs

## Surface Albedo

Surface Temperature (albedo)

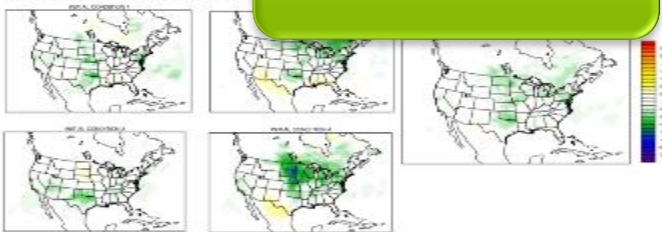


Figure 1. The changes in surface temperature from elevating urban surface albedo during summer of 2005. The four initial conditions have starting dates of Dec. 1 to Dec. 4, 2004, respectively, while the Ensemble Mean is the average of the four initial conditions. Green color represents cooling from decrease in surface temperature due to elevating albedo, while yellow represents warming.

Research Brief  
Issue 6, 2015



## Newsletter

### Headlines

- Research Briefs:  
[Streamlined Embodied LCA of Residential Buildings](#)  
[Quantifying Climate Impacts of Surface Albedo](#)
- Hub News:  
[CSHub Team Visits Ready-Mixed Concrete Plant](#)



**Researcher Profile**  
In a new feature, we profile CSHub researchers. This month, [meet](#)

## Presentations



## Talking Points



MIT  
CONCRETE  
SUSTAINABILITY  
HUB

PAVE

## Pavement-related research

### CONTEXT

Funding for roads will remain constrained for the foreseeable future. Short-sighted decision-making means that the costs of pavements get passed to future generations.

- The U.S. is not sufficiently investing in its ailing road system. The U.S. requires \$170 billion in annual capital investment, yet the road system is bankrupt.
- The road system gets a grade of D from the American Society of Civil Engineers, which reports that congested highways cost roughly \$101 billion in wasted time and fuel annually.



MIT  
CONCRETE  
SUSTAINABILITY  
HUB



## Sustainable Pavements

U.S. road transportation accounts for 83% of greenhouse gas (GHG) emissions from the transportation sector and 27% of all GHG emissions in the U.S. The road system requires 350 million tons of materials annually for maintenance. It gets a grade of D from the American Society of Civil Engineers, which reports that congested highways cost roughly \$101 billion in wasted time and fuel annually.

For the foreseeable future, U.S. infrastructure funding will remain significantly below what is required to improve conditions and performance. Because of the environmental impact of pavements and the economic

SHEET  
JULY 2014

# CSHub is presenting outcomes to a wide range of audiences

## RMC & Cement Organizations

- **RMC**
  - NRMCA
  - States: IA, GA, KY, MN, MD, NC, SC, VA
  - Latin America
- **Cement**
  - PCA
  - CNCA
  - Intercem
  - CSI
- **ACI**
- **NCC**

## Other Industries

- **Paving**
  - ACPA
  - ACPA NW
  - IGGA
  - MO/KS CPA
  - NCC
  - Ontario
- **Buildings/Architecture**
  - FLASH
  - USGBC
  - CLF
- **Civil**

## Government Agencies

- AASHTO
- DHS
- EPA
- FEMA
- FHWA
- IDB
- GAO
- OMB
- State DOTs
- TRB
- US Council of Mayors
- White House

## Research

- **Disciplines**
  - Material science
  - Mechanics
  - Buildings LCA/LCCA
  - Pavements LCA/LCCA
- **Regions**
  - US
  - Canada
  - China
  - Europe
  - Latin America

~40 Presentations for 2016



# \$6.2M in additional research

International  
sponsors

Tata  
Founda-  
tion

French  
Gov't

North-  
western  
U

US  
Army  
CoE

Domestic  
sponsors

BASF

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Cimpor



Schlum-  
berger

Portifici  
a U  
Chile

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Siam  
Cemen  
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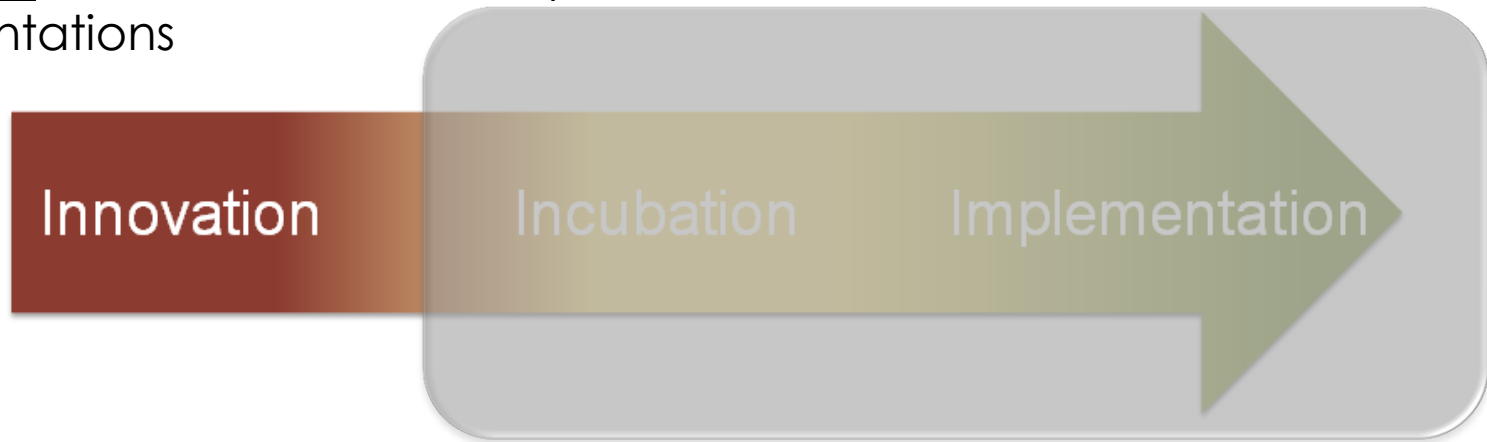
UNB

Politec-  
nico  
Torino

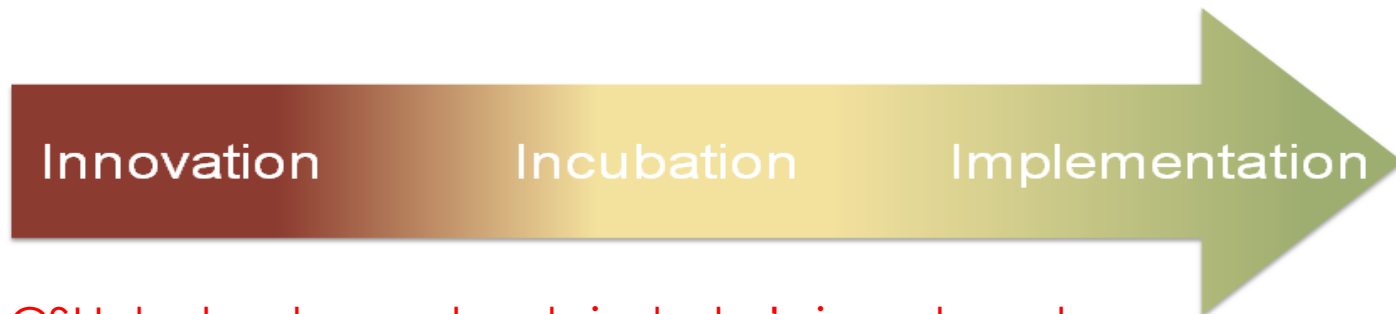
Collaborator  
s

# Hub Value

**Without the CSHub:** research, publications, conference presentations



**With the CSHub:** research, publications, conference presentations, administration, implementation, communication, industry interaction, webinars, education, interaction with other industry and research efforts



The CSHub structure extends industry's investment

# CHANGING THE RULES OF THE GAME



The CSHub is changing the way concrete is  
evaluated & implemented  
in infrastructure projects





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More information available  
at:

[http://cshub.mit.edu/  
cshub@mit.edu](http://cshub.mit.edu/cshub@mit.edu)