



# Sustainability of Concrete Pavements

By: Chuck Cox, LEED-AP

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**“Sustainability is the ultimate relation of action and consequence.”**

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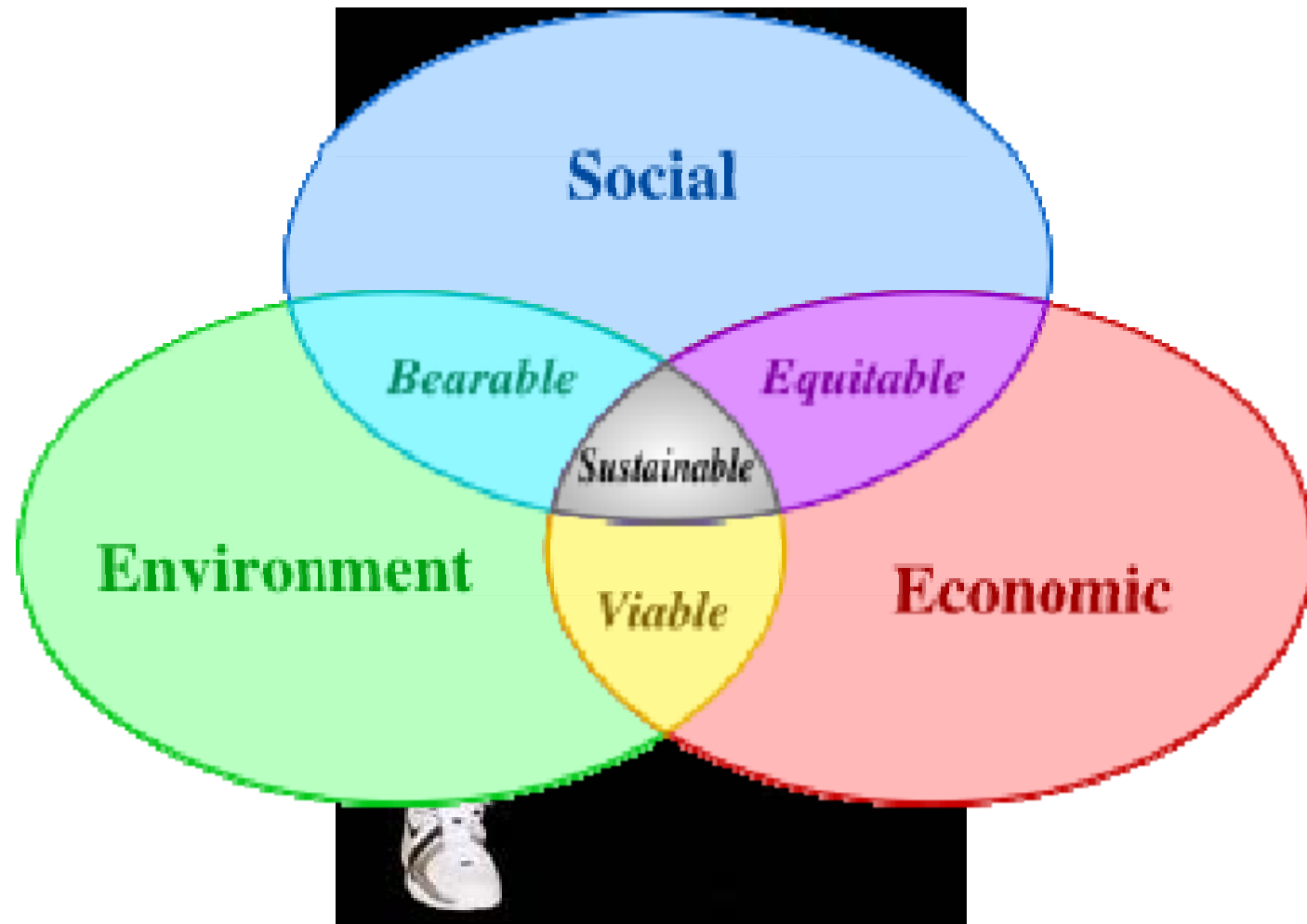
“The maximum rate of resource consumption and waste discharge that can be sustained indefinitely in a given region without progressively impairing the functional integrity and productivity of the relevant ecosystems.”

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(Paul L. Bishop, in *Pollution Prevention: Fundamental and Practice*, 2000)



# “Triple-Threat” Approach



## 2009 Grades

Aviation	D
Bridges	C
Dams	D
Drinking Water	D-
Energy	D+
Hazardous Waste	D
Inland Waterways	D-
Levees	D-
Public Parks and Recreation	C-
Rail	C-
Roads	D-
Schools	D
Solid Waste	C+
Transit	D
Wastewater	D-

America's Infrastructure GPA: **D**

Estimated 5 Year Investment

Need: **\$2.2 Trillion**

## Where we are today...

- Growth in areas of high population density
- Facilities need to be repaired or replaced

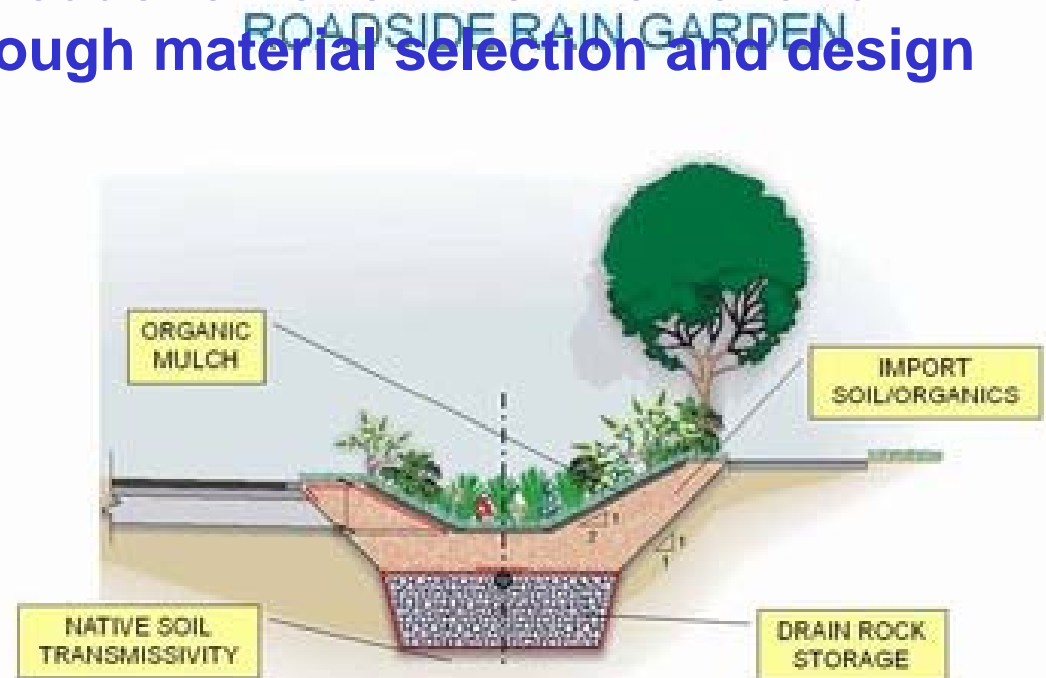
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## **Sustainability at this Conference:**

- **Pervious Concrete**
- **Replacing Asphalt with Concrete**
- **Life-Cycle Cost Analysis**
- **Sustainability of Concrete Pavements**
  - Design
  - Materials
  - Application

# Design for the Environment

A concept or philosophy applied to the design process that advocates the reduction of environmental and human impacts through material selection and design strategies



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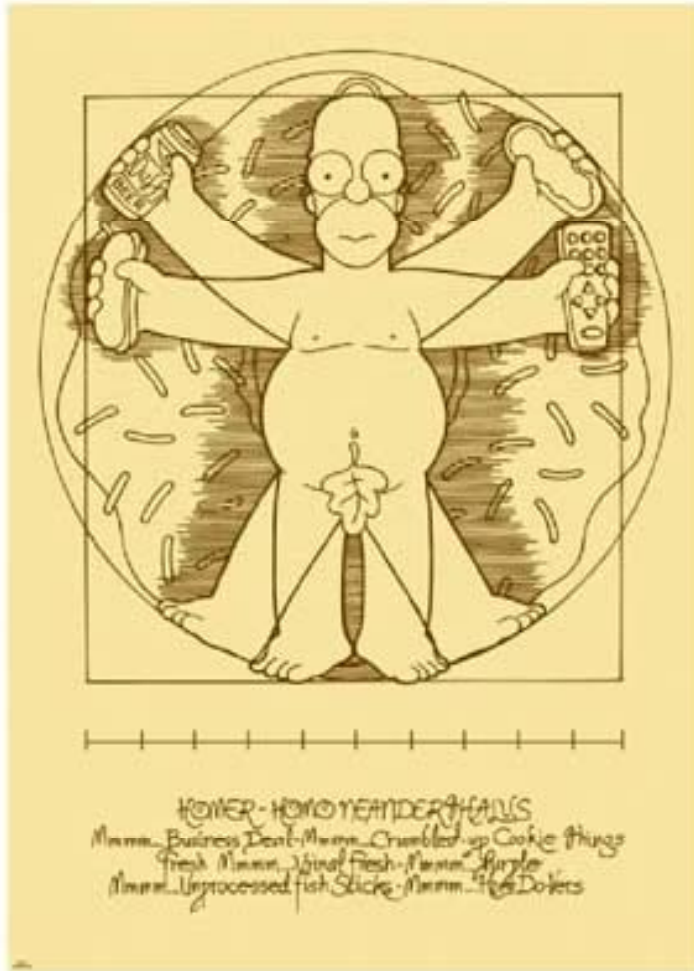




## Marcus Vitruvius Pollio

- Ten Books on Architecture

“A part of lime is put with 3 parts quarry sand, or two parts of river or sea sand; this is the correct proportion for this mixture and this will be even better if one adds to the sea sand and river sand a third part of crushed and broken tiles.”



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## Why use Recycled Concrete Aggregate (RCA)?

**“Reusing the materials used to build the original highway system...makes sound economic, environmental, and engineering sense.”**

**“Recycled materials must be used in an appropriate manner that...shall not affect the performance, safety or environment of the highway system.”**

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# FHWA Technical Advisory on RCA

- **Characteristics**

- 90% paste & aggregate
- Absorption of less than 10%

- **Standards**

- ASTM & AASHTO
- Management of the fines

- **Performance & Testing**

- Freeze/Thaw Resistance
- Shrinkage

## Material Substitution



## Supplemental Cementitious Materials (SCM's)

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## How do SCMs contribute to Green Design?

- **As a partial replacement for portland cement, SCMs do not contribute to the energy and CO<sub>2</sub> impacts of cement in concrete**
- **Reduced landfill disposal and increased use of recovered industrial materials**
- **SCMs improve concrete service life through greater concrete durability (life-cycle)**

# How do SCMs contribute to Green Design?

## Impact of Cement and SCMs on CO<sub>2</sub> per Cubic Yard of Concrete

<b>Cementitious lbs/yd<sup>3</sup></b>	<b>% SCM</b>	<b>CO<sub>2</sub> lbs/yd<sup>3</sup></b>
564	0	527
470	0	442
376	0	356
564	25	404
470	25	351
376	25	271
564	50	282
470	50	234
376	50	190

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# SCMs in Concrete Mixtures

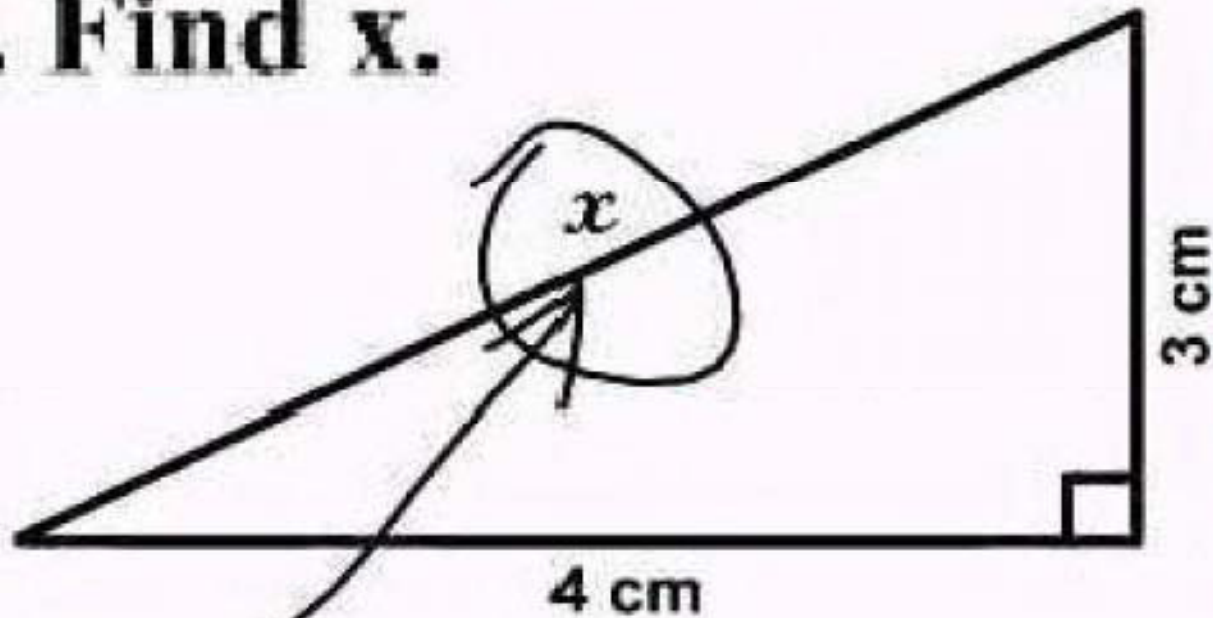
**SCMs are proportioned within concrete as**

- Individual components
- Blended with portland cement

**Blended Cements (ASTM C595)**

- **Blended hydraulic cements are produced by intimately and uniformly intergrinding or blending two or more types of fine materials.**
  - Portland cement, slag cement, fly ash, silica fume, calcined clay, other pozzolans, hydrated lime
  - Pre-blended combinations of these materials

3. Find  $x$ .



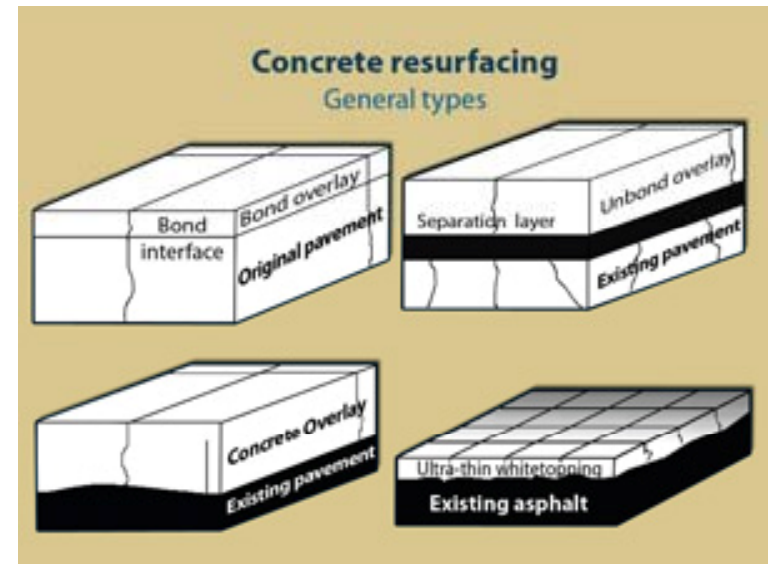
*Here it is*

# SIMPLICITY

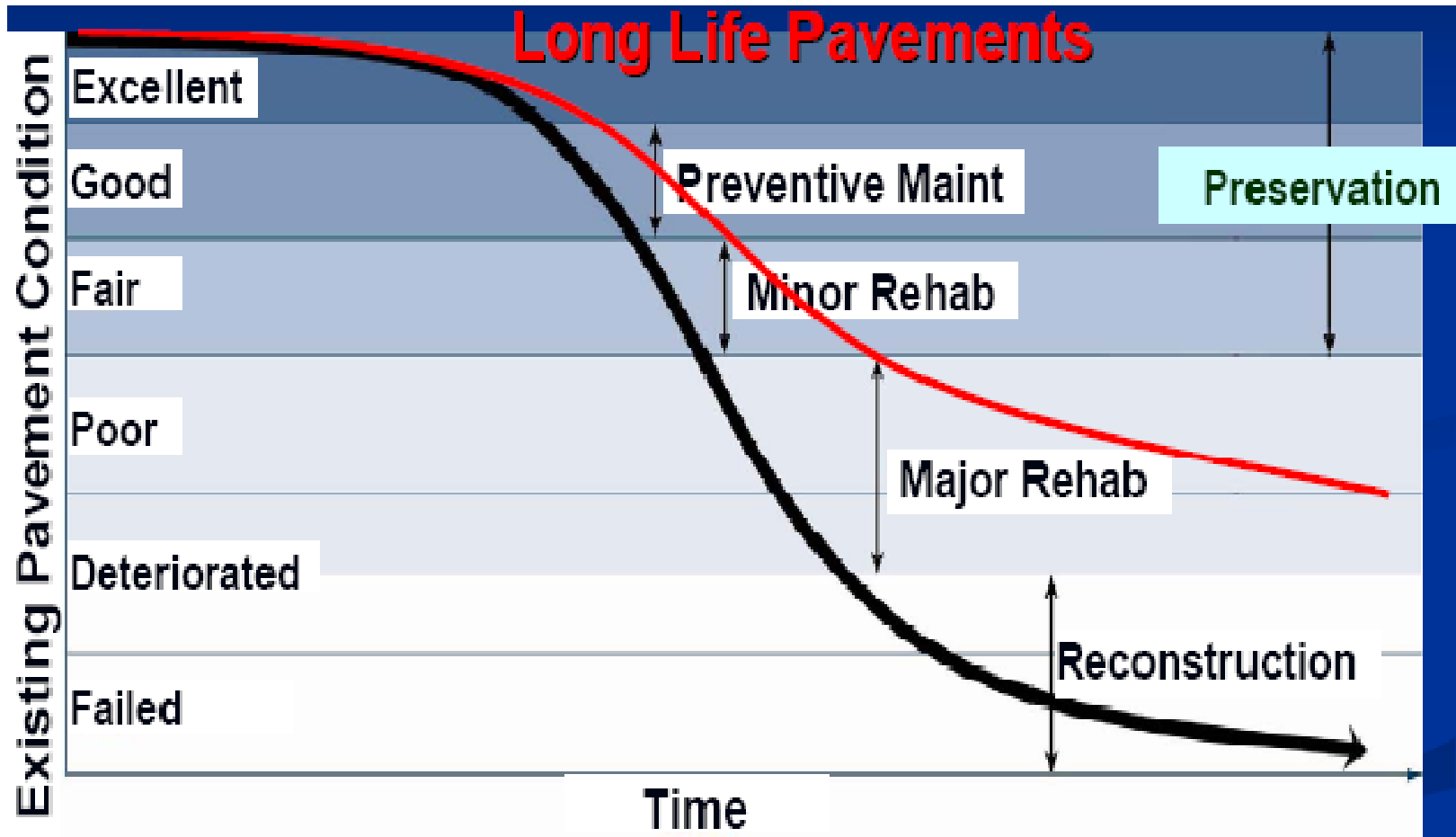
The simplest solutions are often the cleverest  
They are also usually wrong

# Concrete Application Innovations

- **In-Place Recycling**
- **Pervious Concrete**
- **Preventative Maintenance**
  - Unbonded Overlays
  - Diamond Grinding
  - Dowel Bar Retrofit
  - Joint Resealing/Crack Sealing



# Concrete Application Innovations



Smith, Kurt, "California Concrete Pavement Workshop, October 2009

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# Pavements & Sustainability

- Remember the “Triple Bottom Line”
- Change to Holistic Approach
- Materials & Opportunities

