Carbon Footprints and HMA Sustainability

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Overview

- Myths or Fact?
- Carbon footprint basics
- Carbon footprint of an HMA pavement
- Comparison of pavement types
- Summary

Myth or Fact?

Myth or Fact

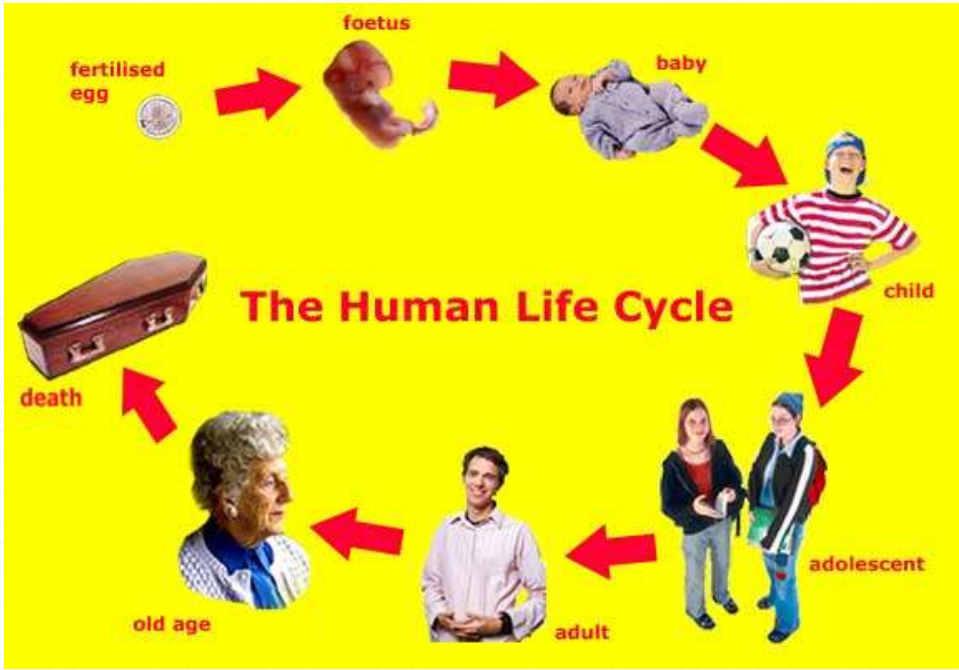
- “Concrete pavements inherently have the lowest overall energy footprint. The primary factors are . . . That [concrete] is not a byproduct of petroleum refining and thus has a much lower embodied . . . energy . . .
- Construction of hot-mix asphalt roadways consumes more than five times as much diesel fuel as the construction of comparable concrete roadways.”

Just the Facts

- "energy footprint" ≠ "carbon footprint"
  - Fuel consumption vs. greenhouse gas (GHG) emissions
- HMA pavement production energy may be higher
  - Process dependant
- "embodied energy" vs. "sequestered energy"
  - Permanently removed or reusable?

Just the Facts

- Cement/concrete: high CO2 emissions
  - Energy and process
- Total life cycle carbon footprint is key
  - Cradle to grave



Carbon Footprint Basics

What is a Carbon Footprint?

- "The total amount of greenhouse gas emissions caused directly and indirectly by a . . . a product [or material]."

- Carbon dioxide equivalents (CO_2e)

Example

- Assumptions
- 10 hour job
- 12.5 miles from plant
- 1,000 gallons of fuel

- Calculations
- HMA Production: 40 tons of CO2e
- HMA Transport: 11 tons of CO2e
- HMA Placement: 3 tons of CO2e
- Total: 54 tons of CO2e

- Does not include raw material extraction or maintenance

Carbon Footprint Components

- Raw material extraction and processing
  - Asphalt binder
  - Aggregate
- Pavement manufacturing
- Pavement placement/transportation
- Pavement maintenance

Carbon Footprints

- Numerous studies have looked at different components
  - Generally, values are embedded as life cycle analysis inputs
- Why should I calculate a pavement's carbon footprint?
  - Mass of materials; potential GHG emissions
  - Municipalities "going green"

Carbon Footprint of an HMA Pavement

Where does all the CO2e come from?

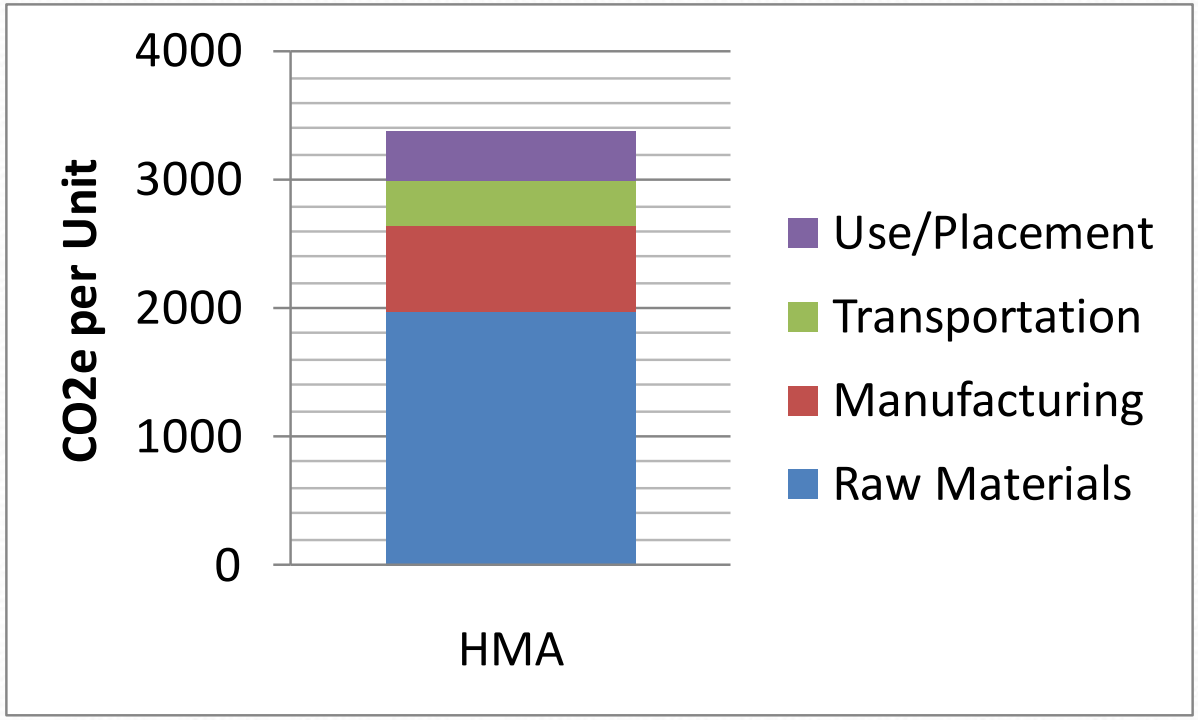
Building for Environmental and Economic Sustainability (BEES)

- Typical parking lot
- 50-year life span
- “unit” = 1 sq. ft
- 7 inch aggregate bed
- 3 inch initial asphalt pavement
  - 3 x 1.5 inch “mill and fill” maintenance
  - 15% RAP

C02e per Unit

- Raw materials: 1975
- Manufacturing: 680
- Transportation: 347
- Use/Placement: 373
- Total: 3,375

- ≈ 60% from raw materials



Raw Materials

- Fractional distillation
- Production of SBS or other modifiers for binder
- Aggregate Processing
  - Extraction, Processing
- Can we reduce this value?

Reducing the CO2e of HMA

RAP

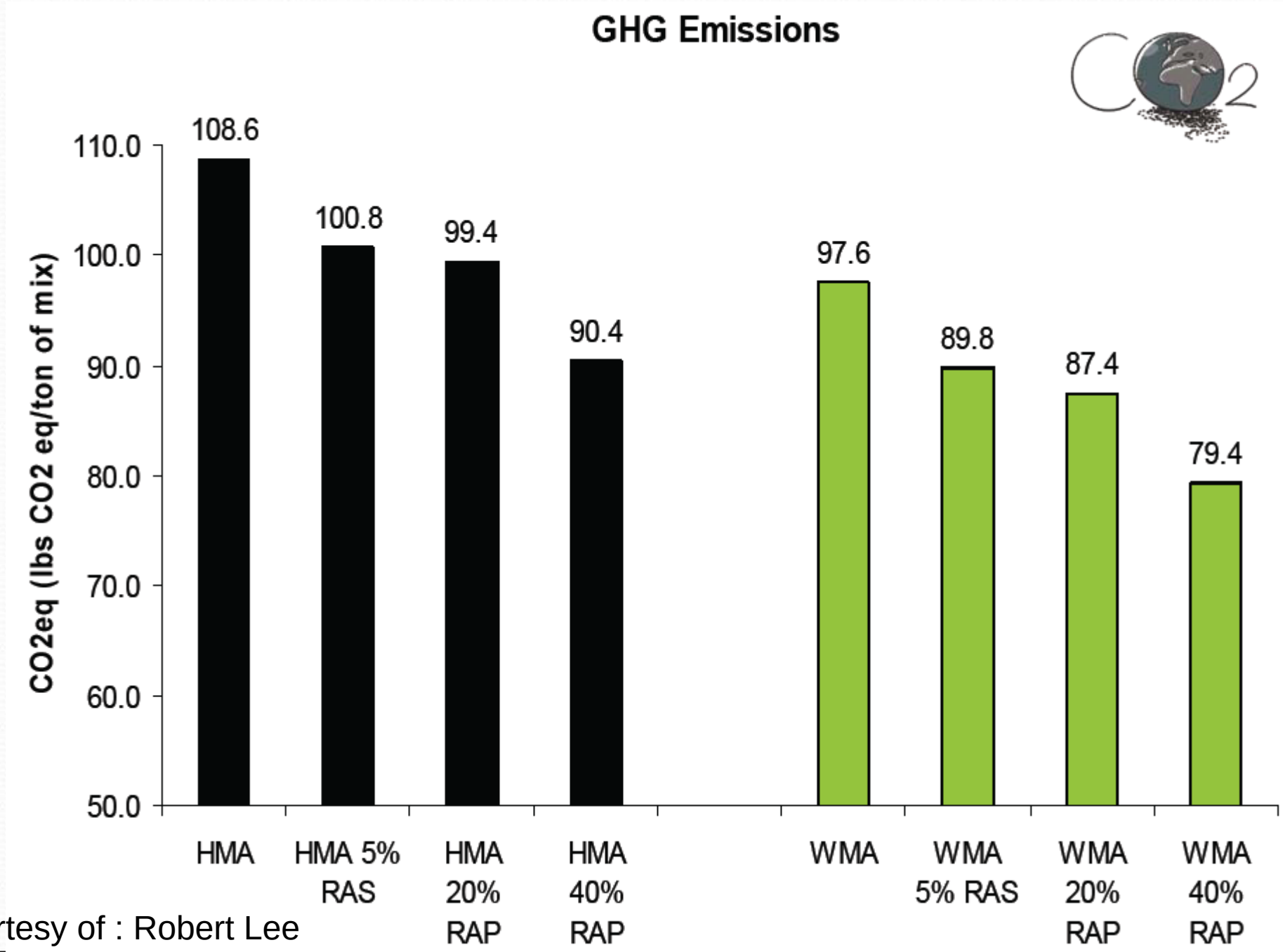
- Reduce carbon output during raw material production/processing
- Robinette and Epps, 2010
- 15% RAP – 6.5% reduction
- 25% RAP – 10-11% reduction
- 40% RAP – 16-18% reduction

Recycled Asphalt Shingles

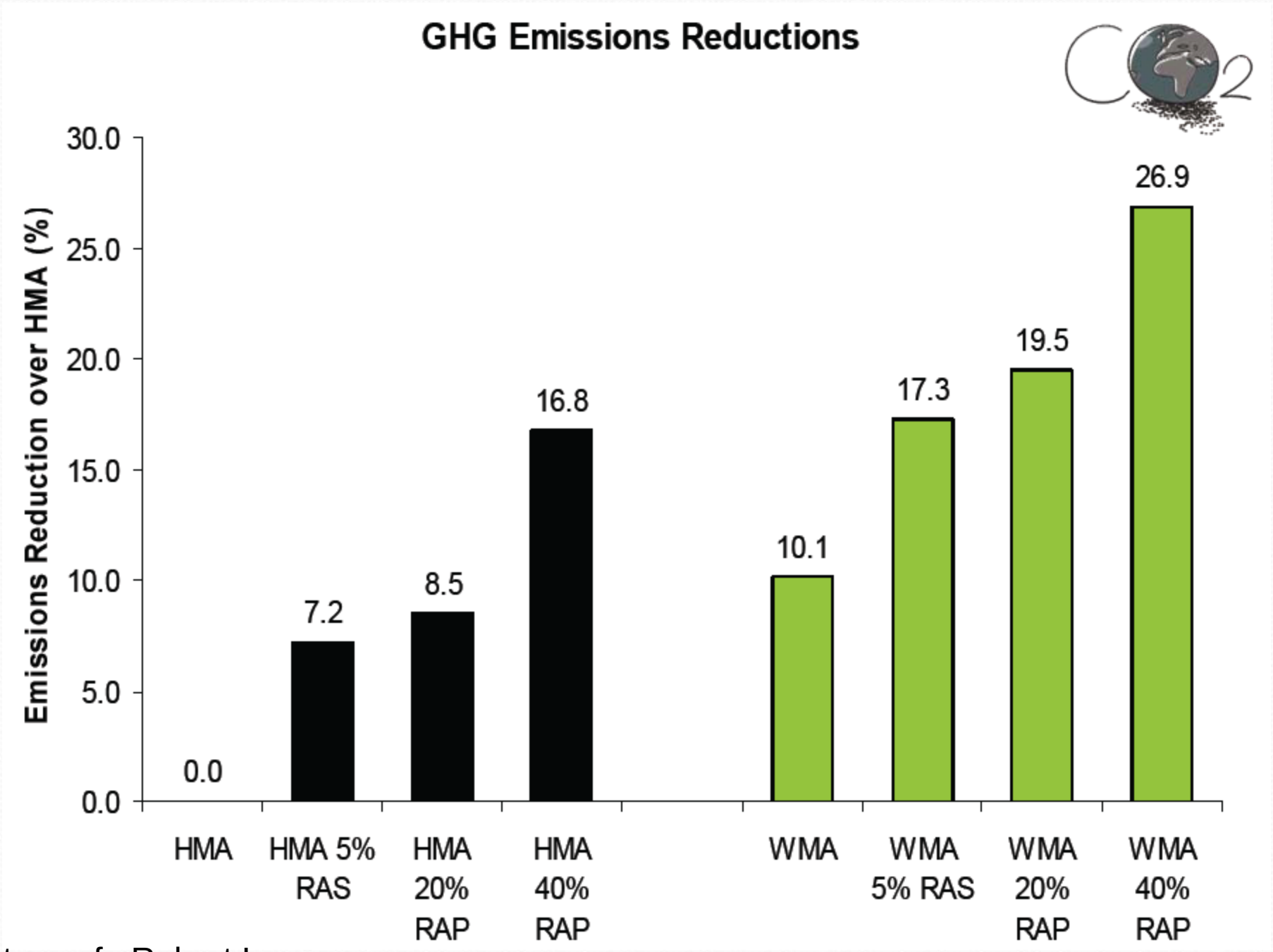
- 10,000 tons of ground shingles replaces:
  - 468,000 gallons of asphalt
  - 8,000 tons of aggregate
- Using 5% RAS in HMA reduces carbon emissions by approximately 7.0%
  - Post-industrial
  - Assume RAS – 23% binder

Warm Mix Asphalt

HMA: 109 lbs of CO_2eq per ton of mix **WMA: 97.6 lbs of CO_2eq per ton of mix**



Courtesy of : Robert Lee



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Combined Technologies

- WMA with 15% RAP and 5% RAS
  - 83 lbs of carbon emissions per ton of mix as compared to 109 for typical HMA
  - 23% reduction in emissions

Comparing Pavement Types

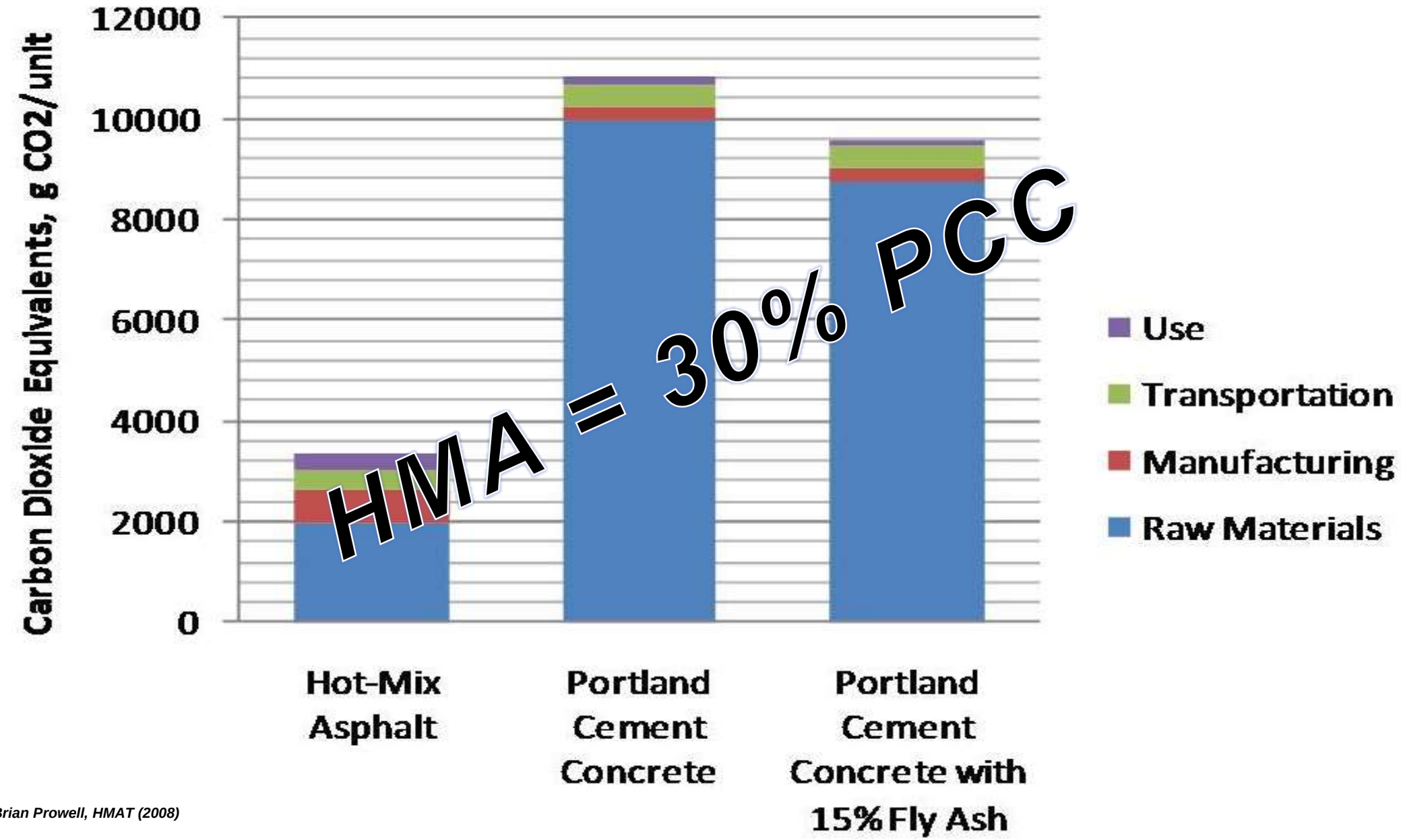
Research Completed

- BEES analysis by Brian Prowell (HMAT, 2008)
- Colas Group (Chappat and Bilal, 2003)
- Athena Institute (2006)

Be Careful . . .

- There is a lot of literature comparing GHG emissions by pavement type
- Must understand assumptions of each study
  - What processes are included in software?
  - Feedstock energy?

Parking Lot Analysis

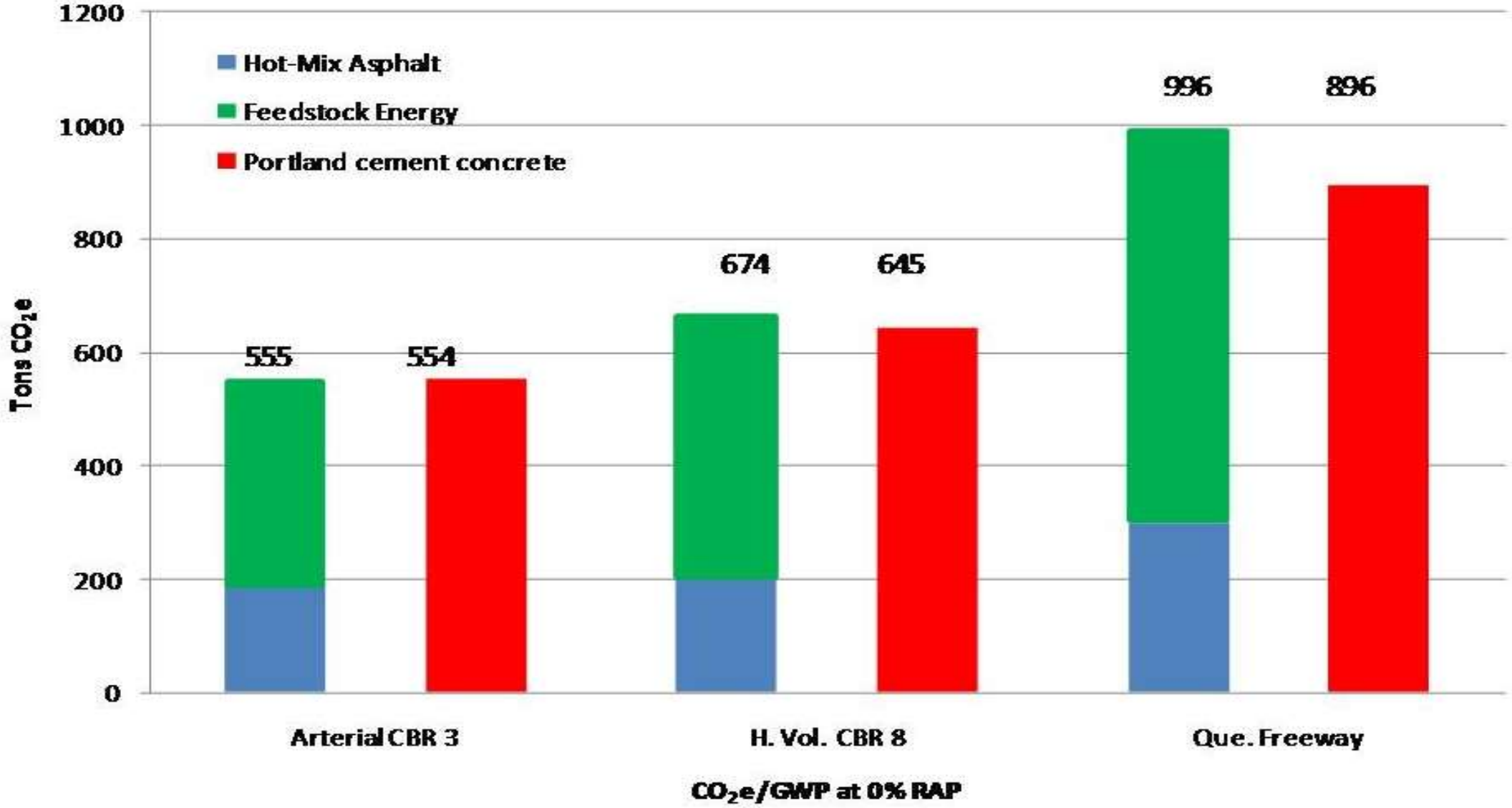


•*Brian Prowell, HMAT (2008)*

Athena Institute

- 2006 study sponsored by the cement association of Canada
- Comparison of embodied energy
  - The caloric potential of unburned asphalt cement
  - Not process related energy
  - Embodied energy is not released
    - Timber

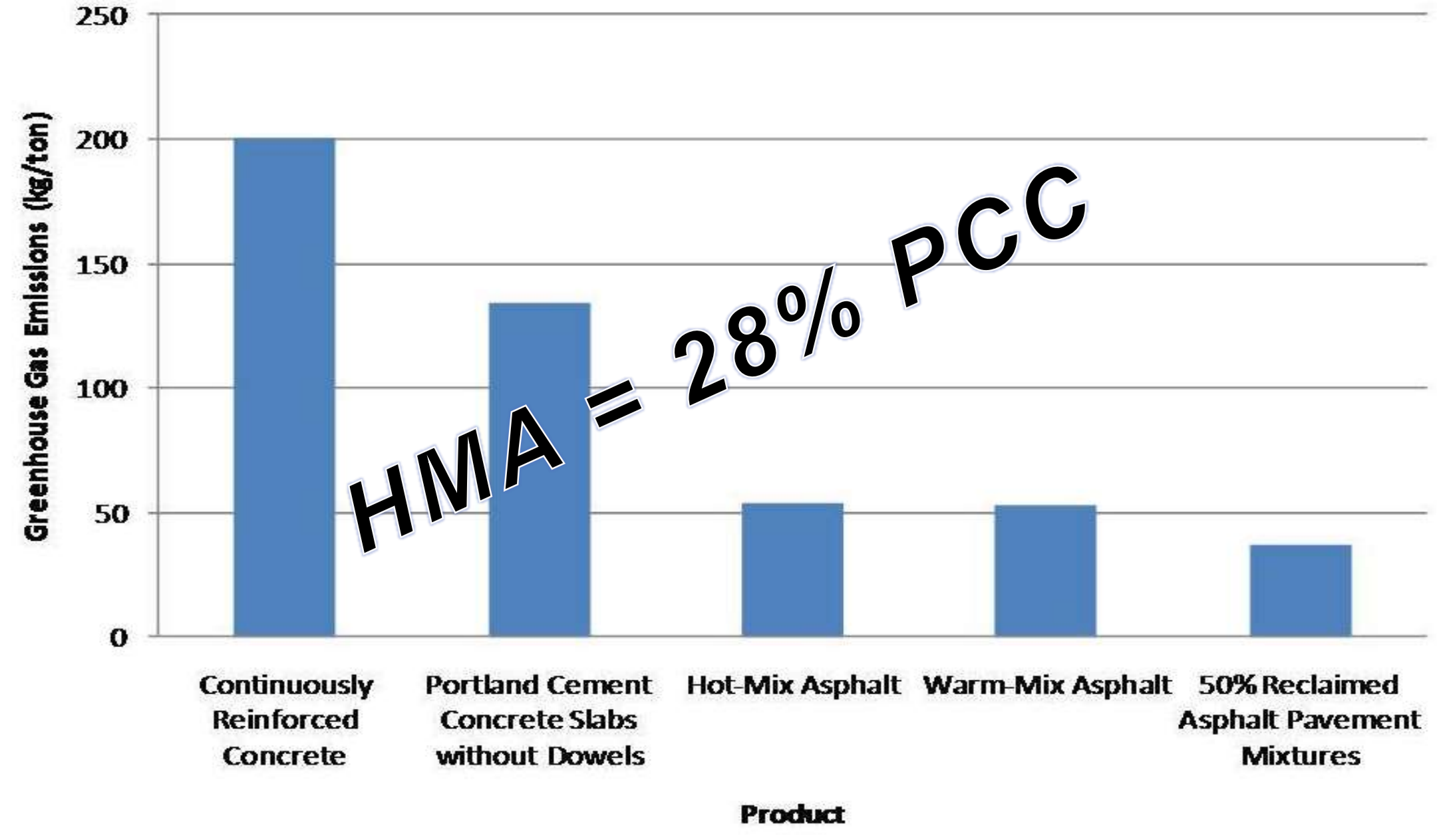
Athena Institute



Colas Group

- 2003 Publication (Chappat and Bilal)
  - Asphalt Concrete
  - High Modulus Asphalt Concrete
  - Warm-mix Asphalt
  - Asphalt Emulsion Mixtures
  - Hot-Recycled Asphalt Mixtures
  - RAP Mixtures
  - Concrete Cement Pavements
- Energy consumption and greenhouse gas emissions

Colas Study


250
200
150
100
50
0
Greenhouse Gas Emissions (kg/ton)
HMA = 28% PCC
Continuously Reinforced Concrete
Portland Cement Concrete Slabs without Dowels
Hot-Mix Asphalt
Warm-Mix Asphalt
50% Reclaimed Asphalt Pavement Mixtures
Product

Summary

- Carbon footprints are the total amount of GHG emitted
  - Not embodied
- Raw material acquisition is largest contributor to GHG emissions in asphalt pavements
- Can further reduce HMA CO2e
  - RAP
  - RAS
  - WMA
- Asphalt pavements have lower CO2e that PCC

Questions?

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