Durable and Efficient Concrete Using Double Recycled Rubber-Fiber Powder

Ahmed Gheni
Mohamed ElGawady, Ph.D.
The world is facing a serious problem dealing with scrap tires!
Introduction

Waste tires cover approximately 36 acres of the ocean floor off of Fort Lauderdale, Fla.
> 750,000 scrap tires blazed in Missouri in 2005
> Nineteen fire departments were not able to extinguish the fire for several months.
Introduction

> Construction consumes 73% of all materials
Introduction

55% Operating

45% Embodied
Introduction

U.S. Civil Engineering Markets

Thousands of Tons

<table>
<thead>
<tr>
<th>Year</th>
<th>2005</th>
<th>2007</th>
<th>2009</th>
<th>2011</th>
<th>2013</th>
<th>2015</th>
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</thead>
<tbody>
<tr>
<td>Value (in Thousands)</td>
<td>640</td>
<td>562</td>
<td>285</td>
<td>295</td>
<td>172</td>
<td>275</td>
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Introduction

Smart Recycling!
Implementing a “Smart rubber recycling” in new infrastructure applications by using it as a:

- Powder
- Fine aggregate
- Coarse aggregate
Recycled rubber as fine aggregate

Cyclic Behavior of masonry Shear Walls

Mechanical Characterization

Thermal and Acoustic Characterization

Finite Element Modelling
Recycled rubber as fine aggregate

Thermal conductivity and Heat resistivity results

- Coefficient of Thermal Conductivity $K$ (W/m.k)
- Heat Resistivity $r$ (m$^2$K/W)

Crumb Rubber Ratio (%): 0, 10, 20, 37, Lightweight block
Recycled rubber as fine aggregate

Sound absorption and noise reduction results

[Graph showing sound absorption coefficient and noise reduction coefficient against frequency and rubber ratio]
Recycled rubber as fine aggregate

Stress vs. Strain of Grouted Four Blocks Masonry Prisms

- 0% Rubber
- 10% Rubber
- 20% Rubber

Strain (in/in)

Stress (psi)
Recycled rubber as coarse aggregate

Rubberized chip seal
Recycled rubber as coarse aggregate

- Texture and Skid Resistance
- Aggregate Retention
- Design and Embedment Depth
- Field Implementation

222 chip seal specimens were tested
4.1: Performance and Aggregate Retention of Rubberized Chip Seal

Material Characterization and Properties

Recycled rubber as coarse aggregate

Two Emulsions

Two Cement Asphalt
Recycled rubber as coarse aggregate

Key results

![Bar chart showing the retention of aggregates with different types of rubber and aggregates.]
Recycled rubber as coarse aggregate

Skid test
Recycled rubber as coarse aggregate

Measuring the Microtexture of Chip seal
Recycled rubber as coarse aggregate
Recycled rubber as coarse aggregate

Metal concentration in leaching solution as a function of pHs

- Copper (Cu)
  - EPA limit = 1300 µg/L

- Antimony (Sb)
  - EPA limit = 6 µg/L

- Barium (Ba)
  - EPA limit = 2000 µg/L

- Zinc (Zn)
  - EPA limit = 5000 µg/L

- Cobalt (Co)
  - EPA limit = N.A.

- Nickel (Ni)
  - EPA limit = N.A.
Recycled rubber as coarse aggregate

4.4: Field implementation
Recycled rubber as coarse aggregate
Recycled rubber as coarse aggregate
Recycled rubber as coarse aggregate
Recycled rubber as powder

Mechanical Characterization
Thermal and Acoustic Characterization

Mechanical Characterization
Recycled rubber as powder

3.1: Mechanical Characterizations of Rubberized Mortar
3.2: Thermal and Acoustic Characterization of Rubberized Mortar.
3.2: Thermal and Acoustic Characterization of Rubberized Mortar.
Recycled rubber as powder

Key results
Recycled rubber as powder

- Bulk resistivity (kΩcm)
  - Negligible corrosion risk
  - Low corrosion risk

- Surface resistivity (kΩcm)
  - Moderate
  - High

- Charge passed (Coulomb)
  - High
  - Moderate
  - Low
  - Very low

Graphs showing the relationship between RFP ratio and various properties.
Recycled rubber as powder

(0%)

(5%)

(10%)

(15%)

(20%)

(25%)

F/T Durability