Using Biochar as Sand Replacement in Construction Materials

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WASTE MANAGEMENT CRISIS
CONSTRUCTION SAND DEPLETION & SHORTAGE
LOCAL ECO-PRACTICES - PYROLYSIS

Waste in Lebanon

Pyrolysis Plant in Lebanon

- Provision of Cheap & Clean Energy Production
- Adequate Waste Disposal & Management
- Water Conservation
- Low GHG Emissions
- Popularly Increasing Waste Management Technology Worldwide
BIOCHAR PHYSICOCHEMICAL CHARACTERIZATION

- High Specific Area > 300 m²/g
- Very Low Specific Gravity ~ 0.668 g/cm³
- High Porosity
- High Water Holding Capacity
- High Carbon Sequester
MORTAR MIX DESIGN & EXPERIMENTAL SETUP

Mix design:
- M0
- M1
- M2
- M3
- M4
- M5

Curing regimes:
- Water curing
- Air curing
- Sealed under vacuum

Test Methods:
- 132 mortar cubes of size 50 mm tested for compressive strength
- 25x280mm mortar prisms tested for drying shrinkage using LVDTs and temperature monitoring with thermocouples embedded in the specimen
- 25x25mm thin and polished sections of mortar tested for visual observations of the interfacial transition zone under scanning electron microscope & x-ray mapping
**EXPERIMENTAL FINDINGS – UNDERSTANDING THE MICROSCALE BEHAVIOUR**

- Better Mechanical Interlocking
- Enhanced Interfacial Transition Zone
- Reduced Micro cracking
- Internal Curing Potential

**Micro Scale Analysis of Plain Mortar**

**Micro Scale Analysis of Biochar Mortar**
EXPRESSMENT FINDINGS – UNDERSTANDING THE MESOSCALE BEHAVIOUR

- Almost Equal Structural & Durable Performance to Normal Mortar up to 10% Volume Fraction
- Reduction in Weight - Lightweight Mortar
- Reduced Shrinkage Cracking in Dry Environments
- Internal Curing Potential for a Selected Optimum Mix Design
**PATH FORWARD**

**POTENTIAL RESEARCH PATHS**
- Biochar in Concrete Masonry Blocks
- Biochar as Cementitious Material in Concrete
- Biochar as Sand Replacement in Structural Concrete Elements
- Sister Material to Biochar
- Biochar in Asphalt Pavement

**RESEARCH PATH DEVELOPMENT**

**PHASE 1 – LITERATURE REVIEW & TECH TRANSFER**
- Literature Review of Different Biochar Forms
- Field Exploration Study in Different Regions in Europe

**PHASE 2 – MATERIAL ACQUISITION, FURTHER TESTING & ANALYSIS**
- Material Acquisition
- Physicochemical Characterization & Testing
- Analysis of Results

**PHASE 3 – MIX DESIGN OF CONCRETE MASONRY BLOCKS**
- Formulation of Concrete Masonry Blocks mix design
- Cast Concrete Masonry Blocks & Test for Compressive & Flexural Strength, Water Absorption & Durability at Specific Time Intervals

**PHASE 4 – LAB TESTING FOR CO₂ ABSORPTION**
- Cast Concrete Masonry Blocks & Test for CO₂ Absorption in Closed Tank. Monitor CO₂ Levels in Tank, Collect Data & Analyze
- Test for Compressive Strength, Water Absorption & Durability of Block After CO₂ Injection

**PHASE 5 – UPSCALE EXPERIMENT TO ROOM SCALE, COMFORT MONITORING & DATA COLLECTION**
- Build 2 Rooms each made of Biochar & Sand Concrete Masonry Blocks
- Monitor Thermal Comfort & CO₂ Levels in Rooms
- Collect Data, Analyze & Formulate Reports

**RESEARCH TIMELINE**
- Oct 2018
- Dec 2018 PHASE 1
- Mar 2019 PHASE 2
- Aug 2019 PHASE 3
- Feb 2020 PHASE 4
- Oct 2020 PHASE 5
Beirut: Carbon Sink City

Possibilities

Section of Typical External Walls

If 10% of Biochar is used:

- 13% reduction in weight of mortar
- 4.17 Million Tons/year reduction of Municipal Solid Waste in Lebanon.
- 1 million Tons/year reduction of Sand consumption in Lebanon.