University of Wyoming | School of Energy Resources
University of Wyoming | College of Engineering and Applied Science, Civil and Architectural Engineering and Construction Management

Eco-friendly High Performance Building Material

DE-FE0031996

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U.S. Department of Energy
National Energy Technology Laboratory
Resource Sustainability Project Review Meeting
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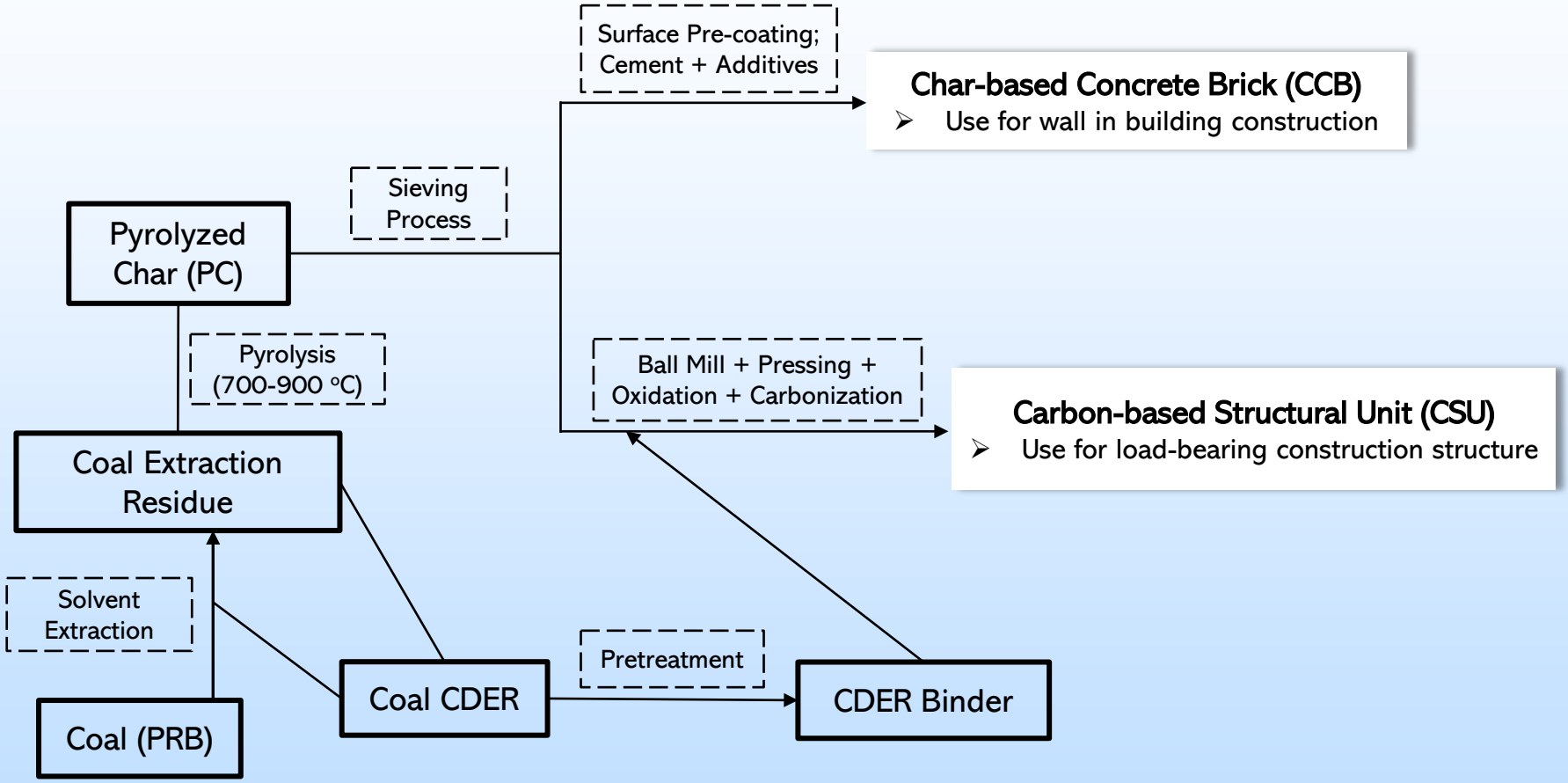
Project Overview

- Funding: $467,620 from DOE and $116,879 Cost Share from the School of Energy Resources, UW.
- Duration: 01/01/2021 to 09/30/2023
- Project Participants:
  - University of Wyoming and School of Energy Resources: Dr. Maohong Fan, Dr. Hua Yu, Md Tarik Hossain and Kim Lau
  - P&P Consulting Services
- Overall Project Objective:
  - Develop New Building Materials from Coal-derived Materials with Good Engineering Performance

Technology Background



Patent: WO 2019/055529

Technology Background

Technical method/attributes	CCB		CSU	
	State-of-the-art	Proposed	State-of-the-art	Proposed
Composition	PC, cement, aggregate	PC, cement	PC/coke, coal tar pitch	PC, CDER derived pitch
Carbon Content from Coal	27-45%	70%	80 – 85%	90%
PC particle size	PC particle size: <5 mm	PC particle size: 0.5-1.5 mm	PC/coke particle size: <35 μm	PC particle size: <35 μm
Density	1.2-1.8 g/cm^3 at PC ratio 45-27%	1.0 – 1.5 g/cm^3	1.0-1.3 g/cm^3	1.0 – 1.3 g/cm^3
Mechanical compression	9-19 MPa at PC ratio 45-27%	≥14 MPa	9 - 63 MPa at tar pitch 13% - 40%	>30 MPa
Thermal conductivity	0.5-0.9 W/m.K at PC ratio 45-27%	< 0.4 W/m.K	-	-
Specific fabrication requirement/method	-	Surface pre-coating used	Commercially available coal tar pitch used	CDER derived pitch as binder

Technical Approach/Project Scope (Fabrication of CCB)

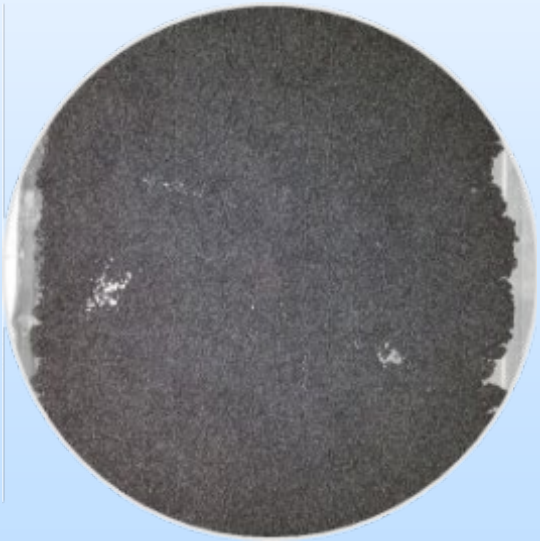
Task	Description	Milestone	Success Criteria	Risk & Mitigation
2.1	PC feedstock acquisition and Characterization	M4 (06/30/2021)	Acquisition of PC; Characteristics	Medium. SER + Partners Produced PC for Years
2.2	Surface Precoating PC	M5 (09/30/2021)	Coated PC with Surface Performance: Coating Thickness; Pore Structure	None
2.3	Lab-scale Manufacturing of CCB Samples	M6 (09/30/2022)	Carbon ≥ 70 w/w%; Strength ≥ 14 MPa; Thermal Conductivity < 0.4 W/mK	None
2.4	Preliminary Pilot-scale Manufacturing of CCBs	M7 (03/31/2023)	Manufactured Two Batches	Medium. Schedule Trial Run for CCB Manufacturing

Technical Approach/Project Scope (Fabrication of CSU)

Task	Description	Milestone	Success Criteria	Risk & Mitigation
3.1	PC and CDER Feedstock Acquisition and Characterization	M8 (06/30/21)	Acquire High Quality CDER: Softening Temperature > 200 ºC	Medium. PIs' Experience; SER + Partners on Coal Refinery for Years; Existing Pitches as Alternative
3.2	Lab-scale Manufacturing of the CSU Samples	M9 (12/31/22)	Strength > 30 MPa; Density: 1 to 1.3 g/cm^3	None
3.3	Mechanism Study of the CSU Manufacturing	M10 (09/30/23)	CSU Manufacturing Mechanism Report	None

Progress and Current Status of Project (CCB)

- Pre-coating Methods
  - Paste Method (PM)
  - Spray Water Method (SW)
  - Wet Method (WM)



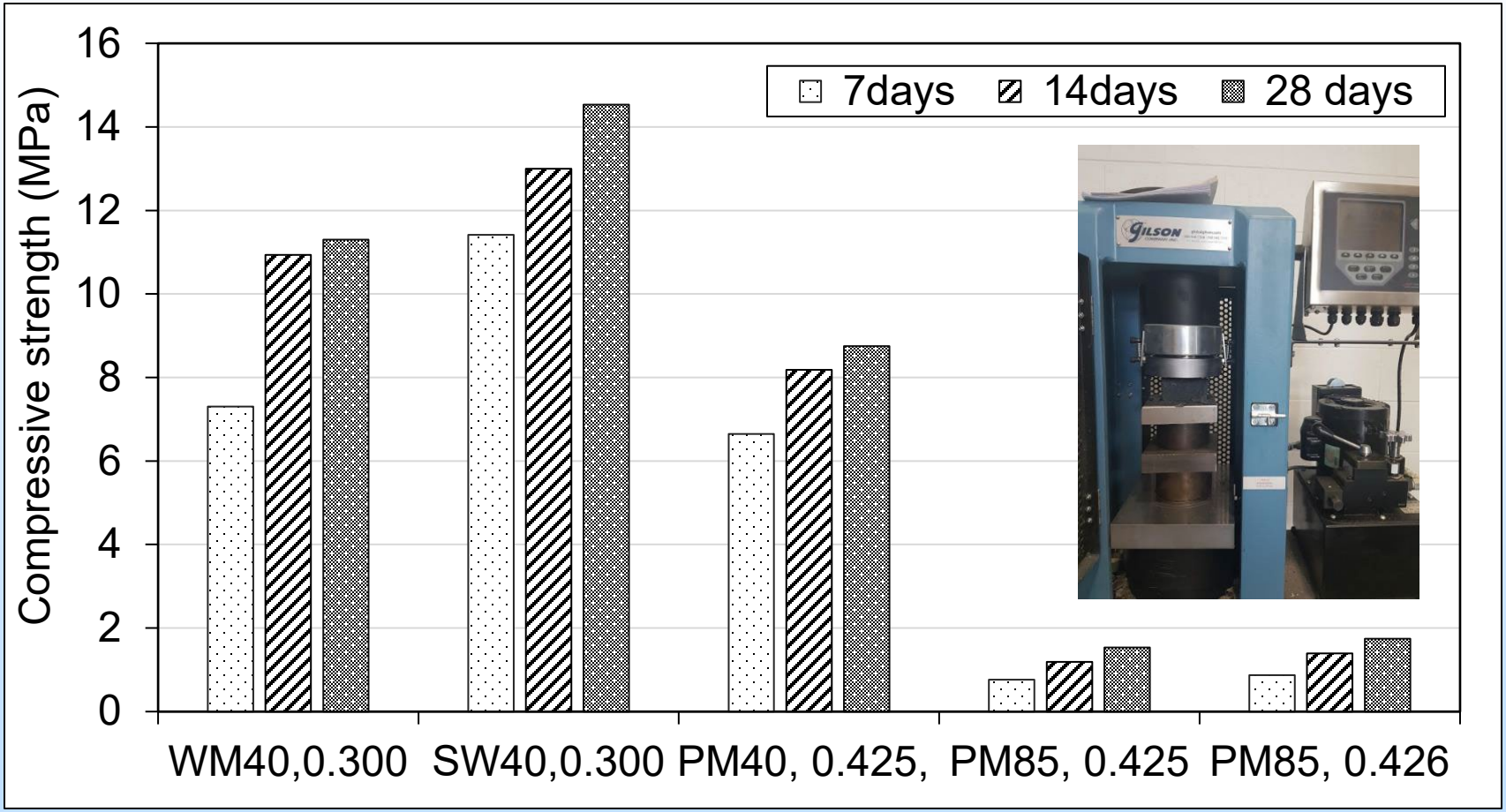
PM Pre-coating PC Sample

SM Pre-coating PC Sample

WM Pre-coating PC Sample

U.S. Provisional Patent 63/355,020

Progress and Current Status of Project (CCB)



U.S. Provisional Patent 63/355,020

Progress and Current Status of Project (CCB)

- Compaction Methods
  - Manual Compaction Method
  - Standardized Compaction Method
  - Pre-pressing Method

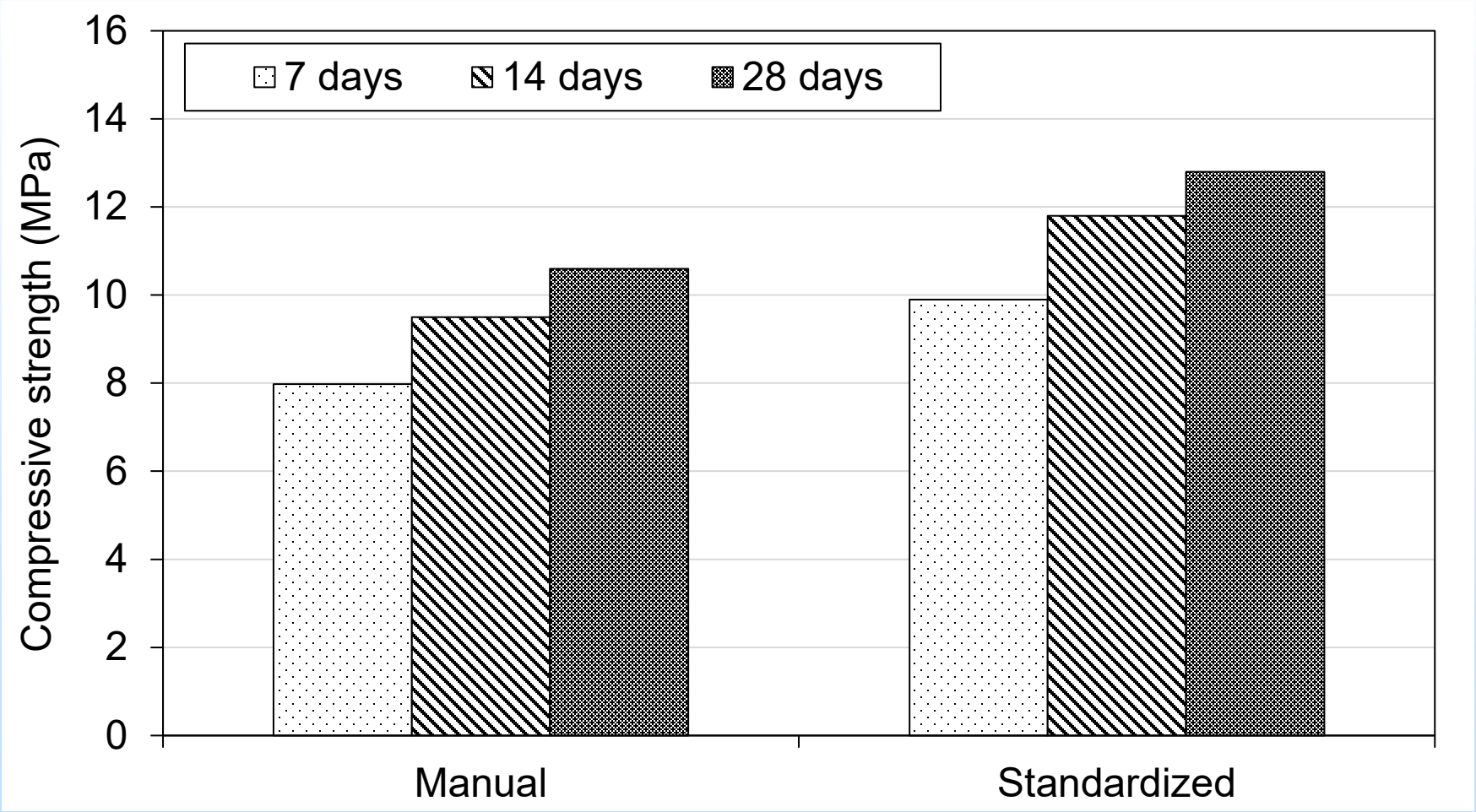
Manual Compaction

Standardized Compaction

Pre-pressing

U.S. Provisional Patent 63/354,742

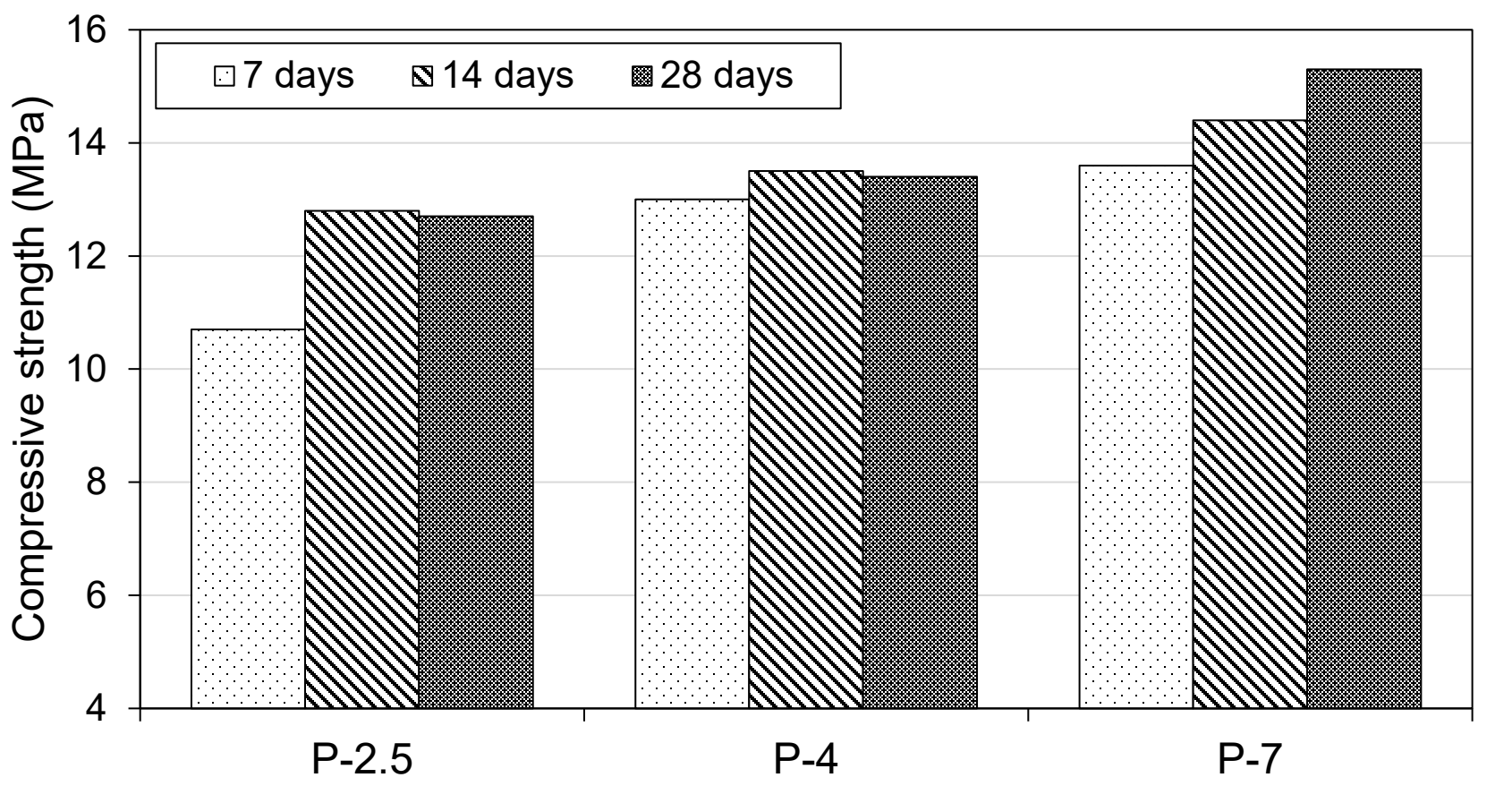
Progress and Current Status of Project (CCB)



U.S. Provision Patent 63/354,742

Progress and Current Status of Project (CCB)

- **Thermal Conductivity of P-7 CCB sample = 0.26 W/m.K < 0.4 W/m.K**
- **Average Density ≈ 0.8 g/cm^3**



U.S. Provision Patent 63/354,742

Progress and Current Status of Project (CCB)

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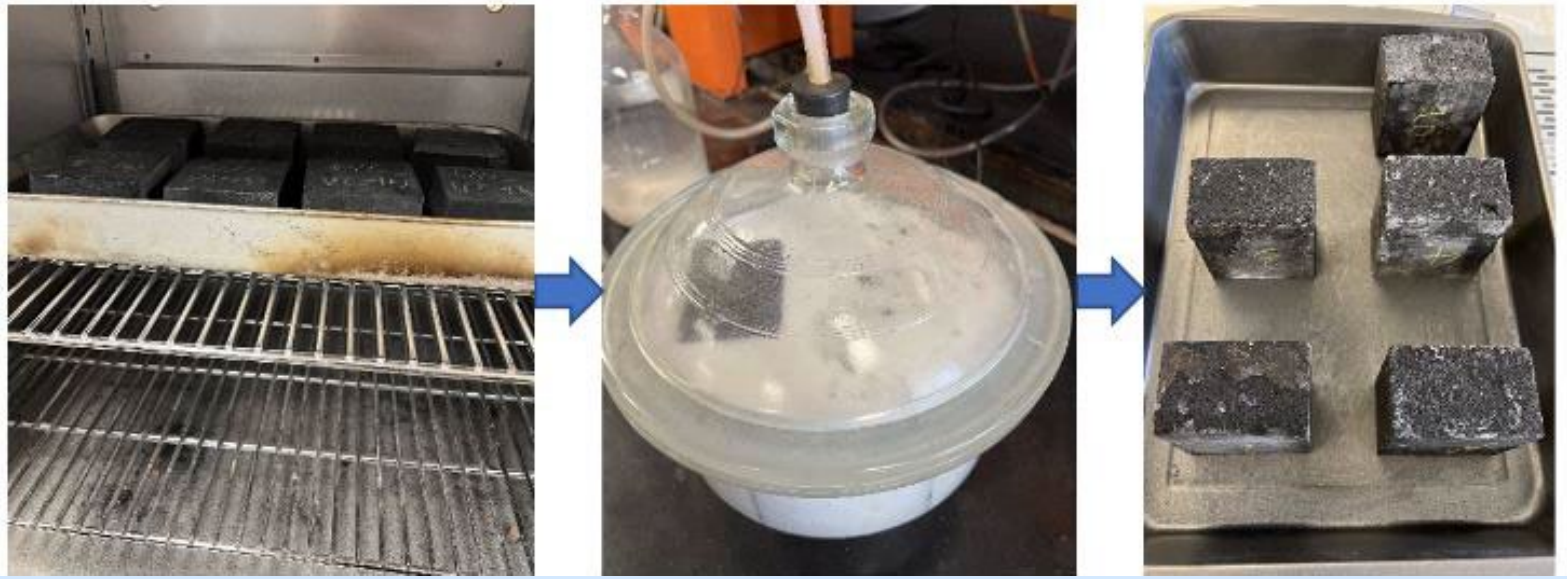
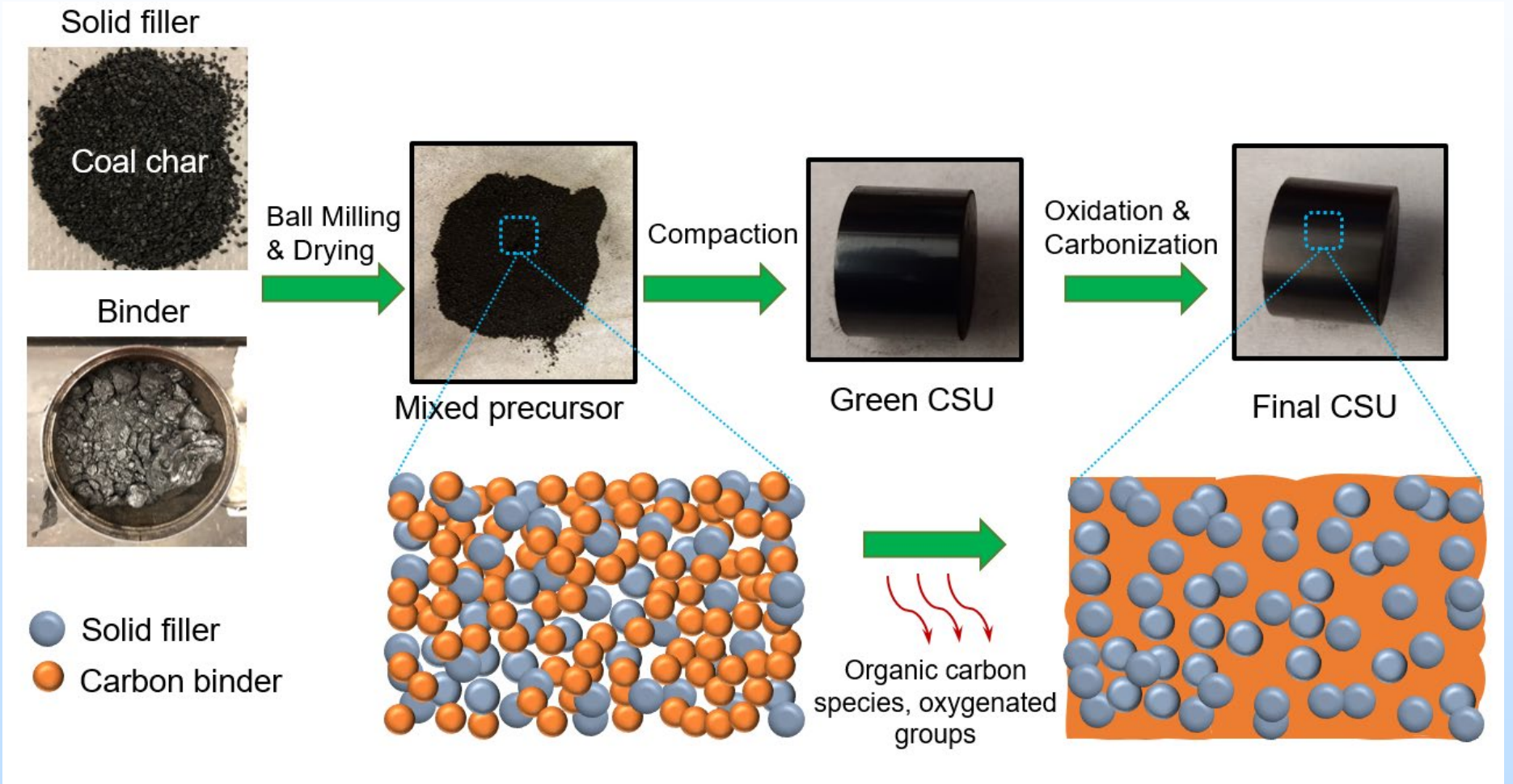


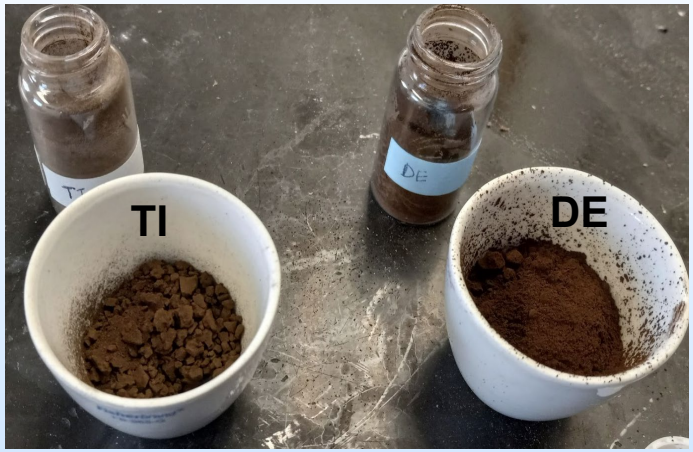
U.S. Provision Patent 63/413,522

Progress and Current Status of Project (CSU)



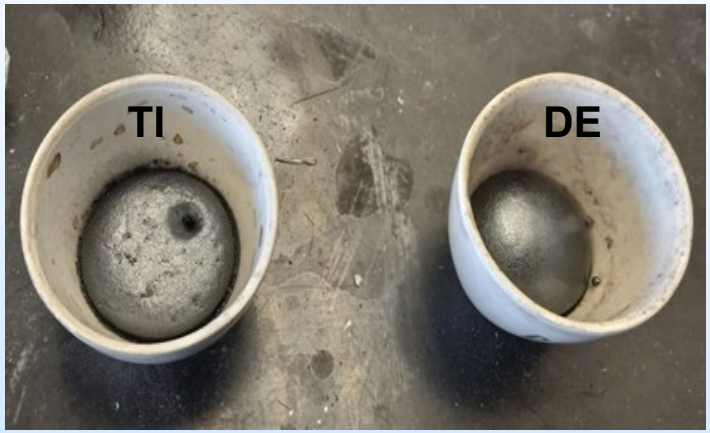
U.S. Provision Patent 63/355,426

Progress and Current Status of Project (CSU)



Before treatment

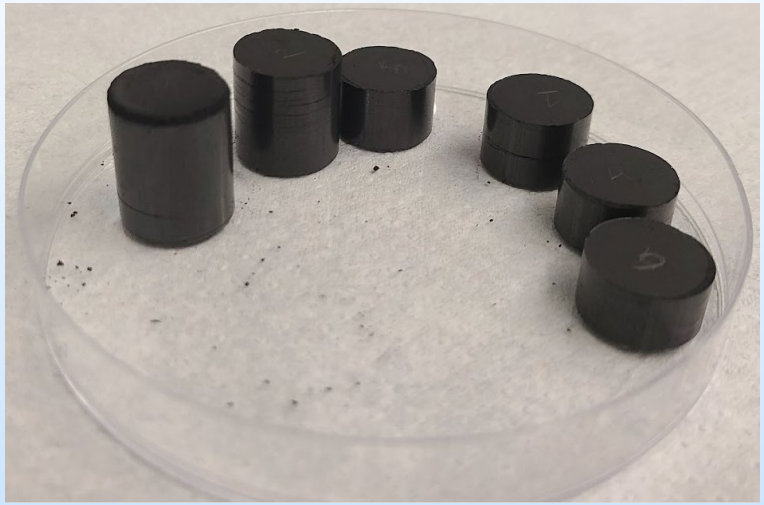
High Temperature w or w/o Pressure @ Inert Environment



After treatment

U.S. Provision Patent 63/355,426

Progress and Current Status of Project (CSU)



U.S. Provision Patent 63/355,426

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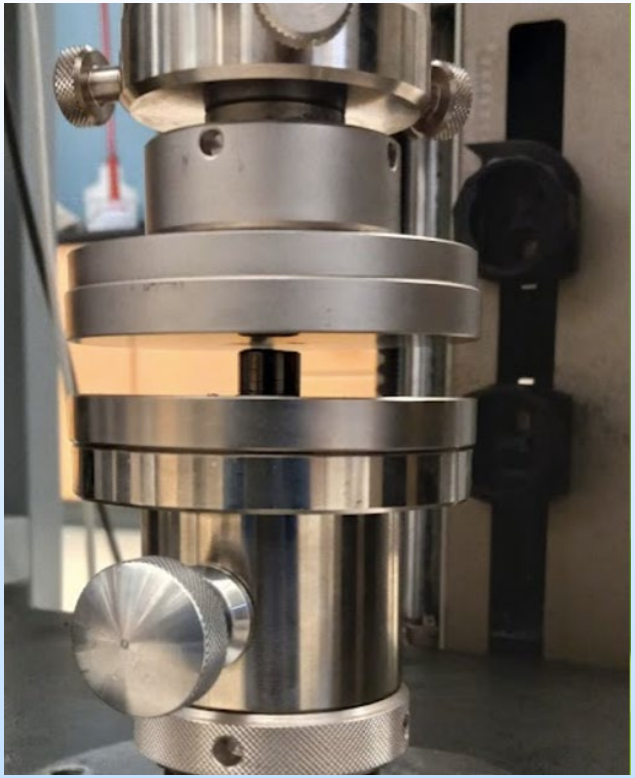
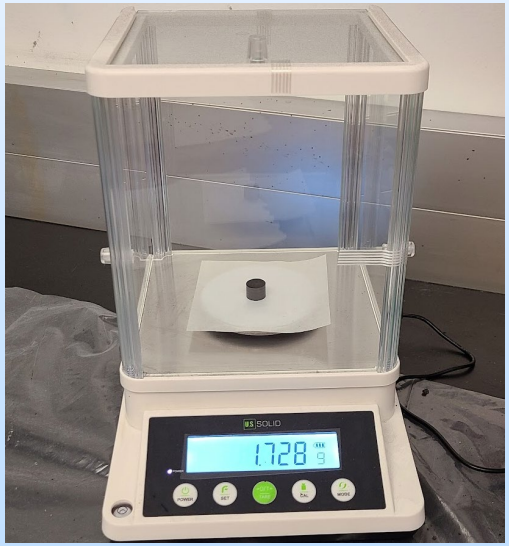


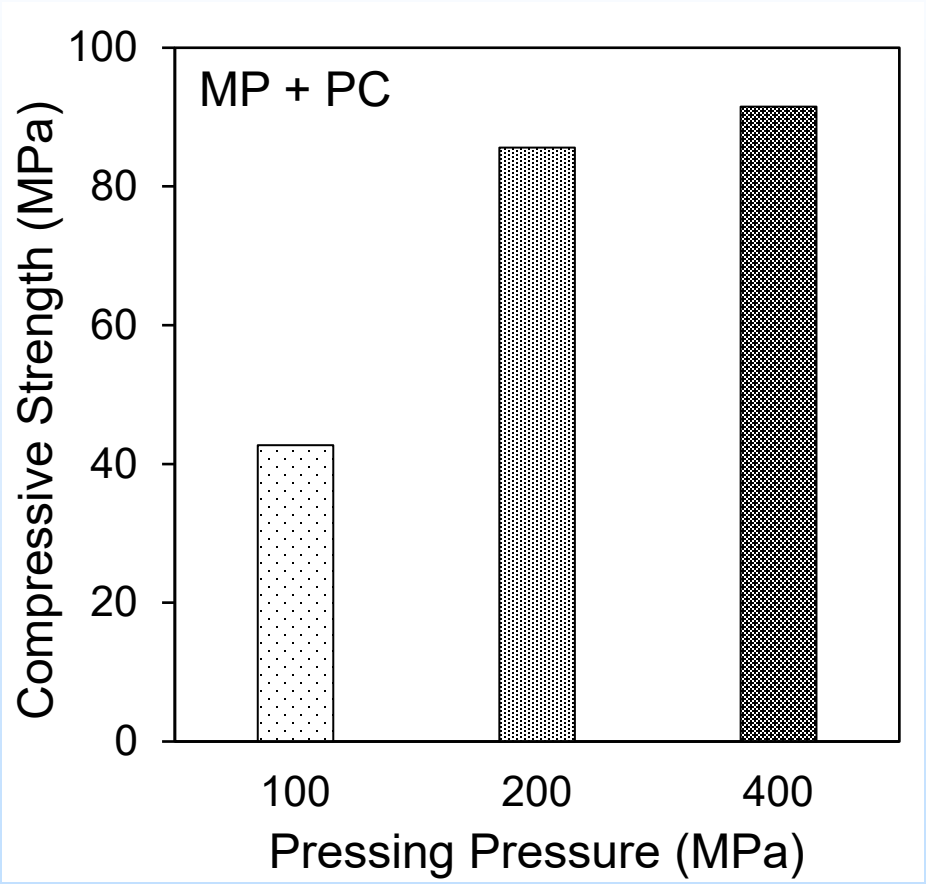
Compression Test

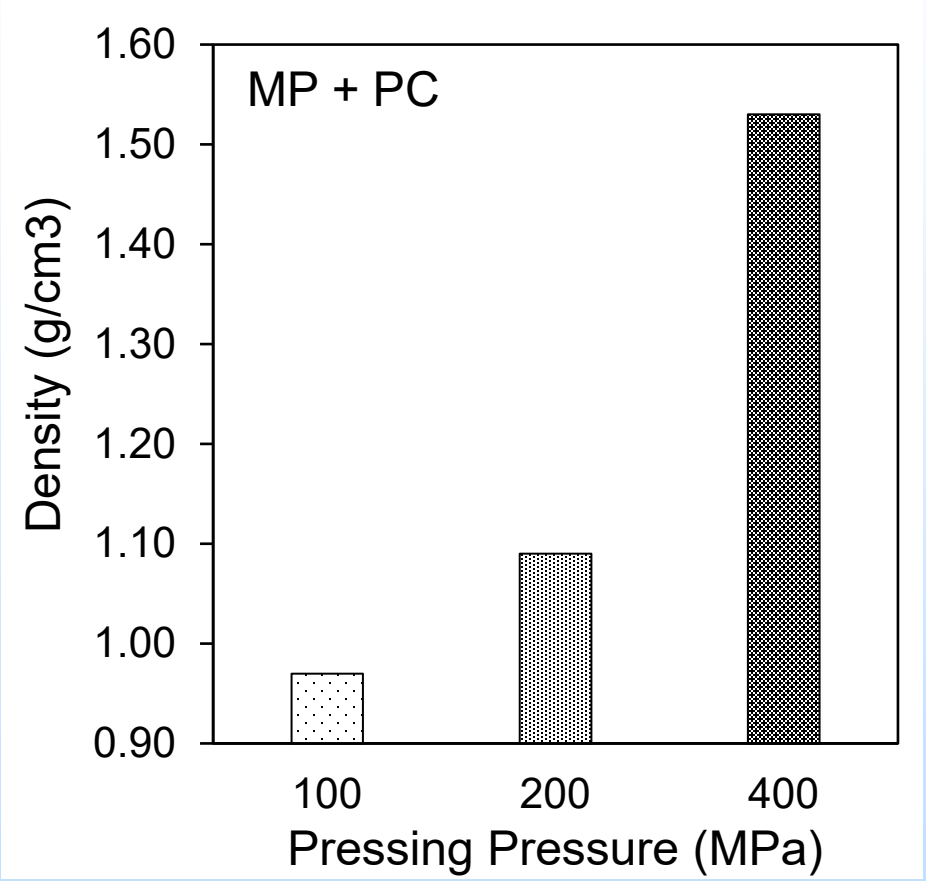
Thermal Conductivity Test



Density Measurement

Progress and Current Status of Project (CSU)

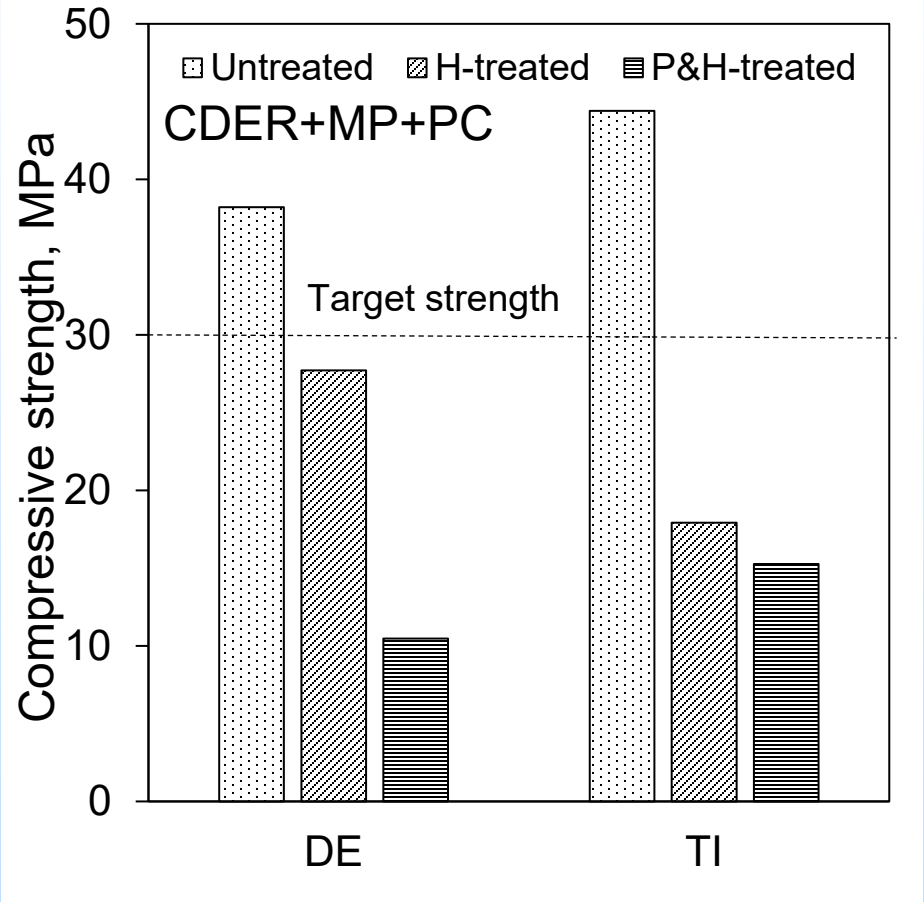


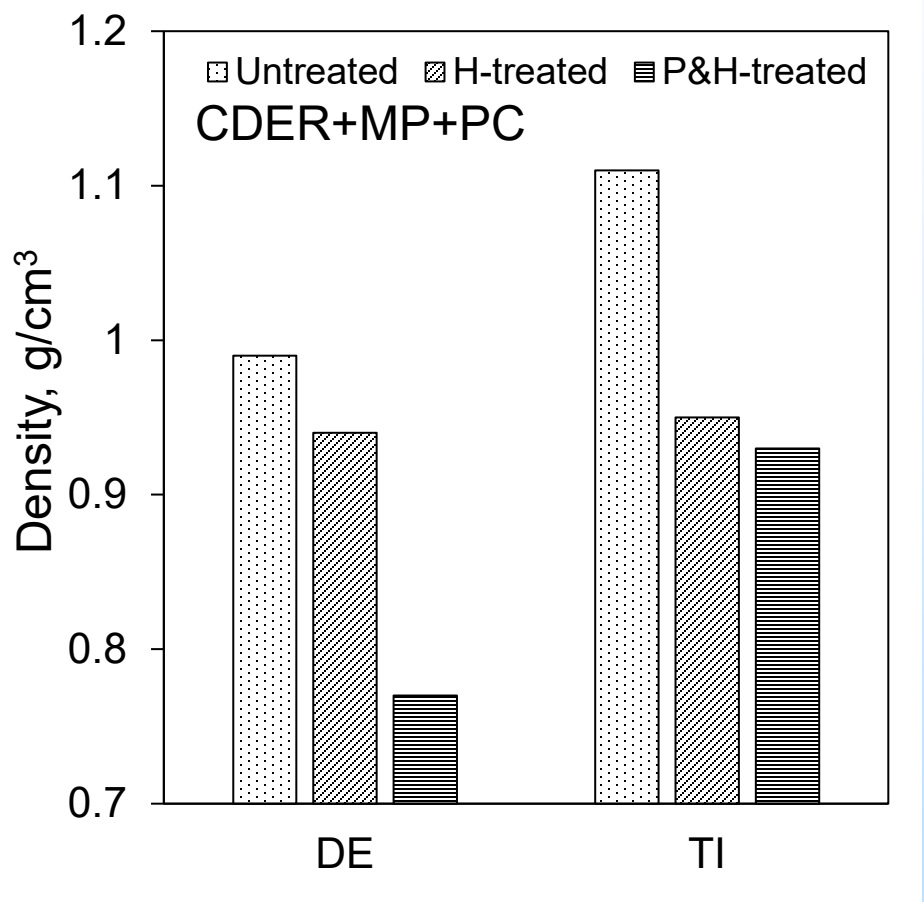


U.S. Provision Patent 63/355,426

Progress and Current Status of Project (CSU)

- **Thermal Conductivity of CSU samples = 0.175 to 0.257 W/m.K**





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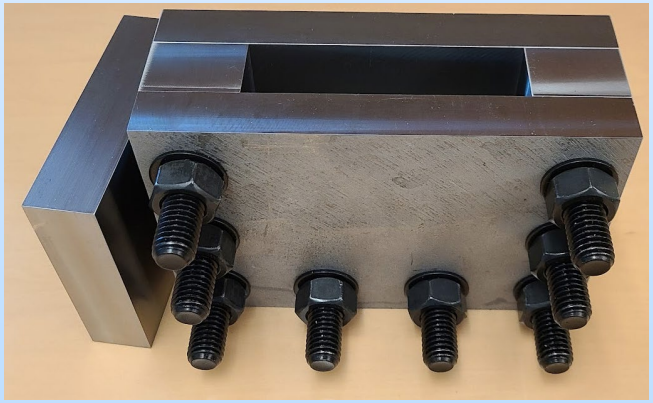
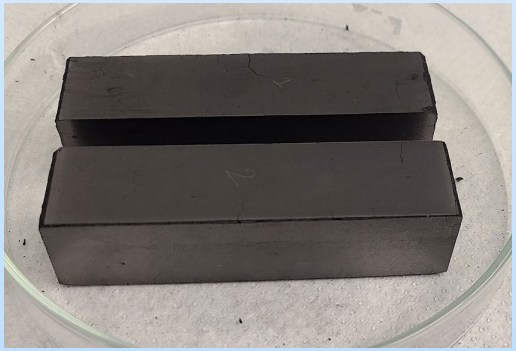
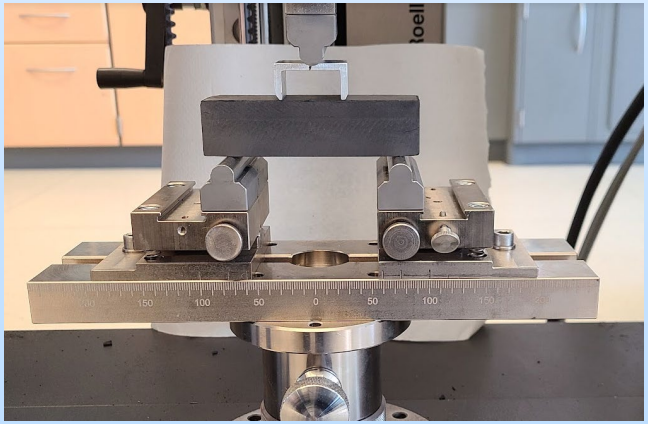






Plans for future testing/development/ commercialization (CCB)

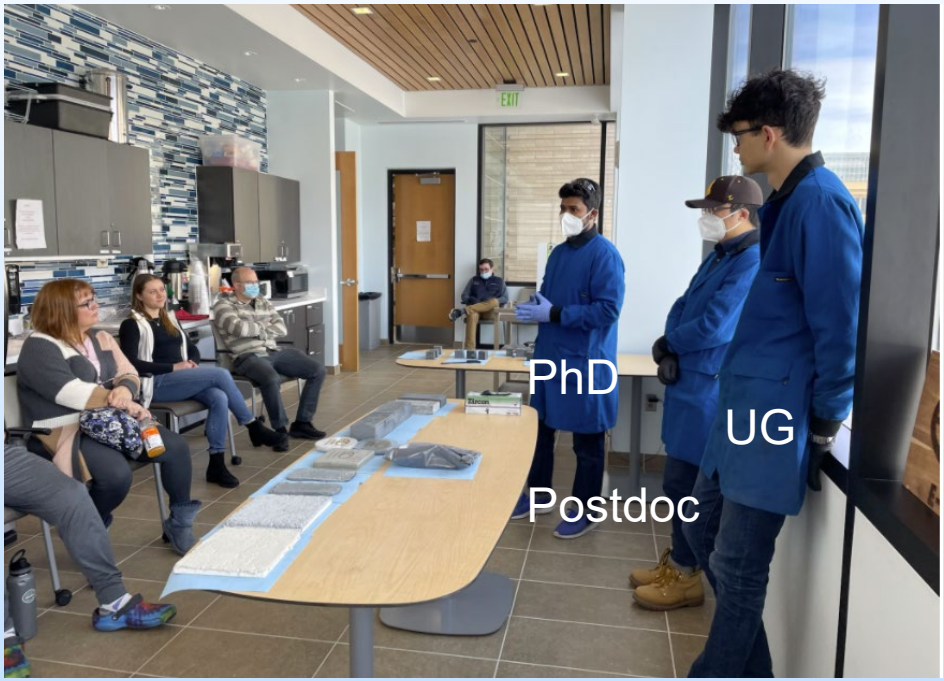
- This Project:
  - Durability; Flexural Strength; Techno-economic Analysis; Patent Applications
- Future Project:
  - CCB Prism and Wall System Performance
  - Compliance with Building Specifications
  - Life Cycle Assessment
- Scale-up Potential:
  - CCB Manufacturing Equipment
  - Workforce Development
  - Investment and Market Analysis

Plans for future testing/development/ commercialization (CSU)

- This Project:
  - Mechanism Study of Manufacturing; Patent Application
- Future Project:
  - Structural System Performance
  - Durability; Burning Characteristics; Fire Resistance
  - Techno-economic Analysis
  - Life Cycle Assessment
- Scale-up Potential:
  - Develop Manufacturing Equipment
  - Workforce Development
  - Investment and Market Potential

Outreach and Workforce Development Efforts or Achievements

- Outreach – Education Events and Orientation at UW.



- Workforce Development:
  - One Postdoc, One PhD Students, One MS Student and UG Students.

Summary

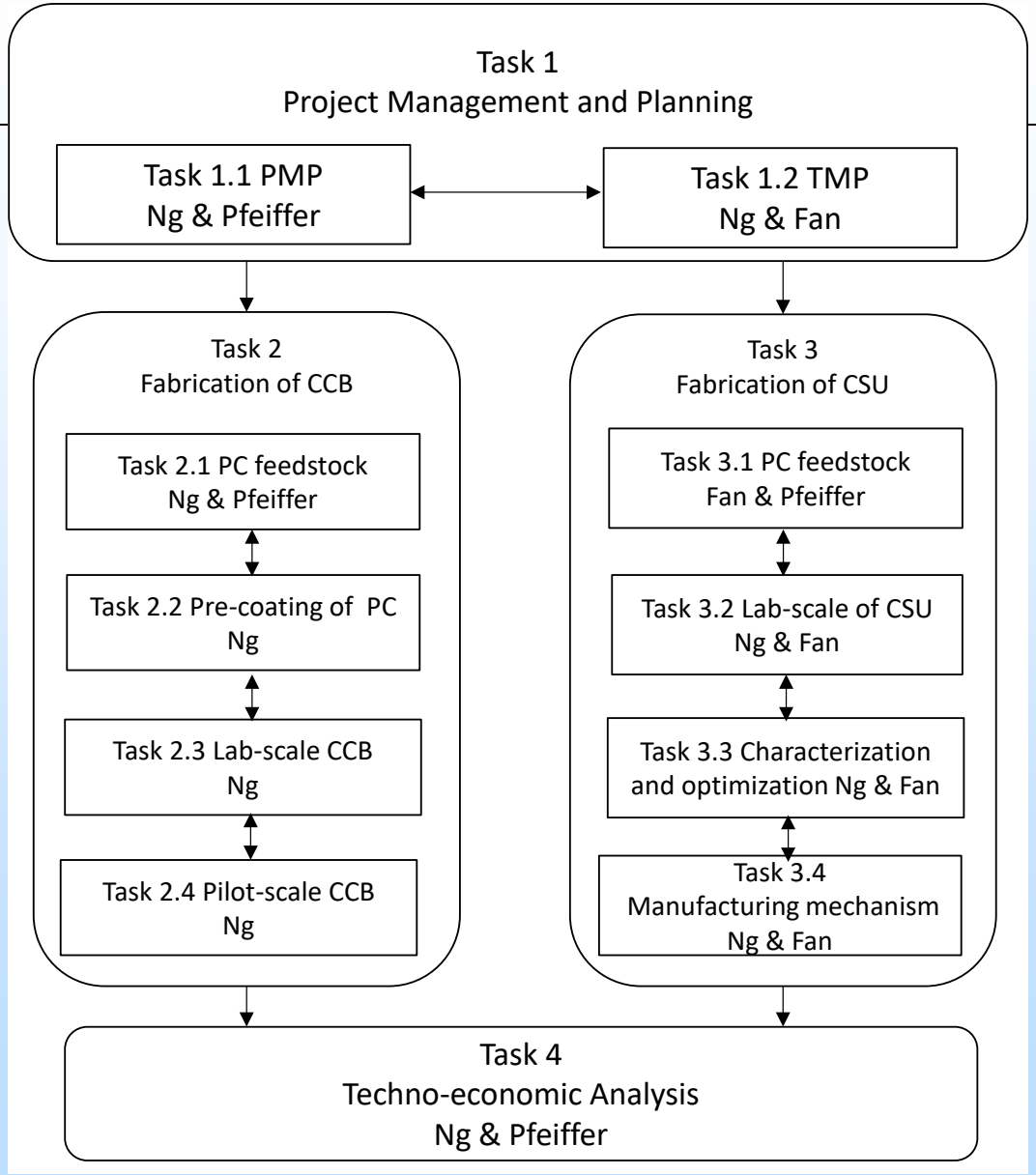
- High Volume of Coal can be Utilized in Building Materials.
- CCB: 70% Carbon, > 14 MPa, 0.8 g/cm^{3,} Low Energy Manufacturing.
- CSU: 90% Carbon, > 30 MPa; 1 to 1.3 g/cm^{3}.
- Potential for Commercialization and Scale-up Manufacturing.

Acknowledgement:
Program Manager: Dr. Brett Hakey

Appendix

- Organization Chart
- Gantt Chart

Organization Chart



Gantt Chart

Task Name	Project Period based on Quarters										
	2021				2022				2023		
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3
Task 1. Project management and planning											
Subtask 1.1 Project management plan	M1										
Subtask 1.2 Technology maturation plan	M2										M3
Task 2 Fabrication of CCB											
Subtask 2.1 PC feedstock acquisition and characterization		M4									
Subtask 2.2 Surface pre-coating PC method			M5								
Subtask 2.3 Lab-scale manufacturing of CCB							M6				
Subtask 2.4 Preliminary pilot-scale manufacturing of CCB									M7		
Task 3 Fabrication and characterization of CSU											
Subtask 3.1 PC and CDER feedstock acquisition and characterization		M8									
Subtask 3.2 Lab-scale manufacturing of CSU								M9			
Subtask 3.3 Characteristic analysis of CSU and optimizing preparation condition											
Subtask 3.4 Mechanism study of the CSU manufacturing											M10
Task 4.0 Process development & techno-economic analysis				M11							M12