



Emphasizing Technologies for Low-Carbon & Lean Construction (TLC)

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On behalf of the Research Team

*Expertise: Construction Materials, Construction Management,
and Building Science and Automation*

IIT Madras has initiated a project along these lines, with

- *20 faculty members*
- *30 research scholars,*
- *several collaborators from around the globe, and with*
- *potential for collaboration with entities such as ACI and RILEM.*

<https://civil.iitm.ac.in/pcoe/tlc/>



Critical Questions Addressed

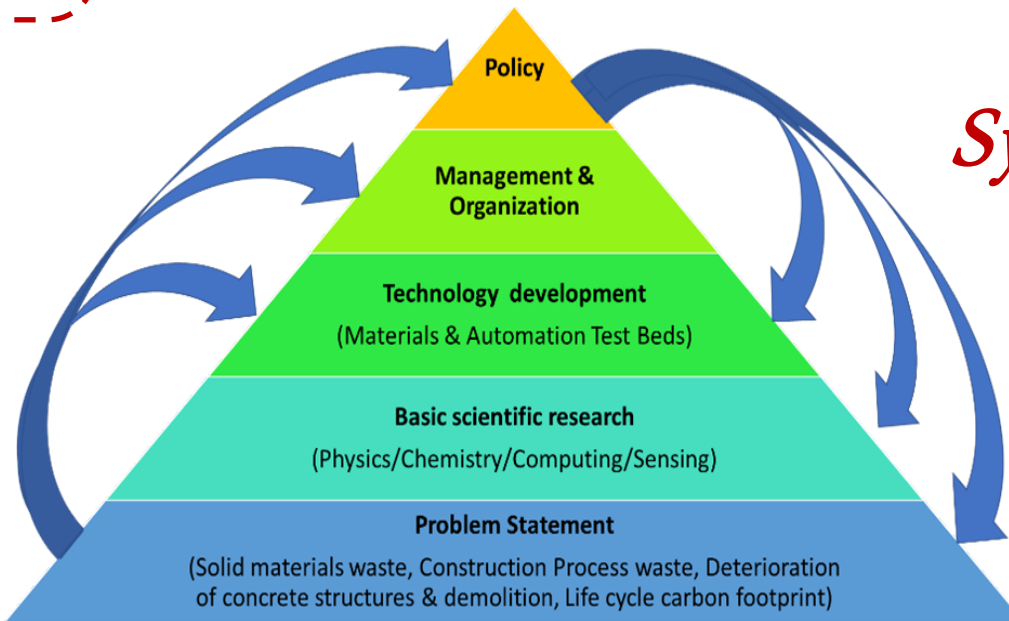
Material Waste?



Process Waste?



Sustainable Construction



Systems-Thinking



Life-Cycle Approach

Waste Material from other sources



National maps for waste materials for socio-economically optimized use in construction

Raw Materials

Material Supply Chain

Design

Construction

Durable Performance

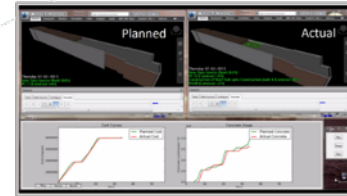
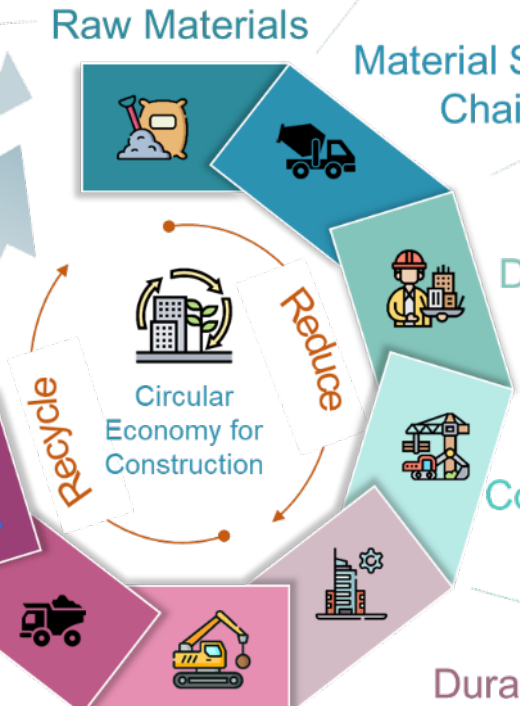
Demolition

C&D waste Collection

Recycle

Circular Economy for Construction

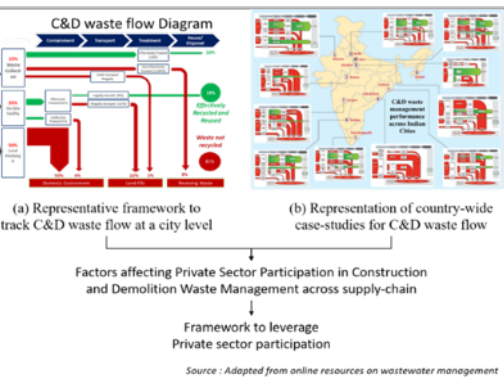
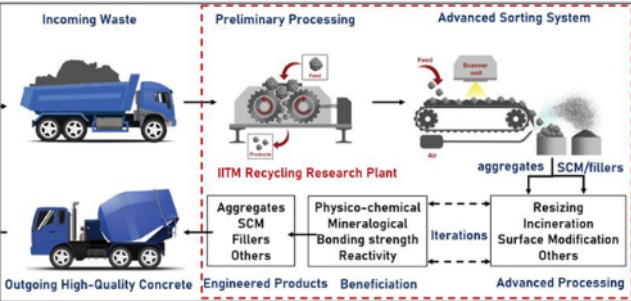
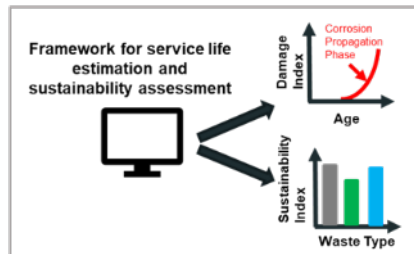
Reduce



nD BIM Simulations



India's First 3D Printed House (IITM-Tvasta Initiative)



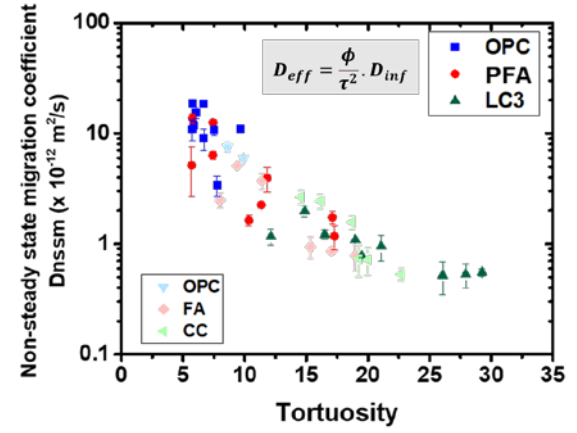
Track 1 - Basic Scientific Research

- Physico-chemical processing of waste for high-volume use in construction materials
- Use of the processed waste in 3D printing, precast products and pavements
- Correlation of material characteristics of processed waste, mixture proportioning and mechanical properties of concretes
- Transport/corrosion characteristics and service life of low -carbon concretes in various environments
- Sustainability indicators and life cycle assessment

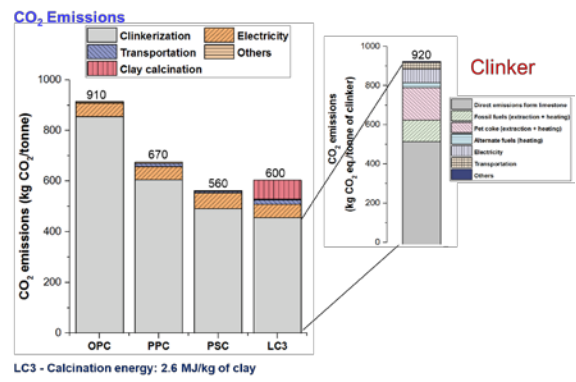
Track 1 - Basic Scientific Research

- **Relating concrete performance to characteristics of wastes used as supplementary cementitious materials:**
 - Pore structure evolution and connectivity
 - Chloride diffusion
 - Carbonation
- **Sustainability Indicators based on LCA**

Tortuosity based on conductivity (Manu Santhanam)

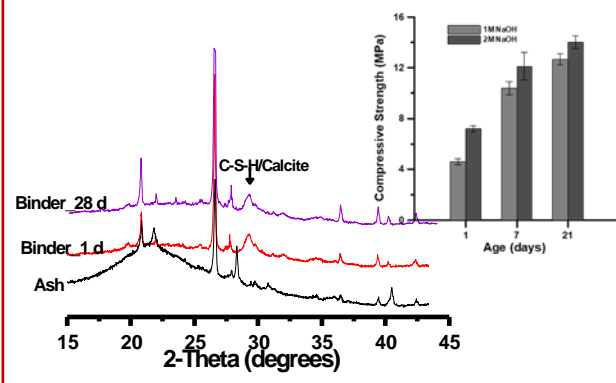


Life cycle assessment (Ravindra Gettu & Sivakumar Palaniappan)



- **Biomass Ash:** About 32% of the primary energy in India is derived from biomass. Current availability is around 750 million metric tons per year; Surplus biomass corresponds to about 28 GW of electricity
- **Plans:**
 - Establishing composition-reactivity relationship for Indian biomass ashes
 - Developing a framework for high volume utilization of biomass ash in structural materials
 - Mapping of agro-wastes (type/quantity/location)
 - Development of low CO₂ biomass ash-based binders for structural applications

Example: Biomass Ash Bricks (Piyush Chaunsali)



Binder: 70% Ash, 20% Clay, 10% lime, 1M NaOH activator (w/b - 0.4)



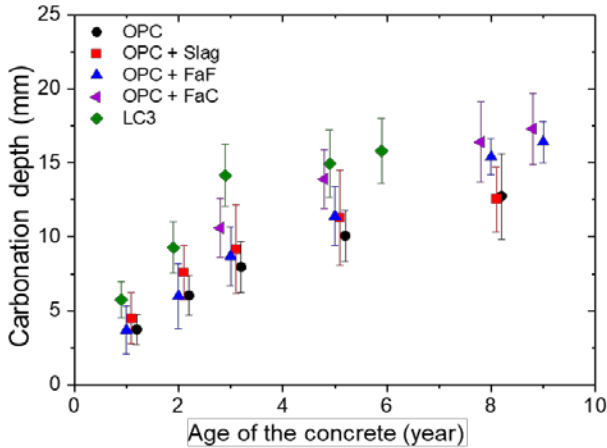
Track 2 - Applied Research leading to Technology Development

- Lab-to-field implementation
- 3D printing technology for reinforced concrete and robotics
- Software/tools to estimate service life for durability-based design
- Low-cost, 'lighter', ready-to-use analytical tools and dashboards to minimize waste due to construction processes/practices
- Sustainability indices and carbon footprint of various materials and systems

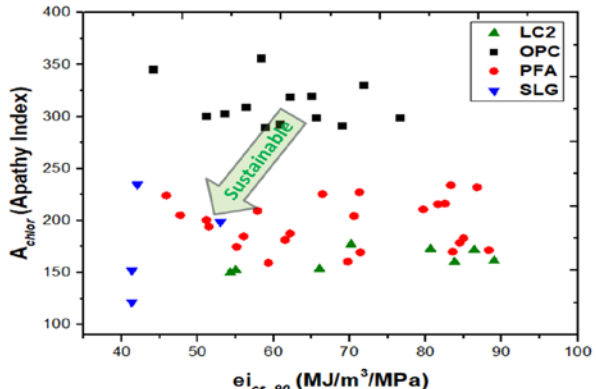
Track 2 - Applied Research leading to Technology Development

- **Durability for Sustainability:**
 - Corrosion threshold of coated and uncoated steel reinforcement in different concretes
 - Carbonation in temperate climates
 - Service life modelling
 - Framework for choosing concrete composition based on sustainability criteria

Long-term studies of carbonation



Sustainability framework



- **Construction Automation:** Aiming to develop fast and efficient construction systems for residential buildings with a high level of automation that is appropriate for Indian conditions
- **3D Printing for Buildings:** Software, Materials and Systems

Mentoring Tvasta, an IIT Madras startup (Manu Santhanam, Koshy Varghese)

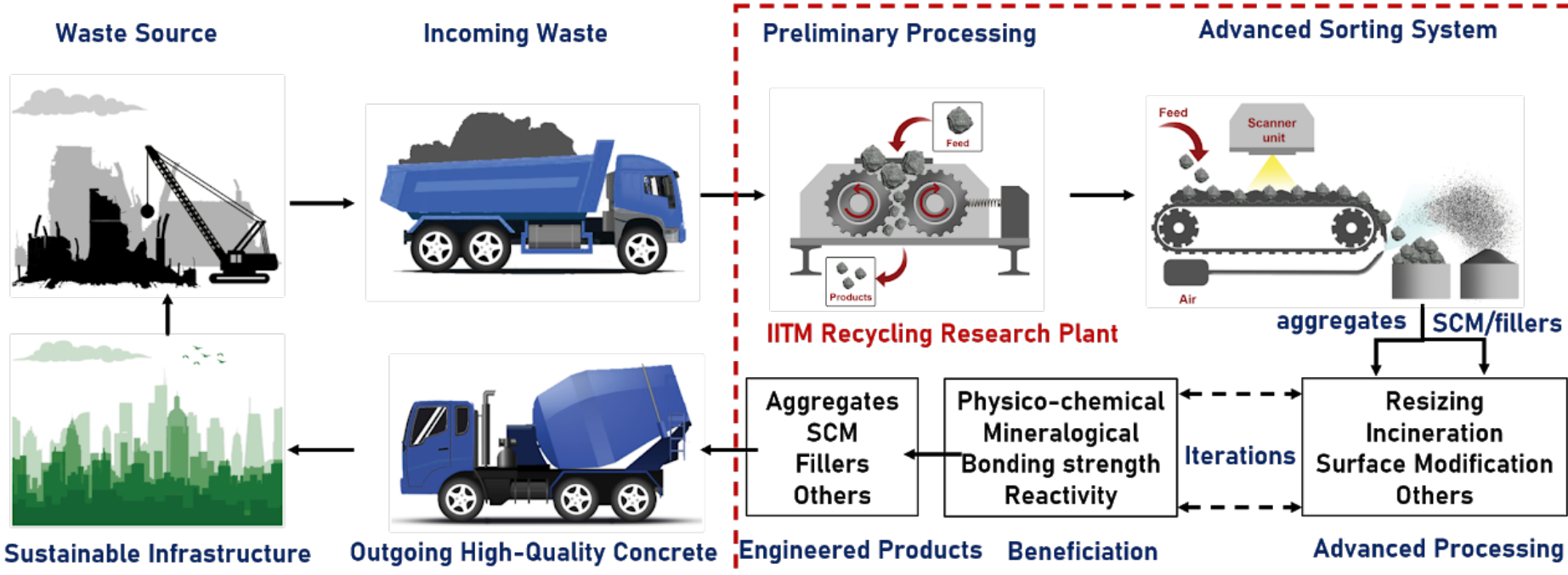


3D Printing integrated with robotics
 - Placing reinforcement and service lines (Benny Raphael)

Track 3 – An Integrated Test-Bed for Large-scale Processes and Visualization

- Physical recycling test-bed for automated screening and physico-chemical processing of various waste materials
- Optimisation of the usage of recycled materials in concrete
- Physical, AI-VR integrated testbed environment to identify optimal use of materials, simulate and optimize construction practices, and minimize carbon footprint
- Integrated simulation and game-based learning facility on management adoption strategies, organizational training, and specialty skill training on lean process

Track 3 – An Integrated Test-Bed for Large-scale Processes and Visualization



Wastes being studied:

- Pond and bottom ash
- Urban (mixed) demolition waste
- Bio-mined plastic waste
- Coconut coir
- Greywater

Recycled Asphalt Pavement as Concrete Aggregates

(Surender Singh)



Track 4 - Organizational & Policy Research

- National maps on current/future availability of waste materials (based on socio-economic-environmental sustainability aspects)
- Strategies for modifying organizational work practices to increase the adoption of lean construction practices
- Framework for leveraging the private sector participation across supply-chain of concrete materials during the life-cycle of construction projects
- Policy Notes for large-scale implementation of various waste utilization and reduction technologies

Track 4 - Organizational & Policy Research (Ashwin Mahalingam, Nikhil Bugalia)

- **Motivation for Policy Research:** Significant shifts required in project delivery approaches and policies related to the construction industry to meet future needs. Must work closely with government to foster innovation, quality and user satisfaction.
- **Policy Advisory:**
 - Innovative Construction Materials, Processes and Systems
 - Digitalization and Automation in Construction
 - Improving Project Governance (e.g., Contracts, Flexible Public-Private Concession Agreements)
 - Infrastructure Planning and Urban Development (e.g., Simulation based approaches, Resilience Strategies)

Public Private Partnerships; Housing & Infrastructure

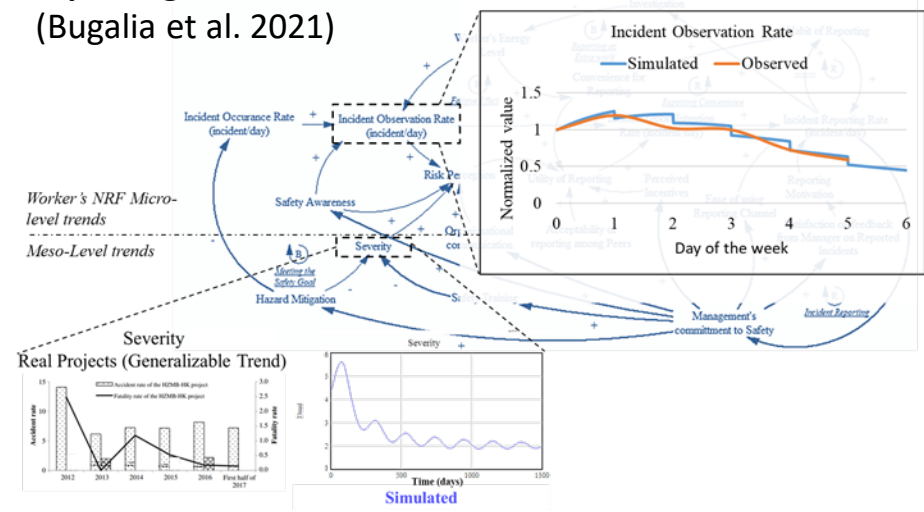
- State Acts on Infrastructure Development & Transparency in Tenders
- Report on Public-Private Partnerships
- Model Concession Agreement for Ports
- State Policy for Rural and Urban Housing



- **Safety Management practices:** Safety-II, System-Thinking and Resilience Engineering Framework
- **Goal:** A system-dynamics based numerical simulation game for emulating good safety practices of construction organization despite resource constraints
- **Impact:** Capacity Building and Management Training for industry stakeholders to promote good safety practices

System Dynamics based simulation for near-miss reporting

(Bugalia et al. 2021)





Thank You!

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<https://civil.iitm.ac.in/pcoe/tlc/>

or, contact us at

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