Special Concrete Applications in India

Work of the TLC2 CoE

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IIBCC Colombo, Nov 2024

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ASLAM KUNHI MOHAMED

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PIYUSH CHAUNSALI

SURENDER SINGH

ASHWIN MAHALINGAM

SIVAKUMAR PALANIAPPAN

NIKHIL BUGALIA

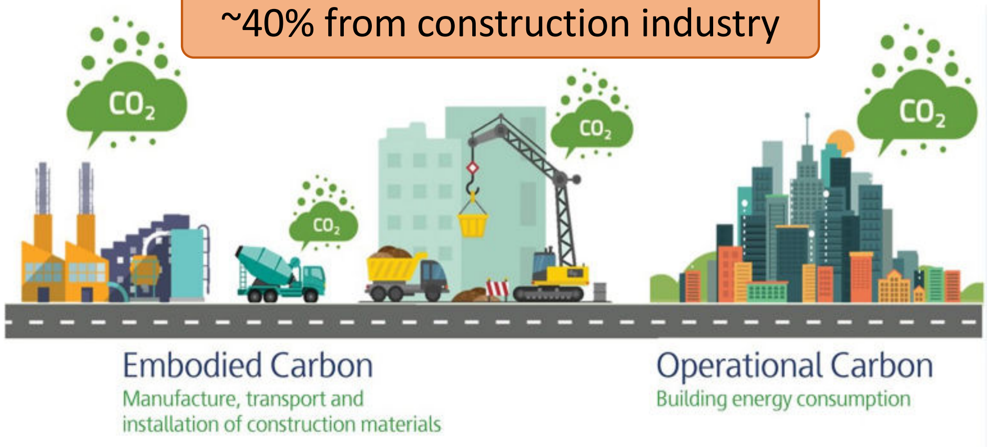
MURALI JAGANNATHAN

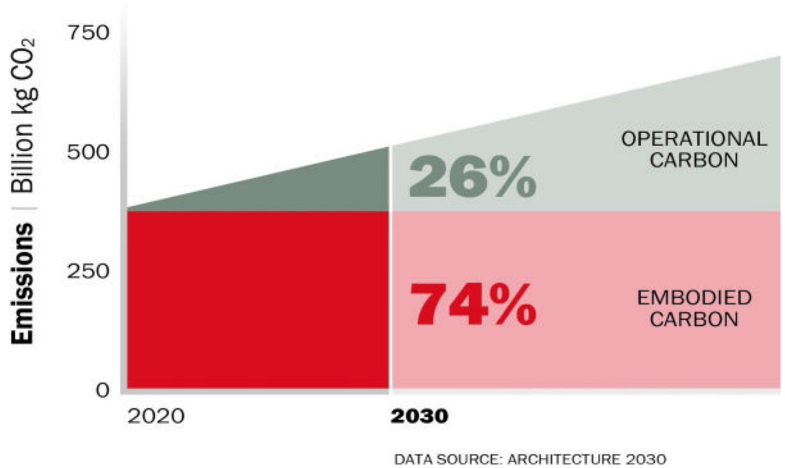
Relevance**:** **Construction materials, Construction management, and building science**

More than 30 collaborators internationally

Zero-Carbon & Zero-Waste Challenge for Construction

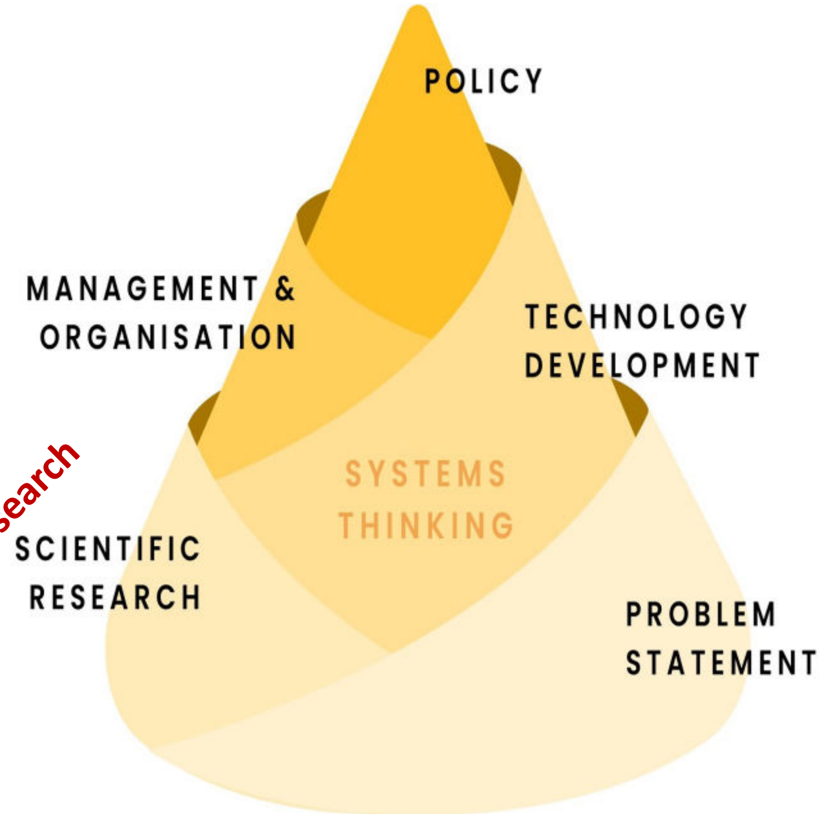
~40% from construction industry





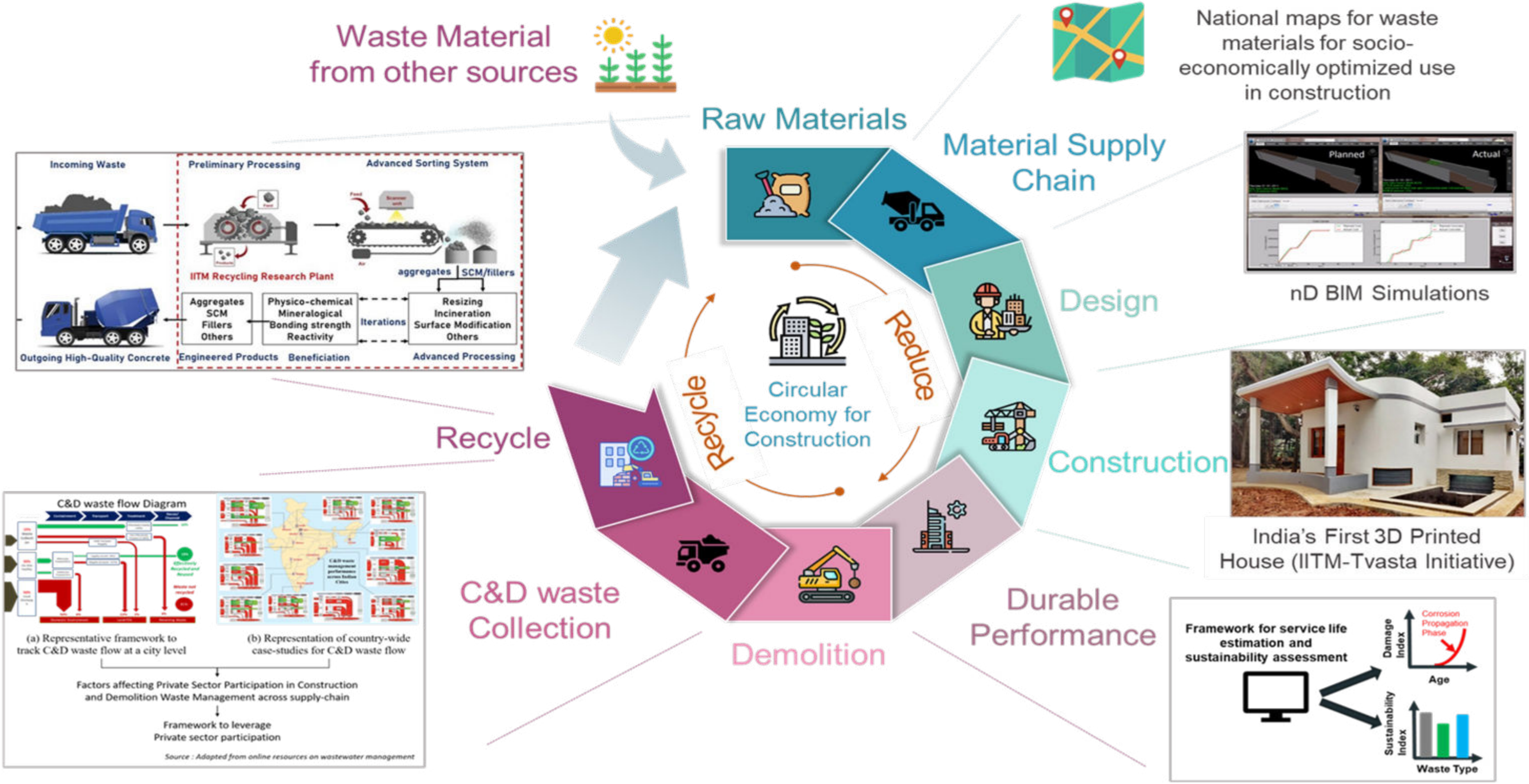
Source : https://www.architects.org/news/the-new-net-zero

Translational and Transformational Research



Vision

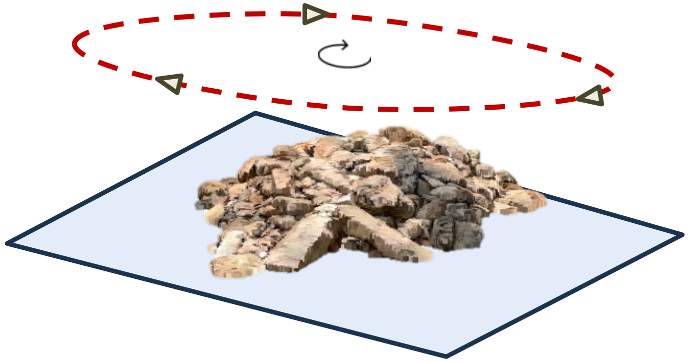
Zero-Carbon & Zero-Waste Construction



Our Projects

Use of recycled materials

Digitized Quantification



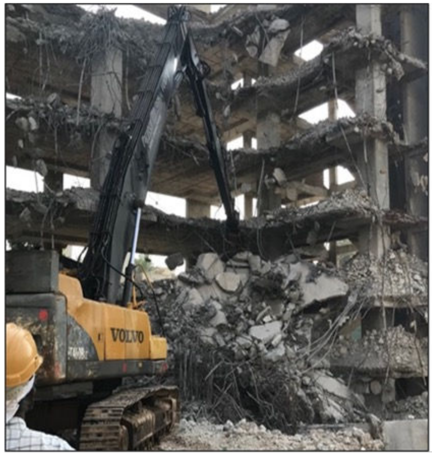
Intelligent Segregation

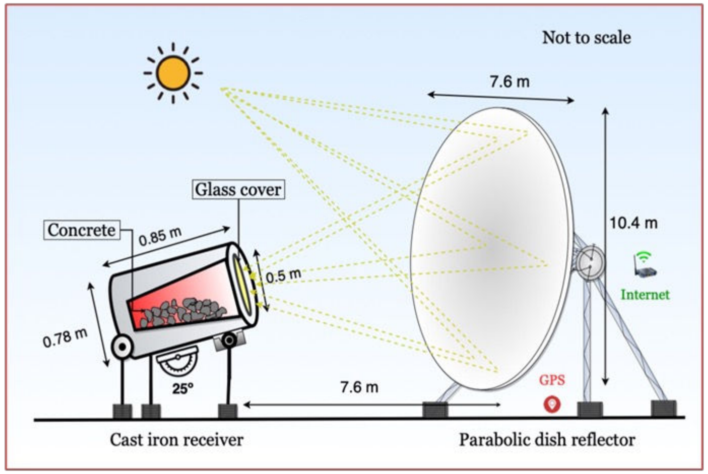
Sustainable Processing

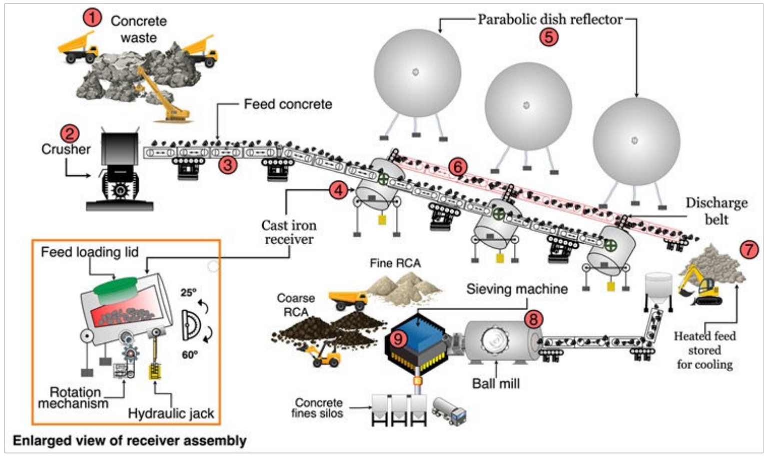
Solar Energy

Recycled Aggregates

RCA through solar processing







Proposed Plant Details

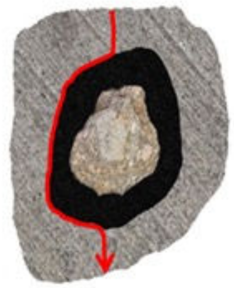
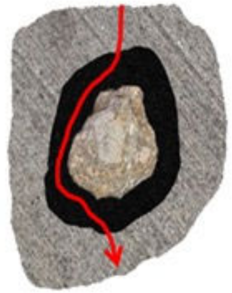
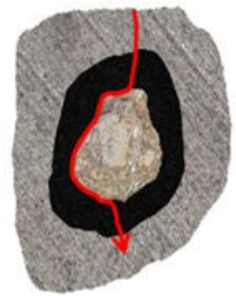
Rohit et al. 2022

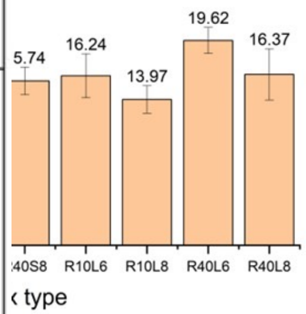
Use of Recycled Asphalt Pavement (RAP)

- More than 100 m

Milling of

- RAP cannot be re

					
Failure mode	**Mode I**: Cohesion failure of mortar	**Mode II**: Adhesion failure at the asphalt-mortar interface	**Mode III**: Cohesion failure of asphalt	**Mode IV**: Adhesion failure at the asphalt-aggregate interface	**Mode V**: Cohesion failure of aggregate
Prevalent conditions	Not observed	Mostly for limestone and sandstone aggregates when used for mortar grades ≤ M20	Mostly for limestone and sandstone aggregates when used for mortar grades ≥ M30 Mostly for higher grades of asphalt when aged beyond short-term aging, irrespective of aggregates mineralogy	Prevalent for granite aggregates only	Not observed



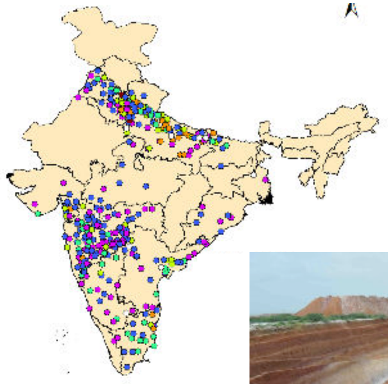
Our Projects

Low carbon concrete

Alternative Raw Materials	Low-carbon Cements	Sustainable Concrete

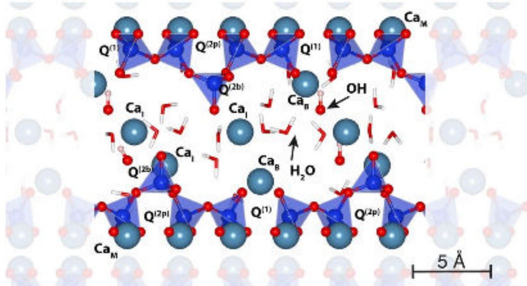
Alternative Raw Materials

Resource Mapping



- Low-Grade Limestone
- Biomass
- Overburden Clay

Low-carbon Cements



- Mini cement plant
- Low Energy Cement
- Molecular Modelling

Sustainable Concrete

- LC3 house
- LC3 Tetrapod
- Biomass Ash bricks

LC3 demonstration projects

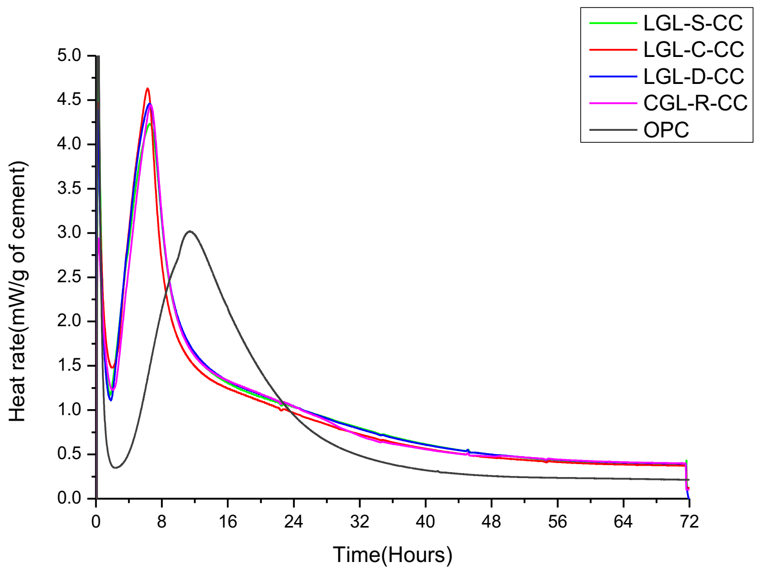
» Aggressive groundwater with 17000 mg/l Chloride and 1500 mg/l Sulphate; Frequent inundation of site!

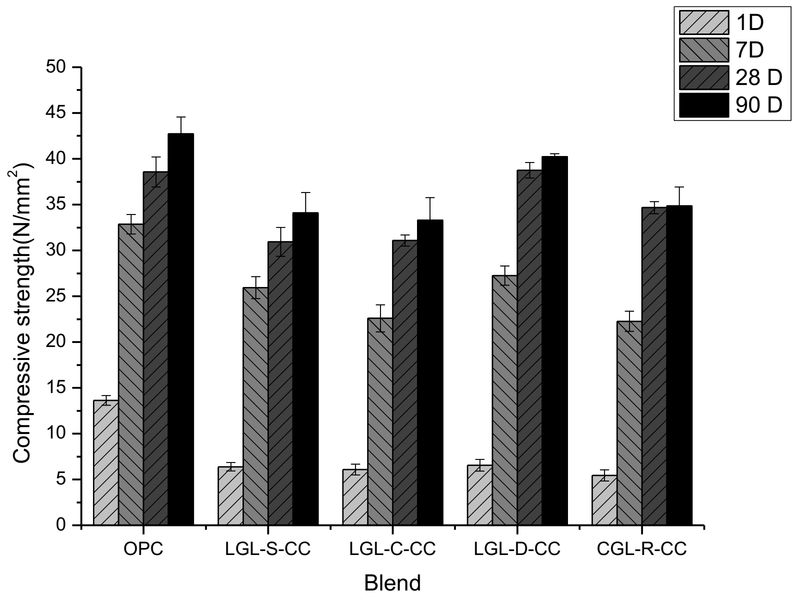
Other structures that have been in service for > 5 years:

- LC3 pavement slab at Chennai
- LC3 parking slab at high altitude (~11000 ft) at Leh

LC3 with low grade limestone

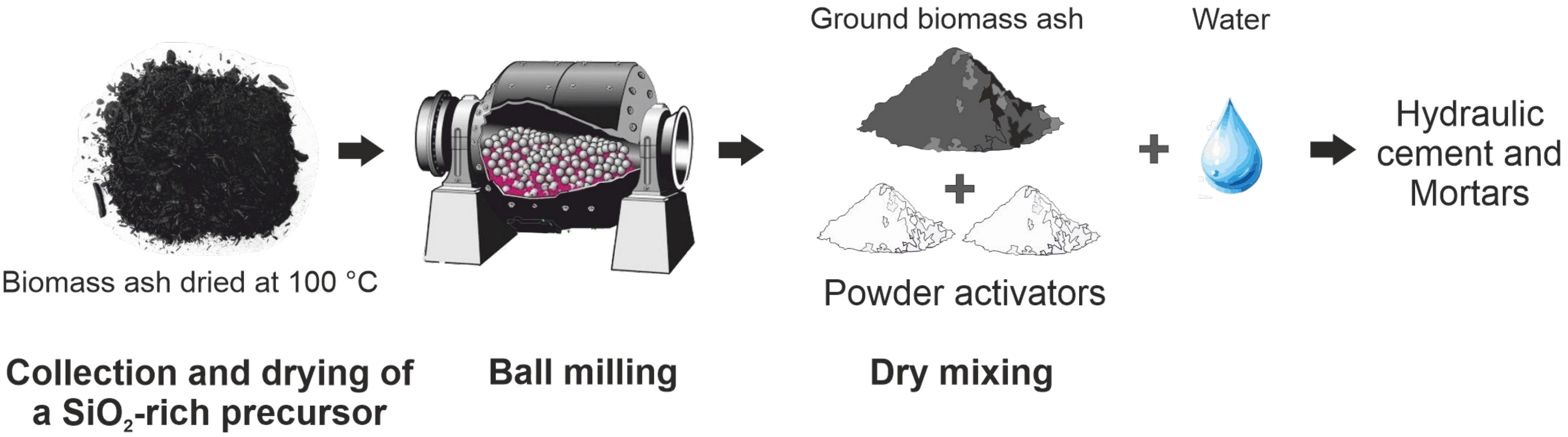
- Limestone which doesn't qualify for cement production
- Contains impurities like silica, clay, dolomite etc. beyond the limits specified
- Dumped in huge quantities in mines





Dolomitic limestones look promising, although siliceous and clayey limestones also perform well

One-part activation of Si-rich precursor



Caustification reaction

$Ca(OH)_2 + Na_2CO_3 = CaCO_3 + 2NaOH$

Reaction products

Silica gel, $CaCO_3$, Ca- modified silica gel and C-S-H

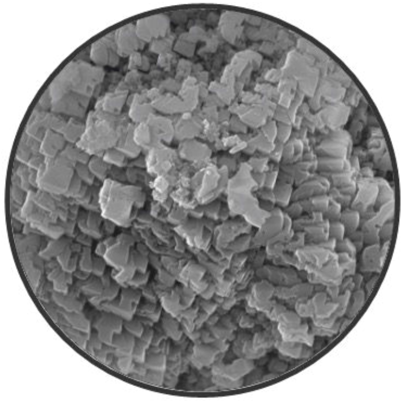
One-part activation of Si-rich precursor

Alkali-activated Mortars
(one-part activation)

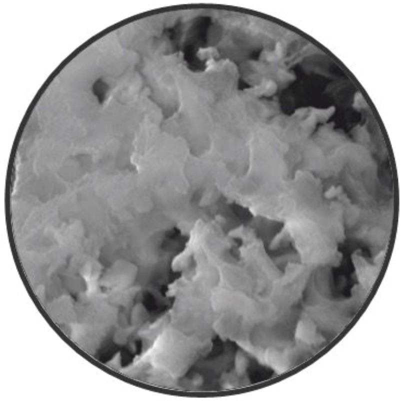
RHA + Glass Waste
20 MPa

Biomass ash
(paper industry)
10 MPa

RHA + Granite Waste
12 MPa

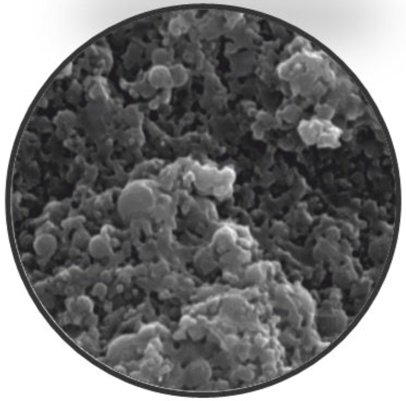

Calcite-like


Semi-crystalline $CaCO_3$


Low-Ca C-S-H


Ca-modified silica gel

Morphology of reaction products


Silica gel

Our Projects

Precast construction

Technology Development

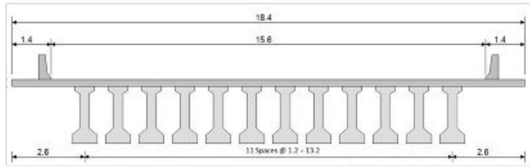
- Tendonfill grout
- TRC Sewage treatment plant
- FRC tunnel linings

Promotion and Implementation

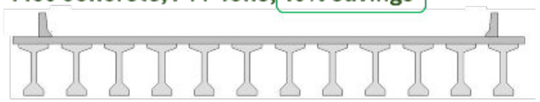
- Completed sports complex
- Upcoming PPVC hostel, designed for deconstruction

Standardization

M45 concrete; 1284 Tons



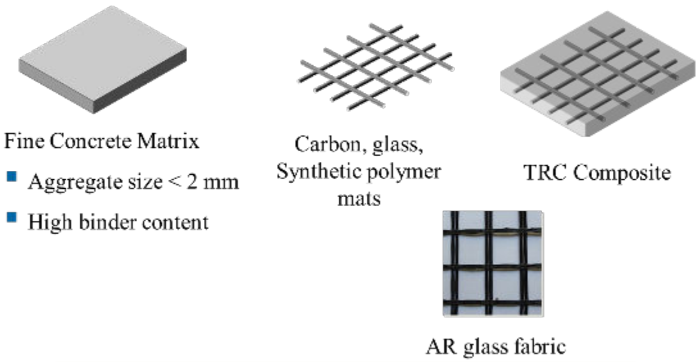
M60 concrete; 744 Tons; 40% savings



Bridge sector

- BIS standard

Textile Reinforced Concrete (TRC)



- Optimal section size
- Lower dead weight
- Durability
- Shrinkage and cracking resistance

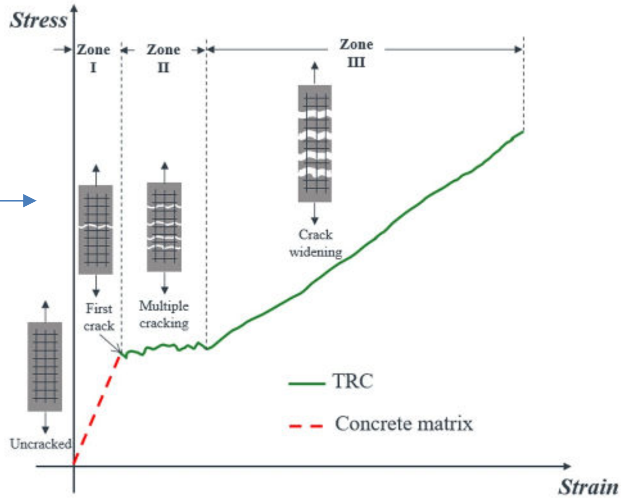
Stage I: Initial response dominated by the matrix.

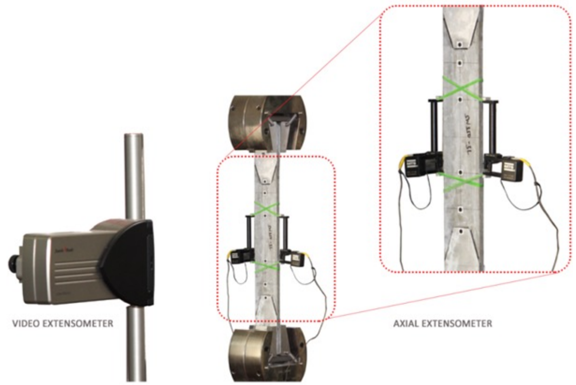
Stage II: Multiple cracking of the matrix

Stage III: Cracks open. Load carried by the textile filaments until rupture

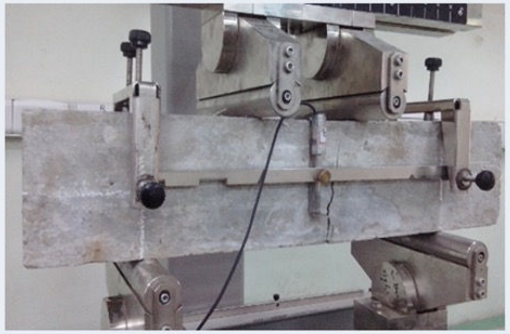
Influence of number of layers, textile geometry etc. also studied

Applications: column strengthening, water tank, ring modules for sewage treatment system

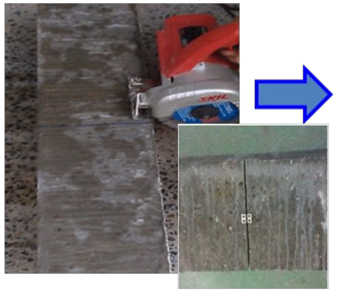




Fibre Reinforced Concrete (FRC)

	Unnotched Beam Test	Notched Beam Test
Control Variable	Displacement	CMOD
Occurrence of Crack	Within middle third span 	At the central span: Variability and scatter are less 
Measuring devices	LVDTs for displacement 	Clip gage for CMOD (LVDTs optional) 

Fibre Reinforced Concrete (FRC) – Long Term Creep



Notches of 25 mm depth and 3 mm width were made by wet saw cutting at mid span

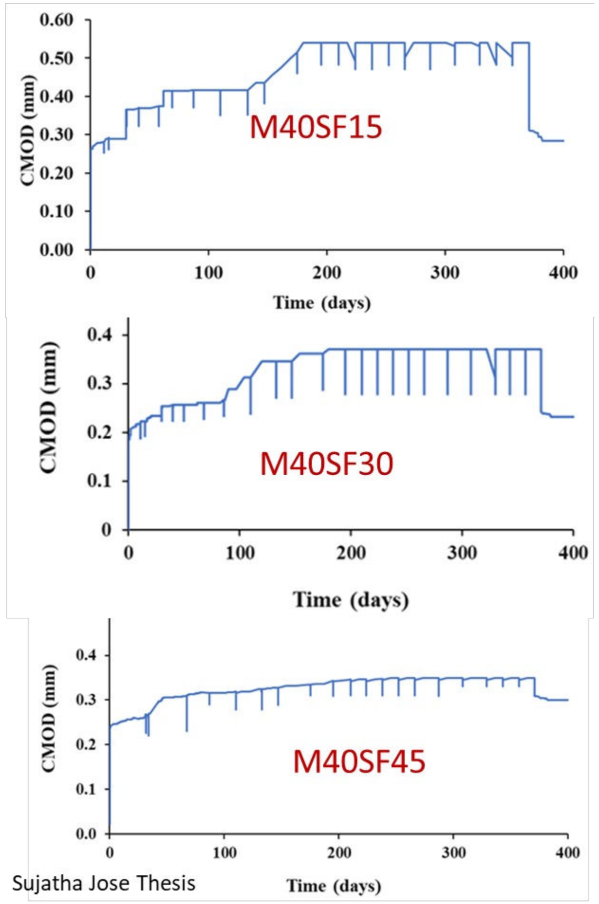
Specimens in controlled environment, Temp 25°C and 65% RH

Pre cracking done according to EN 14651 with CMOD control

Creep loading is applied after a correction for two point loading (correction factor 1.43) in the frame in controlled environment

Load cells measure load and CMOD is measured by clip gauges which is connected to DAQ which monitors continuously

viscoelastic solid like response



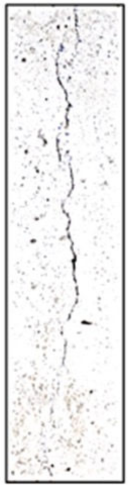
Sujatha Jose Thesis

Fibre Reinforced Concrete (FRC) – Plastic state cracking

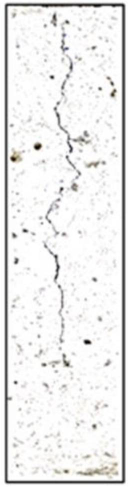
Plastic Shrinkage Mould
(ASTM C1579)

Keeping in the environmental chamber (Controlled environment with constant temperature, relative humidity, and wind velocity)

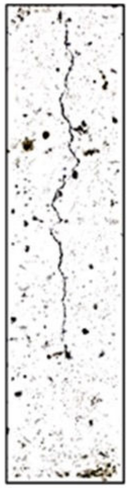
Plastic shrinkage crack in OPC mix (OC)



Plastic shrinkage crack in slag mix (GC)



Plastic shrinkage crack in slag mix with short DCF (GC-S-0.1)



Plastic shrinkage crack in slag mix with long DCF (GC-L-0.1)

Mix ID	Plastic shrinkage cracking			
	Length (mm)	Max. width (mm)	Mean width (mm)	Area (mm^2)
OC	315	0.3	0.15	50
OC-S-0.1	No cracks			
OC-S-0.4	No cracks			
OC-L-0.1	No cracks			
OC-L-0.4	No cracks			
GC	392	1.1	0.35	139
GC-S-0.1	300	0.7	0.34	103
GC-S-0.4	No cracks			
GC-L-0.1	312	0.9	0.33	106
GC-L-0.4	No cracks			

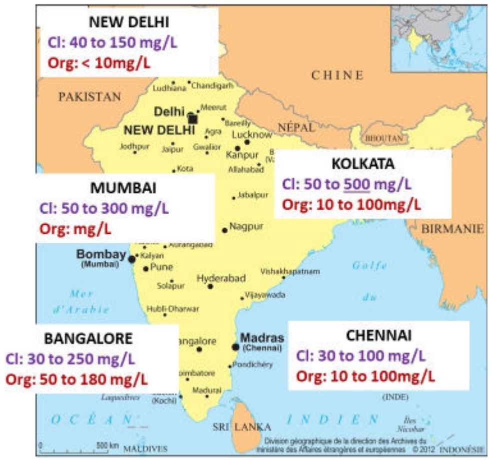
Plastic shrinkage cracking reduces with the incorporation of coir fibres in the mix.
Cracks mitigated in 0.1% dosage in OPC mix and 0.4% in slag mix irrespective of fibre lengths considered

Our Projects

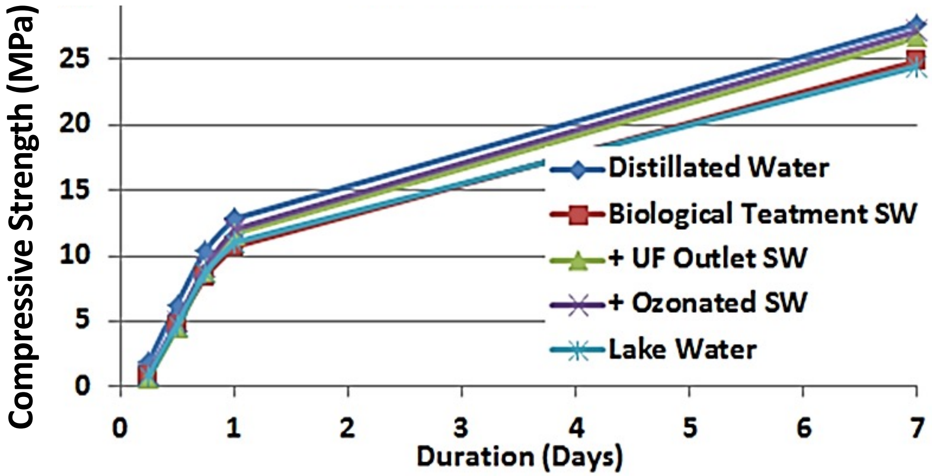
Wastewater recycling

Source Water Characterization

Chloride content of water used for concrete in different regions



Concrete with Treated Wastewater



- BIS standard
- Policy to allow non-potable water (with clear guidelines) in construction

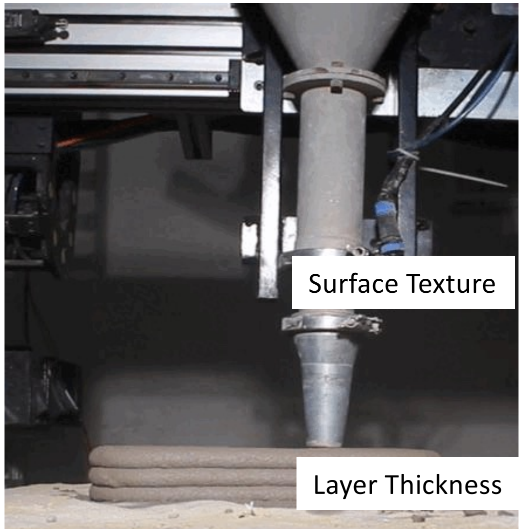
Our Projects

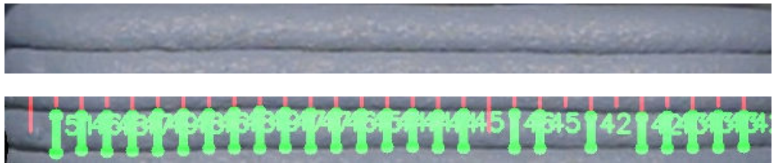
Quality and Safety

Virtual Reality Training

- VR training for workers for Quality

AI-based Risk Assessment





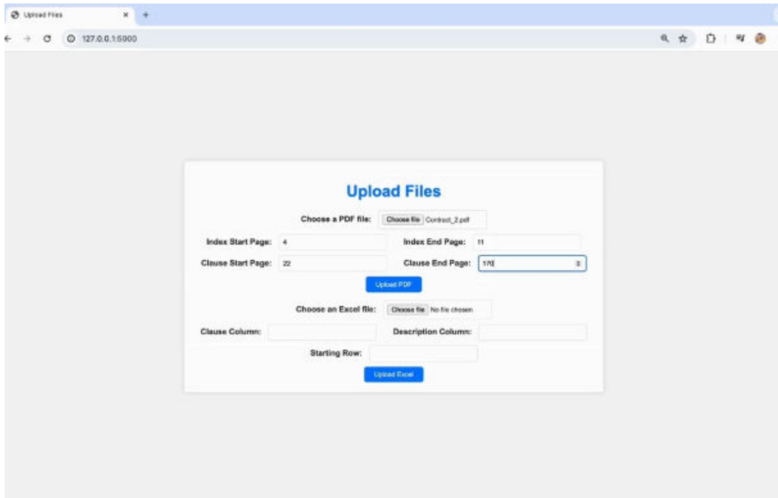
- Early Prediction of Failure

- Posture Analysis

Our Projects

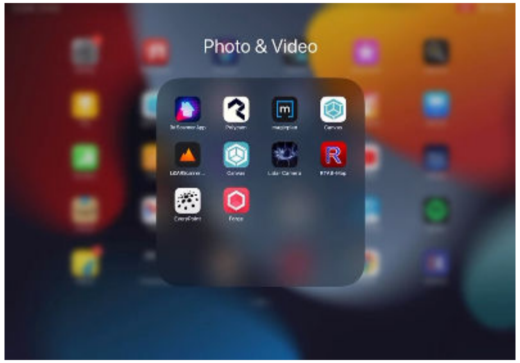
Contract Management

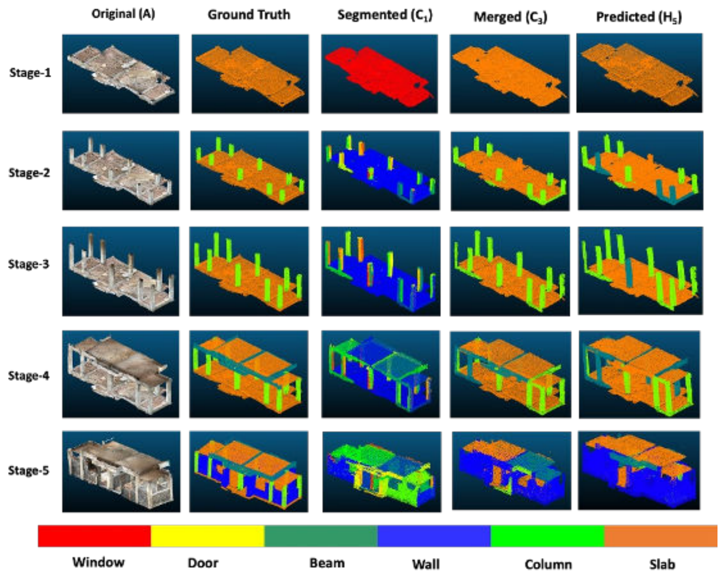
AI-based Contract Risk Assessment



- Cross-Referencing Implicit Clauses
- Contract clauses and their risk potential

AI-based Contractual Progress Monitoring





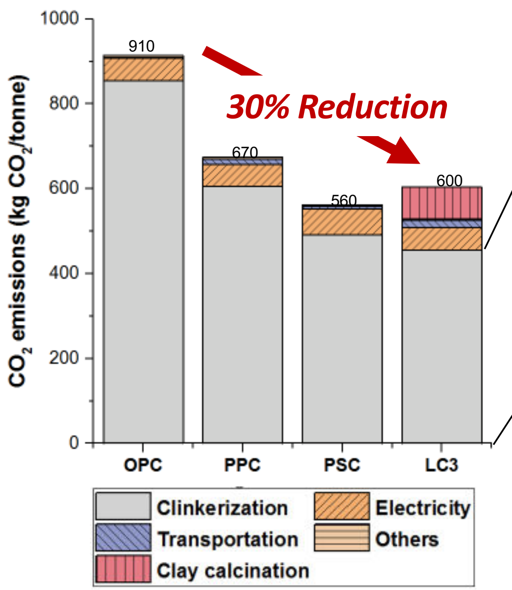
- Stage-wise progress detection

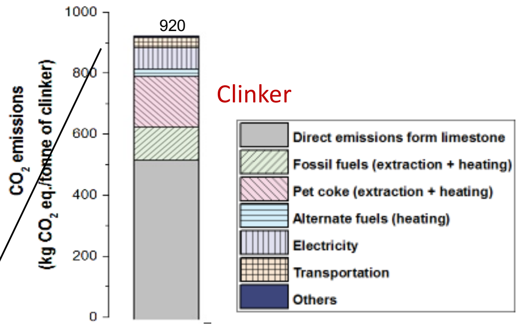
Our Projects

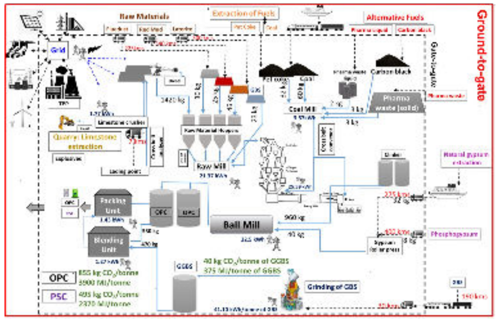
Life Cycle Assessment (LCA)

Cement

Low-carbon materials

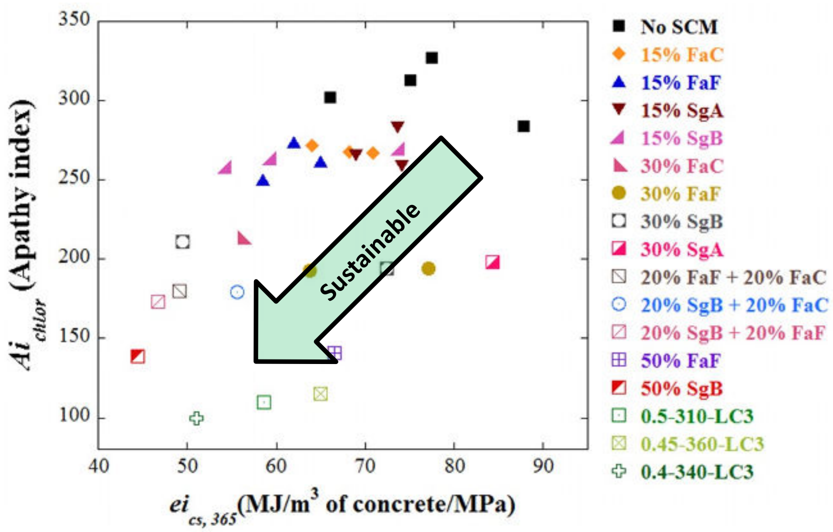






Process mapping of cement manufacturing

Concrete Mixes



Framework for sustainable concrete design

- Strength and Workability
- Durability

Technology Translation

Concrete foundation
(1000-year design life)
Ayodhya

125 years service life
Coastal Bridge, **Kollam**, **Kerala**

Durable repair (50-year life extension)
Rashtrapati Bhawan, New Delhi

Low-carbon materials

Technology Translation

Lean project delivery for
Godrej Constructions, Mumbai

Guest house construction
(3D concrete printing)
IIT Madras, Chennai

Structural assessment of 3D printed panels

Our collaborators – Industry

JSW Cement
World's #1 eco-friendly cement company

Dalmia DSP CEMENT

RAMCO CEMENT

HITECH

SAINT-GOBAIN

UltraTech CEMENT
The Engineer's Choice

MBI

RMX
MIX WITH PRIDE

TATA STEEL

L&T Construction

tvasta

CHIR-AYU
CHIR-AYU CONTROLS PVT. LTD.

VECTOR
VECTOR CORROSION TECHNOLOGIES

BUILDING TRUST
Sika

SCHWING Stetter

Since 1981
Krishna Conchem Products Pvt. Ltd.
Speciality construction chemicals

ALCCOFINE
MICRO MATERIALS

FOSROC

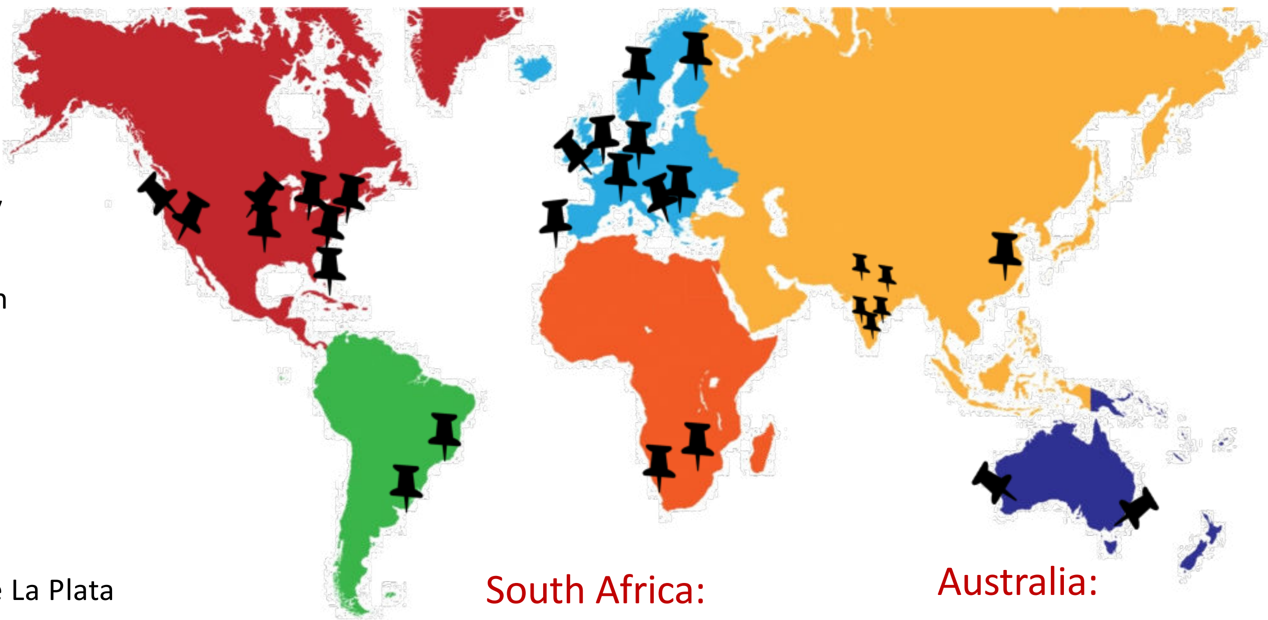
FLSmidth

UHPC INDIA

Our collaborators – Academic

North America:

- Massachusetts Institute of Technology
- Oregon State University
- Texas State University
- Clemson University
- Michigan State University
- Stanford University
- Univ. of Texas at Arlington
- Univ. of Toronto
- Virginia Tech Univ.
- Arizona State Univ.



South America:

- Universidad Nacional de La Plata (Argentina)
- Univ. Federal de Rio de Janeiro (Brazil)

South Africa:

- Univ. of Cape Town
- Univ. of Witwatersrand

Australia:

- University of New South Wales
- Curtin University

UK & Europe:

- University of Leeds
- Norwegian University of Science and Technology
- Brunel University
- Karlsruhe Institute of Technology, Germany
- Politechnico di Milano, Italy

Asia:

- Hong Kong Polytechnic University (China)
- National University of Singapore
- IIT Bombay
- IIT Roorkee
- IIT Kanpur
- IIT Tirupati
- NIT Calicut
- MACE, Kerala

Thank you!

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- https://tlc2.iitm.ac.in

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