Eco-friendly bricks: A new material in civil Engineering
DST File No.: DST/TSG/STS/2011/123-G

Principle investigator: Dr. Janki N. Thakker
Department of Biotechnology
P.D. Patel Institute of Applied Sciences
Charotar University of Science and Technology (CHARUSAT)
Changa-388421
Anand, Gujarat

SUMMARY OF THE ACHIEVEMENTS DURING PROJECT

- **Our initial research consisted with collection of soils from various locations of Gujarat and characterizing them to prepare bricks with optimum compressive strength**
  - o Soils were collected from different part of Gujarat i.e. Dry pond at Kakroli, Charusat Campus, Little Runn of Kuchha, Bhimnath Bhavnagar, Narmada River Bed Bharuch, Yellow soil Bharuch (Used by local brick makers) etc.
  - o Soils were classified using Sieve test and Atterberg Limits (%) as per Unified classification system as well as **AASHOT M145** and **ASTM D3282** where the results suggested that soils were belonging to groups **SM, CH, CL, and ML (Unified Classification system) or A4 to A7 (ASTM D3282). Soils were also characterized based on XRD.**
  - o A4 and A7 soils are mixed in different proportion to observe change in Atterberg Limit.
  - o Adobe bricks form all the different soil types and there mixtures were prepared and tested for its compressive strength. Bricks with high compressive strength can be prepared from the **soil with sand content 53 ± 3%, silt + clay content 48 ± 5% and Plastic Limit (PL) in the range of 2-6.**
  - o During this study we optimized the soil grain size ratio for the adobe bricks which can provide maximum compressive strength. **On this aspect we published an article "Soil property apotheosis to corral the finest compressive strength of unbaked adobe bricks. Construction and Building Materials, 48: 948-953."**
- **Further, effect of charuzyme was tested on these optimized soil**
  - o Establishment of relationship between **enzyme dosage and spreading agent** using Response surface methodology.
  - o Where, over all 12 to 27 % higher compressive strength achieved in different soil types on 1 ml/ kg dosage of charuzyme.
- **After optimizing dosage of "Charuzyme", Its stability was studied to determine its shelf life**
  - o Characterization of protein, carbohydrate and EPS from the final product was done on storing charuzyme at various environmental conditions.
  - o Protein Profiling was also checked by using SDS-PAGE analysis from cell pellet of isolates as well as supernatant of final product incubated at different temperature with time scale.
  - o These analysis suggested that there was maximum destruction of protein and carbohydrate content from charuzyme when it was stored at temperature 45ºC or above.
  - o Further protein and carbohydrate content in the charuzyme remained intact when stored at cooler temperatures 8°C or below.
- **Later we implemented the process of bacterial bio-calcification.**
  - o As the process of Bacterial Bio-calcification requires the action of urease, where we determined urease enzyme activity from charuzyme.
  - o Further, we identified the presence of genes coding urease. After a detailed literature analysis we designed specific primers of 7 essential genes for urease activity and performed gene amplification to determine their presence. Till date such urease gene identification using gene specific primers is not yet reported from the bacterial strain we used for the research.
  - o Here we published an article "**Elucidating multifaceted urease producing marine *Pseudomonas aeruginosa* BG as a cogent PGPR and bio-control agent**"
  - o Successful biocalcification was determined using XRD analysis that showed presence of $CaCO_3$.
  - o Soil treated with Charuzyme were analyzed by Scanning Electron Microscopy (SEM) for the conformation of bio-calcification occurring in the "Charuzyme" treated soil, where we found the precipitated $CaCO_3$ as calcite anamorph.
- **Model houses constructed using bricks stabilized by "Charuzyme".**
  - o Semi-automated brick molding machine is procured, installed and bulk production of bricks was done
  - o 2 Model houses were prepared.

o Model houses showed thermal insulation ranging from 2°C to 5°C during summer in the month of June from date 1st to 10th 2014.

Objectives as stated in the project proposal/Objectives met

Objectives as per the approved Project	Fully/Achieved/Partially Achieved *(indicated shortfall)*	Reason for partial Achievement
To develop an eco-friendly process of bricks manufacturing using enzyme/bacteria based technology	Fully achieved	
To develop "charuzyme" for brick preparation	Fully achieved	
Develop a process which is not a function of soil	Fully achieved	
To prepare specifications of bricks according to Bureau of Indian Standards (BIS)	Fully achieved	

Milestones fixed as per the agreement/ Milestones achieved

Milestones fixed as per the approved Project	Fully/Partially/ Not Achieved	Reason for partial Non Achievement
Process and specification for preparation of eco-friendly bricks	Fully achieved	
Eco-friendly bricks which could replace conventional burnt clay bricks for construction purpose	Fully achieved	
Saving of biomass, in form of coal and trees and energy	Fully achieved	
Environmental control as no burning process involved	Fully achieved	
Technology transfer to brick industry	Not achieved	Contacting the industry is in process
Earning carbon credit	Fully achieved	

List of publications with details

Title of the Paper	Journal, Issue, etc.	Authors
"Soil property apotheosis to corral the finest compressive strength of unbaked adobe bricks."	*Construction and Building Materials* 48 (2013): 948-953. Impact Factor: 2.293	Dhandhukia, Pinakin, Dweipayan Goswami, ParthThakor, and **Janki N. Thakker**
"Elucidating multifaceted urease producing marine *Pseudomonas aeruginosa* BG as a cogent PGPR and bio-control agent"	*Plant growth regulation* (2014) DOI:10.1007/s10725-014 9949-1 Impact Factor: 1.6	Dweipayan Goswami, Krupa Patel, SwapnsinhParmar, HemendrasinhVaghela, NamrataMuley, PinakinDhandhukia and **Janki N. Thakker**