

Topic (Corrosion Control):

Extending the service life of corroding concrete structures by 50 years by using galvanic cathodic protection

Faculty advisor (name, email, website):

Radhakrishna G Pillai, pillai@civil.iitm.ac.in , <https://civil.iitm.ac.in/faculty/pillai/>

Description or abstract (less than 100 words):

Corrosion of steel in concrete structures is analogous to 'cancer' in humans and costs about 5 % of GDP. Galvanic cathodic protection can stop corrosion of steel, extend the service life, and reduce the carbon footprint and life cycle cost of concrete structures. This study will aim to make galvanic anodes with a zinc piece encapsulated in a special mortar with interconnected pores, activators, and humectants. I am looking for students who can perform analytical and experimental studies on the cement chemistry of mortar, electrochemistry/corrosion of zinc in mortar, time-variant clogging and evolution of pore structure of mortar, simultaneous transport of zinc corrosion products and various ions through porous mortar.

Keywords:

Concrete, steel, corrosion, repair, cathodic protection, service life, durability, low-carbon

Pre-requisites, if any:

None

Any other information:

This project will lead to at least one MS thesis and one PhD thesis. I am looking for persons with good background in either civil engineering, material science, or applied mechanics. More importantly, I am looking for a person with a passion for research towards developing technologies for preserving and conserving the huge inventory of ageing/corroding concrete infrastructure. For more details, please visit my website or email me seeking an appointment for an online meeting.

Topic (CSA Cement):

Durability Studies on Laboratory-Synthesized Calcium Sulfoaluminate Belite Cement

Faculty advisor (name, email, website):

Piyush Chaunsali; pchaunsal@civil.iitm.ac.in ; <https://civil.iitm.ac.in/faculty/pchaunsali/>

Description or Abstract (less than 100 words):

Calcium sulfoaluminate belite (CSAB) cements are low CO₂ binders having useful properties such as rapid hardening and shrinkage-compensation. This project will involve the synthesis (in furnace and rotary kiln) of CSAB cements (having varying compositions) using locally available raw materials, and monitoring of mechanical and durability properties of mortar/concrete made of laboratory synthesized cement. The main objectives of the proposed research are to 1) establish composition-performance relationship of laboratory synthesized CSAB cement, 2) investigate long-term durability of CSAB cement concrete, and 3) estimate the service-life of CSAB cement system.

Keywords:

Calcium Sulfoaluminate Cement; Low CO₂ Cement; Durability

Pre-requisites, if any:

UG/PG Course on Concrete Technology

Any other information:

Topic (Construction Safety):

Developing Virtual Reality based Construction Safety Training Programs for India

Faculty advisor (name, email, website):

Dr. Nikhil Bugalia. nbugalia@civil.iitm.ac.in (<https://civil.iitm.ac.in/faculty/nbugalia/>)

Description or Abstract (less than 100 words):

The construction sector in India, the second largest employment generator, faces significant challenges due to skill gaps, with 81% of the workforce considered poorly skilled. This leads to poor quality execution, safety issues, project delays, and cost overruns. The Indian government has recognized the potential of digital technologies like Virtual Reality (VR) in enhancing construction-related training for safety and quality. However, significant work is needed to scale the impact of VR technology, particularly in the Indian context. Key aspects include creating site-specific/trade-specific training programs, developing VR training scenarios that represent Indian conditions, and offering affordable training programs for small and medium construction companies. A hybrid training strategy, where VR complements existing industry training programs, needs to be developed and rigorously evaluated.

Keywords:

construction, safety, VR, training, games

Pre-requisites, if any:

willingness to learn

Any other information:

Topic (Construction Contracts):

Opportunistic Behaviour and Construction Disputes: Measurement and Mitigation

Faculty advisor (name, email, website):

Murali Jagannathan, muralij@civil.iitm.ac.in, <https://civil.iitm.ac.in/faculty/muralij/>

Description or Abstract (less than 100 words):

When a contractual claim submitted by a party to a construction contract is meritorious, there should not be an issue in timely claim settlement. However, when submitted claims are frivolous, non-contractual, and (or) inflated, delayed settlement of claims and disputes from such opportunistic behaviour are inevitable. With dispute resolution already a time-consuming activity, opportunistic behaviour further increases the cost of dispute resolution, putting projects at stake. Therefore, the research question is, "What is the extent of opportunistic behaviour in contractual claims submission, and can it be measured so that mitigation mechanisms can be put in place to prevent delayed dispute resolution and unjust enrichment?"

Keywords:

Contract, Opportunistic Behaviour, Construction Industry, Claims, Disputes

Pre-requisites, if any:

Knowledge of statistical analysis tools and techniques

Any other information:

The research will involve a mixed methods approach wherein qualitative and quantitative techniques will be employed to answer the research question.

Topic (Sustainable Construction):

A Framework for Implementing Lean and Sustainable Construction Practices in Projects

Faculty advisor (name, email, website):

Murali Jagannathan, muralij@civil.iitm.ac.in, <https://civil.iitm.ac.in/faculty/muralij/>

Description or Abstract (less than 100 words):

Research on lean and sustainable construction is fast picking up, and researchers have shown results that can not only support the journey toward a sustainable future but also help increase construction productivity in an industry prone to time and cost overruns. Notwithstanding the developments, the construction practices at the site have not changed, and problems continue. The research question, therefore, is, 'What does it take to implement sustainable construction practices at project sites practically?' The researcher will be expected to explore various facets affecting implementing lean and sustainable construction practices and develop a validated framework to support implementation.

Keywords:

Lean, Sustainability, Construction Industry, productivity

Pre-requisites, if any:

Knowledge of statistical analysis tools and techniques

Any other information:

The research will involve a mixed methods approach wherein qualitative and quantitative techniques will be employed to develop the framework.

Topic (Institutional change):

Institutional Change for Sustainability in Construction

Faculty advisor (name, email, website):

Ashwin Mahalingam. Mash@civil.iitm.ac.in, <https://civil.iitm.ac.in/faculty/mash/>

Description or Abstract (less than 100 words):

Companies tend to exhibit 'institutionalized' behaviours where they tend to use the same practices, organizational structures and contracts, over and over again. If the construction industry is to become more sustainable, firms need to change the way they work. This research will attempt to study ways in which engineering firms achieve 'institutional change'. In addition firms today have a sustainability strategy. This project will also analyze these sustainability strategies to derive a blueprint for construction firms to transform their existing practices into sustainable ones

Keywords:

Sustainability, Institutions, Construction, Business Models

Pre-requisites, if any:

None

Any other information:

Independent thinking is required.

Topic (Benchmarking):

Coordination and benchmarking for Sustainability in Construction

Faculty advisor (name, email, website):

Ashwin Mahalingam. Mash@civil.iitm.ac.in, <https://civil.iitm.ac.in/faculty/mash/>

Description or Abstract (less than 100 words):

In order to truly build low carbon buildings or infrastructure, architects, civil engineers, mechanical and electrical engineers, contract managers and others need to join hands and align their visions. This project will attempt to develop a framework for such coordination. The project will also attempt to design a measurement framework that will enable the measurement of the carbon footprint of a building at the design stage, and use this to guide the project team as to what strategies they can use in design, construction and operation, to minimize the carbon impact.

Keywords: Sustainability, Low Carbon, Construction, coordination, Benchmarks and Metrics

Pre-requisites, if any:

None

Any other information:

Independent thinking is required.

Topic (Cement Hydration):

Nucleation and growth of cement hydrates using molecular dynamics and density functional theory calculations

Faculty advisor (name, email, website):

Aslam Kunhi Mohamed, akm@iitm.ac.in, akm@civil.iitm.ac.in, <https://civil.iitm.ac.in/faculty/aslam/>

Description or abstract (less than 100 words):

Using molecular dynamics simulation and density functional theory calculations we have a better understanding of the main hydration product of cement, the calcium silicate hydrates (C-S-H). We know that the atomic level features of C-S-H are similar to that of tobermorite minerals consisting of calcium silicate sheet structure which forms the repetitive layers separated by an interlayer space containing water and calcium or other ions. With the brick model, the defective nature of C-S-H is modelled by precisely defining the nature and location of several defects in a tobermorite-like structure, thus enabling us to make full three-dimensional bulk and surface structure of C-S-H. Now we would like to understand the formation pathway of C-S-H and what is the origin of its nano size. Relevant papers are given below.

Keywords:

Molecular dynamics, Density functional theory, molecular simulations, cement hydrates, cement chemistry, advanced sampling methods

Pre-requisites, if any:

Students with the following basic degrees can apply

- B.Tech. in Materials Science, Civil Engineering, Mechanical engineering, or similar
- Bachelors or masters in chemistry, physics

Any other information:

No coding skills are required, however some interest towards learning Python is preferred. LAMMPS, Quantum Espresso or similar packages will be used.

Relevant papers on C-S-H¹⁻⁴:

1. Kunhi Mohamed, A., Parker, S. C., Bowen, P. & Galmarini, S. An atomistic building block description of C-S-H - Towards a realistic C-S-H model. *Cem Concr Res* **107**, 221–235 (2018).
2. Kumar, A. *et al.* The Atomic-Level Structure of Cementitious Calcium Silicate Hydrate. *The Journal of Physical Chemistry C* **121**, 17188–17196 (2017).
3. Kunhi Mohamed, A. *et al.* The Atomic-Level Structure of Cementitious Calcium Aluminate Silicate Hydrate. *J Am Chem Soc* **142**, 11060–11071 (2020).
4. Morales-Melgares, A. *et al.* Atomic-Level Structure of Zinc-Modified Cementitious Calcium Silicate Hydrate. *J Am Chem Soc* **144**, 22915–22924 (2022).

Topic for PhD:

Investigating splitting and spalling fracture in steel fibre-reinforced concrete segments

Faculty advisor (name, email, website):

Keerthana Kirupakaran, keerthanak@civil.iitm.ac.in, <https://civil.iitm.ac.in/faculty/keerthanak/>

Description or Abstract (less than 100 words):

The use of tunnel boring machine (TBM) technology for tunnel lining construction is consistently rising in India. During the construction stage, concrete precast segments undergo splitting and spalling fracture due to highly concentrated compressive loads from the TBM jacks which in turn affect their durability and service life. The use of steel fibre-reinforced concrete (SFRC) precast segments is advantageous in such scenarios due to its higher toughness and better crack width control. The objective of this research is to investigate the fracture behavior of SFRC segments under highly concentrated compressive loads through experimental, analytical, and numerical methods.

Keywords:

Steel fibre reinforced concrete, splitting, spalling, fracture, toughness, crack width, tunnel segment

Pre-requisites, if any:

None

Any other information:

I am looking for passionate students with a good background in structural engineering or applied mechanics.

Topic for PhD:

Study of stress-parallel fracture in fibre reinforced concrete

Faculty advisors (name, email, website):

Ravindra Gettu, gettu@civil.iitm.ac.in; and Keerthana Kirupakaran, keerthanak@civil.iitm.ac.in
(<https://civil.iitm.ac.in/faculty/keerthanak/>)

Description or Abstract (less than 100 words):

Fracture energy of concrete is generally considered to be a material parameter related to tensile stresses. However, recently Bazant has suggested that crack-parallel stresses can affect the response. This is of consequence in splitting and spalling of concrete under compressive stresses, such as in segmental tunnel lining, bearing stresses and diagonal shear in beams. Work could include testing and analysis of fibre concrete blocks using servohydraulic systems and digital image correlation, analysis with the finite element method, and development of equations that could be used in practice, e.g., for the design for actuator forces on tunnel lining during boring.

Keywords:

Fracture of concrete, Fibre reinforced concrete, Splitting, Spalling, Cracking

Pre-requisites, if any:

Basic knowledge of reinforced concrete design, and finite element analysis.

Any other information:

Student should be interested in laboratory work.

Topic for PhD:

Developing a framework for the sustainability assessment of concrete structures.

Faculty advisor (name, email, website):

Radhakrishna G. Pillai, pillai@civil.iitm.ac.in and Ravindra Gettu, gettu@civil.iitm.ac.in

Description or Abstract (less than 100 words):

Sustainability assessment of reinforced concrete has mostly centred on the use of waste materials and low-carbon cement, and reduction of clinker content in the concrete. However, sustainability should be assessed at the structural level incorporating durability and service life extension, which has been considered but often only in the material or sectional level. It is intended to develop a methodology to assess the entire structure considering durability and reduction in material usage, without affecting the structural requirements. Aspects that dominate local scenarios, such as the lack of water, may also have to be addressed.

Keywords:

Sustainability, Carbon footprint, Durability, Reinforced concrete

Pre-requisites, if any:

Good knowledge of reinforced concrete design

Any other information:

Students who have worked in the field would be preferred.