Indian Institute of Technology Madras

Technologies for Low-Carbon and Lean Construction

NEWSLETTER

October 2023

The IRIS webinar on TLC2 was conducted on 31st October by IIT Madras to highlight the ongoing research by the Centre of Excellence on Technologies on Low-Carbon and Lean Construction (TLC2).

Prof. Miroslaw Skibniewski (Mirek), Professor of Construction Engineering and Project Management in the Department of Civil and Environmental Engineering at the University of Maryland, moderated the webinar.

Profs. Piyush Chaunsali and Aslam Kunhi Mohamed with current PhD students from our centre and alumni at the 16th ICCC 2023 in Bangkok

The 17th International Congress on the Chemistry of Cement (ICCC) will be organized by the National Council for Cement and Building Materials (NCCBM) along with IIT Delhi and IIT Madras in New Delhi in 2027.

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EVENT

IRIS Webinar 2.0 on TLC2 organized by IIT Madras on 31st October

NEWS IN BRIEF

- IS Code on Solid Round Glass Fibre Reinforced Polymer (GFRP) Bars for concrete Reinforcement — Specification (IS 18256:2023) has been published

Prof. Radhakrishna Pillai, co-PI in TLC2 project, was the convener of the working group for the formulation of the standard

- The 16th International Congress on the Chemistry of Cement (ICCC) 2023 held in Bangkok

Our PhD students Tom Damion, Nilakanmani Manimaran, Bipina Thaivalappil presented their research work on various TLC2 themes

UPCOMING EVENT

The 3rd International Workshop on Technologies for Low-Carbon and Lean Construction (TLC2) – 2024

28th – 31st January 2024

IC&SR Auditorium, IIT MADRAS, Chennai, India

EVENT IRIS WEBINAR 2.0 ON TLC2

The webinar was conducted by Prof. Nikhil Bugalia. Prof. Radhakrishna Pillai, Prof. Koshy Varghese and Prof. Manu Santhanam, first presented the updates and opportunities on sustainability and circular economy in the built environment on behalf of the centre. Prof. Pillai talked about the ongoing research in the centre on recyling of agricultural, industrial and C&D waste to produce quality concrete. He explained the development of simplified engineering tools (nomograms) to perform durability-design of concrete structures using various low-carbon materials. He also emphasized the need of knowledge transfer between the research lab and industry by showing an example of a recent project on a coastal highway bridge in Kerala where the researchers showed experimentally how the use of Portland Slag Cement (PSC) can quadruple the corrosion-free service life.

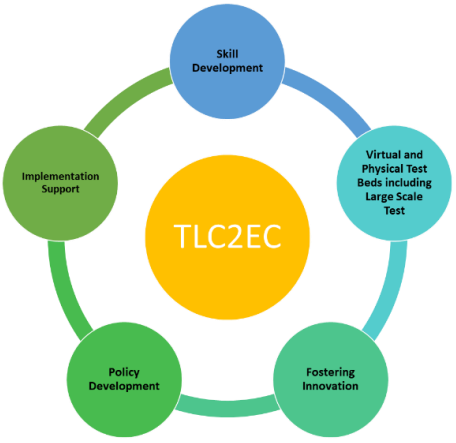
Valiazheekleal bridge at Kollam, Kerala Courtesy: Kerala Highway Research Institute (KHRI)

Prof. Koshy Varghese explained the benefits of Lean Maturity Models for the improvement of project delivery. Among the various existing Lean Maturity Models, he explained the ILCE Lean maturity model with examples from two recent pilot projects on cement plant and metro site.

Concept of Lean adoption

The presentations were followed by the Q&A session moderated by Prof. Miroslaw Skibniewski. Various pertinent issues related to concrete, alternative cementitious material, construction management and sustainabilty were discussed and faculties from the other groups in the Civil Engineering department and all TLC2 professors and students actively participated in the discussion.

Towards the end of the webinar, Prof. Manu Santhanam talked about establishing the TLC2 Experience Centre (TLC2EC), an unique initiative taken by the centre with multifaceted objectives related to TLC2 projects in Chennai. The primary objectives of the TLC2EC will be implementing state-of-the-art research in pilot scale applications, facilitating the evaluation of alternative materials and construction strategies through 'physical' and 'virtual' test beds and skill development to practice TLC2 ideas. It has been planned that there will be designated space in the workshop in TLC2EC for 3D concrete printing facility, large scale testing facilities, industrial and agricultural waste processing unit and solar-enabled thermal treatment for recycled concrete aggregate. A 50 seater classroom with multiple sophisticated labs like BIM / LCA lab, VR experience lab, Policy and contract management lab have also been planned to be built in TLC2EC.



Objectives of TLC2EC


Rice-husk ash


Bagasse ash


Fly ash


Slag


Low-grade limestone

Various sources of agricultural and industrial waste

Excerpt from the Q&A session

Prof. Skibniewski: How can we address the issue of efficient recycling of construction and demolition waste within the framework of construction management?

Prof. Koshy Varghese: In our centre, we try to connect Fundamental materials science, Applied concrete technology, Accelerated construction and Policy towards a sustainable construction ecosystem. Our PhD students are working on using AI and robotics for the Segregation of C&D waste. Demolition debris is being


Use of Robotics in waste segregation

converted into aggregates to be used in 3D printing concrete.

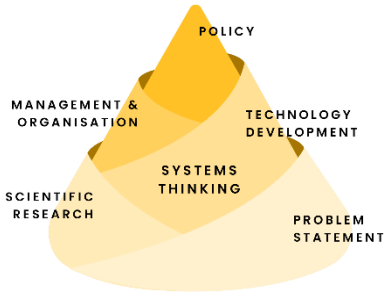
Prof. Nikhil Bugalia: We also have to be cognizant of the fact that in India, there's a lot of informal sector exists and whenever demolition happens, the informal sector kicks in and they recover the highly precious materials. We have to develop technology specific to our needs. There's also a trade-off between demolishing fast using mechanized processes and manually with slow pace. With mechanized process, the recovery goes down. But if we use manual process, the recovery of material can become efficient. But then there are a lot of safety related issues that comes to this workforce. So, these are very interesting questions and that's where we are always thinking about a "systems thinking" approach.

Prof. Skibniewski: Can you throw some light on the use of Recycled Fine Aggregate (RFA) in concrete because more research is there on RCA but less on RFA?

Prof. Ravindra Gettu: Mostly people focus on coarse aggregates and we know that we generate a lot of fine aggregates as well during the crushing process and the beneficiation. The proper processing in terms of crushing or some beneficiation, probably with some thermal treatment can yield fine material that can replace sand. One has to be careful because fine material means that you would need to add more water or more cement. So, what we did is we fractioned out everything that was finer than 300 microns and then we use them in concrete such as self-compacting concrete or 3D printed concrete which need a lot of fines. We are also looking at the possibility of using recycled fine aggregates in an activated way as an admixture or maybe as material for making cement from.

Prof. Skibniewski: For sustainability of construction projects, how do we connect the design professionals with the construction professionals to make things happen?

Prof. Ashwin Mahalingam: There are several aspects to ponder over to



Our approach towards Translational and Transformational Research

answer this. I think when we look at design, say architectural design for instance, passive strategies should be discussed in terms of how we could orient buildings so that they have lesser energy and things like that. You also have structural design where I think we've got to make efforts to see how sort of thin or light we can make our elements so that you consume as few resources as possible. So, there's an engineering component, as well as material component there. When you look at design, you're also looking at designing, heating, ventilation, air conditioning systems. So, I think each of these aspects need to be optimized, not just individually, but collectively as well. We need to start setting benchmarks on what the embodied carbon of various kinds of buildings is, I mean, a six-story university building versus a three-story residential building, and so on.

Prof. Ravindra Gettu: We should talk about sustainability holistically considering the 17 SDGs and not just about embodied carbon. Everyone in the concrete field knows that there are infinite concrete mixes that could satisfy the requirement of a construction project based on workability and compressive strength. So, we made a chart or a framework for any site which would have indices based on four components. One would be the embodied energy which also reflects the cost and the use of raw materials, the strength of the concrete. The other component would be the durability. We insist that durability is key to designing something sustainable with concrete construction. We cannot afford to have something that's not durable enough and the 4th aspect would be the environmental bringing in the carbon footprint.

We have to start looking at it from the design point of view. We have found that in the contract stage itself, you have to know where your materials came from. That means when you put a specification out for bidding, the contractor has to be ready to tell you where all the materials came from so that you can calculate the carbon footprint. We are thinking of a material passport where people can put up the values that they obtain not only for the mechanical properties but durability and so on, so people can look up and then use this for an educated choice of sustainable materials and technologies in Construction.

Prof. Skibniewski: My next question is about the development of the proper decision support tools to guide us in the process of arriving at a most sustainable project possible. How can we harness the power of the most advanced information technologies to make our construction projects more sustainable?

Prof. Koshy Varghese: There's a lot of decision support tools out there, but all of them is driven by data. So, the organizational effort or the policies is required to make sure that the data we use to calibrate these tools are relevant. In the Indian context, there is a of lot of pipelines we have to develop to start gathering this data and we see that these pipelines are starting to fall in place and as policy in the government and policy among clients. With the computing power and the technology, the simulations we can generate will probably be able to give us a better way of coming to the right decision.

Prof. Murali Jagannathan: One another direct application of AI based tools or technique that we can apply is to use large language models or LLMS in trying to access the extent to which the policy is actually helping us in implementing sustainable practices or lean

construction practices. Like if you look at the current literature, there are a lot of articles that classify whether a given text or given part of a contract, is helping and promoting amicable resolutions or is it causing disputes? In similar way, we can think of whether a particular clause can support collaborative construction practices which is again supporting lean construction, or whether the clauses are drafted in a manner that really do not support implementing these practices in consultation project.

Prof. Skibniewski: How do we see the path to the creation of national and international standards that would advance the cause of sustainable construction?

Prof. Koshy Varghese: I think we'll take that question in two parts. One is the engineering and material standards and the other one is management standards.

Prof. Radhakrishna Pillai: We are working towards modifying the standards. The challenge is to attract more people towards the development of the standards. There is a lot of hesitation even to participate in the standard committee meetings. I would say there is a significant effort from the Bureau of Indian Standards to accelerate the inclusion of new technologies and research findings into the standards. We are also working on various standards on reinforced concrete design, precast concrete and also on the material side and different steel reinforcement. I feel we need more people especially from the industry to be the part of Standard committees.

Prof. Koshy Varghese: The science behind a management standard is not as well formed as the science behind an engineering standard. Once material standard gets published, there is a reasonable adherence and the results are followed. Now the question is how do you actually make the engineering standards usable and user- friendly with management standards? Most of the time standard exists but nothing gets implemented. The culture of management standards is only coming in to India now. Slowly it has to take root and as there is more client demand and more corporate demand for this, I think we are going to see more adherence to it.

Prof. Ashwin Mahalingam: I think we have to differentiate between standards and practices. Standards are sort of enshrined by some kind of a body that gives it some legal standing. But we also have to keep sight of the fact that there are lots of construction practices that can be influenced by the research that we are currently doing which can make the construction far more sustainable.

Prof. Manu Santhanam: I agree that not all the research that we do will end up in making standards which are relevant to the construction practices. We can, of course provide a range of options for people to choose from in terms of the solutions for any given issue that they can face during construction with concrete.

Prof. Skibniewski: How can we best impart the results of research and development into construction practice that we will be able to certify an entire project, not just a building or not just the final product of the project but the project itself? Is there any effort in India or anywhere else that you know aimed at that effort at project certification towards sustainability?

Prof. Koshy Varghese: We have the energy compliance certificate issued by the Indian Green Building Council (IGBC or LEED India) and the Green Rating for Integrated Habitat Assessment (GRIHA). But all of those ratings are towards a particular building and not on the construction or the design processes. Each group tends to use its own approach for that.

Prof. Ashwin Mahalingam: I think the standards, the ratings, the certifications that we have are more product certifications. We don't have a combined certification for product and process. I'm not aware of it's existence anywhere in the world holistically, and therefore it's probably something that academics like us should focus on developing as we go forward.

"Just worrying about embodied and operational CO_2 gas emissions from the construction industry is an oversimplification of the problem. We should also consider naturally occurring phenomena such as water vapor emissions into the atmosphere. Water vapor is actually a greenhouse gas that has arguably play even a larger role in climate change than CO_2. Other greenhouse gas like Nitrous Oxide emissions from agriculture, mining and waste management is too a big threat for our civilization. We should take action to address the issue of climate change considering all greenhouse gas sources"- Prof. Miroslaw Skibniewski

Architect's imagination of the TLC2 Experience Centre (TLC2EC)

The full webinar is available in YouTube: Click here to watch

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