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CSIR–SERC
ENGINEERING SUSTAINABLE STRUCTURES

e-STRUCT

e-Newsletter of CSIR-Structural Engineering Research Centre

In this issue

From the Director's Desk

I am very happy to present Vol. 5, No. 2, 2021 issue of e-STRUCT. This edition of newsletter highlights our R&D pursuits, achievements, new facilities, skill development initiatives and other significant endeavors during April - June 2021.

CSIR-Structural Engineering Research Centre (CSIR-SERC), Chennai has developed ambient temperature cured concrete blocks using geopolymer technology. These blocks are of different types - building blocks, paver blocks, hollow blocks and lightweight blocks. This technology offers a speedy, cost-effective and environment-friendly alternative to conventional Portland cement based blocks. The production of GPC blocks leads to a scientific, systematic and eco-friendly utilization of industrial wastes. The work done by CSIR-SERC is detailed in Research highlights section of this edition of eNewsletter.

During this quarter, a license agreement was signed between CSIR-SERC and M/s. L&T Construction, Mumbai, for the technology Textile Reinforced Concrete Boundary Wall Panels and Precast Drains and an umbrella agreement was signed with M/s. Lab To Market Innovations Pvt. Ltd., Bengaluru for Development and Deployment of Structural Health Monitoring Systems to meet the Requirements of Monitoring and Managing the Assets and Operations of Railways.

During the period, CSIR-SERC organized one online advanced courses as a part of CSIR Integrated Skill Initiative for the benefit of the student and research community. The campus celebrated 130th birth anniversary of Babasaheb Dr. B.R. Ambedkar, National Technology Day 2021, 56th Foundation Day of CSIR-SERC and International Yoga Day 2021 with great enthusiasm. This has indeed been a challenging but eventful quarter and as always we look forward to more exciting opportunities in future.

1.11.2021 Dr. (Mrs.) N. Anandavalli

CSIR-SERC Campus

Research highlights

Geopolymer- An eco-friendly material for construction

Concrete - the second biggest commodity in the world, after water, is both a very old and a new material with constant new developments that have had and will continue to have a significant importance for social development in the world. The volume of concrete cast annually is more than twice that of all the other building materials. More than a ton of concrete is produced every year for each human on the planet earth. Even though the main greenhouse gas emissions from production of concrete come from the production of cement, Portland cement (P-C) is still remaining as the main binder in concrete construction. The cement production is highly energy intensive. A tonne of P-C production involves emission of about 0.85 tonne of CO_2 which is a greenhouse gas causing global warming. The contribution of P-C production worldwide to the greenhouse gas emission is estimated to be about about 7% of the total greenhouse gas emissions to the earth's atmosphere. Alternate binders are introduced due to the extensive consumption of energy during the manufacturing of ordinary P-C (OPC). Alternate binders are technically viable and possess considerable environmental and economic advantages when compared to binders manufactured using Portland cement alone.

Geopolymer, a new binder, was introduced by the French scientist Prof. J. Davidovits to name the three-dimensional alumino-silicate. He utilised silica (SiO_2) and alumina (Al_2O_3) available in the specially processed clay (metakaolin) to get inorganic polymeric system of alumino-silicates. Two main constituents of geopolymers are geopolymer source materials (GSMs) and alkaline activator liquids. The GSMs should be alumino-silicate based and rich in both silicon (Si) and aluminium (Al) and thus, by-product materials such as fly ash, silica fume, slag, rice-husk ash, red mud, etc can form GSMs. Geopolymer concretes (GPC) are inorganic polymer composites, which are prospective concretes with the potential to form a substantial element of an environmentally sustainable construction by supplementing the conventional concretes.

Eco friendly building/paver blocks using Geopolymer

Concrete building block technology offers a speedier, cost effective, environmentally sound alternative to conventional walling materials. Due to the non-availability of good quality fired clay bricks, cement concrete based building blocks and pavers are the most widely used concrete

components other than structural concrete. Even though concrete building block technology offers a speedier, cost effective, environmentally sound alternative to conventional walling materials and less energy consumption compared to burnt bricks, the embodied energy of concrete is still fairly high due to dependence on cement and fast dwindling resources like natural stone aggregates and river sand. In the construction sector, geopolymers represent an eco-friendly, low cost and low energy alternative of traditional inorganic matrices and composites due to the use of industrial by-products as solid precursors and low calcination temperatures.

CSIR-Structural Engineering Research Centre is working on ambient temperature cured geopolymer for about two decades. The advantages of the above technology are eco-friendliness, high early strength, Portland cement free binder, no water requirement for curing, less energy requirement, low carbon footprint, good mechanical and durability properties. Geopolymer based block technology can be easily adapted to suit special needs of users by modifying design parameters and is a highly profitable business for micro and small scale building material producers and construction companies. It can be extensively used in buildings, landscaping, in container yards, foot paths, parking lots, etc. The production of GPC blocks lead to a scientific, systematic and eco-friendly utilization of industrial wastes, components will be more versatile in terms of structural efficiency, durability and minimize the consumption of currently used energy–intensive materials, increased conversion of wastes to wealth. These new eco-friendly blocks will lead to a drastic reduction in the carbon footprint, embodied energy. Due to faster rate of development of strength at early ages, faster rate of construction and overall saving in the life cycle cost. It shall be effectively used in the precast industries, so that huge production is possible in short duration and the breakage during transportation shall also be minimized.

The GPC blocks developed incorporating fly ash and GGBS as source materials and sodium based alkaline solutions as reaction generating liquid and were cured at room temperature conditions. Analysis of the test results shows that the blocks made with both GGBS and FA and fly ash aggregate based hollow and solid blocks satisfying the respective Indian standard codal provisions (IS 2185 (Part I&III) and IS 15658). The studies showed that the blocks have rapid rate of strength development in ambient temperature conditions and do not necessitate water curing up to 28 days as in case of conventional concrete. Due to the high early strength, GPC blocks shall be effectively used in the precast industries, so that huge production is possible in short duration and the breakage during transportation shall also be minimized.

Based on the studies on geopolymer block technology, three technologies are transferred to industry on (i) Lightweight Geopolymer blocks, (ii) Geopolymer Bricks and (iii) Geopolymer Paver Blocks. Fig. 1 shows the technology demonstration of geopolymer paver blocks from lab scale and pilot scale.

Fig. 1: Pilot scale demonstration of geopolymer paver block technology

Geopolymer foam concrete (GeFoCON)

In search of materials offering high thermal insulation has become a target of the modern construction and building industry. Foam concrete is relatively low thermal conductivity, usually 10–50%, than normal dense concrete, depending on the designed material density and composition. The low thermal conductivity brings good thermal insulation as well as energy efficiency in operation. Recent developments in alternative binders, have led to the manufacture of foam concrete using a geopolymer as the binder. One of the most potential benefits of geopolymer is the reduced energy consumption and less CO_2 emissions compared to ordinary Portland cement. The innovation of ambient temperature cured GeFoCON creates an approach of developing energy-efficient materials from material manufacturing to building operation, which seems to offer the possibility to be eco-friendly across the whole life cycle.

Lightweight geopolymer foam concrete is obtained by using geopolymer source materials with or without river sand and with synthetic foaming agents. The geopolymer source materials are fly ash and ground granulated blast furnace slag (GGBS). Lower molar concentration of sodium hydroxide with combination of sodium silicates is used as alkaline solution. High density stable foams are manufactured by the mechanical foaming machine with pre-formed foam (Fig. 2a). The resulting GeFoCON mixes (Fig. 2b) gained strength in the ranges of 1.38 MPa – 11.43 MPa and with a density ranges of 575-1100 kg/m^3.

Fig. 2a: A pre-formed mechanical foam

Fig. 2b: Fresh geopolymer foam

Ecological parameters of Geopolymer concrete

The eco-friendliness of GPCs vs. Conventional Concrete (CC) can be quantified by computing the embodied energy (EE) and embodied carbon dioxide emission (ECO2e) per cubic meter of concrete.The comparative assessment of M40 grade Geopolymer concretes (28 days compressive strength 55 MPa) with M40 grade OPC concrete (28 days compressive strength 52 MPa), with respect to ECO2e and EE are carried out. The total consumed EE of GPCs and CC are 1701MJ/m3and 3138MJ/m^3, respectively. The total CO2 emission (ECO2e) for the GPCs and CC are 242 kgCO2e/m^3 and 389 kgCO2e/m^3, respectively. The total reduction in ECO2e and EE attained in GPCs are 147 kgCO2e/m^3 and 1437 MJ/m^3, respectively. The EE and ECO2e of GPCs, as compared to Conventional Concrete (CC) were found to be lower by 45% and 37% respectively. The concrete production cost of Geopolymer concrete (6277 Rs/m^3) was about 6% lower than that of CC (6691 Rs/m^3). Thus, for a given strength level in concrete, GPC can be produced utilizing lower amount of energy and lower amount of CO_2 emission.

Major Projects Undertaken

- **Condition Assessment of the Steel Supporting Structures in Ash Handling area of NTPC TSPTS, Kaniha – M/s. NTPC, Kaniha**
- **Condition Assessment of Boiler Supporting Structures and ESP & DUCT Supporting Structures in Six 500 MW Plant (Unit-6) at NTPC, Kaniha – M/s. NTPC, Kaniha**
- **Wind Tunnel Study on Aero-elastic Models of 150m Tall RC Chimneys for FGD System for Ramagundam TPS Unit #7 (1x 500 MW) – M/s. Powertec Engineering Pvt. Ltd., Chennai**

Technology transfer / MoUs

- A license agreement was signed between CSIR-SERC and M/s. L&T Construction, Mumbai, on 7 May 2021 for the technology ***Textile Reinforced Concrete Boundary Wall Panels and Precast Drains***
- An umbrella Memorandum of Understanding between CSIR-SERC and M/s. Lab To Market Innovations Pvt. Ltd., Bengaluru, was signed on 23 June 2021 for ***Development and Deployment of Structural Health Monitoring Systems to meet the Requirements of Monitoring and Managing the Assets and Operations of Railways***

Capacity development

Courses organized as a part of CSIR Integrated Skill Initiative

- An online Advanced Course on ***Engineering of Precast Concrete Technology for Mass Housing*** was organized on 5 - 6 May 2021. Around 36 participants including students, researchers, teaching faculty, professionals from government departments, public sector & industry and private consultants participated in the course.

Events

130th birth anniversary of Babasaheb Dr. B.R. Ambedkar

The 130th birth anniversary of Babasaheb Dr. B.R. Ambedkar was celebrated with great enthusiasm on 16 April 2021, at CSIR-Structural Engineering Research Centre (CSIR-SERC) and CSIR Madras Complex (CMC).

The function was inaugurated with the lighting of Kuthuvilakku and floral tribute to Dr. Ambedkar by Dr. K. Ramanjaneyulu, Director, CSIR-SERC and Coordinating Director, CMC. The staff of CSIR-SERC and CMC also paid floral tribute to Dr. Ambedkar.

This was followed by a function organized through MS Teams platform. Dr. P. Kuganantham, Head of the Department of Social Medicine & Infections Diseases at SIMS hospital, Chennai. Former Director of Communicable Diseases Hospital in Chennai, Consultant for UNICEF, was the Chief Guest of the function.

Dr. Ramanjaneyulu, in his presidential address remembered Dr. Ambedkar as one of the most outstanding leaders of India, as a crusader of equality, a visionary who stood for women empowerment and advancement, first law minister of India, recipient of Bharat Ratna, a scholar and a prolific writer. He said that for millions of people in India, Dr. Ambedkar is a part of their daily life and no other icon has touched their lives as Ambedkar did. His said that his contribution towards drafting our constitution is unmatchable and said that the greatest tribute to him would be to take his vision forward and stand for the eradication of all social evils.

The chief guest of the function, Dr. Kuganantham, gave a lecture on Dr. Ambedkar, the great human being who sacrificed himself for modern India, in which he shared his thoughts on Dr. Ambedkar and his contributions to our country and society. He remembered Dr. Ambedkar as a great human being; who always stood for non-violence, who stood and worked for liberation of all human beings from all kinds of social sufferings; and who aspired India to be a modern nation. He said that Babasaheb was the herald of the depressed classes in the society and said that although many people talk about Dr. Ambedkar all the time, they are not serious about his works and for what he stood for.

He said that Babasaheb stood for liberating human beings, a casteless society, equality, women empowerment, and empowerment of all marginalized classes of Indian society. He also briefed on the key contributions of Babasaheb – his meticulous drafting of the constitution of India that accommodated all citizens and made every individual as the unit of the constitution; Hindu code bill that gave several important rights to women; his contributions for worker's rights and social safety - through labour laws, rights of working women, health insurance for workers, etc.; conceptualization of Reserve Bank of India; his pioneering contributions in the development of India's national policy for water and electricity, etc. He said that Babasaheb was a key contributor for bringing equality in modern India, a great Indian to be celebrated by all and modern India is thriving in many ways because of the foundations laid by Dr. Ambedkar.

National Technology Day 2021

The National Technology Day was celebrated virtually through MS Teams platform on 11 May 2021, by CSIR-Structural Engineering Research Centre (CSIR-SERC) and CSIR Madras Complex (CMC).

The function was presided over by Dr J. Rajasankar, Director (Additional Charge), CSIR-SERC and Coordinating Director, CMC. Dr Rajasankar welcomed all the participants on the eve of 23rd National Technology Day and mentioned that this day can be viewed as a day of recognition to all engineers and is nationally being celebrated to commemorate India's three significant technological achievements namely, to mark the anniversary of the POKHRAN nuclear tests of 1998 first flight of the indigenously designed HANSA lightweight aircraft and the development of the surface to air missile TRISHUL. He pointed out that the three achievements have put India on the world technological map and that it is a matter of intense pride. Further, he touched upon the fact that the nodal agency for technology development is the Technology Development Board and that this year's theme is Science and Technology for a Sustainable Future.

Speaking on the role taken by CSIR in its fight against the COVID 19 pandemic he stated that under the coinage CSIR: fight against COVID-19, CSIR devised a five-pronged strategy, the first being the creation of five verticals for surveillance, diagnosis, therapies hospital assistive devices, supply chain and logistics. Further he mentioned the contributions made in this regard by CSIR-SERC and the CMC units and appreciated the efforts put by the various scientists and technicians. He concluded by requesting everybody to be safe and help the needy in this hour of distress.

Dr. B.H. Bharatkumar, Chief Scientist & Advisor(M), CSIR-SERC, introduced the speakers, Dr G.S.Palani, Chief Scientist & Head, TTRS, CSIR-SERC and Shri A. Robert Sam, Senior Principal Scientst & Scientist-in-charge, CSIR-CSIO, CMC, Chennai to the audience. Dr G.S.Palani delivered his lecture on Contribution by CSIR-SERC towards Temporary and Short-Term Hospital Structures for Rapid Construction. In his talk Dr Palani elaborated the work done by CSIR-SERC in view of the COVID-19 pandemic and the need for more healthcare facilities. He spoke in detail supported by schematic diagrams and images on the three schemes proposed, viz., Poli-Tal-1, Poli-Tal-M and Pre-Tal. Further he illustrated the field implementation procedures of the 10-bed isolation centre, Poli-Tal-M and Pre-Tal with images and a video, giving in detail the materials used and steps followed to set up the structures.

Shri A. Robert Sam in his talk on In-Campus initiatives to mitigate Covid-19 briefed upon the trials and tribulations in studying a virus which has caused the COVID-19 pandemic through out the world. He then briefed upon the tasks and activities taken up by CSIR-CSIO under the CSIR fight against COVID-19 banner under the following categories Ultra violet germicidal irradiation systems, Sanitizing viroxygelly for COVID-19, Microbial aerosol sampling

system, UVGI testing and SARS-CoV-2 coronavirus, UVGI surface disinfection systems, air disinfection system, testing and characterization of large disinfection system, dark room facility UVC testing.

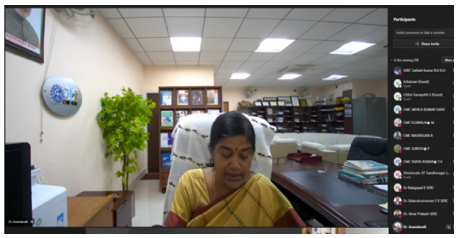
He stated that more than 70 companies, such as Godrej, Bajaj, Borosil, Wipro, Philips, Steel Tech, etc., had sent as many as 120 products for testing during the pandemic period. The contribution of CSIR-NEERI by way of developing hand sanitizer and development of low-cost personal protective kits using copper-based nano-composites, sewage sample analysis was highlighted. Shri Robert Sam briefed upon CSIR-CECRI's contribution towards COID-19 pandemic by way of hand sanitizer preparation and distribution, designing and developing the AI based face recognition attendance system. He then touched upon the work done by the campus front line workers by taking preventive measures of sanitizing all laboratories and other facilities.

56th Foundation day of CSIR-SERC

CSIR-Structural Engineering Research Centre (CSIR-SERC), celebrated its 56th Foundation Day with great enthusiasm, on 10 June 2021. The function was presided over by Dr. (Mrs.) N. Anandavalli, Director, CSIR-SERC and Coordinating Director, CMC. Prof. Sudhir K. Jain, Director, Indian Institute of Technology Gandhinagar, was the chief guest of the function and delivered the Prof. G.S. Ramaswamy Memorial Lecture through Microsoft Teams platform.

Extending a warm welcome to the chief guest and the octogenarians from CSIR-SERC and CSIR-CMC units, Director, Dr. N. Anandavalli, touched upon the fact that although structural engineering is present in all realms of life, the importance of structural engineers is felt only after the occurrence of disasters. She went on to state that keeping in mind the safety and environmental protection aspects, structural engineers need to provide solutions with a multi-disciplinary approach. She also recalled the vision of Prof. G.S. Ramaswamy, Founder Director of CSIR-SERC to achieve self-sufficiency in structural engineering skills and the hard work of the former employees of the organisation. Further she reiterated that the organization should be taken to greater heights to carry forward the glory to the future generation by much more dedication in order to honour the work and efforts put in by the founders of the institute.

Director detailed the contributions of CSIR-SERC by working in tandem with the Government of India for its fight against the pandemic situation faced by the nation. Mentioning the contributions which included providing of three types of technology for construction of make shift hospitals, innovation of the Emergency Retrieval System, TRC panels, geopolymer blocks and the subsequent transfer of the technologies. She congratulated the teams involved respectively. She briefly touched upon the new facilities added to the centre and congratulated all the staff members who received their Doctoral degrees and to the scientists who were awarded the Institution of Engineers' Award, Dr. Kanchana Devi and Dr. Prabhat Ranjan Prem. Director congratulated all the staff members on the occasion of 56th foundation day of CSIR-SERC.



Welcome address by Director

The chief guest of the function, Prof. Jain delivered the Prof. G.S. Ramaswamy Memorial Lecture on ***Some reflections on earthquake engineering and engineering education.*** He pointed out that CSIR-SERC is ***one of the finest laboratories the country has*** and also traced his association with CSIR-SERC right from the student days and thereafter. In his presentation Prof. Jain talked in detail upon the Indian earthquake problem, examples of local solution, capacity building initiatives, confined masonry construction and the challenges and opportunities of building a new university – the IIT Gandhinagar with several examples and visuals. He talked about the engineered vs non-engineered constructions and the solutions that were adopted to mitigate earthquake, seismic retrofitting in Andaman Islands and the confined masonry method adopted in IIT Gandhinagar. Further he elucidated the initiatives undertaken to promote the discipline of earthquake engineering and capacity building initiatives for continuing education programmes, the establishment of the National Information Centre of Earthquake Engineering (NICEE), National Program of Earthquake Engineering Education (NPEEE), interventions towards architects, earthquake tips, etc. While concluding his presentation Prof. Jain opined that the discipline of earthquake engineering requires ***mostly common sense plus some calculations***, attitude to solve problems, sense of responsibility, team work, etc. Describing in detail the programmes being conducted at IIT Gandhinagar, he said, while working towards instilling a sense of good work ethics they placed students as their priority, followed by doing research that makes an impact and worked towards greater societal contribution.

Prof. G.S. Ramaswamy Memorial Lecture by the Chief Guest

Participants durig the function

International Yoga Day 2021

The International Day of Yoga was celebrated at CSIR-Structural Engineering Research Centre (CSIR-SERC) and CSIR Madras Complex (CMC), on 21 June 2021. In her welcome address, Dr. (Mrs.) N. Anandavalli, Director, CSIR-SERC and Coordinating Director, CMC, emphasized on the significance of yoga in achieving physical and mental well-being. She said that this year's theme of International Yoga Day - Yoga for well-being, is much relevant for our times in a society still recovering from the impact of Covid-19 pandemic. She also briefed on the five layers which one has to experience before connecting the mind, body and soul with nature and Yoga will help in the process. Ms. R. Manasa Devi, Yoga expert was the chief guest of the function. Dr. Mymoon Moghul, Head, Knowledge Resource Division, CSIR-SERC, briefed on the International Yoga Day and introduced the chief guest to the audience. One hour session on Yoga was organized. Stressing the need for practicing yoga regularly, Ms. Manasa Devi, conducted the practice session on yoga. She spoke on the illnesses/health problems people are facing due to Covid-19 pandemic such as diabetes, low oxygen level, high blood pressure, body pain, etc., and explained/ demonstrated the asanas that can help in healing such health issues. Around 100 staff members from both CSIR-SERC and CMC participated in the event.

Honours, awards & recognitions

- Dr. (Ms.) N. Anandavalli, Director, CSIR-SERC, has become Member, Board of CIDC, for the term 2021-2023, under the category ***Institutional Members***

Invited Lectures

- Dr. B. Arun Sundaram, Principal Scientist, delivered an invited lecture titled ***Instrumentation techniques for performance evaluation of civil engineering structures*** at Webinar on Advanced Instrumentation for Structural Engineering Applications, organized by Department of Civil Engineering, PSG College of Technology, Coimbatore, on 29 May 2021
- Dr. (Ms.) Smitha Gopinath, Principal Scientist, made an online presentation on the outcome and recommendations of the webinar titled ***Opportunities and Challenges with BuildTech Textiles for Construction Sector***, organized by CSIR-SERC based on the research carried out at CSIR-SERC in the area of textile reinforced concrete, at the 6th Meeting of BIS Technical Sectional Committee TXD 34-Textiles for Buildtech Applications on 8 June 2021.
- Dr. (Ms.) Smitha Gopinath, Principal Scientist, delivered a guest lecture on ***Textile Reinforced Concrete - Emerging Opportunities for Buildtech Textiles*** at 49th Meeting of the Board of Directors of Indian Technical Textile Association (ITTA), held through video conferencing on 17 June 2021.

Paper Publications

- **SCI Journals - 6**
- **Reputed Indian Journals - 4**

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