January - March 2025 Vol. 9, No. 1

e-STRUCT

e-Newsletter of CSIR-Structural Engineering Research Centre

In this issue

The e-STRUCT newsletter showcases a journey of continued resilience in the quarter gone by, coupled with optimism for a better future through the scientific activities and myriad events that are part of day-to-day life on the CSIR-SERC campus. I am very happy to present Vol. 9, No. 1, 2025 issue of e-STRUCT. This edition of the newsletter showcases the varied skills of the CSIR-SERC community, highlighting our R&D pursuits, achievements, skill development initiatives, and other significant events & endeavors during January – March 2025. Three technologies of CSIR-SERC, viz, Portable Lightweight Folding-type Modular System for Makeshift Hospital and other Needs (Poli-Tal(M)), Emergency Retrieval System for Power Lines (ERS), High Velocity Multi-Hit Resistant Movable Protective Booth/Shack for Security Personnel, were transferred to the industry during the period.

This issue's research highlight is about a movable prototype developed – protective booth for security personnel, a cementitious composite-based booth that combines strength, safety, and practicality. The main motivation behind the development of prototype movable protective booth for security personnel was to provide better alternative solution to the conventional sand bag type protection. In this quarter, eight major projects were undertaken, two new technologies were developed and various capacity development programmes were held. Various events such as Vishwa Hindi Diwas Celebration, Observance of Awareness Week on Prevention of Sexual Harassment at Workplace (POSH 2025), International Mother Language Day 2025, Nation Science Day and International Women's Day Celebration were organized in the campus during this period.

This has indeed been a challenging but eventful quarter and as always, we look forward to more exciting opportunities in future.

With best wishes,
Dr. N. Anandavalli
17.9.2025

Research highlights

Prototype movable protective booth for security personnel

The development of protective structures capable of withstanding high-velocity impacts such as those from short-calibre projectiles has become increasingly important due to the rise in global terrorist threats. The recent research project builds upon prior expertise in designing composite panels that can endure multiple strikes from 7.62 mm armor-piercing (AP) projectiles. The primary goal of this research was to develop a prototype of a movable, multi-hit resistant security booth intended for use by security personnel. In this significant stride towards enhancing the safety of frontline security personnel, CSIR-Structural Engineering Research Centre (CSIR-SERC) has developed prototype movable protective booth. Designed to replace present practice of sandbags and metallic shield type morchas for defense, this development leverages advanced composite materials and structural engineering to offer **multi-hit resistance** against high-velocity projectiles such as those from AK-47 rifles while ensuring mobility, modularity, and ease of deployment.

Need for the development

Conventional sandbag barriers (Fig. 1), though widely used at airports, railway stations, and sensitive installations, suffer from several limitations:

- Inconsistent protection due to variable sand quality and packing density
- Issue with positioning when using sand bags
- Risk of ricochet when using steel plates shield
- Weather effects due to heat and rain etc.

Fig. 1 Conventional sand bags for protection typically at airports and railway stations

To address these challenges, CSIR-SERC has developed a cementitious composite-based booth that combines strength, safety, and practicality. The main motivation behind the development of prototype movable protective booth for security personnel was to provide better alternative solution to the conventional sand bag type protection.

Science behind the development

Cementitious composites under dynamic loading and impact resistance

Engineers recognized that compressive strength is inversely related to the water-to-cement (w/c) ratio. By reducing this ratio and incorporating superplasticizers or surfactants to maintain workability, concrete mixes achieving strengths up to 100 MPa were developed. To achieve this, materials such as silica fume, mineral fillers, superplasticizers, and discrete fibers were introduced. While conventional concrete design typically considers quasi-static loading, modern protective structures must also withstand dynamic and impulsive loads such as impacts and blasts. These high strain-rate events generate extreme stress and pressure at the point of contact, affecting both the target and projectile materials. To accurately assess material behaviour under such conditions, testing must replicate the expected strain rates, or rely on constitutive models that incorporate strain rate sensitivity, temperature effects, and strain hardening. Concrete, being a quasi-brittle material, exhibits strain softening under slow loading rates and limited strain hardening at high strain rates. To enhance its performance under dynamic loads, the use of fiber-reinforced concrete has become increasingly prevalent. Short fibers improve tensile strength, ductility, energy absorption, and control of microcracking. A key requirement for such materials is their ability to absorb the kinetic energy of projectiles. Therefore, understanding the mechanical behavior of fiber-reinforced composites particularly the influence of fiber type, size, and volume fraction is essential for designing effective impact-resistant structural elements. When dynamic loading is applied to a structure, the inertia begins to play an important role, which is negligible in the case of quasi static loading. Further, if the rate of loading is very high, then shock wave propagation through the materials also governs the response of structures.

Analysis of support frame work of security booth

The framed structure made up from the steel material where various members of different shapes like I-section, channel section, box section and built-up sections were used. The base module is provided with caster wheels which have locking arrangement. In the analysis of the steel frame the design loads as per the latest code of practice IS:875 part 1 to part 3, expected on the security booth during service life were considered namely; dead loads, live load due to security personnel movement, wind load, and handling loads. Critical load combinations as per the latest code of practice IS:800-2007 were considered for the design of support frame members. The maximum wind speed of 50 m/s at various angle of incidences between 0 deg to 90 deg was considered.

Element cross section geometry shapes

The security booth consists of steel frame and composite panels. The steel frame consisted of different shapes like I-section, channel section, box section and built-up sections. The composite panels were made using M100 grade of cementitious materials with enhanced properties by adding steel hooked end fibres. The schematic details of the security booth are given in Fig. 2.

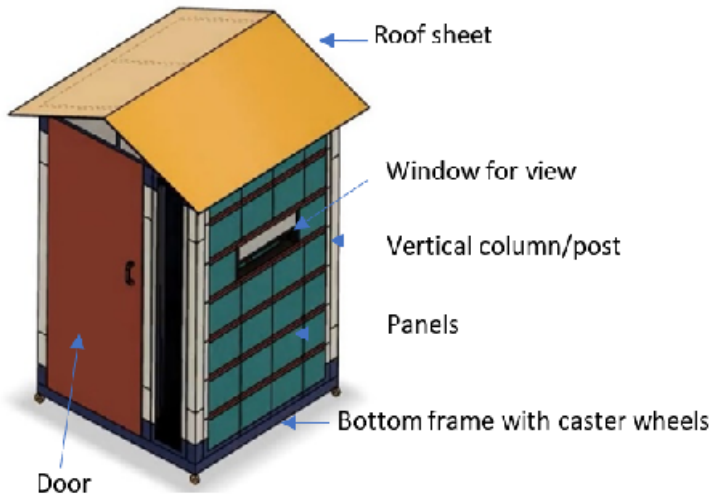


Fig. 2 Schematic details of the security booth

Stability of booth during movement - The checking for stability during rolling over and handling was carried out. In order to calculate force required to move the booth in horizontal direction coefficient of rolling friction μf was taken as 0.04 (range of μf is 0.03 to 0.04 for castor wheel on concrete like hard surface). The security booth was found safe for rolling on rigid ground.

Numerical simulations and responses

Before starting experimental investigations for optimum thickness of fibre reinforced cementitious panels, a comprehensive numerical study was carried out. For numerical simulations of ballistic impact of 7.62 AP projectile on the composite panels, a commercial software was used.

In recent time, the most general approach to solve nonlinear dynamic problems is the numerical simulations. Main advantage of this approach is that, any limitations on the geometry of a problem are removed. Both material and geometric nonlinearities can easily be considered. To be practical the main drawback of the numerical models is that they require a complete description of the material behaviour in all loading regimes like; elastic behaviour, yielding, flow, and failure. Pressure, strain, strain rate and temperature effects also need to be accounted. This lack of a complete material description, especially as it relates to material failure, is the single greatest limitation on the use of wave propagation computer codes to predict high strain rate material behaviour.

Steel fibre reinforced cementitious composite (SFRCC) panels are numerically investigated for their impact performances under high velocity impact of short projectiles. Numerical responses using advanced constitutive material model proposed Riedel-Hiermaeir-Thoma (RHT) for cementitious materials and adopting appropriate modelling techniques were obtained. Effects of steel fibre volume and the thickness of panels on the impact performance are mainly highlighted in the present study. Various characteristics phenomenon during impact on cementitious composite panels namely, spalling, cracking, scabbing and perforation, are captured which is a difficult task, otherwise. Various critical aspects of numerical modelling, like, boundary conditions, material input parameters, and handling severe distortion of the Lagrangian based finite elements are appropriately explained. The engineering properties of materials determined using quasi static tests in laboratory are used. In present work the material properties obtained at macroscopic level from laboratory tests are used in the numerical simulations.

It was found numerically that for the specified matrix strength and fibre types and volume fractions, a minimum thickness of 75 mm is needed to resist multi-hits of 7.62 mm AP projectile. It was also observed that the thickness less than 60 mm will exhibit perforation. Hence, 75 mm thickness with special provision to break the line of sight through joints panels were casted. Numerical responses for damaged contours for various thickness targets are shown in Fig. 3.

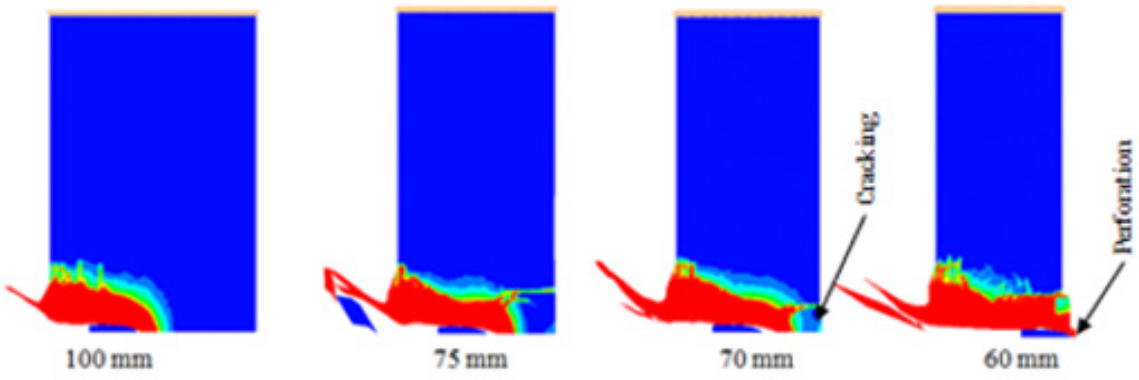


Fig. 3 Damage contours for different thickness of panel under 7.62 mm calibre

Significant achievement/ contributions towards technology/ product/ process development:

The prototype of high velocity multi-hit resistant movable security booth is an advanced protective structure which was developed to resist up to 7.62 AP projectiles complying to NIJ level-III. The booth structure is capable of resisting multiple projectile impacts effectively with better ricochet resistance than that of a metallic Morcha.

The development process of security booth technology was successfully demonstrated by CSIR-SERC (Fig. 4).

Stake holders:

CISF, CAPF, CRPF, BSF, Armed forces, Defense facilities, Embassies, Airport authorities, and so on.

Fig. 4 Prototype movable security booth showcased in Aero India 2025 during 10-14 February 2025 at Bengaluru

Technology transfers / MoUs

- CSIR-SERC's technology ***Portable Lightweight Folding-type Modular System for Makeshift Hospital and other Needs (Poli-Tal(M))*** was licensed to M/s. Hemagni Build-Pro Industries Pvt. Ltd., Hosur, on 17 January 2025.
- CSIR-SERC's technology ***Emergency Retrieval System for Power Lines (ERS)*** was licensed to M/s. Hi-Tech Systems and Services Ltd., Kolkata, on 17 January 2025 .
- CSIR-SERC's technology ***High Velocity Multi-hit Resistant Movable Protective Booth/Shack for Security Personnel*** was licensed to M/s Sehgal Doors, a member of Laghu Udyog Bharati (LUB) on 7 February 2025.

Capacity development

Courses / training programmes

- An advanced course on ***Seismic Engineering and Testing (ACSET 2025)***, was organized during 28 - 30 January 2025 at CSIR-SERC. Forty one participants attended the course.

- An advanced course on ***AI Assisted Techniques for Health Monitoring and Assessment of Special Structures***, was organized during 27-28 February 2025. A total of twenty nine participants attended the course.

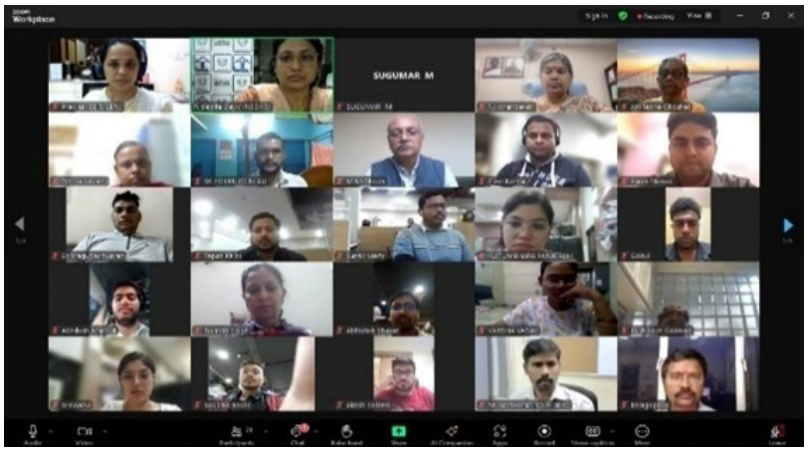
Major Projects Undertaken

- Performance evaluation of two spans of PSC segmental girder type railway bridge EAK-31 in Trivandrum Division of Southern Railway near Cochin (ERS-ALLP-KYJ section) for running higher axle loads - through instrumentation, field testing and numerical investigations, Southern Railway, Indian Railways, Kerala
- Failure analysis of the collapsed NDCT PVC fills and supporting structures at BTPS UNIT – 3, M/s. Karnataka Power Corporation Limited, Karnataka
- Slosh and vibration studies on fuel tank for smoke dispensation of Hawk aircraft, Indigenisation Section, Air Force Station, Maharashtra
- Wind tunnel investigations for the assessment of aerodynamic behaviour of the proposed 150 m tall twin flue RC chimney at Marwa, Chhattisgarh, M/s. Invictus Consultancy Services, Maharashtra
- Condition assessment of penstock supporting structures of Nagarjuna Sagar Main Power House, Telangana Power Generation Corporation Limited, Telangana
- Instrumentation and field testing for stress state evaluation and health condition of the identified ten numbers of span of the open web girder bridge BR No 57 (UP&DN) across river Rupnarayan between Kolaghat (KIG) & Deulti (DTE) stations in Kharagpur division of South Eastern Railway, South Eastern Railway, Indian Railways, West Bengal
- Evaluation of existing prestress in the superstructure of Taratala Flyover in Kolkata, Public Works Directorate, West Bengal
- Vibration testing of AIP components (10 tests), Naval Materials Research Laboratory (NMRL), Maharashtra

New Technologies Developed

- FlexiHeatModule
- Paver blocks with recycled aggregates

- A short-term customized training program on ***Selected Aspects in Steel Design*** was organized jointly by CSIR-SERC and the Institute for Steel Development and Growth (INSDAG), during 17-28 February 2025. The aim of the training was to equip the participants with modern methodologies and principles in the field of structural steel advancements including concepts such as limit state design, composite construction, and earthquake-resistant design



Jigyasa

Student-Scientist Connect Programme - A group of 24 students and 9 teachers from Greater Chennai Corporation Schools, Chennai, visited CSIR-SERC on 5 February 2025. The students had the opportunity to gain practical experience and insights into various research projects conducted by the institution. The event was organized under the guidance of Dr. N. Anandavalli, Director, CSIR-SERC, who encouraged the students to be innovative and creative, urging them to pursue success through participation in science-related activities. Dr. S. Maheswaran, Senior Principal Scientist, CSIR-SERC, gave a talk about the CSIR Jigyasa program, which aimed to inspire school students to engage in science and research. He emphasized how participating in such initiatives can enhance their scientific thinking and research skills. The students expressed their gratitude for the opportunity, sharing that it sparked their interest in science and research. During the visit, they toured various laboratories at CSIR-SERC, interacted with the scientists, and witnessed first-hand ongoing research activities at the centre.

Participation in exhibitions

- CSIR-SERC participated in the AERO INDIA 2025, held during 10-14 February 2025 at Yelahanka Air Force Station, Bengaluru. As part of this event, a team of Scientists from CSIR-SERC exhibited and showcased the technology - High velocity multi-hit resistant movable protective booth complying to NIJ level III protection - developed at CSIR-SERC. The security booth is useful for both civilian and defence sector to provide protection against upto 7.62 mm AP calibre projectile hits as per NIJ standards. The developed panels can also be used in baffle ranges in various training academies. Various ministers, renowned personalities, leading technologists, researchers and presently serving 47th Vice Chief of the Indian Army Staff, Mr. N.S. Raja Subramani visited the stall and interacted with CSIR-SERC scientists and staff.

- CSIR-SERC set up a special exhibition stall on Energy and AI Theme at the TRYST'25 Technological Expo, organized at IIT Delhi during 10-12 March 2025 - to showcase it's energy related R&D initiatives. Various renowned personalities, leading technologists, researchers and students visited the stall and interacted with CSIR-SERC scientists.

- CSIR-SERC participated in the Chennai Science Festival 2025, organized by Science City during 26-28 March 2025 at Periyar Science and Technology Centre (Birla Planetarium), Chennai. The exhibit showcased CSIR-SERC's pioneering research and innovations in structural engineering, attracting students, researchers, and science enthusiasts

Special lectures

- As a part of CSIR-SERC Diamond Jubilee Celebrations, a special lecture titled ***Deep Ocean Mission and Blue Economy for Sustainable Development*** by Dr. M.V. Ramana Murthy, Director, National Centre for Coastal Research (NCCR), Chennai and Mission Director, Deep Ocean Mission, was arranged under the Thrust Area ***Offshore Structures***, on 10 January 2025. The lecture gave an overview of the deep ocean mission of the Government of India besides explaining the purpose, associated features and the benefits of blue economy for sustainable development. The speaker emphasized on the role of innovation and R&D on the topic for sustainable development. He also highlighted the emerging sectors and requested CSIR-SERC to take up and be a part of the mission through advanced R&D on offshore structures.

- Mr. P.Y. Manjure, Member, Research Council, CSIR-SERC and Director, M/s. The Freyssinet Prestressed Concrete Co. Ltd., Mumbai, delivered a lecture of the CSIR-SERC Diamond Jubilee Series titled ***Rehabilitatin of Bridges and Other Structures - Challenging Discipline***, on 29 January 2025.

Events

Vishwa Hindi Diwas Celebration

Vishwa Hindi Diwas was jointly celebrated by CSIR-SERC and CSIR Madras Complex on 13 February 2025. Dr. Sham Sunder Kathuria, Deputy Director, ESIC was the chief guest of the function. The celebration was a meaningful reminder of the cultural and linguistic heritage that Hindi represents, fostering appreciation and love for the language among all participants. The event featured a Hindi elocution competition that saw active participation from numerous staff members and students, showcasing their proficiency and enthusiasm for the Hindi language.

Observance of Awareness Week on Prevention of Sexual Harassment at Workplace (POSH 2025)

CSIR-SERC and CSIR Madras Complex combinedly organised a Programme on ***Prevention of Sexual Harassment (POSH) at Workplace*** as a part of Observance of Awareness Week (17-21 February 2025) on 20 February 2025. Ms. Vidya Shankar, Chairperson, RELIEF FOUNDATION, Chennai, was the chief guest of the function. The chief guest in her speech spoke about workplace bullying, the Sexual Harassment of Women at Workplace (Prevention, Prohibition and Redressal) Act 2013, and how it provides the right of complaining and also punishes wrongful complaints. A poster competition was also organized with the theme ***Prevention of Sexual Harassment at Workplace.***

International Mother Language Day 2025

The International Mother Language Day was celebrated with great enthusiasm at the CSIR-Structural Engineering Research Centre (CSIR-SERC) and CSIR Madras Complex (CMC) during 20-24 February 2025. The whole programme comprised of four sessions - an inaugural programme, presentation of research activities and technical / literary talks in mother language, cultural programme and valedictory programme. Prof. Karu. Nagarajan, President, Tamil Academy, SRM University, Kattankulathur & Former Member-Secretary, Tamil Nadu State Council for Higher Education, Chennai, and Thiruvarur Nagaichuvai Navalar Pulavar R. Shanmugavadivel, were the chief guests of the inaugural and varledictory functions.

Nation Science Day

National Science Day was celebrated with great enthusiasm at CSIR-SERC and CSIR Madras Complex on 6 March 2025. Prof. Dr. Stephan Grill, Director, Max Planck Institute of Molecular Cell Biology & Genetics, Germany was the chief guest of the function. As a part of the National Science Day celebrations, the second edition of Dr. N. Lakshmanan Memorial Science Quiz Competition was organized at the CSIR Campus on 28 February 2025, exclusively for the Greater Chennai Corporation School students.

The main aim of the quiz was to inculcate the aptitude for scientific research in young minds. The quiz was organized by Shri. A.K. Farvaze Ahmed, Principal Scientist, CSIR-SERC, and his team. Ninety-three students from thirty-one schools from all across Chennai actively participated in the quiz competition. The prize-winning schools were awarded trophies, and the prize-winning teams were given shields and prize money by Dr. N. Anandavalli, Director, CSIR-SERC and Coordinating Director, CMC.

International Women's Day Celebration

International Women's Day was celebrated at CSIR-SERC and CSIR Madras Complex, during 8-20 March 2025. Women's day function was celebrated on 20 March 2025. Dr. Purnima Jalihal, Scientist G, Head of Energy and Fresh Water Group, National Institute of Ocean Technology, Chennai and Mrs. Hema Chandrasekhar, Senior Vice President, Northern Trust Corporation, were the chief guests of the function.

Earlier, FIT India Pledge was taken on 11 March 2025 followed by **Yoga session** by Ms. Vanathi, Yoga Trainer. A special lecture on **Diet and Nutrition** was given by Prof. S. Thangamani, of Dr. Mohan's Diabetes speciality Centre, Chennai, as part of celebrations. Also, various team games were organized on the eve of International Women's Day 2025 at the CSIR campus during 12-17 March 2025. A large number of women actively took part in the games.

Other Notable Events

- 76th Republic Day was celebrated at the CSIR-SERC Campus and TTRS on 26 January 2025. Dr. N. Anandavalli, Director, CSIR-SERC & Coordinating Director, CMC, unfurled the National Flag and delivered the Republic Day address.

- Sixty-ninth Research Council meeting was organized during 29 - 30 January 2025.
- CSIR-SERC and CMC jointly organised a free eye awareness camp by Vasan Eye Care Hospital during 27-28 March 2025.
- 149th Official Language Implementation Committee Meeting was held on 14 March 2025.

Invited talk/lectures

- Dr. Amar Prakash, Senior Principal Scientist, delivered an invited talk titled *Analysis and design of structures subjected to extreme loading due to impact and blast events,* organised by MNNIT, Allahabad, on 13 January 2025 at MNNIT, Allahabad.
- Dr. P.S. Ambily, Senior Principal Scientist, delivered an invited lecture titled *An introduction to concrete 3D printing* at TNCST Sponsored National Level Seminar on Innovation in Civil Engineering Materials and Construction Technologies, organised by Department of Civil Engineering, KSR College of Engineering in association with ICI Students Chapter and Erode District Civil Engineering Association, on 6 February 2025 at KSR College of Engineering, Erode.
- Dr. A. Kanchana Devi, Principal Scientist, delivered an invited lecture titled *Application of finite element analysis for structural engineering problems* at One-Day Workshop on Finite Element Analysis for Structural and Geotechnical Engineering, organised by Department of Civil Engineering, Sri Sivasubramaniya Nadar College of Engineering, Kalavakkam, Chennai, on 4 March 2025.
- Dr. C. Bharathi Priya, Principal Scientist, delivered an (online) invited lecture titled *Semi active control devices for Improving the seismic resilience of structures* at Faculty Development Program on Building Resilient Infrastructure for Natural Disasters and Climate Change, organised by Department of Civil Engineering, Sri Venkateswara College of Engineering, Sriperumbudur, on 6 March 2025.
- Dr. J. Prawin, Principal Scientist, delivered an invited talk titled *Bridging the gap: direct and drive-by vehicle measurements for vibration-based structural health monitoring of bridges* at Workshop on Structural Health Monitoring from Research to Reality organised by Christ University, Bengaluru, on 7 March 2025.
- Dr. A. Ramachandra Murthy, Chief Scientist, delivered a keynote lecture titled *AI Applications in Structural Engineering and Repair and Retrofitting of Concrete Members with UHPC* at ANRF Sponsored National Seminar on AI-Driven Innovations in Civil Engineering: Enhancing Energy Efficiency, Sustainability and Safety Standards, held during 20-21 March 2025, at Mahindra Engineering College, Namakkal.

Honours/awards/recognitions/nominations/ PhDs

- Dr. S. Parivallal, Chief Scientist & Advisor (M), was nominated as a ***Member*** of the Planning Board of Menonmaniam Sundaranar University, Tirunelveli, by the Hon'ble Governor-Chancellor, for a period of three year from 5 March 2025.
- Dr. N. Anandavalli, Director, CSIR-SERC, was awarded the ***ICI-Ultratech Awards 2024 - Outstanding Women Concrete Engineer*** sponsored by M/s. Ultratech Cements Ltd., Schwing Stetter India Pvt. Ltd., Floormart Global (FMG), Mumbai, on 6 March 2025.
- Dr. K. Sathish Kumar, Chief Scientist, was nominated as a ***Member*** of the Planning Board of Alagappa University, Karaikudi, by the Hon'ble Governor-Chancellor, for a period of three years from 7 March 2025.
- Dr. A. Ramachandramurthy, Chief Scientist, was elected as ***Fellow*** of the Indian Association of Structural Engineers during March 2025.

Paper publications

- **SCI Journals - 8**
- **Reputed Indian Journals - 2**