

e-STRUCT

e-Newsletter of CSIR-Structural Engineering Research Centre

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From the Director's Desk



I am very happy to present Vol. 6, No. 1, 2022 issue of e-STRUCT. This edition of newsletter highlights our R&D pursuits, achievements, skill development initiatives and other significant endeavors during January - March 2022.

CSIR-SERC has developed a sixty-degree steel and GFRP angles for optimum triangular based communication towers. This technology can be highly useful as a rapid growth in the telecommunication system requires a large number of antennae supporting structures with a square or triangular base. The work done by CSIR-SERC is detailed in research highlights section of this edition of eNewsletter.

During this quarter, CSIR-SERC's technology on Eco-Friendly Geopolymer Concrete Blocks was licensed to M/s. Debrigue Creative Labs Pvt., Ltd., Chennai. A contract agreement was also signed with M/s. Power Grid Corporation of India Ltd., Gurgaon, for the project titled Design Vetting 400 kV Double Circuit Towers (4 nos.) with Quad ACSR Moose Conductor for WZ-5. Ten major projects were also undertaken during this period.

During the period, CSIR-SERC organized ten online advanced courses as a part of CSIR Integrated Skill Initiative and a webinar for the benefit of the student and research community. A cardiac screening camp in co-ordination with M/s. Gleneagles Global Health City, Chennai, was also organized that received a huge response from the staff members. As a part of Jigyasa programme, competitions, quiz programmes and workshops for students were organized that drew wider participation from across the country. For the first time, International Mother Language Day was organized at the campus.

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



Republic Day 2022 celebrations at the CSIR Campus

Research highlights

Sixty-degree steel and GFRP angles for optimum triangular based communication towers

The rapid growth in the telecommunication system requires a large number of antennae supporting structures with a square or triangular base. Triangular-based towers result in significant weight reduction compared to conventional square-based towers. Hot rolled 90° steel equal angle sections are generally used in latticed towers for both leg and bracing members since the 60° angles are not readily available. In triangular-based towers, for smooth connection between the leg and bracing members, the included angle between the two flanges of the main leg member shall be 60°.

Analytical and experimental studies on cold formed 60° angle sections

The analytical procedure for prediction of compressive strength considering both equivalent and minimum radius of gyrations is formulated for 60° angle sections. Since hot rolled 60° angle sections are not available in the Indian market, studies are conducted using cold-formed 60° equal angle sections. Experiments were conducted at the element level on different section sizes and thicknesses for various slenderness ratios. Torsional-flexural buckling associated with local plate buckling is observed in short columns, torsional-flexural buckling is observed in intermediate lengths and flexural buckling is observed in long columns.

Studies on cold formed 60° angle section at structure level

A 5.5 m high triangular roof-top

communication tower using 60° angles for leg members and 90° angles for bracing members was designed based on the buckling curve developed from the element level studies and successfully tested (Fig.1). Numerical investigation of the tower is carried out by using NE-NASTRAN software considering both geometric and material nonlinearities. The experimental and numerical behaviour of the tower was observed to be in good agreement.

Studies on triangular communication tower with Schifflerized, 60° and 90° angle sections

Studies on ground-based triangular communication tower have been conducted by using three different shapes of angle sections such as 60°, schifflerized and 90° angle sections for leg members and conventional angle sections for all



Fig. 1: Triangular roof-top communication tower

other members (Fig.2). In the case of the tower with 90° degree angle sections with bent-up gusset plate, the deflection is found to be 40% higher compared to the other two towers due to out-of-plane deformation of the bent-up gusset plates and thus increasing the joint flexibility. Deflection is one of the important criteria governing the serviceability requirement in communication towers, since excessive deflection results in signal loss.

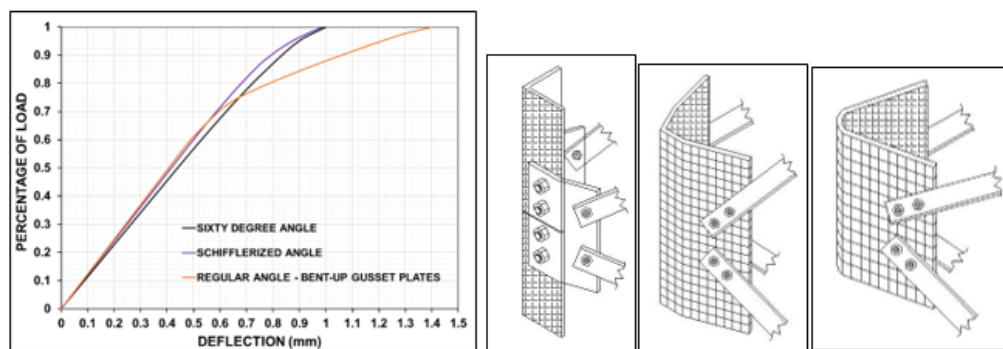


Fig. 2: Comparison of deflection in towers

Leg to bracing connections 90° , schifflerized 60°

- In the Indian code of practice, 60° and schifflerized angle sections are not existing. These sections eliminate the bent-up gusset plates and increase the overall stiffness of the triangular communication tower and reduce the weight by 20%.
- Torsional flexural buckling governs compressive strength of 60° angle sections up to a slenderness ratio of 40.
- For triangular towers made of 90° angle sections with bent up gusset plate, the deflection is found to be about 40% higher compared to towers using Schifflerized and 60° angles due to joint flexibility in the connection region.

Triangular Communication Towers with Pultruded GFRP 60° Angles

The strength and buckling behaviour of GFRP 60° equal angle sections with different slenderness (L/r) and width to thickness (w/t) ratios under axial compression is studied experimentally (Fig.3) and numerically by modelling the GFRP struts in ANSYS software. The GFRP 60° angle struts exhibited torsional-flexural buckling mode. Test failure mode and loads are compared with the analytical load predicted by using mathematical models in the literature.

Fig. 3: Behaviour of 60° angle section without and with intermediate redundant members

Behaviour at a structural level

CSIR-SERC has developed and successfully demonstrated the use of GFRP angle sections by testing a 9 m high GFRP- Steel hybrid roof-top triangular communication tower (Fig. 4a). 60° GFRP angles for leg members and 90° steel angles for bracing members are used. For a leg to bracing connection steel bolts were used. Since there are no standards available for the design of GFRP sections, the members and connections were designed based on the buckling curves and design guidelines developed by CSIR-SERC. A 24 m ground based triangular communication tower made of GFRP 60° equal angles for leg members and 90° angles for other members as shown in Fig. 4b was also tested.



Fig. 4a: GFRP-Steel hybrid roof top tower



Fig. 4b: Ground based GFRP tower

Recommendations to enhance the strength of GFRP angles

i) GFRP 60° angles sections with stitched mat fail by TF buckling mode till failure but finally fails by de-bonding of layers. The angle sections with multi-axial technical fabrics ($\pm 45^\circ / 90^\circ$) and without stitched mat the fails by TF buckling mode till failure but finally fails by shearing of the cross-section. For a given angle section size and length, the strength reduces significantly as the w/t ratio increases.

ii) The commercially produced GFRP profiles are unidirectionally reinforced and hence lack continuity of fibres between the individual components of the cross-section. Fibre continuity across both the flanges/ legs of the GFRP 60° angle section may enhance the strength and buckling behaviour similar to the steel angle section and the GFRP 60° angle section is a good alternative to the 90° angle section for triangular-based communication towers.

Major Publications

- Engineering Failure Analysis, 2017
- KSCE Journal of Civil Engineering, 2017
- Journal of the Institution of Engineers India (Series A), 2020

Technology transfers / MoUs

- CSIR-SERC technology on *Eco-Friendly Geopolymer Concrete Blocks* was licensed to M/s. Debrigue Creative Labs Pvt., Ltd., Chennai, on 23 March 2022
- A contract agreement was signed between CSIR-SERC and M/s. Power Grid Corporation of India Ltd., Gurgaon, for the project titled *Design Vetting 400 kV Double Circuit Towers (4 nos.) with Quad ACSR Moose Conductor for WZ-5* on 31 March 2022

Major Projects Undertaken

- Quasi static studies on metro couplers - Voith Turbo Pvt Ltd., Hyderabad
- Condition assessment of the steel structure in TG and offsite areas in TSTPS of NTPC - NTPC, TSTPS, Kaniha
- Assessment of structural adequacy of three numbers of RDSO's standard composite bridge spans (BR238, BR27, BR32) near Barkakana/ Dhanbad division of ECR - East Central Railways (ECR), Bihar
- Structural integrity assessment of open web steel bridge girder of Mayar bridge and Main Rihand bridge - NTPC, Rihand
- Wind tunnel investigations on the scaled model of 35m tall hybrid mosaic tower - Ramboll India, Hyderabad
- Wind tunnel investigation on aero-elastic model of a RC Chimney for 2x500 MW NTPL Tuticorin FGD System - M/s. BHEL, Uttar Pradesh
- Wind tunnel investigation to evaluate the aerodynamic characteristics of a special airfoil - Department of Aerospace Engineering, Indian Institute of Technology Madras, Chennai
- Fatigue life evaluation of reinforcing bar couplers - Kridhan Infratech Pvt Ltd., Mumbai
- Condition assessment of 275m RC Chimney and recommendation for repair measures - Stage III - NTPC Rihand
- Integrity assessment of the pretressed Trunnion beams of the spillway of Polavaram dam project through acoustic emission (AE) and advanced non-destructive evaluation (NDE) techniques - Chief Engineer, Polavaram Irrigation Project, Head Works Circle (PIPHW), Andhra Pradesh

Capacity development

A total of ten courses were organized as a part of CSIR Integrated Skill Initiative

- An online advanced course on *Computational Mechanics and Simulations for Materials and Structures* was organized during 19-21 January 2022. Around 17 participants attended the course
- An online advanced course on *Applications of Soft Computing Techniques in Structural Engineering* was organized during 24-25 January 2022. Around 29 participants attended the course
- An online advanced course on *Geopolymer Concrete* was organized during 27-28 January 2022. The course drew active participation with 35 participants
- An online advanced course on *Applications of Multiscale Modelling in Structural Engineering* was organized during 9-11 February 2022
- An online advanced course on *Use of Alternate Reinforcement in Concrete Applications* was organized during 22-23 February 2022. The course had a huge response with 49 participants
- An online advanced course on *Failure Analysis, Retrofitting and Strengthening of Transmission, Communication and Broadcasting Towers* was organized during 24-25 February 2022. This course also an overwhelming response with 44 participants
- An online advanced course on *Quality Control and Assessment of Field Concrete* was organized during 3-4 March 2022
- An online advanced course on *Advances in the Design of Steel Structures* was organized during 7-9 March 2022. Around 23 participants took part in the course
- An online advanced course on *External Post-tensioning for Strengthening of RC members with Limited Distress* was organized during 15-16 March 2022
- An online advanced course on *Forensic Analysis of Concrete Structures* was organized during 24-25 March 2022. Around 19 participants took part in the course

Webinar organized

- A webinar on *Nano-gas films for achieving super hydrophobic coating applications* was organized on 8 March 2022 with 24 participants

JIGYASA

CSIR-SERC had organized JIGYASA student competition through online mode for the year 2021-2022. This year the competitions were conducted for school students under three categories viz:

- Government of Tamilnadu Schools
- Government of Puducherry Schools
- Kendriya Vidyalaya Schools (Nation-wide)

The SCIFIC (Individual Event) competition is about scientific fiction

story-writing, meant for the students of class 6-8. The event attracted registration by 325 students from 14 states. However, 82 final entries were submitted by the students

The TECHNOVATION (Team Event) competition is about technology development activity presentation, meant for the students of class 9-12. For this competition, total of 124 groups (consisting of 497 students) registered from seven states across India. However, 71 final entries (271 students) were submitted by the students.

The certificate of honour and the prize money for the student winners including consolation prizes were distributed to the students through their respective schools. The teachers who guided the students for the TECHNOVATION team event were given mentors' certificate. In addition, all the participants were given certificates.



Jigyasa Vigyan Mahotsav Online lecture and Quiz Programme (Boot Camp-I)

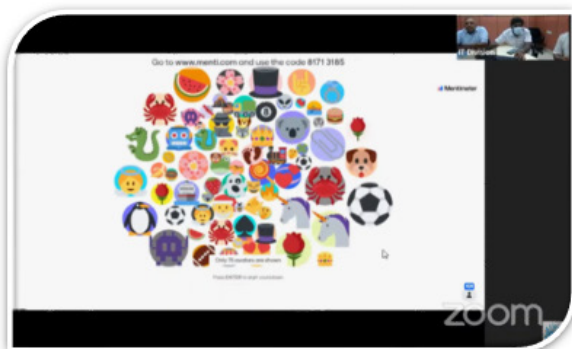
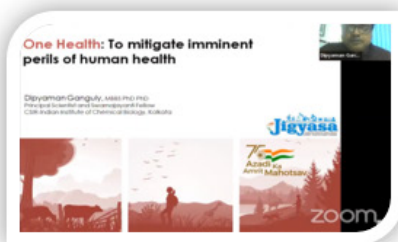
As part of Azadi ka Amrit Mahotsav (AKAM) and Amrit Mahotsav Science Showcase: Roadmap to 2047 celebrations, Council of Scientific & Industrial Research (CSIR) organised a national level scientific creativity competition under Jigyasa Vigyan Mahotsav 2022 (JVM-2022). An online competition was organised by CSIR on content creation for virtual lab (VL) for different themes.

CSIR-SERC participated in the event and chose the theme **Disaster Mitigation**. The theme events were coordinated by Dr. S. Maheswaran, Senior Principal Scientist and Shri. E. Ashok Kumar, Scientist. The coordinators developed suitable write-up for ideation and formalization, problem description, implementation strategy, etc. for the theme events.

An online boot camp was also organized for the participating students. The details of the activities of Jigyasa program, virtual lab (VL) platform and registration process, etc. were explained to the participants. Following this, lectures were delivered on 11 January 2022 by two eminent scientists on Disaster Mitigation:

- Dr. S. Gomathinayagam, Former Director General, NIWE, Chennai.
- Dr. Dipyaman Ganguly, Principal Scientist, CSIR-IICB

An online quiz program was organized based on the lectures to provide an opportunity to the participants to further develop their scientific knowledge and exhibit their creative skills.



CSIR JIGYASA ATL workshop

A two day, CSIR JIGYASA ATL workshop was organized during 24-25 February 2022, exclusively for the students of the adopted schools in Tenkasi and Tirunelveli districts of Tamil Nadu. Six scientists (also mentors of adopted ATL schools) of CSIR-SERC and CSIR-CMC visited the schools and delivered the lectures on topics related to basic science, latest scientific advancements, etc., and also witnessed the facility created under ATL programme. About 500+ students and 20 teachers participated in the workshop.



Events

Vishwa Hindi Diwas Celebrations

CSIR-SERC and CSIR Madras Complex, (CMC), Chennai, jointly organized Vishwa Hindi Diwas Celebrations on 10 January 2022. On this occasion, various Hindi programs viz. presentation of special scientific poster & research papers in Hindi, Moukhik (Oral) presentation of kavita, story telling, singing, etc. were organized for all staff and students at the campus. The programme started with the lighting of lamp and saraswati vandana.

Dr. N. Annadvalli, Director, CSIR-SERC and Coordinating Director, CMC, delivered the welcome address. In her presidential address she gave warm wishes and congratulations to all the staff members

on the occasion of Vishwa Hindi Diwas. Talking on the importance and need of Vishwa Hindi Diwas in her presidential address, she said that Hindi is the third most spoken language in the world. She said that the main objective of celebrating this day is to make Hindi accessible to the people and to get it an international status. She pointed out that it is very necessary to make aware of scientific and technological achievements in the official language of India. Shri P. Suresh, Principal Technical Officer, CMC, proposed vote of thanks and requested all the officials to extend their cooperation in the implementation of Official Language.



International Mother Language Day

The International Mother Language Day was celebrated with great enthusiasm at the CSIR-SERC and CMC, on 21 February 2022. The full-day programme spanned across three sessions. In first session, Dr. N. Anandavalli, Director, CSIR-SERC and Coordinating Director, CMC, welcomed all participants and in her address briefed on the history of International Mother Language Day and emphasized on the significance of mother language for achieving excellence. Prof. M Muthuvelu, Member, State Official Language Legislative Commission and Former Registrar, The Central Institute of Classical Tamil was the Guest of Honour and delivered a keynote address on *Education in mother tongue & science in Tamil literature*. In second session,

presented their scientific research in their mother language.



In third session, the Chief Guest of the function, Ezhuthu Chelvar Kalaimamani Dr. Lena Tamilvanan, Writer and Publisher, Manimegalai Prasuram, Chennai hosted the website of CSIR-SERC in Tamil language and delivered the International Mother Tongue Day lecture on *Mother tongue for achieving excellence in life*. Congratulating the efforts of CSIR-SERC

in bringing out its Tamil website in a commendable way, he said that every community has responsibility towards protecting their mother language in this era of globalization. He requested all to work towards making their mother language as language of education and language of lifestyle to take it to the next level.



National Science Day

The National Science Day was celebrated with great enthusiasm on 28 February 2022, at CSIR-SERC and CMC on MS Teams platform. The function was presided over by Dr. N. Anandavalli, Director, CSIR-SERC and Coordinating Director, CMC. Prof. V. Kamakoti, Director, Indian Institute of Technology (IIT) Madras was the Chief Guest of the function. In her welcome address, Dr. Anandavalli reiterated the importance of science for sustainable development and briefed on the genesis of National Science Day. Mentioning about this year's theme of Integrated

approach in Science and technology for Sustainable effort, she said that it is conceived keeping in mind the immediate concerns of the nation, society and world as a whole. Prof. Kamakoti delivered the National Science Day lecture on *Data Science, Artificial Intelligence, IOTs & Cyber Physical Systems*. In his address, he talked about the emergence of cyber physical systems, wireless communication and high bandwidth communication. He said that IIT Madras was a part of the National Mission on Interdisciplinary cyber Physical Systems

initiated by the GOI and Department of Science and Technology wherein 26 Innovation hubs have been developed. He further invited CSIR-SERC to partner with IIT Madras to be a part of developing cyber physical systems which will be a great contribution towards addressing societal problems.



International Women's Day was celebrated on 8 March 2022. Ms Alpa Sheth, MD, VMS Consultants Pvt. Ltd., Vakil Mehta Sheth Consulting Engineers, Mumbai, was the chief guest. *Gender equality today for a sustainable tomorrow* was the theme for International Women's Day 2022. An introduction on women's day at CSIR campus was given by Dr. C. Bharathi Priya, Sr. Sct. Dr. N. Anandavalli, Director, in her welcome address spoke on the genesis of women's day and this year's theme, and said that the role of women is important for Nation building. She pointed out that women are still under-represented and encouraged women to achieve equality. Dr. P. Kamatchi, Sr. Pr. Scientist, introduced the chief guest.

International Women's Day

The chief guest, in her special talk titled Women and Leadership – Why are we so afraid to embrace it? spoke on the discrimination faced by women in all spheres. She said that in future the gender fluidity will accelerate the breaking of barriers and women will have the opportunity to explore the still unexplored and untouched frontiers. Citing examples of the efficient leadership roles played by women around the world during Covid-19 pandemic, she urged women to take up the leadership role to change the world. Two presentations on the theme of International Women's Day 2022 were made by the scientists of CSIR-SERC and CMC. Smt. VVS Lakshmi, COA, CSIR-SERC proposed vote of thanks.



- 73rd Republic Day was celebrated with great enthusiasm at the CSIR Campus and TTRS campus on 26 January 2022. Dr. N. Anandavalli, Director, CSIR-SERC & Coordinating Director, CMC unfurled the **National Flag**

Other Events

- The staff clubs of CSIR-SERC & CMC organized Cardiac Screening Camp in co-ordination with M/s. Gleneagles Global Health City, Chennai, at CSIR Campus on 3 March 2022



Honours, awards & recognitions

- Dr. Smitha Gopinath, Principal Scientist, was recognized by German Embassy India as another great women scientist on the occasion of International day of women and girls in science and presented on its Twitter page on 11 February 2022
- Dr. N. Anandavalli, Director, was nominated by Hon'ble Governor-Chancellor of Tamil Nadu as Member of the Planning Board of Bharathidasan University, Tiruchirapalli for a period of three years from 18 February 2022
- Dr. K. Sathish Kumar, Chief Scientist, was nominated by Hon'ble Governor-Chancellor of Tamil Nadu as Member of the Planning Board of Bharathiar University, Coimbatore for a period of three years from 18 February 2022
- Dr. S. Vishnuvardhan, Principal Scientist has been nominated by the Honourable Governor-Chancellor to the Planning Board of Periyar University, Salem, for a period of three years from February 2022
- CSIR-SERC was awarded first prize by Town Official Language Committee (TOLIC) for effective implementation of official language policy of the Government of India / Council of Scientific & Industrial Research (CSIR) for the Assessment Year 2020-21 & 2021-22 on 7 March 2022
- Dr. V. Marimuthu, Principal Scientist has been nominated as a Member of Board of Studies for UG Curriculum of Civil Engineering in NIT, Tiruchirappalli for the year 2021-2022
- Dr. N. Anandavalli, Director, delivered the Chief Guest address for the NCRS 2022 Conference organised by IIT-M held on 10 March 2022 at IIT Madras, Chennai
- Dr. N. Anandavalli, Director, delivered the Chief Guest address for the International Women's Day at CSIR-CECRI, Karaikudi held on 17 March 2022
- Dr. S. Bhaskar, Senior Principal Scientist, received the 13th CIDC Vishwakarma Awards 2022 under the category of Achievement Award for Academician/Technologist/Scientist/Innovator [Code-D] on 28 March 2022
- Dr. P.S. Ambily, Principal Scientist, acted as Indian Examiner for Ms. Rajapriya, Research Scholar, Anna University for her PhD thesis titled Mix proportion methodology and performance characteristics of concrete using laterite sand

Invited Lectures

- Dr. S. Bhaskar, Senior Principal Scientist, delivered an invited/guest lecture titled *NDT&E for Condition Assessment of Reinforced Concrete Structures* for M.Tech. Structural Engineering students organized by Structural & Geotechnical Engineering Division, School of Civil Engineering, VIT, Chennai on 6 January 2022
- Dr. M.B. Anoop, Senior Principal Scientist, delivered an invited lecture titled *Performance-Based Seismic Design of Bridges* for Advances in Bridge Engineering - Design and Research Perspective (Sponsored by TEQIP-21-25 march 2022) organised by Government Engineering College, Thrissur on 22 March 2022
- Dr. Smitha Gopinath, Principal Scientist, delivered an invited lecture titled *Emerging Trends of Textile Reinforced Concrete in Construction* for 2nd International Virtual Conference on Emerging Research Trends in Structural Engineering (ERTSE-2022) organised by Indian Concrete Institute Chennai Centre and ICI Student Chapter, School of Civil Engineering (SEC), VIT, Chennai on 25 March 2022.

Technology Showcase

CSIR-SERC participated in the pan-CSIR technologies demonstration pavilion through MSME meet CSIR-National Physical Laboratory (NPL) 75th Foundation Day Celebration, during 4-6 January 2022 at CSIR-NPL, New Delhi

Paper Publications

- SCI Journals - 11
- Reputed Indian Journals - 2



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