वार्षिक प्रतिवेदन

ANNUAL REPORT

2019-2020

सीएसआईआर-केंद्रीय भवन अनुसंधान संस्थान, रुड़की

CSIR-Central Building Research Institute, Roorkee

With Best Compliments from

Dr. N. Gopalakrishnan
Director

CSIR-Central Building Research Institute, Roorkee

director@cbrimail.com
director@cbri.res.in

Annual Report

2019-2020

सीएसआईआर-केंद्रीय भवन अनुसंधान संस्थान, रुड़की-247667 (भारत)

CSIR-Central Building Research Institute, Roorkee- 247667 (India)

Phone: +91-1332 272243; Fax: +91-1332 272272, 272543

E-mail: director@cbrimail.com; director@cbri.res.in

Website: http://cbri.res.in

Compiled & Edited by

Dr. Atul Kumar Agarwal, Senior Principal Scientist
Publication Group, CSIR-CBRI, Roorkee-247667 (Uttarakhand), India

CONTENTS

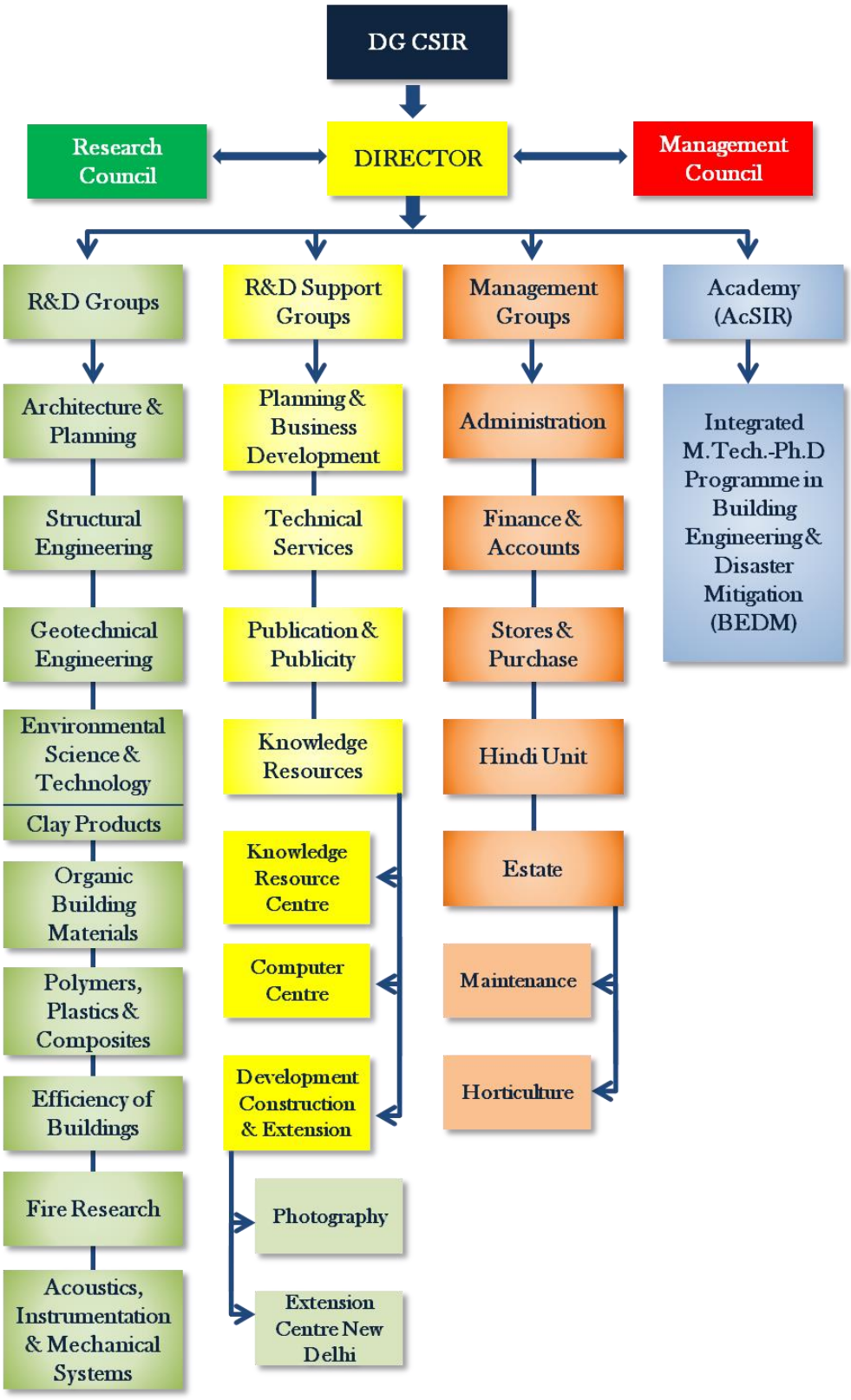
Our Vision

To be a world class research and knowledge centre of national importance for providing innovative solutions to all aspects of building science and technology.

Our Mission

Devotion to research, development, and innovation (RD&I) in solving national challenges of planning, design, materials, capacity building and construction including disaster mitigation in buildings to achieve safety, sustainability, resilience, smartness, comfort, functional efficiency, speed, productivity in construction, environment preservation, energy efficiency and economy.

CSIR-CBRI Organogram



Research Council

Chairman
Prof. N. Raghavan
Professor of Practice
Indian Institute of Technology, Madras

Members

Prof. B. Bhattcharjee
Professor, Department of Civil Engineering,
Indian Institute of Technology, New Delhi

Dr. R. K. Bhandari
(Ex-Director, CSIR-CBRI, Roorkee)
302, Kamadgiri Tower, Kaushambi, Ghaziabad

Dr. Pradyumna Vyas
Director,
National Institute of Design, Ahmedabad

Dr. M. Ravi Kanth
CMD, HUDCO
Lodhi Road, New Delhi

Prof. P. P. Mujumdar
Professor, Department of Civil Engineering,
Indian Institute of Science, Bengaluru

Prof. S. Kapuria
Director,
CSIR-Structural Engineering Research Centre,
Chennai

Prof. Satish Chandra
Director,
CSIR-Central Road Research Institute, New Delhi

Dr. N. Gopalakrishnan
Director,
CSIR-Central Building Research Institute, Roorkee

Secretary
Dr. Shantanu Sarkar
Chief Scientist
CSIR-Central Building Research Institute, Roorkee

Management Council

Chairman
Dr. N. Gopalakrishnan
Director
CSIR-Central Building Research Institute, Roorkee

Members

Dr. Santosh Kapuria
Director,
CSIR-Structural Engineering Research Centre,
Chennai

Mr. Ravindra Singh Bisht
Senior Scientist,
CSIR-Central Building Research Institute, Roorkee

Dr. Harpal Singh
Chief Scientist,
CSIR-Central Building Research Institute, Roorkee

Sh. I.A Siddiqui
Senior Technical Officer (1),
CSIR-Central Building Research Institute, Roorkee

Dr. B.S. Rawat
Senior Principal Scientist,
CSIR-Central Building Research Institute, Roorkee

Head
Planning and Business Development,
CSIR-Central Building Research Institute, Roorkee

Dr. Leena Chaurasia
Primcipal Scientist,
CSIR-Central Building Research Institute, Roorkee

Mr. J.K. Chaurasia
F&AO,
CSIR-Central Building Research Institute, Roorkee

Member Secretary
CoA/AO
CSIR-Central Building Research Institute, Roorkee

HOUSING - STRUCTURE & FOUNDATION

Development of Fast, Durable & Energy Efficient Mass Housing Scheme

Mission Director: Dr. N. Gopalakrishnan
Nodal Officer: Dr. Ajay Chourasia
Co-Nodal Officer: Dr. Ashok Kumar

To meet the housing construction requirements of the nation, CSIR-CBRI has continued its efforts through well planned R&D programmes to provide long-lasting solutions through innovative, disaster-resilient, cost-effective, environment friendly and affordable construction technologies, that reinforces the National Mission - "Housing for All".

In continuation of the earlier efforts (as reported in CBRI Annual Report 2018-2019), some of the significant outcomes of the programmes include:

- Developed "Construction Technology Demonstration Park" at CSIR-CBRI Roorkee. The Park is a construction technology fusion ranging from vernacular to blue-sky (3D Printing, emerging Precast/prefab...). The technologies are not only demonstrated but also shall be evaluated for different functional tests viz. water tightness, acoustics, thermal comfort, axial/lateral loads etc. The emerging technologies being evaluated are Precast Hybrid buildings, Confined Masonry, Low Energy Building, Cold Form Steel, Dry Construction, Bamboo Housing System, 3-S Precast Building System, Prefab Steel Housing Building; and Recycled Construction Waste Material.
- Lateral displacement control load tests under varying axial loads have been conducted on Cold Form Steel Panels with alternative schemes.
- Lateral load tests on different precast RC shear walls viz. (i) precast hollow core RC wall (ii) precast wall-column connected through loop bar have been conducted. Also numerical analysis of (i) precast hollow core RC wall, (ii) precast wall-column connected through loop bar, and (iii) in-situ RC column-wall, have been carried out demonstrating excellent agreement between experimental and numerical results.
- Developed plain, grooved and ribbed headed bars for robust RC beam-column joint performance, demonstrating excellent performance and transfer of technology to industry.
- Developed typified architectural designs and layouts for mass housing schemes for EWS/LIG houses in different geo-climatic regions of India including the thermal performance of buildings using different materials and other parametric studies.
- Developed bricks made from recycled masonry aggregates /recycled concrete dust and RC planks using C&D wastes.
- Developed affordable mobile crane, plastering machine, and modified C-Brick making machine.
- Developed structural designs of EWS houses in different seismic zones for one to four storey buildings using confined masonry technique.
- Developed hollow core light weight concrete blocks for construction of confined masonry buildings.

- Completed construction of 6 lakhs houses using S&T interventions and CBRI technologies in Odisha state.
- Conducted training of 4500 engineers of different states of the country on multi-hazard resistant housing construction.
- Conducted Shake-table tests on liquefiable ground subjected to sequential acceleration levels i.e. 0.1 g, 0.2 g, 0.3 g and 0.4 g and Installation of sand compaction piles, PVDs, stone columns and encased stone columns for ground improvement.

List of Tasks at CSIR-CBRI:

- Development of Materials for Mass Housing Structural Elements
  - Development of Bio-Based Construction Material for Sustainable Mass Housing
    Leena Chaurasia* & L.P. Singh
  - Development of Cold-Formed Steel (CFS) Wall Panels with Improved Structural Performance & Fire Resistance
    Chanchal Sonkar* & A.K. Mittal
- Performance Evaluation of Precast Panels & Framed Structural System
  - Development of Prefab RC Shear Wall Systems & Evaluation of their Lateral Load Resistance
    Ajay Chourasia* & C. Shermi
  - Development of Efficient Mechanical Anchorage Device for Precast Beam-Column Joint
    Ajay Chourasia*, C. Shermi & S.K. Panigrahi
  - Comparative Evaluation of Performance of Various Precast Panel & Frame Systems Developed by Various Research Groups for Specified Functionality Test
    Ajay Chourasia* & C. Shermi
  - Standardization of Designs & Layouts of Prefab Housing Units with Improved Thermal Performance
    Sayantani Lala*, Ashok Kumar, Seraj Alam, Kishor Kulkarni, Chandnan Swaroop Meena & Ashutosh Singh
  - Development of Dry-Construction Technology in Buildings
    Kishor Kulkarni*, Sayantani Lala, Ashok Kumar & Tabish Alam
- Reducing Resource Use in Housing Construction
  - Recycling of Agricultural/Industrial/Solid Wastes for Building Infrastructures
    Soumitra Maiti*, Monalisa Behera, Santha Kumar G. & Neeraj Jain
  - Eco-Friendly Corrosion Inhibition to Improve Concrete Durability
    S.R. Karade* & P.C. Thapliyal
  - Protective Coating for Improved Energy Efficiency in Buildings
    P.C. Thapliyal* & S.R. Karade
- Mechanization in the Housing Construction Sector
  - Mechanization in Construction Process of Pre-Fabricated Building Components for Mass Housing

Ravindra Singh Bisht*, S.K. Panigrahi, Soju J. Alexander, Ajay Chourasia, Narendra Kumar & Sameer

- Mechanization in Production of Prefabricated Building Components & Wall Plastering for Mass Housing
  S.K. Panigrahi*, Ravindra Singh Bisht, Soju J. Alexander & Ajay Chourasia

- Disaster Resiliency in Housing Constructions
  - Design Interventions for Enhancement of Robustness in Traditional Construction, Numerical & Experimental Investigation
    S.K. Negi*, R. Dharmaraju, Ajay Chourasia & Ashish Pippal
  - Design of Confined Masonry Construction using Different Types of Units (Concrete Masonry Block, ACC Block)
    Ajay Chourasia*
  - Improvement in CSIR-CBRI Developed Prefab Technologies
    S.K. Negi, Ashish Pippal* & Ajay Chourasia
  - Design of Fire Safety & Evacuation Strategy for Buildings
    Shorab Jain*
- Geotechnical Solutions for Mass Housing Schemes
  - Ground Improvement Technique to Mitigate Liquefaction Hazards for Safe Building Construction
    S. Ganesh*
  - Ground Improvement using Granular Pile Anchor Foundation (GPAF) System
    Pradeep Kumar* & K. Pandit
  - Development of Modified Static & Seismic Design Methodology of Piled-Raft Foundation
    M. Samanta*, S. Ganesh, K. Pandit, D. Kumar, Z. Ahemed & A. Dwivedi
  - Design & Strengthening Measures for Building Foundation Systems in Hilly Regions
    K. Pandit*, S. Sarkar, M. Samanta, S. Ganesh, A. Dwivedi, B. Bisht & Z. Ahmed
- Dissemination, Promotion & Extension of Interventions for Mass Housing Schemes Developed (Combined Contribution from all Participating Laboratories, Coordinated by CSIR-CBRI & CSIR-SERC)
  - Formulation of Guidelines for Constructing Mass Housing including the Cost Analysis
    N. Gopalakrishnan
  - Organization of Skill Development Programmes
    Ajay Chourasia
  - Demonstration of Developed Technology/Know-How(s)
    Ajay Chourasia

For achieving the overall objective of the project, a comprehensive database has been prepared by collecting field data on existing problems in foundations for buildings in hills (composed of only soils, soil-rock mix or rock slopes). This database also includes an extensive field and laboratory test results conducted for characterisation of the foundation media (soil/rock) by various practitioners and researchers. Later, a plan for conducting parametric numerical studies has been made for formulating design guidelines on different scenarios of building foundation-slope system. The numerical models have been developed

upon validation against published studies to increase confidence level in the conducted studies.The comprehensive parametric study includes different shallow foundation types (isolated and strip footings) and other important design parameters. Further, some unique foundation solutions/technologies such as combination of bracing systems of buildings with engineered design of shallow foundations, ground improvement etc. have been investigated for optimal solution of foundation problems. Finally, design guidelines have been formulated based on the local geology and geotechnical aspects for foundations in hilly regions.

Manpower Trained:

1. 6 Ph.D. (Awarded : 2, In progress : 4)
2. 50 project assistants
3. 35 M.Tech. Dissertations
4. 50 B.Tech. Dissertations
5. 1500 engineers trained
6. 2000 artisans trained
7. 600000 housing units constructed using CBRI technologies across India

Technologies Developed:

1. Innovative couplers for concrete element connections
2. Dry construction technology
3. Cold formed steel panel housing system
4. Confined masonry using rubble stone masonry
5. Confined buildings using light-weight cellular concrete blocks
6. Affordable mini-climbing crane
7. Wall plastering machine
8. Headed bars for beam-column joints

Products Developed:

1. Bio-bricks and RBM Bricks
2. Light-weight cellular concrete blocks
3. Building components using C&D Wastes
4. Corrosion inhibitor and multifunctional coating using agro-industrial waste

Business Linkage:

1. Ministry of Housing and Urban Affairs, New Delhi
2. B.G. Shirke Construction Technology Pvt. Ltd., Pune
3. Everest Industries, New Delhi
4. Reliable Insupacks (P) Ltd., Greater Noida
5. Disha Pavers, Nagpur
6. TVASTA, Bangaluru
7. HILTI India, New Delhi
8. Indian Institute of Technology, Tirupati
9. Indian Institute of Technology Bombay
10. Manipal Institute of Technology, Manipal

Development of Bio-Based Construction Material for Sustainable Mass Housing

Leena Chaurasia

Objective:

To develop bio-based construction material for sustainable mass housing.

Progress Highlights:

Several experimentations have been done to understand the self-healing mechanism of concrete using bacteria. It has been observed that strength and durability of concrete increases considerably with bacteria as self-healing agent. An experimental investigation carried out to determine the consolidating effect of ureolytic, non-ureolytic Bacillus sp. on desert sand wherein, bacteria infused desert sand bricks were prepared using various binders (cement, lime, fly ash) and their engineering properties were evaluated. The strength characteristics have been evaluated and water absorption of bacteria treated/untreated desert sand-lime bricks showed significant improvement in engineering properties. The compressive strength and water absorption obtained was > 6 MPa and 11 to 14 % respectively, for desert sand briquette comprising ureolytic and non-ureolytic bacteria. The tests were performed in accordance with IS -3495, Part 2: 1992.

The study was performed on desert sand and Brahmaputra River sand. The tests were carried out for sieve analysis, specific gravity, fineness modulus, and bulk density (as per IS 383.1970). To utilise the desert sand and Brahmaputra River sand for bricks production, mix proportioning has been performed comprising sand with/without bacteria and cement and water. The results showed an increasing trend of compressive strength and reduction in water absorption in bio-bricks. Further study was performed incorporating ureolytic and non-ureolytiv bacteria in desert sand. The results were quite promising for non-ureolytic bacteria as compare to ureolytic bacteria.

Outcomes:

- Developed bio-bricks using desert sand. (Fig. 1)
- Developed bio-mortar using desert sand. (Fig. 2)
- Developed bio-concrete using desert sand. (Fig. 3)

Fig. 1: Bio-Bricks using Desert Sand

Fig. 2: Bio-Mortar using Desert Sand

Fig. 3: Bio-Concrete using Desert Sand

Development of Cold-Formed Steel (CFS) Wall Panels with Improved Structural Performance & Fire Resistance

Chanchal Sonkar & A.K. Mittal

Objective:

To investigate the effect of sheathing boards and parametric variation of quantities, which include number of sheathing layers, screw spacing, and joint details on axial strength of CFS wall panels.

Progress Highlights:

A comprehensive study has been carried out experimentally and analytically on axial performance of 16 number of CFS wall panels including one bare CFS wall frame, sheathed CFS walls and single column stud (with and without sheathing). In the present study, effect of Magnesium Oxide (MgO) double-layer sheathing on one-side and both-sides on axial strength of CFS panels, which has not been addressed earlier, is investigated in detail. The impacts of various parameters, such as screw spacing, joint detailing and number of layer of sheathing on axial strength of CFS wall panels have been studied and some important conclusions are drawn. The experimental axial strength multiple-studs CFS wall panel specimens have also been compared with analytically predicted values. Analytical modelling of CFS wall panels with MgO board sheathing is carried out by simulating the equivalent stud restraint provided by screw-sheathing system by considering springs, as specified by Schafer (2013) and Vieira et al. (2013). Thereafter, CUFSM (Constrained and Unconstrained Finite Strip Method) Tool version 4.05 is used to carry out elastic buckling analysis of the stud with sheathing based springs, consecutively axial strength of CFS wall panel has been calculated using Direct Strength Method (DSM) as per AISI S100.

The analytical results are found to be in agreement with the experimental results. The present study can be used as benchmark study of researchers working in CFSWP as analytical results are in agreement with the experimental results. CFS sections commonly have mono-symmetric or point-symmetric shapes, and normally have stiffening lips on flanges and intermediate stiffeners in wide flanges and webs, therefore special design methodology have to be adopted for the sections. An illustrative design example of a G+3 storey building discusses the basic methodology and demonstrates how the sheathing-braced design check would work in compression, compression + bending and in-plane shear. A G+1 storey CFS building has been constructed at Demo Park, CSIR-CBRI, Roorkee as a part of this project.

Details of the Prototype CFS Building:

The building is basically constructed using CFS wall panel framing technology. The main axial load-bearing members are Cold-formed Steel Wall Panels other than open front area and staircase area. These wall panels also act as the main lateral load resisting system. CFS walls are constructed using C-sections of 550 MPa yield strength. The outer layer of the external panels are covered with two layers of 6 mm + 9 mm of Heavy Duty Fibre Cement Boards (HDFCB) (breathable vapour barrier in between outer layer of external panels) and inner layer of the external panels are covered with two layers of 8 mm Fibre Cement Boards (FCB) + 12.5 mm of Gypsum Boards. Whereas internal wall panels consists of 8 mm Fibre Cement Boards (FCB) + 12.5 mm of Gypsum Boards both the sides. Rockwool is sandwiched in between the boards for insulation. Slab basically consists of wire mesh and metal decking placed on the joists, concreting is done thereafter.

Construction Sequence of CFS G+1 Storey CFS Building

Fig. 1-7 shows the various stages of construction of CFS G+1 storey CFS building.

Fig. 1: Erection of HR Steel Columns at Staircase & Front Areas

Fig. 2: Erection of CFS Wall Panels

(a)

(b)

Fig. 3: Erection of First Storey CFS Walls

Fig. 4: Casting of First Floor Slab

Fig. 5: First Layer of Sheathing Under Progress

Fig. 6: Second Layer of Sheathing in Progress

Fig. 7: Completed CFS Building Structure

Outcome:

- Cold formed steel panel housing system.

Development of Precast RC Shear Wall Systems & Evaluation of their Lateral Load Resistance

Ajay Chourasia & C. Shermi

Objective:

To evaluate the seismic performance of precast RC shear wall systems.

Progress Highlights:

The study covers experimental and numerical investigations on: (i) displacement controlled quasi-static reverse cyclic lateral load test on precast RC hollow core wall (PHCW), and (ii) displacement controlled quasi-static reverse cyclic lateral load test on precast RC wall-column connected through loop bar connection (PWCL). The results of lateral load tests are interpreted on the basis of several key aspects pertaining to RC walls like damage pattern, failure mode, lateral load carrying capacity, stiffness, drift, ductility, response reduction factor and energy dissipation. To compare the effectiveness of precast RC shear walls, numerical analysis of cast-in-situ RC shear wall-column was carried out and compared with the performance of similar precast RC wall-connected through loop bars. The test setup for precast RC walls is shown in Fig. 1.

The proposed wall systems, i.e. precast RC hollow core wall and precast wall-column connected through loop bars, whose effectiveness is demonstrated by examining their seismic performance through displacement controlled quasi-static lateral load reversed cyclic tests in accordance with relevant standards. The experimental results were compared with the numerical results, which showed good agreement between the two. Precast RC wall systems demonstrated ductile behaviour with satisfactory lateral load carrying capacity and deformation characteristics, along with remarkable energy dissipation. The research program concluded the proposed precast RC walls to be promising in terms of strength, speed, economy and execution considerations.

Fig. 1: Test Set-Up for Precast RC Walls

Outcomes:

(i) Precast RC hollow core shear wall system for multi-storey buildings, addressing the issue of laborious handling and transportation in precast construction.

(ii) Loop bar connection for precast RC walls and columns.

(iii) Innovative technological solutions for precast RC shear walls leading to higher level of safety and speed in mass housing.

Development of Efficient Mechanical Anchorage Device for Precast Beam-Column Joint

Ajay Chourasia & S.K. Panigrahi

Objective:

To evaluate the performance of headed bars as mechanical anchorage system for RC beam-column joints.

Progress Highlights:

In reinforced concrete (RC) buildings, the structural performance of beam-column joints is a primary concern, which often does not achieve adequate strength due to poor workmanship. Conventional anchors such as straight and hooked bars which anchor the flexural longitudinal bar terminating at the joint, have many design and construction drawbacks like steel congestion, leading to honey combing in concrete and difficulties in implementation. The headed bars are embedded in concrete within beam-column joint and positioned parallelly such that it is not in contact of each other. The head anchor in the headed bar develops the diagonal compression mechanism. The advantages of headed bar over hooked bar relate to reduction in steel congestion when placed at the desired location, saves construction costs, leads to better concrete consolidation, provides adequate anchorage, offers better bond strength and speed in construction. Various parameters such as head geometry, embedment depth, grade of concrete, grade of steel, spacing between bars etc. influence the behaviour of headed bar in the joints. This report presents extensive experimental investigations and numerical studies on headed bars and other prevalent anchorage systems for RC beam-column joints.

Outcomes:

Plain, grooved and ribbed headed bars for RC beam-column joints.

Comparative Evaluation of Performance of Various Precast Panel & Frame Systems Developed by Various Research Groups for Specified Functionality Test

C. Shermi, Ajay Chourasia & Siddharth Singh

Objective:

To evaluate the thermal performance by measuring the real-time temperature profile of newly constructed different technology buildings at Construction Technology Park, CSIR-CBRI, Roorkee.

Progress Highlights:

The present study evaluates the thermal, acoustic and water tightness performance on a two storey building constructed using different technologies namely precast RC building (3S Precast System) with AAC (Autoclave Aerated Concrete) block infills (Fig. 1); steel building with Rapicon panels as infill (insulated fibre cement sandwich panels); bamboo building (bamboo strips walling) and CSIR-CBRI developed precast building component building using Round Boulder Mortar (RBM)/Stone Concrete Blocks walls.

Similarly, thermal, acoustic, humidity test, ambient and indoor parameters were recorded and analysed for 24-hours over seven days' period for April to June (2019) month (summer season) and November (2019) to January (2020) month (winter season). The temperature variations in AAC block infill walls building shows that maximum temperature inside the building does not exceed 32 ^{o}C and relative humidity (R.H.) 60 percent with no external cooling agents and with no ventilation.

Outdoor indoor noise reduction (OINR) values at frequencies ranging from 100 Hz to 3000 Hz are also noted. The maximum noise reduction for wall, window components is found in the range of 35-40 dBA. The test data showed slightly higher values inside room temperature for a comfort living, in case of no ventilation. With proper ventilation and avoidance of direct sunlight in the room, suitable comfortable condition can be achieved in 3S precast buildings.

The water tightness test was performed firstly by ponding the water on floors/roof, 75 mm deep for 7 days and secondly under a simulated rain fall condition of 210 mm per hour for continuously 5 hours on each face the building, including roof top. The water tightness was examined by superimposing thermal imaging before the rainfall and after 1, 7 and 15 days of rainfall respectively, on different elements and joints of the 3S precast building.

Thermal performance of a building refers to the process of modelling the energy transfers between the building and the surrounding. With the sound knowledge of energy associated with the building, energy efficiency of the building can be improved.

The sound isolation studies carried out on different types of materials viz. AAC block, burnt solid clay bricks, cement fiber board and bamboo building.

Based on the real time measured temperature, humidity, solar radiation finding the thermal comfort of the building is measured as per SP 41, NBC: 2016, ISO 52016-1:2017 and ISO 52017-1:2017.

Based on the extensive functionality tests performed in this research on different building technologies, the systems regarded as functionally efficient building.

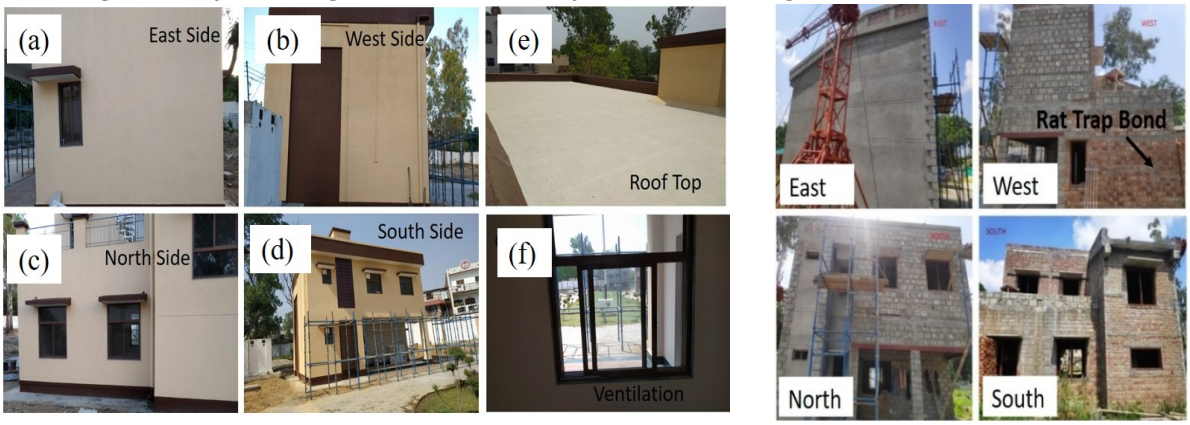


Fig. 1: Directional Faces of AAC & Brick Masonry Building with Rat Trap Bond

Standardization of Designs & Layouts of Prefab Housing Units with Improved Thermal Performance

Sayantani Lala, Ashok Kumar, Seraj Alam, Kishor Kulkarni, Chandan Swaroop Meena & Ashutosh Singh

Objective:

To develop standardized designs of houses using the concept of modular coordination complying space efficiency, climate responsiveness, energy efficiency, disaster resilience and cost-effectiveness.

Progress Highlights:

Standardization can be defined as the process of implementing and developing standards for products or technologies to maximize compatibility, interoperability, safety, repeatability and quality, based on

the consensus of different concerned parties, in order to facilitate the commoditization of a custom process. Hence, this project was conceived to design and develop and promote the use of standardized plans and layouts of buildings, catering to people in different economic baskets like Economically Weaker Section (EWS), Lower Income Group (LIG) and Middle Income Group (MIG), with due considerations to space efficiency, climate responsiveness, thermal comfort and energy efficiency, for the various geo-climatic regions of India.

In order for prefab technologies to be implemented, standardization of the following parameters needs to be done.

- Standardization of dimensioning to promote flexibility of usage of prefab technologies
- Standardization of building plans
- Standardization of modular building components
- Standardisation of thermal properties of building technologies

However, standardization of modular building components are not within the scope of this project. As an outcome of this project, the 50 types of unit and cluster plans are developed for EWS, LIG and MIG houses following modular coordination dimensioning system, where 1 Module (M) = 100 mm. All the provisions of NBC 2016 pertaining to space efficiency have been followed in each of the plans. In addition to these plans, typified designs of flexible housing plans are also developed, for the EWS such that, it is compatible with any prefab/traditional technology following the modular coordination system. Two layouts of LIG multiple housing clusters are also designed.

These plans are analysed in building simulation software, to estimate the optimum orientation and window-wall-ratio (WWR) of buildings for different climates. Daylight studies are conducted to optimize on adequate illuminance in the usable areas of the building plan, thus deciding upon the optimized fenestration areas. The typified standardized details of 19 windows and 8 doors are also developed. Energy consumption studies are carried out to ascertain the most energy efficient building fabric for each geo-climatic zone.

Further, the static and dynamic thermal characteristics have been evaluated for various building envelope combinations for walling and roofing, mentioned in the National Building Code (NBC 2016). With the help of these thermal properties, the internal operative temperature and cooling load of various building plans at different places has been evaluated. For this purpose, the climatic data is taken from Indian Meteorological Department (IMD) and the thermal performance indices are derived by using CIBSE Cyclic (Admittance) method. In addition to this, the dynamic thermal properties of all combinations of building fabric prescribed in National Building Code (NBC 2016) have been derived. Thus, the standardization of thermal performance of the building units is undertaken.

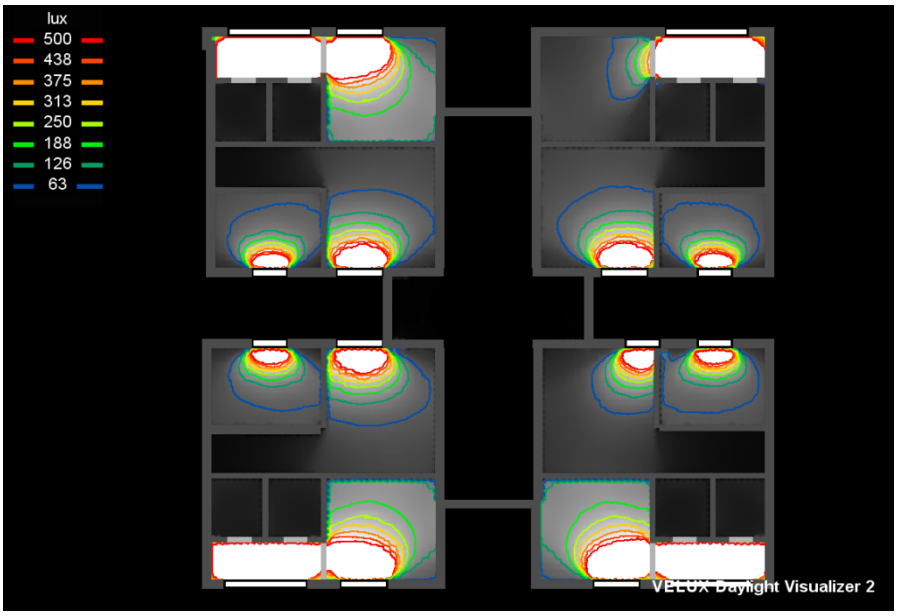
Parametric Studies of Thermal Performance of Building:

The purpose of the building energy simulations is to optimize on the different design parameters of the building, to reduce the energy consumption required for achieving thermally comfortable indoor living conditions. The energy efficiency of the building plans can be improved by optimizing various parameters like Orientation, Shape, Window-to-Wall Ratio (WWR), Useful daylight illuminance, Optimized sizes of sunshades, Material of the building fabric, Occupancy and Lighting etc. Each of the parameters is discussed for their methodology and feasibility of optimization. Only an understanding about how the parameters interact and affect the thermal performance of the building can help in standardization of the designed building plans.

From the analyses, it is inferred that the square building form receives the least amount of heat and hence, is the most energy efficient form. As it is not always feasible to align the building in the

optimum orientation owing to various administrative constraints like building area available, plot boundaries, building bye-laws etc; hence it is advisable to orient the building within a range of the optimum direction in order to achieve a reasonable trade-off with the energy consumption of a building. It has been estimated that an orientation ranges between ±30° will cause an increase of 10% of the energy consumption in the building.

The daylight analysis of a typical EWS house in Velux Daylight Vizualizer Software (Fig. 1). Daylight analysis of a building is important in order to finalize on two parameters: (i) Optimum WWR and (ii) optimum orientation. Hence, a reasonable trade-off between least energy consumption and maximum usable daylight will dictate the optimum orientation of a building, whereas a trade-off between minimum solar heat gain through glazing and maximum daylight penetration will give the optimum WWR for a particular building at a particular place. Since this methodology contains a lot of epistemic uncertainties, it is cumbersome to standardize each plan for each place for optimum orientation and WWR.



Daylight Distribution on 21st June

Fig. 1: Daylight Analysis of EWS House

Thermal Performance Evaluation of Building Plans:

The thermal performance of the building plans is evaluated based on two parameters: (1) Operative temperature (2) Cooling load. The operative temperature is derived from the various combinations of wall and roof combinations of a building plan. The CIBSE Cyclic method which utilises the both the static and dynamic thermal characteristics of the material is used for this purpose. The operative temperature and cooling load of each of the building plans are calculated for 23 cities belonging to different climatic zones of India.

The following inferences are derived from the results:

- AAC consumes approximately 15% less energy than base case.
- LGSF unit consumes approximately 38% less energy than base case.
- Insulated roofing material consumes approximately 7% less energy than RCC roofing unit.

Development of Dry-Construction Technology in Buildings

Kishor Kulkarni, Sayantani Lala & Ashok Kumar

Objective:

To develop Dry Construction Technology for mass housing suiting to provisions of National Building Code.

Progress Highlights:

The dry construction system has been developed to allow rapid assembly of steel frame structures and, equally, their rapid disassembly. Dry construction system is a primary steel structure which is made up of structural hollow sections, which having higher efficiency in resisting compression, bending and torsion in comparison with conventional sections. The application of hollow structural steel sections in building frameworks is limited, as suitable connection configurations have not been developed for hollow structural steel members. The study provided an important understanding of HSS-to-HSS moment connection behaviour, detailing requirements, and failure modes leading to potential beneficial use of HSS in low-rise seismic Intermediate Moment Frame (IMF) and Special Moment Frame (SMF) applications. The present research focuses on development of prequalified connections as per the AISC 358 seismic provision for G+3 storey steel framed building.

The three types of blind bolted beam-column joint connections including prefabricated Connector Element Fitted Connection (CEFC), Flange with Straight Rib Plate Connection (FSRPC) and Collar with Inclined Rib Plate Connection (CIRPC) were experimentally tested under quasi-static cyclic loading. The bolted connection was designed in accordance with Steel Constructional Institute (SCI) and the British constructional steelwork Association design codes. The Hollo-bolt system developed by Lindapter UK were employed in the present study as it represents a widely available configuration and the bolting mechanism does not require any special installation devices. Fig. 1 shows the general configuration of joint specimen and typical experimental test setup of the HSS-HSS beam-column joints tested under seismic loading. The tests were carried out quasi-static by applying cycles of incremental displacement amplitudes. The FEMA 350 (SAC joint venture) loading protocol for seismic moment connections was applied to simulate the seismic loading condition. Based on the experimental test results, moment rotation hysteresis behaviours, stiffness, energy dissipation and ductility properties were evaluated. The detailed Finite Element (FE) analysis is carried out to simulate the connections behaviours and to describe the experimental responses under cyclic loading. The three-Parameter Power Model (PPM) proposed by Kishi and Chen is used to corelate analytical model of the connection moment (M)–rotation (θ) characteristics.

The experimental results for specimens were also compared with the Eurocode 3 to provide the design guidance for the beam-to-column joints.

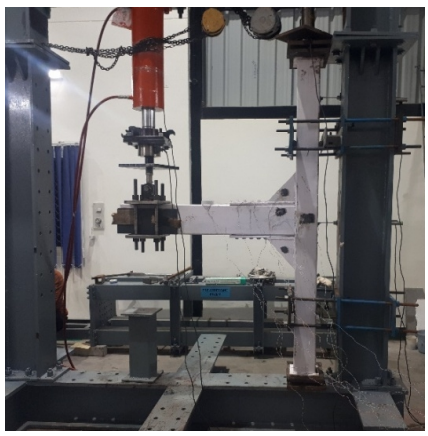


Fig. 1: General Configuration Experimental Test Setup Beam Column Joint

Results & Discussion:

The test results of the specimen on maximum moment, stiffness at yield and ultimate, ductility factor and drift angle are summarized in Table 1. On the basis of the results, all the connections are reached 0.04 rad drift angle which is > 0.04 rad drift ratio specified by AISC 341-16 to qualify connections used in the special seismic force resisting system. The Moment -rotation hysteresis curve for both the beam-column connections are shown in Fig. 2. All the connections, rotation exceeding ± 40 mrad were reached without signs of notable or strength degradation. The energy dissipation ratio obtained as 2.0, 1.75 and 3.58 for CEFC, FSRPC and CIRPC connection type respectively. Fig. 3 shows the failure of te specimens after the testing. The Eurocode 3 model perfectly fits the in-test results with shape factor (Ψ) 0.55 and 0.50 for FSRPC and CIRPC respectively. Fig. 4 shows the demonstration of the Dry Construction Technology in a EWS type house building.

Table 1: Test Results of the Tested Specimen

Connection Type	M_{max} (kNm)	Stiffness at Yield Point (kN/mm)	Stiffness at Ultimate Point (kN/mm)	Ductility Factor (Δmax/Δyield)	Drift Angle (θ facture) (rad)
CEFC	68.45	2.70	2.39	1.13	0.04
FSRPC	83.27	1.57	1.06	1.25	0.05
CIRPC	51.75	1.30	1.07	1.30	0.04

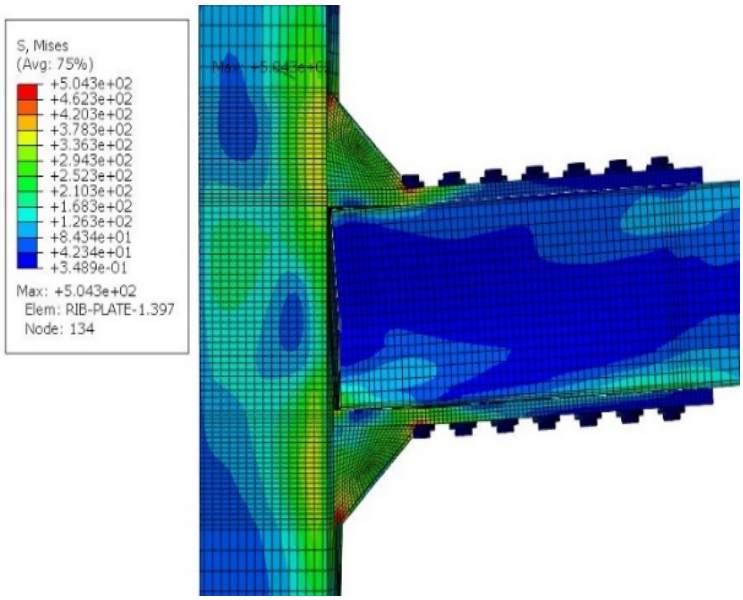


Fig. 2: Moment-Rotation Hysteresis Curve & Typical FE Analysis Model for Tested Joint

Fig. 3: Failure of the Specimens


Fig. 4: Dry Construction System in EWS Type House Building

Outcome:
Dry construction system for mass housing.

Recycling of Agricultural/Industrial/Solid Wastes for Building Infrastructures

Soumitra Maiti, Monalisa Behera, Santha Kumar G. & Neeraj Jain

Objective:
To develop prefabricated value added building products using construction demolition waste, agro-industrial waste (bagasse ash, rice husk ash, etc) and evaluate their performance.

Progress Highlights:
Waste is an unavoidable natural by-product of any natural process on Earth but nature reuses all of its by-products. Human interventions have however, disturbed this balance, by producing toxic and non-degradable wastes. Toxic wastes, if disposed inappropriately and/or dumped illegally; there would be serious risk to health of people and to the ecosystem. Such situations affect the fertility of land and create the environmental pollution also. The issues of sustainability are of prime concerns these days as we use large amount of natural resources for producing materials such as concrete. In fact, the recent ban over extraction of sand from rivers and seabed in India has put the spotlight on the need to recycle, reuse and substitute naturally sourced building material.

In this work, C&D Wastes, Bagasse Ash, RMC Sludge, Rice Husk Ash have been used as construction material to reduce the social and environmental problems against disposal of wastes and depletion of natural aggregate resources.

(i) Development of Building Components using RMC Sludge

Ready-mixed concrete sludge (RMC) is generated from ready-mixed concrete plants during concrete production and is classified as a corrosive hazardous material. If it is disposed of at landfills, it would cause detrimental effects for our surrounding environment and ecosystems due to its high pH value as well as heavy metal contamination and accumulation. The objective of the present research is fabrication of bricks and block by the incorporation of RMC sludge obtained from residue flow of waste concrete and evaluation of the physical and mechanical properties of block and bricks. RMC Sludge was collected from M/S Godrej & Boyce Mfg. Co. Ltd., Mumbai. Physical and chemical properties of RMC Sludge have been determined as per Indian Standard. The properties like specific gravity and water absorption of RMC Sludge vary from natural

aggregate and major chemical constituents in RMC sludge are CaO and SiO_2. A total of nine concrete mixtures were tried for fabrication of two layered interlocking paving blocks of 250 mm x 150 x 100 mm size using RMC sludge as replacement of fine aggregate from 30-50 % at different cement dose. The compressive strength of concrete paving blocks after 28 days of curing were determined which vary from 28 to 37MPa. It depicts that the compressive strength is lower for blocks using RMC sludge content as compared to control specimens and it decreases with increase the replacement percentage from 30 and 50 % by weight of RMC Sludge content. Similar trend was observed for flexural strength, which varies from 3.76 to 4.29 MPa. Cement bricks were also developed using RMC sludge 40-45 % and strength varies from 4 to 9 MPa.

(ii) Optimization of Rice Husk Ash as Replacement of Cement

The objective of the work is to develop prefabricated/light weight value added building components using agro-industrial waste like rice husk ash. Sample of rice husk ash was procured and characterized for physio-chemical properties, XRD and SEM which shows that it micro porous with high surface area and contain more than 90 % of amorphous silica making it super-pozzolalanic material. The XRD shows peaks of cristobalite and tridymite which are polymorph of quartz. Since, mix optimization has been carried out to find out the optimum maximum level of replacement of cement by rice husk ash (RHA) and natural coarse aggregate by recycle concrete aggregate (RCA) to be used for the development of building products. The mixes are optimized by taking RHA at 5%, 10%, 15%, 20%, 25% and 30% on the basis of the compressive strength obtained w.r.t ages. The results of compressive strength show increase w.r.t RHA replacement level of 25% . The influence of the 30% replacement level of RHA on compressive strength shows decrease. From the results, it was observed that the compressive strength increased with the increase in the replacement level of RHA up to 25%. Maximum compressive strength was obtained by the mix 25% of RHA and without RCA. The RCA replacement level has been considered at two different levels such as 50% and 100%. For 50% RCA replacement level, the maximum Compressive strength was obtained with 25% RHA i.e. 53.8 MPa at 56 days. Similarly, for 100% RCA replacement level, the maximum Compressive strength was obtained with 25% RHA i.e. 47 MPa at 56 days.

(iii) Development of Paver Blocks using Recycled Aggregates

Twenty thousand paver blocks of size 200 mm x 160 mm x 80 mm have been casted by replacing natural coarse aggregate with recycle coarse aggregate and used in pavement of mass housing site. These paver blocks are developed by compaction technique and cured under water at 27 ± 2 ?C for a period of 28 days. Different tests of these paver blocks were carried out as per Indian standard. Compressive strength, flexural strength and water absorption of these paver blocks are: 41 MPa, 3.9 MPa and 3.8 % respectively. And these paver blocks can be used for medium traffic purpose as these are satisfying the minimum strength requirements of M-40 grade as per IS: 15658:2006.

(iv) Development of Hollow Blocks Using Rice Husk Ash

The building products such as hollow block of having dimensions of 400 mm x 200 mm x 150 mm has been casted (BIS 2185) using the cement to aggregate ratio of 1:6 ratio. The water binder ratio was maintained at 0.38. The cement was replaced by RHA at its optimized percentage (25%), which was optimized from the compressive strength test results. The hollow blocks have been developed for four mixes with and without RCA and RHA. The blocks are cured under water for 28 days. The properties like block density, compressive strength and the water absorption value have been determined to compare the result with each other and to see the influence of RCA and

the RHA on the properties of the concrete blocks. The dimensions have also been checked. The compressive strength of hollow blocks varies from 6.5 to 10.3 MPa and water absorption was less than 10 %. Followings are the photographs (Fig. 1) of various building components developed in this project.

Fig. 1: Photographs of Building Components developed using C&D Wastes, Baggase Ash, RMC Sludge, Rice Husk Ash

Eco-friendly Corrosion Inhibition to Improve Concrete Durability

S.R. Karade & P.C.Thapliyal

Objective:

To develop corrosion inhibitors for RC from natural plant materials.

Progress Highlights:

Steel reinforced concrete is the most widely used building material throughout the world. Its durability is to be ensured to minimise repairs, casualties and life cycle cost. Corrosion of reinforcing bars is the most critical durability issue, which majorly occurs as a result of chloride attack or carbonation of concrete. This is particularly important for precast RC elements due to low concrete cover. Use of corrosion inhibitors is one of the various techniques, which are employed to prevent and control corrosion. There is a diverse range of commercially available inhibitors based on organic or inorganic substances. Some of them can be deleterious to concrete and can have an adverse effect on the human health and environment due to their toxic nature. Recent studies have shown that use of plant extracts as corrosion inhibitors can be a cost-effective, safe and viable solution to the corrosion problem. This is due to the presence of compounds like flavonoids, alkaloids, and terpenes in the plant extracts, which have high corrosion inhibition efficiency. Few examples of plant extracts that show corrosion inhibition property are Bambusa Arundinacea, Phyllanthus Muellerianus, and Vernonia Amygdalina.

This study is aimed to use natural corrosion inhibitors from various plant extracts and to study the factors influencing their applicability. The results of this study on the new type of corrosion inhibitor

extracted from a natural plant are reported. In this study, the corrosion behaviour of mild steel bars in a saturated calcium hydroxide solution is evaluated using open circuit potential, potentiodynamic polarisation and linear polarisation resistance. Highest efficiency (>92%) were found in Reflux Neem, Eucalyptus and Gooseberry at a dosage of 2%. Corrosion inhibition property of extracts is due to the adsorption of organic compounds on the steel surface, which has led to formation of a uniform film over the steel surface that inhibits corrosion. Addition of extracts has an adverse effect on hydration of cement, which can be countered by using admixtures such as fly ash and silica fume. The envisaged mechanism of corrosion inhibition by these extracts is shown in Fig. 1, while the monitoring of corrosion in extract mixed RC elements is shown in Fig. 2.

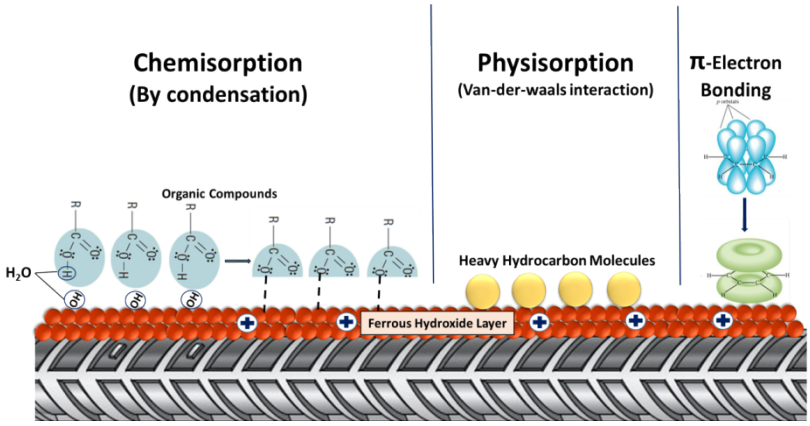
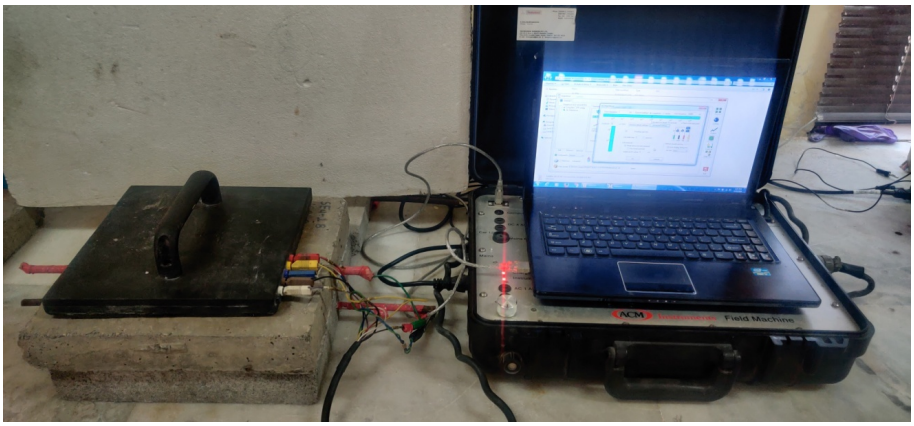


Fig. 1: Proposed Mechanism of Corrosion Inhibition by Extracts



(a) The Setup for Testing of Corrosion in Laboratory

(b) Full-Scale Beam Specimens for Long Term Monitoring

Fig. 2: Corrosion Monitoring of Corrosion Inhibition on Concrete Specimens

Protective Coating for Improved Energy Efficiency in Buildings

P.C.Thapliyal & S.R. Karade

Objective:

To prepare eco-friendly protective coating for RC prefab components with improved performance against corrosion, heat transfer and durability.

Progress Highlights:

The study has been carried out to prepare protective coatings for the RC prefab components with improved performance against corrosion, heat transfer and enhancing the durability. Binding resin is developed by modifying acrylic resin with renewable content and thus reducing use of non-renewable content. Besides addressing the problem of environmentally harmful coatings, care has been taken in the work to enhance and strengthen the existing dominating status of our institute in the area of coatings. It can be inferred that addition of renewable material is influencing the properties of coatings especially in terms of performance evaluation of coatings for corrosion resistance and water resistance. At present, performance evaluation of developed water based coatings is in progress to optimize coating compositions.

Outcomes:

- Seven papers in conferences, one best paper award.
- Coating applied on the outside of a house in the Demo Park (Fig. 1).

Fig. 1: View of Site Pictures from Demo Park

Mechanization in Construction Process of Pre-Fabricated Building Components for Mass Housing

Ravindra Singh Bisht & S.K.Panigrahi

Objective:

To develop mechanized systems for lifting, positioning, placing, and alignment of pre-fabricated building components for mass housing constructions.

Progress Highlights:

The available sophisticated material handling devices like tower crane, truck mounted crane, portal crane, etc. are highly capital intensive, energy-consuming technologies. Builders are using primitive devices like chain pulley blocks and other similar aids for lifting materials. A technological gap,

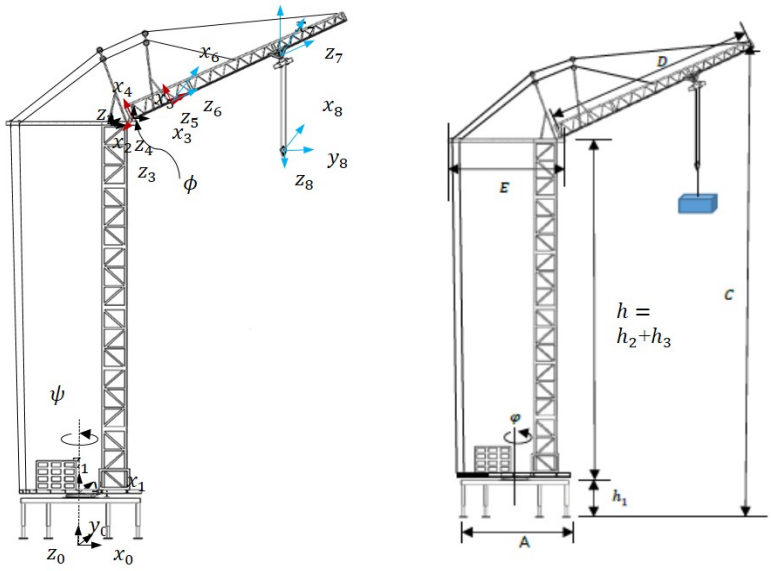
therefore, exists between the sophisticated modern cranes and the on-going age-old traditional methods of material handling, particularly for (G+3) mass housing construction.

Based upon feedback received from various firms and drawbacks of the existing mini-climbing crane, developed by CSIR-CBRI, a new version of affordable mobile crane has been developed with improved design features, with improved design features, covering more workspace with stability primarily useful in the construction process such as lifting, placing and positioning of pre-fabricated building components for mass housing construction. Thus, the new design of the mobile-crane may have versatile applications. Based on the improved design, the developed crane system is cost-effective and portable, along with easy to assemble and dissemble features that are primarily required in site-specific use for ease in shifting from one floor/site to another. The crane is designed based on the concept of modular; therefore, this concept can be scaled up for more height and boom length for high-rise construction without shifting to the floor level. Similarly, the crane design can be scaled down to work in confined spaces.

Results:

(i) Kinematic Model & Workspace Analysis

The mobile crane in Fig. 1 is made of six links viz. base assembly, mast assembly, ring gear assembly, counterweight platform, boom assembly, and hook. The developed kinematic model-based algorithm is used for the derivation of crane workspace, and tip trajectory of the crane hook.



(a) Coordinate frames (b) Geometrical parameters

Fig. 1: Schematic of Mobile Crane for the Development of the Mathematical Model

(ii) Design, Mechanisms, & Analysis

The working model of the mobile crane is designed using Solidworks 3-D CAD software. The design of the mobile crane is modular. Hence, all the parts can be quickly assembled and disassembled with ease to shift from one floor to another. The pole mechanism for the self-erecting of the mobile crane makes the overall crane system very flexible in the construction site. The designed mobile crane for trials has a lifting capacity of 2000 kg at a max loading radius of one meter to a maximum height of about 12 meters. The detailed analysis is performed using finite element model (ANSYS software), and parametric design analysis is carried out using developed MATLAB codings. These results are shown in Fig. 2(a-c).

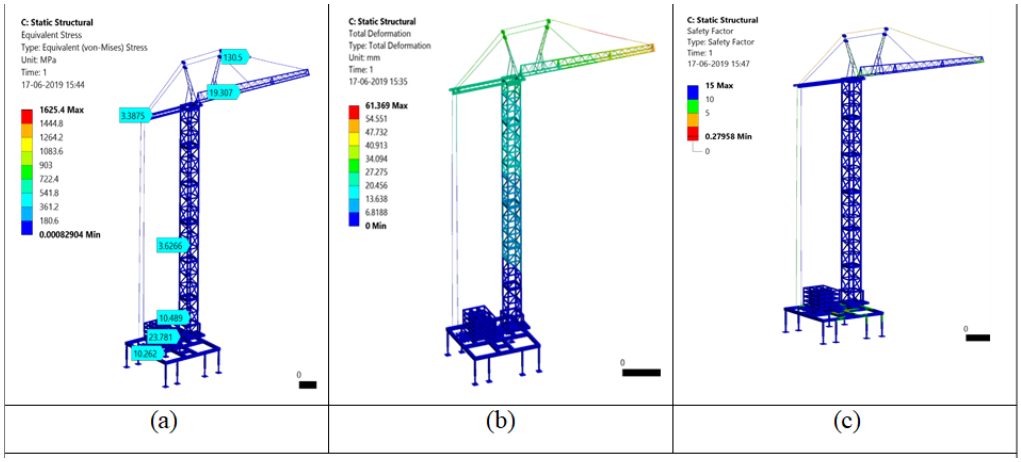
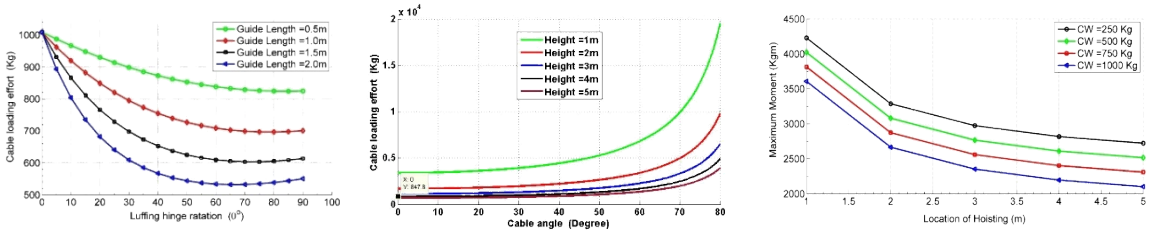


Fig. 2: FEM Analysis of the Newer Version of the Mobile Crane, (a) Stress Analysis of Crane, (b) Deformation Analysis of Crane & (c) FOS Analysis of Crane

Design parameter analysis is used to determine the design parameters that lead to the best performance of the mobile crane using MATLAB programming. For the case of jib-strut design, the optimal design parameters(□ =70□, guide length=2 *m*.) can be seen from Fig. 3(a), similarly for the pole mechanism, the optimal design parameters (height □5 m) can be seen from the Fig. 3(b). Finally, for 2 Ton load capacity, the position (□3-5 m) of counterweight and its balance load (□750-850 kg) can be seen from the parameter analysis shown in Fig. 3(c).



(a) (b) (c)

Fig. 3: (a) Design Parameter Analysis of the Jib-Strut of the Crane, (b) Design Parameter Analysis of the Pole Mechanism of the Crane, (c) Parametric Variation of the Moment about the Ring Gear Axis

(iii) Development & Working Trials of the Mobile Crane

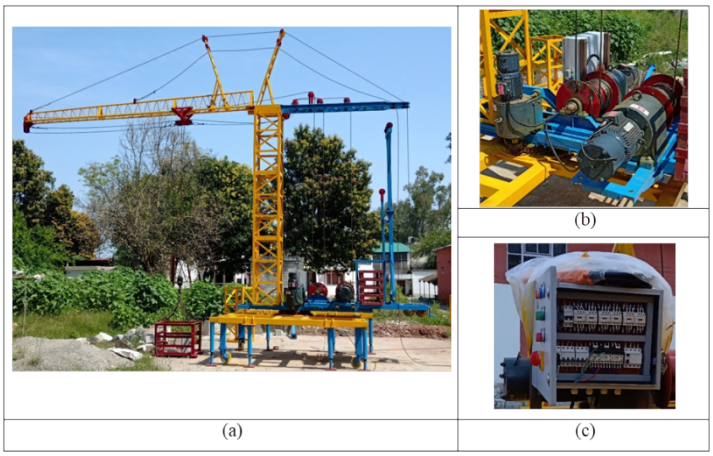


Fig. 4: Instrumented Mobile Crane for Various Motion & Payload Trails, (a) Instrumented Crane, (b) Electric Motors, (c) Control Panel

The affordable modular mobile crane is shown in Fig. 4 is made of several parts viz. (a) complete Mechanical assembly viz. base assembly, mast assembly, counterweight, ring gear assembly, luffing platform, boom assembly, trolley assembly, and chair unit, etc (b) Electric Motors, (c) Control Panel and (d) Remote control. The developed mobile crane employs three motors, one for the hoisting the payload, another for slewing the mobile crane around on the top of the fixed and four wheel-mounted base, and the final one for to-and-fro motion using the trolleying of hoisting load.

(iv) Working Trials & Future Scope of the Work

After the fabrication and assembly of the mobile crane, the instrumented mobile crane is further used for its motion trials and its design validation. Some of the trials, such as trolleying, hoisting, luffing, and slewing motions of the crane, have been successfully conducted and being further explored for self-erecting and payload trials, with full-scale design assembly of the mobile crane and deployment.

Mechanization in Production of Prefabricated Building Components & Wall Plastering for Mass Housing

S.K. Panigrahi & Ravindra Singh Bisht

Objective:

To develop a plastering machine for mechanization in construction process.

Progress Highlights:

Plastering refers to the construction or ornamentation done with plaster, such as a layer of plaster on an interior wall or plaster decorative mouldings on walls. The plastering work involves mortar spraying on the wall, Screeding and finally finishing of plaster. Presently, the plastering is carried out manually standing on scaffolding racks inside and outside the buildings. which are very slow, laborious, expensive and also results in higher social costs due to accidents and improper finishing of plastering of walls. The proposed research is aimed at developing a semi-mechanized system for wall plastering of inside walls of a building. The proposed mechanized system is cost-effective and portable for easy to assemble and dissemble features that is required in site-specific use for ease in shifting from one floor/site to another. The proposed machine for wall plastering is a semi-mechanized one and plaster the walls taking account the drawbacks of available plastering machines in market.

Salient Features of the Developed Machine:

- Portable, easy to transport and install.
- Quick assemble and disassemble features at site.
- Min. wastage of mortar.
- Uniform quality of plastering.
- Less expensive in plastering.
- Semi-mechanized, requires semi-skilled man power.
- Can plaster walls with openings.
- Requires less power.
- Economic and less labor intensive.
- Enhance speed of plastering.
- Can plaster any length of wall.
- Excellent finishing.

Outcome:

The fabrication of all the components have been done in local market and the assembling of the components have been carried out in the institute. The Indian standards are followed in welding and fitting work. The instrumentation of control unit has also been developed and fitted with the developed machine. The dry trials and the full load trials of the machine have been carried out in the institute. The developed machine is semi-automatic type in plastering. The vertical movement of the horizontal frame and the horizontal movement of the tool platform are controlled by a control unit. The up-down and left-right motion of the tool may be controlled by the control unit. The speed of both the motions can also be adjusted as per the requirement and the amount of vertical motion can be fixed using the panel. The horizontal frame moves as per the direction from the control unit. This helps in deciding the thickness of plaster that is required on the wall for the quality of plaster. The limit switches and the proxy switches help in deciding the amount of area to be plastered and overcome the opening area during plastering. Figs. 1-2 show the path planning of the tools for wall without openings and wall with opening.

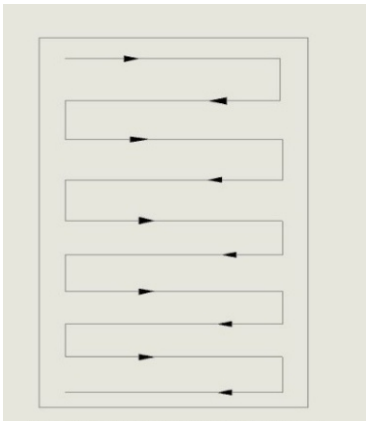


Fig. 1: Path Planning without Wall Opening

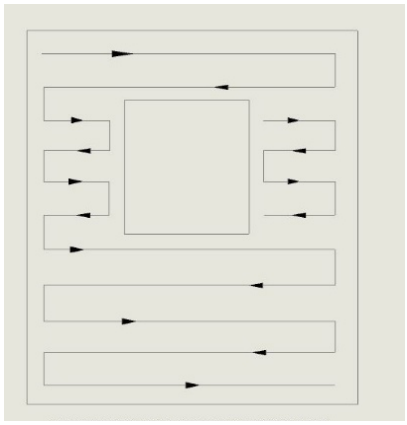


Fig. 2: Path Planning with Wall Opening

Field Trials:

First dry trials have been carried out to see the movement of various tools and the working of the control unit. The machine has been checked for smooth running of all drives for vertical and horizontal movements of the tool supporting platform. The created noise from chain drives and other parts are checked and proper lubrication has been done. Other problems faced during the trial runs have been rectified.

Fig. 3: Putting Sand & Cement Mixer in Mortar Spraying Unit

Full load trials have been done with mortar 1:4 successfully. For this, sand and cement with above ratio have been weighed. The materials have been put inside the Mixer of the Mortar spraying Unit as shown in Fig. 3. Suitable amount of water has been added in the mixer to give a very uniform smooth

mix. As per the instruction from the Mortar spraying unit catalogue, the hosepipe is first cleaned with cement slurry to avoid chocking inside the pipe. The machine is mounted in-between the floor and the roof as shown in Fig. 4. The mortar has been conveyed to the Spraying nozzle through the inbuilt screw pump and the spraying nozzle was mounted on the tool platform. The platform followed the path assigned and sprayed mortar on the wall. The wall with sprayed mortar is shown in Fig. 5. Next screeding operation has been done and finally the finishing operation has been carried out with the power trowel. The finished plastering is shown in Fig. 6.

Fig. 4: Plastering Machine in Working

Fig. 5: Sprayed Mortar on Wall

Fig. 6: Finished Plastered Wall

Design Interventions for Enhancement of Robustness in Traditional Construction, Numerical & Experimental Investigation

S.K Negi & Ashish Pippal

Objective:

To develop robust technologies for traditional constructions in hilly regions of India.

Progress Highlights:

India has a rich vernacular architecture; however, now days it is losing its style slowly due to development of modern construction technologies. Through this project, the factors which are affecting people to use these technologies are identified and are:

- They are economical
- Age old proven
- Utilises local material and manpower, and
- Easily repairable

Locally available materials, problems were identified and S&T interventions were suggested to construct a robust structure using the locally available materials. The suggested S&T interventions are then evaluated using construction of a demonstration building which are not just cost-effective but are also less time consuming and are maintenance free. The houses to be constructed shall be durable (min. 30 years), resistant to local hazards like earthquakes, cyclones, winds, rains, floods etc, require

very low maintenance and shall provide healthier and better living conditions. It is further envisaged that the scheme shall create employment opportunities and shall disseminate better construction practices in the rural fabric.

The S&T interventions also have been suggested in many of the states through PMAY-G, and thousands of rural houses using the same interventions have already been constructed in many of the states. Odisha is one of the states where using the S&T interventions of CSIR-CBRI, Panchayati Raj Dept. has constructed thousands of houses under PMAY-G and Biju Pukka Awas Yojna, very interestingly the houses constructed using our suggestions have survived Faini cyclone very effectively without any sign of damage. A small Technology Demonstration Park also has also been created at SIRD Bhuwaneshwar depicting all the suggestion made by CSIR-CBRI for Odisha state, and it has been made mandatory for all engineers and administrators of Odisha Govt. working in the rural area to visit this demonstration park at least once.

Outcomes:

(i) Typified house designs, appropriate building materials and components and right construction practices for various zones like the coastal flood and cyclonic zones, alluvial plains and river valleys, rocky mountains, remote and inaccessible tribal villages and the black cotton soil areas of the State.

- Rural Technology Park constructed by PR dept. using help of CSIR-CBRI at Bhubaneshwar to help their engineers and administrators understand the technologies for rural housing sector. Refer Fig. 1-2 for various stages of construction of rural park.

Fig. 1: Rural Technology Park-Layout

Fig. 2: Rural Technology Park

- 30-30 engineers and administrators of PR dept were given training at CSIR-CBRI in order to create a force of master trainers to train other engineers and administrators of the state.
- A demo house has been constructed in CSIR-CBRI campus, in which majority of above mentioned technologies have been used with a view to assess the real time functionality of the technologies. Fig. 3-5 represents different construction of demo house at CSIR-CBRI.

Fig. 3: Completed Demo House-Plastering Work in Progress

Fig. 4: Plastering Work in Progress

Fig. 5: Demo House

(ii) The bamboo construction techniques in which bamboo connections based demo construction has been displayed at CSIR-CBRI Technology Demonstration Park. Three structures are being built at Harda dist. (M.P.) for MP forest dept. (sponsored by MP State Bamboo Mission). Major challenges in the construction of structures at Harda are;

- Black Cotton Soil
- Heavy Rainfall
- Sudden wind pressure due to nearby railway track
- 14 m long truss without intermediate supports
- Unskilled labors

A demo house is also constructed at CSIR-CBRI, in order to showcase what we have gained by working on this task under mass housing project. The model as well as actual demo house has been shown through Fig. 6-8. The salient features of demo house are as shown in Table 1.

Table 1: Salient Features of Bamboo Demo House

TECHNOLOGY	FEATURES
• Treatment of bamboo (Boucherie process) • Improved bamboo joints • Protection of bamboo from moisture • Protection of bamboo walls by improved ferro cement treatment • Improved structurally sound bamboo trusses wall frames, built up columns • Use of bamboo corrugated roofing sheets bamboo ply and bamboo board	• Designed for protection against seasonal flooding upto 45 cm, high winds, earthquake safety (Zone 5) • Protection against fire hazard • Environment friendly • Bio-degradable materials being used that result in low CO_2, low energy and use of local materials • Durability improved upto 4 times

Fig. 6: Model (Skeleton) of Bamboo Demo House

Fig. 7: Bamboo Demo House

Fig. 8: Bamboo Demo House

Design of Confined Masonry Construction using Different Types Units (Concrete Masonry Block, ACC Block)

Ajay Chourasia & C. Shermi

Objective:

To develop innovative masonry units for CM, evaluation of cost-effective and seismic resistant retrofit scheme for CM and seismic evaluation of CM building constructed using novel masonry panels.

Progress Highlights:

Most of the low-rise buildings in India, are of unreinforced masonry (URM), which is known for its poor seismic performance. The brick masonry construction in India shows a large variability as compared to those in developed countries. These contrasting differences pose challenge and call for improved technologies for masonry construction. The Confined Masonry (CM), comprising of masonry panels embraced with light reinforced concrete elements, is expected to have better seismic performance. Limited numbers of tests were performed to understand seismic behaviour of scale-down three-dimensional CM buildings, elsewhere in the world, none in India. Little information in literature about seismic behaviour and design features of CM building, with no such attempt in India, urges to address the gap in holistic manner. Moreover, research on retrofitting techniques for CM is scarce, which calls for extensive experimental investigations to propose effective retrofit measure for CM. Another issue to be addressed is the development of lightweight panels for CM, for an efficient and seismic resistant CM system. This study presents characterization of masonry and its constituents with reference to available materials, extensive experimental investigations and numerical studies on Confined Masonry building constructed using different type of units and its retrofit technique.

Phase one of the research program involves material characterization of conventional burnt solid clay units, AAC units and newly developed Round Boulder Mortar (RBM) units. Correlation is developed for masonry units, such as Compressive strength involving Modulus of Elasticity and Shear Modulus involving Modulus of Elasticity. The material properties of former units were compared with burnt solid clay units along with the cost comparison. RBM units have superior physical properties as compared to burnt solid clay units and AAC units.

Second phase of the research program consists of seismic evaluation of retrofitted full-scale CM building. Six different retrofitting techniques: Plastic Cement Bag Mesh (PCBM), Nylon Mesh (NM), Polypropylene Band Mesh (PBM), Industrial Geo-grid Mesh (IGM), Welded Wire Mesh (WWM) and Chicken Mesh (CHM) were evaluated in form of masonry prisms and wallets and most effective one is further used to strengthen damaged CM building. The strengthened building is subjected to quasi-static lateral loading at the roof level. The effectiveness of strengthening is assessed by comparing failure pattern and seismic performance of the Strengthened Confined Masonry building (CM_ST) with its original counterpart (CM) and other previously tested masonry building systems such as Unreinforced Masonry (URM), Unreinforced Repaired Masonry (URM_REP), Reinforced Masonry (RM), and Reinforced Strengthened Masonry (RM_ST). The CM_ST building performed well, with an increase in lateral strength, displacement capacity, stiffness, ductility, drift and energy dissipation capacity, along with minimum structural damage, among all the tested buildings.

Third phase of the research program evaluates seismic performance of full-scale CM building using innovative lightweight cellular (LWC) panels, under displacement controlled quasi-static reversed cyclic lateral loading. The structural behaviour of CM building using lightweight cellular (LWC) panels is studied in terms of crack pattern, load carrying capacity, drift, ductility, stiffness and energy

ratio. Experimental results are validated numerically using ABAQUS, which is FEM based software. The CM building showed excellent behaviour without any significant damage, thus the system can be adopted for construction of low-to-medium rise buildings, providing speed, sustainability and economy.

Outcomes:

Round Boulder Mortar (RBM) Units:
Round boulders in RBM units having three times higher density as compared to AAC units. The water absorption capacity for RBM unit was observed to be 5.56 %, which is reduced by 88.6 % as compared to AAC unit. Compressive strength of RBM unit was found to be approximately five times higher as compared to AAC units. From cost comparison, it was found that the cost for RBM units was reduced by 12 % and 40 % with respect to AAC and burnt solid clay units respectively. Moreover, burnt solid clay bricks lead to air pollution due to their manufacturing process which includes firing, while RBM units involves eco-friendly manufacturing process, thus preventing environmental pollution.

Performance of CM Building using Light Weight Cellular (LWC) Panels & Foam Concrete (FC) Panels
Lightweight LWC and FC panels facilitating rapid construction and easy to construct methodology. Single storey and two storey CM buildings with the proposed LWC panels are favourable for all the seismic zones, while three storey buildings may be acceptable up to zone IV. Fig. 1 shows the experimental and numerical damage pattern of CM building using LWC panels.

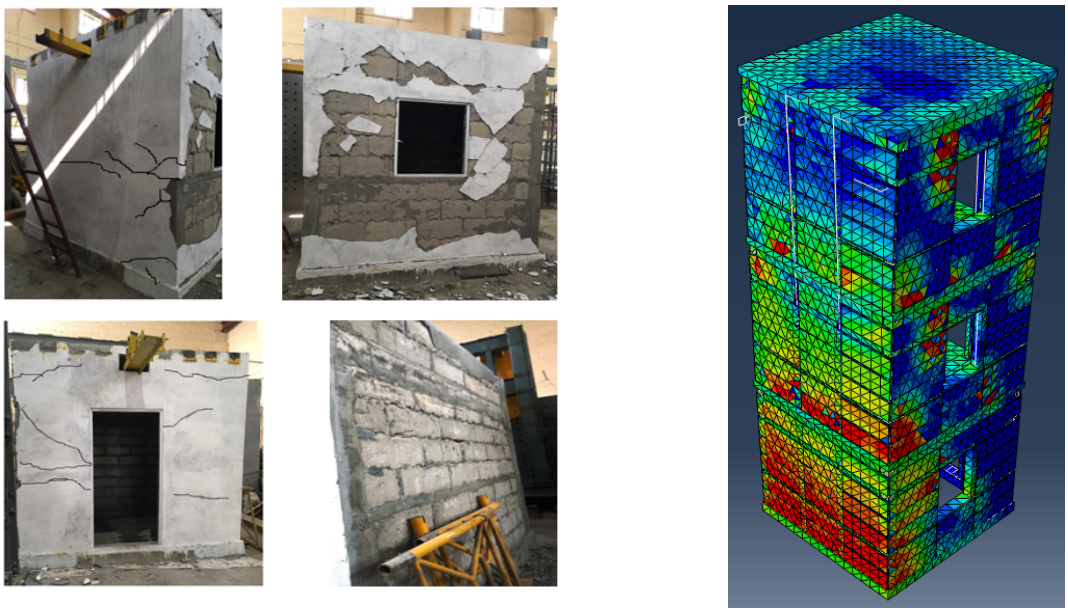


Fig. 1: Experimental & Numerical Damage Pattern of CM Building using LWC Panels

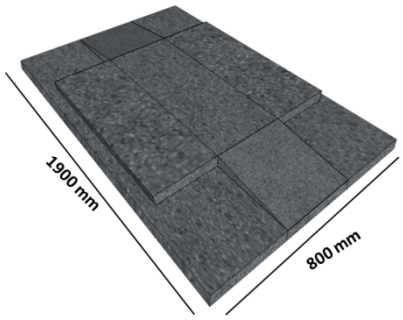
- Round Boulders Mortar (RBM) units.
- Retrofitting technique using Plastic Cement Bag Mesh (PCBM) for masonry buildings.
- Light Weight Cellular (LWC) panels as walling units for masonry buildings.
- Confined masonry building using AAC/foam concrete panels.

Improvement in CSIR-CBRI developed Prefab Technologies

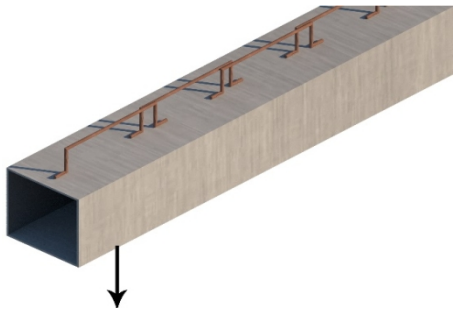
Objective:
Development and modification of CSIR-CBRI developed roofing/flooring technology for utilization as prefab building component.

Progress Highlights:
CSIR-CBRI has developed several pre-fabricated construction technologies such as RC Plank and Joist, Channel Unit, Brick Panel, L-Pan, Pre-Cast Lintel and Chajja, and Pre-Cast Staircases. These technologies have already been demonstrated in lakhs of houses across India. Under this research project, the drawbacks on RC Plank and Joist System, are identified and rectified them for further utilisation by the society.

Outcomes:
Upgradation of RC Plank and Joist system and the demo house construction. The upgraded RC Plank and Joist system can be utilised both manually as well as using machineries. Step-by-step modification and casting of RC plank and joist has been documented in Fig. 1.



Modified RC Plank



Modified Steel Joist

Oiling of Mould for Casting

Casting of Plank

Modified Plank

Fig. 1: Construction of Modified Plank and Joist

A house is constructed having a foundation of Under-Reamed Pile (double bulb), a total area of 102 sqm (G+1), bamboo reinforced, and confined masonry. The building is an energy efficient building. The salient features of the building are:

- Geothermal Cooling and Heating
- Evaporating Roof Cooling System
- White Glazed Tiles on Roof
- Wall Sprinkler (Cooling)
- Glass Tile (Natural Light)
- Solar Tube (10” Dia.)
- Solar Panel

- Solar Water Heater
- Rainwater Harvesting (Ground Recharge)
- Bricks made up of Desert Sand
- Roof of modified Plank and Joist

The Fig. 2-5 show the different stages of construction.

Fig. 2: Columns with Bamboo Reinforcement

Fig. 3: Construction using Desert Sand Bricks

Fig. 4: Placement of Precast Staircases

Fig. 5: Placement of Plank & Joist System

Ground Improvement Technique to Mitigate Liquefaction Hazards for Safe Building Construction

S. Ganesh

Objective:

To assess the liquefaction and re-liquefaction susceptibility with and without ground improvement techniques.

Progress Highlights:

Soil liquefaction and its associated ground failures during earthquake is one of the major potential hazards in recent years. The important aspect of geotechnical earthquake engineering is to mitigate liquefaction and its associated effects for assuring the safety of foundations.

The present study aims to assess different ground improvement techniques for liquefaction mitigation and to evaluate the efficiency of stone columns and encased stone columns reinforced ground subjected to independent and sequential acceleration conditions. Uni-axial shaking table tests is performed on poorly graded sand with varying density levels subjected to different acceleration conditions. For experimental investigations, tank having of size 1.4m × 1m × 1m is used. Ground having 0.6 m depth has been prepared using wet sedimentation technique with 40% and 60% relative density. For soil reinforcement, stone columns and encased stone columns having area replacement ratio 2.67%, 5% and 9.6% are selected for the study (Fig. 1-3).

The prepared ground is then subjected to independent and repeated incremental sinusoidal acceleration loading of 0.1g, 0.2g, 0.3g and 0.4g simulating medium to very high earthquake magnitude. In addition to acceleration loading, shaking time also plays a major role in initiating liquefaction and reliquefaction behaviour. Hence, the entire acceleration loading is applied for a period of 40s with a total 200 sinusoidal cycles. For repeated loading, the acceleration loading is applied sequentially to the model ground after complete dissipation of excess pore water pressure generated from previous acceleration loading. The variation in soil density, maximum generated excess pore water pressure, soil displacement and foundation settlement at each acceleration loading was monitored continuously and compared with and without ground improvement techniques (Fig. 4). Using PLAXIS 3D Finite element program, experimental test results are validated and parametric studies are performed. From combined experimental and numerical results, the efficiency of soil reinforced ground under independent and sequential seismic loading conditions are assessed.

Fig. 1: Test Assembly for the Shake Table Test on Saturated Sand Reinforced with (a) Ordinary Stone Columns (b) Encased Stone Columns Area Replacement Ratio (2.6%)

Fig. 2: Test Assembly for the Shake Table Test on Saturated Sand Reinforced with (a) Ordinary Stone Columns (b) Encased Stone Columns Area Replacement Ratio (5%)

Fig. 3: Test Assembly for the Shake Table Test on Saturated Sand Reinforced with (a) Ordinary Stone Columns (b) Encased Stone Columns Area Replacement Ratio (9.6%)

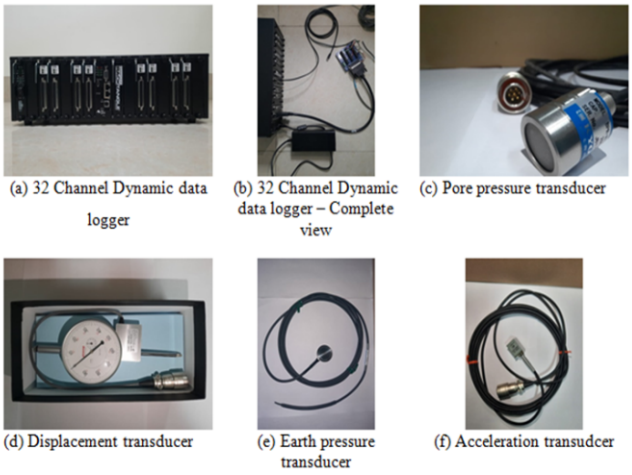


Fig. 4: Instruments used for the Study

Conclusions:

Based on the results from the present investigation, the following conclusions are drawn:

(i) The liquefaction and reliquefaction resistance of untreated soil deposit depends on past input motion characteristics and its shaking duration. Also, occurrence of reliquefaction increases with the increase in subsequent acceleration loading.

(ii) Installation of ordinary and geosynthetic encased stone columns effectively reinforce the liquefiable deposits and make resistant against liquefaction compared to other ground improvement techniques.

a. When stone column improved ground subjected to repeated acceleration loading; intrusion of surrounding soil reduces drainage characteristics, induce generation of pore water pressure and affect column performance.

b. In case of encased stone column, provision of geosynthetic encasement confines the stone aggregates inside the column, prevents column deformation and controls clogging. This resulted in effective load carrying capacity and drainage characteristics even under repeated loading events.

(iii) The experimental study verified that, provision of proper drainage is highly required for improving liquefaction resistance. To mitigate liquefaction and reliquefaction, the ground improvement technique should have a combination of densification and effective drainage system. This will help in improving the efficiency of ground improvement technique in liquefiable soils especially under repeated earthquake conditions.

Ground Improvement using Granular Pile Anchor Foundation (GPAF) System

Pradeep Kumar & K. Pandit

Objective:

To develop a holistic scheme for design and construction of a granular pile anchor foundation (GPAF) system.

Progress Highlights:

Rapid urban and industrial growth demands more land for further development and increasing infrastructure growth in urban and metropolitan areas has resulted in a dramatic rise in land prices and lack of suitable sites for development. In order to meet this demand land reclamation and utilization of unsuitable and environmentally affected lands have been taken up. Structures constructed on soft soils may experience problems, such as excessive settlements.

Few ground improvement techniques, though costlier, are popular in the present-day practice - earth walls, stone columns, soil nailing, deep grouting, dynamic consolidations and many more. At the same time, adopting these techniques, civil engineers may convert weak grounds to behave as per the design requirements for providing foundations with adequate safety. Granular Piles (GP) are installed in a variety of ways to reinforce, densify and facilitate easy drainage in the ground. In addition, they mitigate the liquefaction-induced damages in case of loose saturated sands in seismically active zones and increase the stability of embankments founded on soft ground. It has been reported in published literature that installation of a granular pile anchor foundation (GPAF) system (Fig. 1) can significantly improve the engineering behaviour of the loose sandy soil and soft clay. The proposed technology of GPAF system is a robust, easy to construct and install at site.

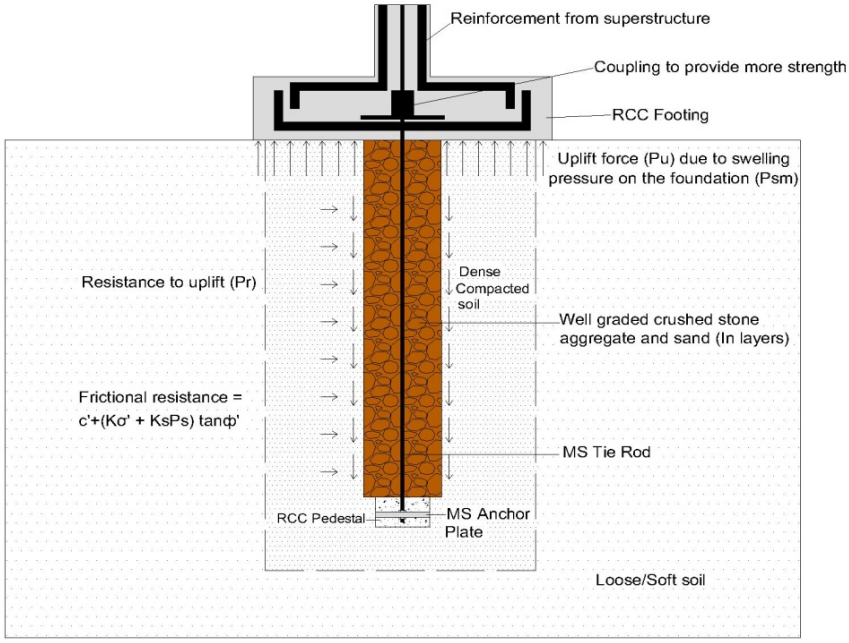


Fig. 1: A Granular Pile Anchor Foundation (GPAF) System

The proposed project envisages the widespread use of a GPAF system for a sustainable built-environment for safer housing and infrastructural activities with improved design life, particularly in the poor site subsoil deposits. Numerical validation of a published research paper on GPAF system against the uplift load, and modification in original GPAF system has been done so as to increase the total uplift capacity of the GAP with same dimension. The Parametric study of total 24 different models GAP (varying length from 0.25 m to 3 m and dia. 0.1 m and 0.2 m) against the uplift loading in loose sand profile is done. The results thus obtained are then compared with the conventional GPAF system and significant improvement is found. Two optimum pile models have been selected from the numerical study to analyse the interaction of GPAF system with soil experimentally. Regression analysis of more than 50 pile models of various diameters (i.e. 0.1 m, 0.2 m, 0.3 m, 0.4 m

and 0.5 m) are carried out to obtain the equation to predict the value of uplift capacity of GAP for given dimension.

The results thus obtained are then again validated with the analytical formulas, which are obtained from available literature. A complete study is performed for the application of GPAF system for the Solar panel Industries. The benefit cost ratio of the GPAF system is also carried out to put the light on the economic perspective of the suggested models. The study for further moved to analysing the behaviour of both the conventional and modified GPAF system in compressive loading (Fig 2-3). Parametric studies of 24 GAP models have been performed. The results reveals in overall degradation of compressive load which could be due to the replacement of granular material with the surrounding bars in modified GAP.

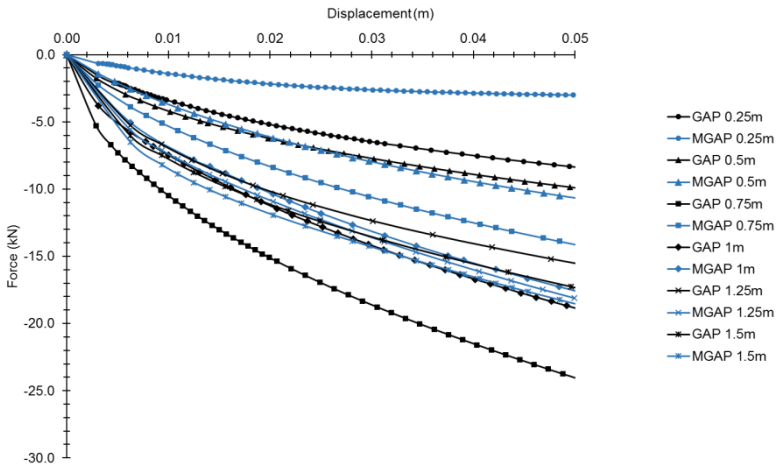


Fig. 2: Compression vs. Settlement for Dia. = 0.1 m

The uplift load behaviour of the modified non-encased GPAF system in sandy soil is shown for such system with 100 mm diameter and different depths in Fig. 3:

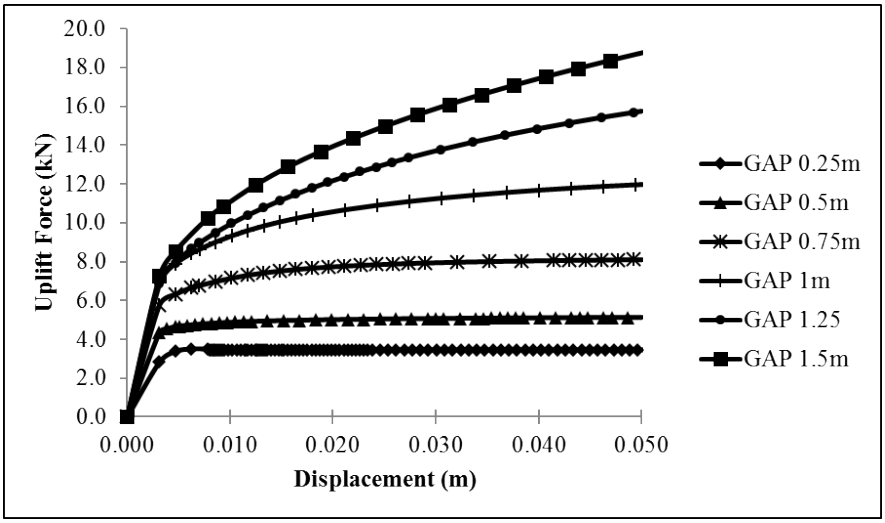


Fig. 3: Uplift Load vs. Displacement Graph for Diameter = 0.1 m for a Modified GPAF System in Sandy Soil

Outcome:

Comparison of compression load capacity a normal GAP and the modified GPAF system.

Static and Seismic Response of Piled-Raft Foundation

M. Samanta, Dinesh K. Malivya & Vaibhav Mittal

Objective:

Development of design methodology of piled raft foundation.

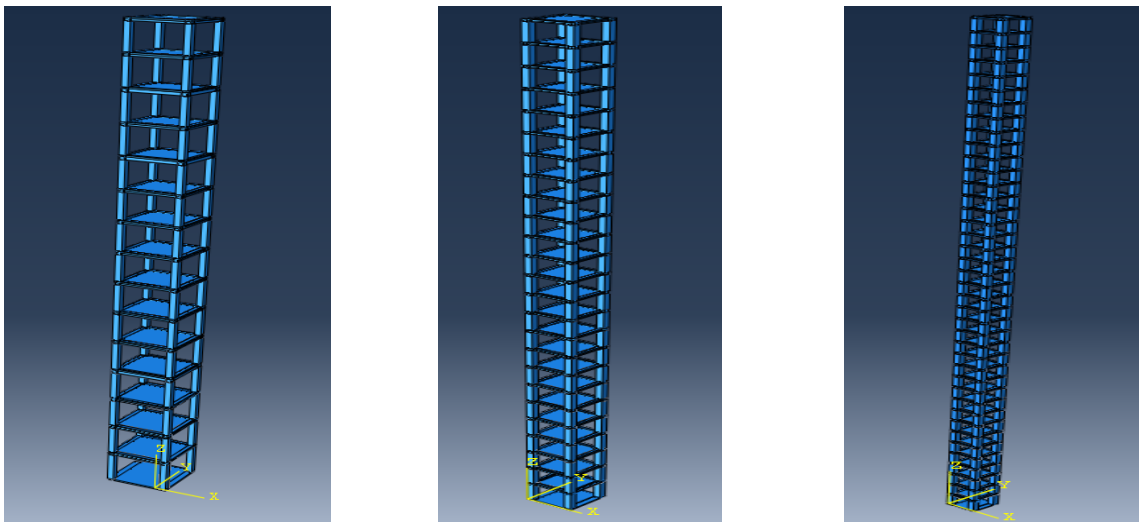
Progress Highlights:

The construction of large infrastructural facilities and tall structures, performances of conventional shallow and deep foundations are found to be conservative under heavy load and seismic conditions. In recent decades, a concept of piled-raft foundation has been developed which is economical and resilient. In a piled raft foundation system, the load coming from the superstructure is partly shared by the raft through its contact with the soil and the remaining load is shared by the piles through skin friction and end bearing. Total resistance of piled raft is cumulative of resistance of shallow component i.e. raft and deep component i.e. pile accounting different interactions among component elements. Large variability in stiffness and geometry and different interactions among the component of piled raft i.e. pile, raft and soil establish it as a unique and complex foundation system. This plays very important role in seismic soil structure interaction of foundation, soil and structure.

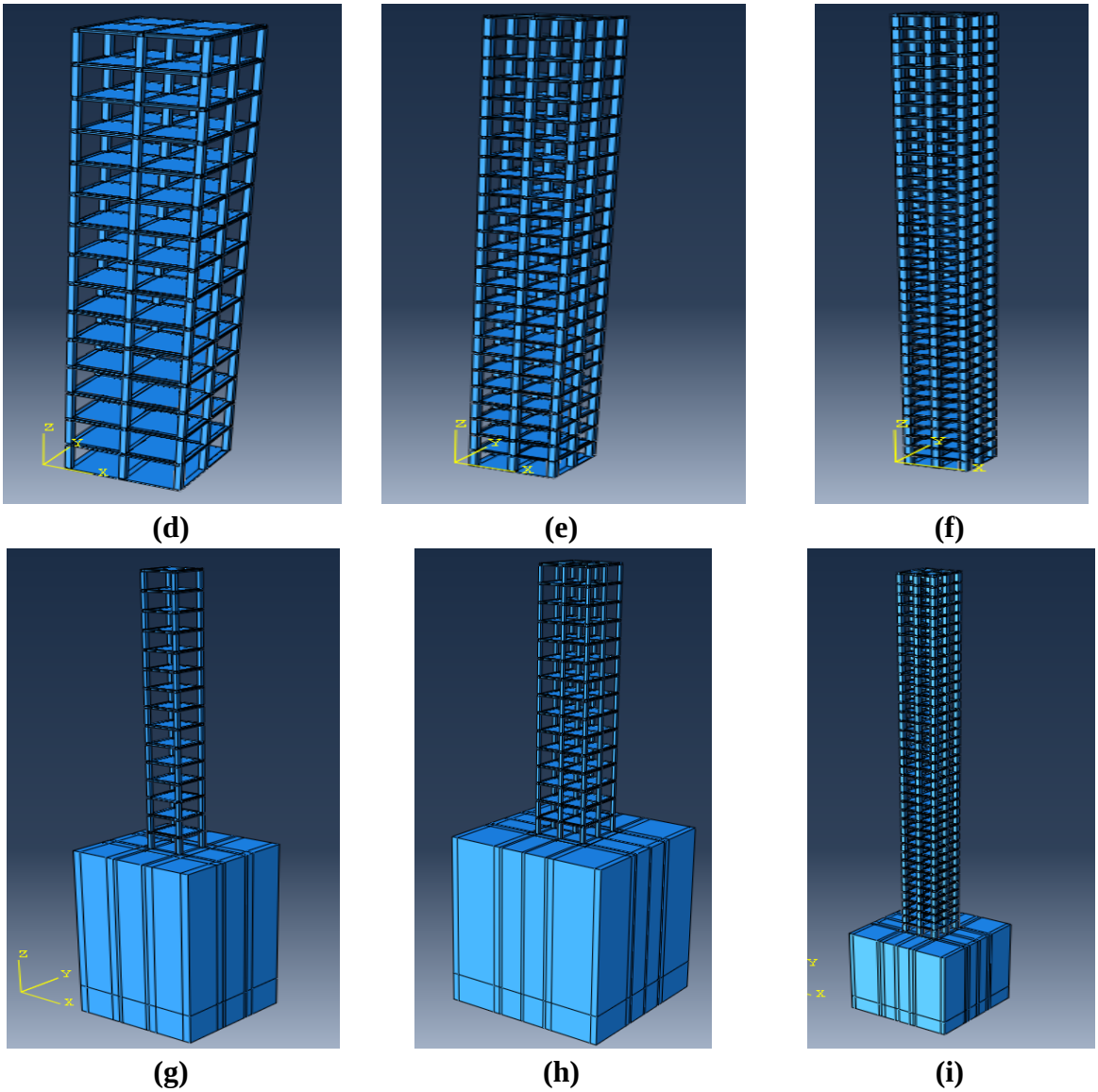
The present study focuses on developing static and dynamic design methodologies for piled raft foundation system. Details of different load sharing and settlement estimation methods along with relative advantages, limitations and importance of different parameters and estimation procedure are discussed here. Different micro details i.e. load sharing ratio, observed settlement, pile and raft details of successful published cases of piled raft foundation around the world are also listed here.

Model test has been performed to study the load sharing and settlement behaviour of piled raft foundation under static and dynamic conditions. Also, finite element simulations have been performed considering wide variation of soil variability. The results obtained are in good agreement with the existing literatures. Tests are also performed in seismic conditions using in house uniaxial shake table. Variation of inter storey drift and displacement for different multi-storeyed buildings supported on fixed and flexible bases of pile and piled raft foundation has been studied through finite element simulations. A parametric study has been performed considering a wide range of practical parameters encountered in the field. Results of the present study are helpful in understanding the different aspect of static and seismic behaviour of piled raft foundation (Fig. 1).

Outcome:



(a) **(b)** **(c)**



(d) **(e)** **(f)**

(g) **(h)** **(i)**

Fig. 1: Different Numerical Model used for Analysis

Table 1: Details of Earthquake Data Used

Parameter	Elcentro, 1979	India Burma, 1988	Loma Prieta,1989	Northridge, 1994	Kobe, 1995	Bhuj, 2001
Peak Ground acceleration (g)	0.438	0.284	0.322	0.344	0.598	0.106
Magnitude	6.6	7.2	7	6.4	6.9	7
Hypocentral distance (km)	27.12	210.1	18	9.5	1	239
Bracketed Duration* (sec)	11.22	19.26	15.18	17.08	13.04	27.67

Table 2: Increment in Top Storey Drift among Different Buildings due to SSSI

		% Increment in drift due to SSSI effects					
Number of Storeys	No. of Bays	Elcentro, 1979	Kobe, 1995	India Burma, 1988	Loma Prieta, 1989	Northridge, 1994	Bhuj, 2001
15	1	54.40	109.07	472.61	71.81	61.41	103.66
	2	35.26	134.68	310.10	61.90	39.59	90.24
	3	8.83	79.45	144.79	9.47	30.93	81.88
	4	4.85	47.36	68.86	10.33	46.60	97.25
25	1	4.52	95.04	19.77	3.92	10.25	53.03
	2	88.58	393.25	80.09	176.32	41.56	81.75
	3	6.85	43.74	177.84	230.04	379.33	64.04
	4	13.73	97.95	815.48	26.56	126.30	72.40
40	1	54.90	34.85	63.26	14.67	25.26	36.03
	2	87.67	148.43	117.76	57.56	93.49	245.04
	3	22.28	86.23	67.88	112.15	130.66	175.76
	4	31.60	2.98	33.08	153.93	301.88	29.12

Numerical analysis have been performed using finite element package such as Abaqus and PLAXIS 3D (Table 1 & 2). Finite element analysis of piled raft foundations shows the efficacy of its load sharing and settlement behaviour. Significant amount of load has been shared by the pile and raft in piled raft foundation system. This will help in designing a more economical and efficient structure. Different soil conditions ranging from loose soil medium to stiff soil medium were adopted during the simulations, which will help in development of modified design methodology for piled raft foundation in real time field conditions. Also, different soil stiffness ratios, pile spacing, raft geometry, raft thickness were considered for comparison with actual field foundations.

Design & Strengthening Measures for Building Foundation Systems in Hilly Regions

K. Pandit & S. Sarkar

Objective:

To provide design solutions for suitable foundation systems for housing in hilly regions as well as strengthening measures for their improved stability.

Progress Highlights:

Foundation aspects are complex, especially in a hilly region due to its sloping profile, varying geo-strata conditions, difficult geology and unconventional geotechnical challenges often encountered by the builders. Seismic characteristics of hillside buildings could be very different from similar buildings on flat terrains, significantly depending on the foundation systems and load transfer mechanism from the superstructure to the sub-surface load bearing strata. Hence, no identical foundation design can address all the issues pertaining to the foundation problems for buildings in hills (Rautela et al., Current Science, vol. 99, no. 4, 2010).

The present activity proposes an inclusive geotechnical solution package for the design and stability of building foundations as well as of the safety of construction sites in different geological conditions for housing in hilly regions. There are many design requirements that foundation structure need to

meet in order to perform its function adequately and serve its purpose. For instance, it should be strong enough to minimize differential settlement and should be able to safely support and transfer combination of various loads like dead load, live load, environmental load, and exceptional loads such as strong earthquakes to the subsurface soil layer. The proposed task deals with most of the above aspects presented and seek for a holistic research solution. The scope of work of the project are:

- To assess stability of building foundations in hills,
- To estimate the effect of foundation size, its location and load intensity on stability (factor of safety) of slopes,
- To provide strengthening measures for soil/rock mass for safety and stability of building foundations, and
- To develop a design guideline for foundations in hilly regions.

The adopted methodology is shown in Fig. 1. A comprehensive database has been prepared by collecting field data for existing problems in foundations for buildings in hills (composed of only soils, soil-rock mix or rock slopes). This database also includes an extensive field and laboratory test results conducted for characterisation of the foundation media (soil/rock) by various practitioners and researchers. The numerical models have been developed upon validation against published studies to increase confidence level in the conducted studies. The comprehensive parametric study includes different shallow foundation types (isolated and strip footings) and important design parameters. Further, some unique foundation solutions/technologies like the combination of bracing systems of buildings with engineered design of shallow foundations, ground improvement etc. have been investigated for EWS building plans prepared by CSIR-CBRI regarding mass housing. This provides an optimal solution of foundation problems. Finally, design guidelines have been formulated based on the local geology and geotechnical aspects for foundations in hilly regions.

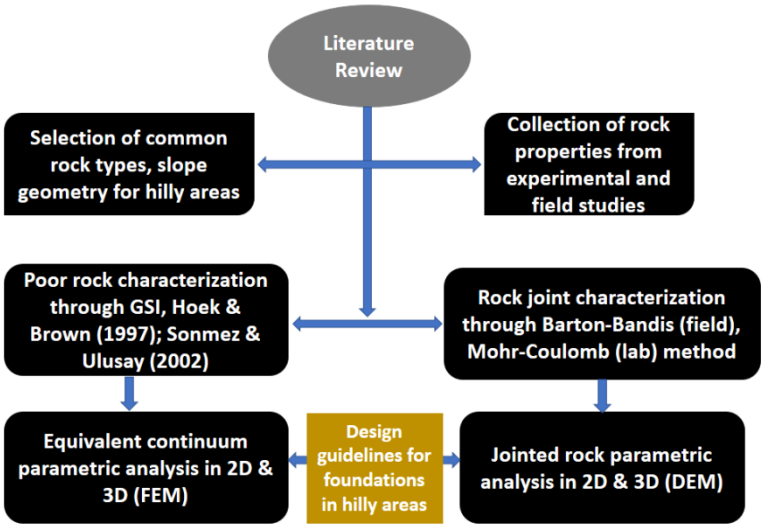


Fig. 1: The Adopted Working Methodology

For foundation analysis, a total of 13 EWS (Economically Weaker Section) building plans proposed and published by CSIR-CBRI have been considered. All these plans have been structurally analysed for earthquake zones IV and V, which are the prevailing conditions for the hilly regions in India. Staad Pro v8i, a structural analysis and design software widely used to analyse and design structures for bridges, towers, buildings, transportation, industrial and utility structures, has been utilized for the present study. The RCC frame structures of all these 13 plans are analysed by applying earthquake loading as per IS: 1893 (Part 1) and footing reactions are obtained at each column end. Out of all the possible load combinations, the maximum footing reaction is selected for further analysis.

For the present study, the seismic bearing capacity factors such as N_{cE} , N_{qE} and $N_{\gamma E}$ have been computed from their correlations with internal friction angle of slope material for computed horizontal seismic coefficient for a given earthquake zone of study and a slope angle, α selected. These bearing capacity factors are then substituted in the recommended bearing capacity equations to find the seismic bearing capacity of the shallow foundations. In this study, typical soil parameters like the unit weight and shear strength parameters have been evaluated after studying characteristic sample values from different locations in the state of Uttarakhand, especially from the hilly areas.

It is often found that the sloping hilly terrain consists of layered strata that are soil layer of 1 to 5 m (usually) at top, a debris (soil-boulder mix) or weathered rock mass at middle and bedrock underlain. Hence, it is required to study the shallow foundations resting on such layered strata in slopes and to determine the corresponding bearing capacities. The present study deals with such scenarios. For current slope stability analysis, the whole finite element model is divided into three layers, layer 1 that consist of 10 m thick soil whose material properties are derived from the available literature on the geotechnical properties of soil (Fig. 2).

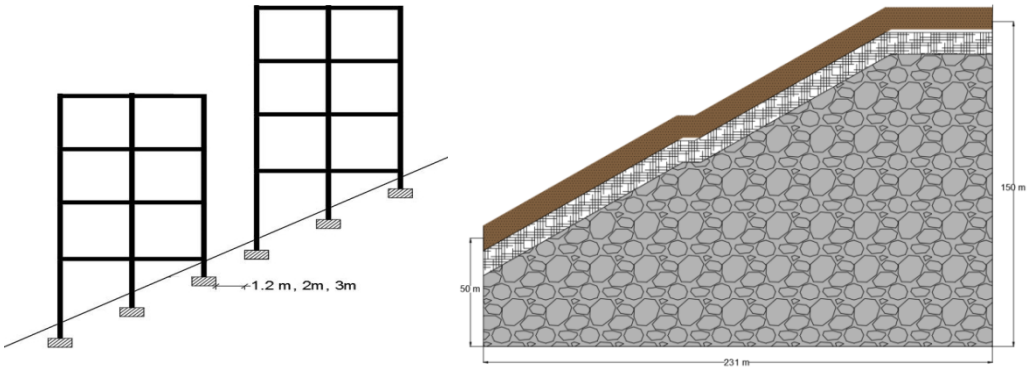


Fig. 2: A Representative Building Cluster with Different Offset Values & the Layered Hilly Strata

The stability evaluations of slopes with foundations on it have been analysed and the corresponding bearing capacity also determined in the present work so that the design of foundations can be carried out from the design charts.

Results:

- The load vs. displacement curves for 20 and 30 degree sloping terrains for layered geo-strata are shown in Fig. 3.

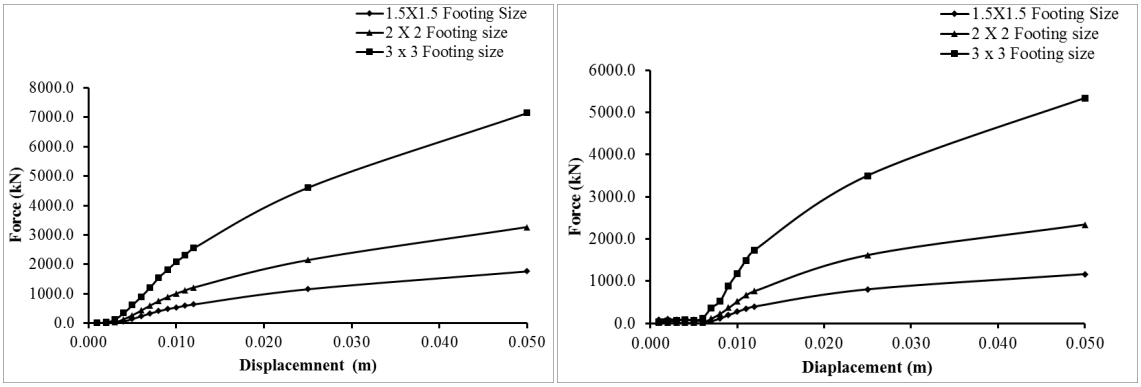


Fig. 3: Load vs. Displacement Curves

- It is observed that the X-type bracing system is useful to increase the rigidity of the structure and it helps to reduce the inter-storey drift and storey displacement in the structure. It is observed that steel bracing system is economical and effective measures for RC multi-storey buildings in hilly areas. X type steel bracing system distributes load efficiently on the footing and hence decreases the cost of foundation.
- For 30° slope angle the percentage decrement in footing load observed in EWS-1 is 7 %, EWS-2 is 10 % and EWS-3 is 11 %. The percentage reduction in footing load for 45° slope angle was observed to be 8 % for EWS-1, 17 % for EWS-2 and 5 % for EWS-3.

Outcome:

- Design guidelines for foundations in hilly regions.

Development of Innovative Hybrid Connections for Precast Concrete Construction

S.R. Karade & R.S. Chidambaram

Objectives:

- To develop an effective and economical hybrid connection technique using fiber reinforced composites and mechanical splices at the joints in pre-cast framed structures.

- To investigate the effectiveness of the hybrid connection in transmitting the forces at beam-beam, column to column and beam-column joints subjected to static as well as cyclic loading.

Progress Highlights:

The developed rebar coupler for different rebar diameters were used for making RC beam specimens and tested under static loading. Similar size of beam specimens with threaded couplers were also used for examining their effectiveness and compared with the performance of the hybrid rebar coupler-enabled beams. Fig. 1 shows the comparative load deflection graph.

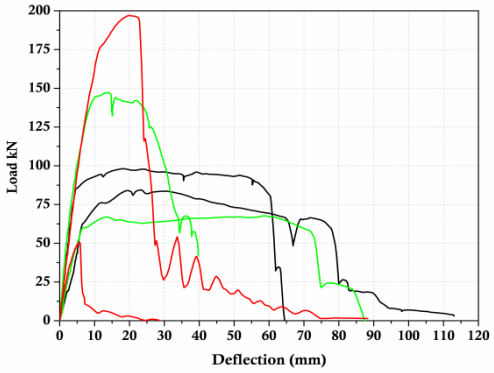


Fig. 1: Load-Deflection Curves under Static Loading

The developed couplers have been used to connect different precast elements and tested under tension and cyclic loading. Fig. 2 shows the static tension and cyclic tension test.

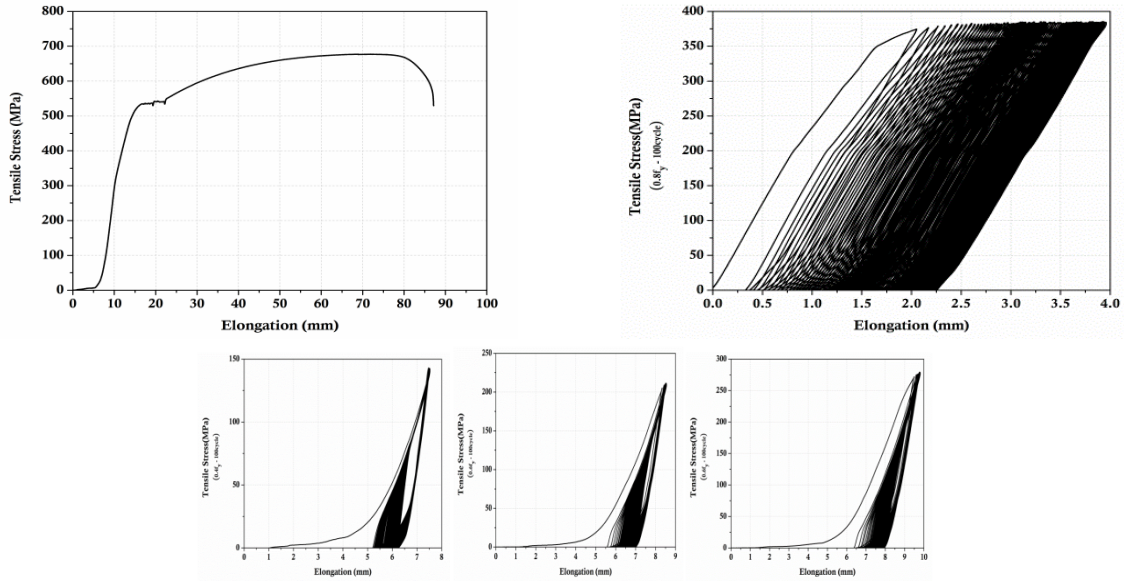


Fig. 2: Static & Cyclic Tension Test on Rebar Couplers

The precast beam to column joint section has been prepared with different configuration and with the proposed connection techniques, in which the precast column specimen was cast separately and beam was cast separately and kept curing for 28 days. After proper curing, the specimens were connected together using the proposed connection technique as shown in Fig. 3. The specimens were then tested under cyclic loading. Fig. 4 shows the beam column joint test setup.

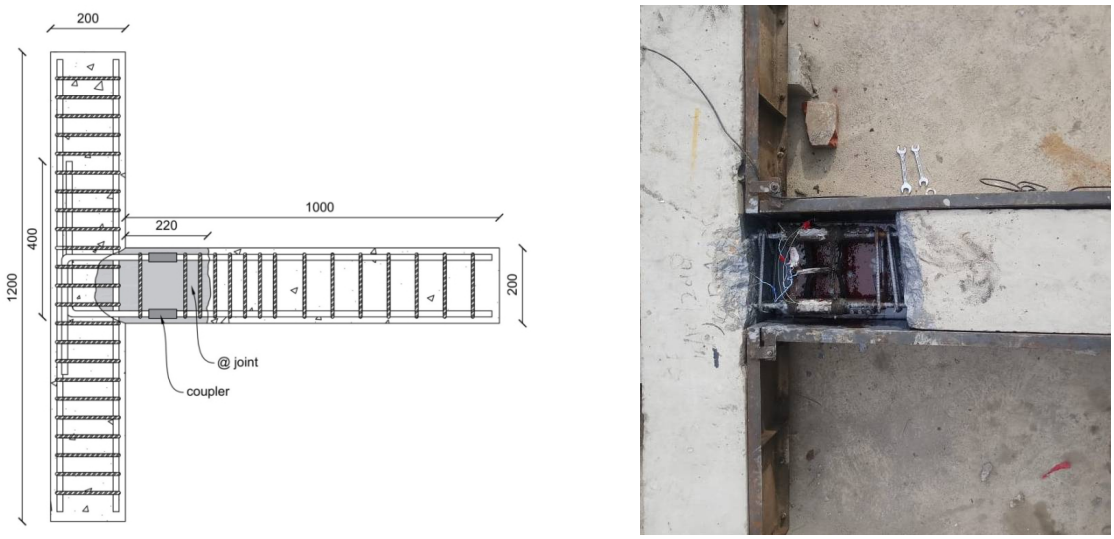
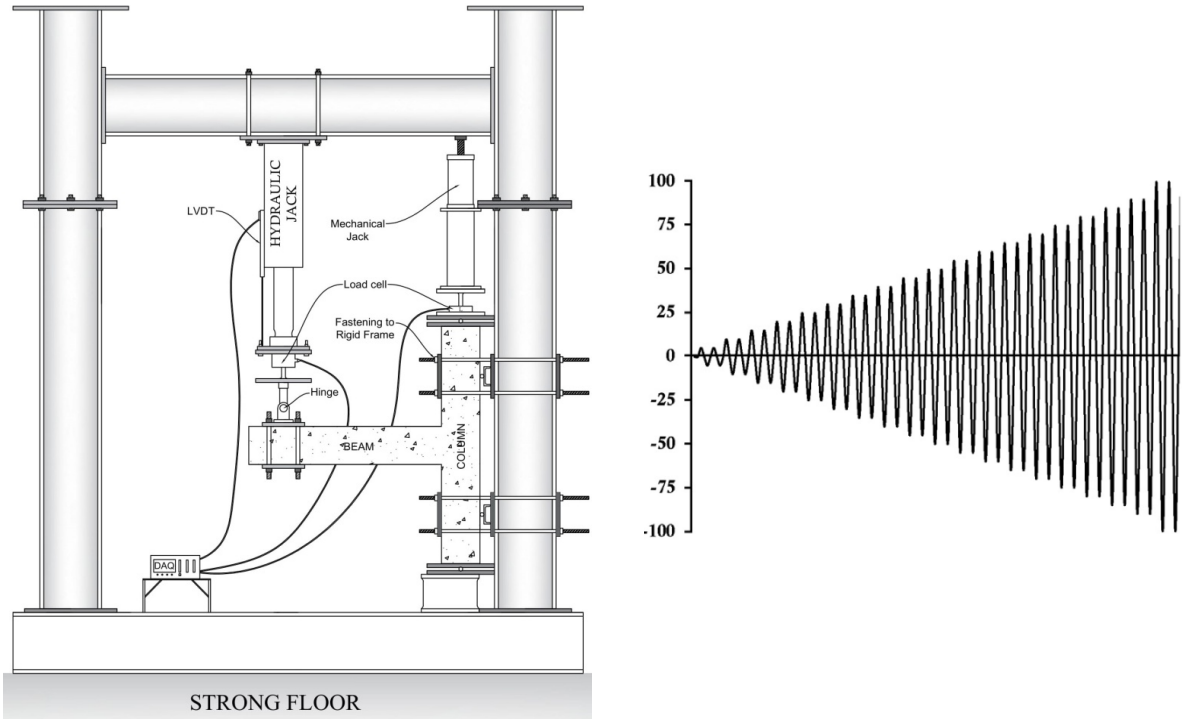


Fig. 3: Beam-Column Connection

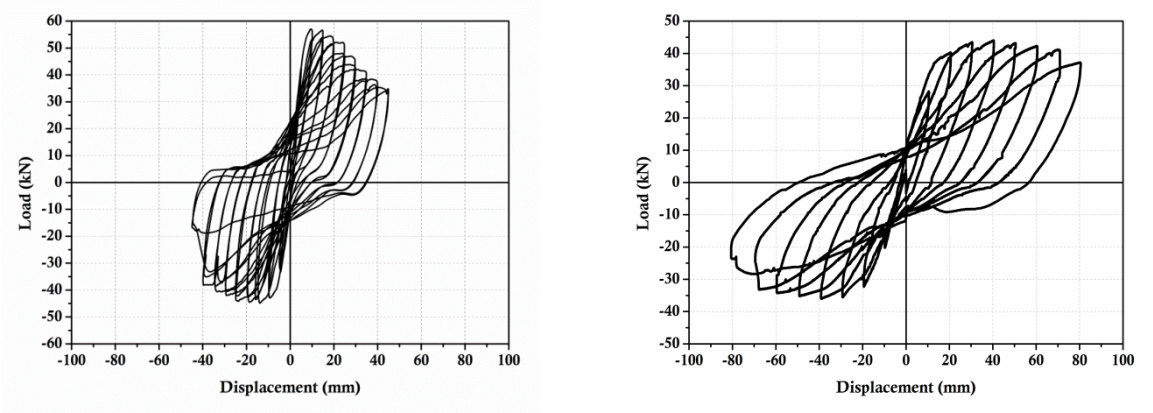


(a) **(b)**

Fig. 4: (a) Test Setup (b) Loading Protocol

In order to compare the performance of the developed precast connection, a connection, being currently used in construction practice, has been tested and the performance has been compared. Fig. 5 shows the comparative hysteresis behaviour. It shows that the CSIR-CBRI developed

connection works well in lateral load resistance and offers better inelastic behaviour than the joints in practice.



(a) **(b)**

Fig. 5: Hysteresis Curves (a) In Practise (JMP) (b) CBRI Tech

CONSERVATION OF HERITAGE STRUCTURES

Technologies for Robust Structural Health Monitoring of Critical Infrastructure & Conservation & Restoration of Heritage Structures

Mission Director: Dr. N. Gopalakrishnan

Mission Coordinator: Dr. Achal Kumar Mittal

Envisioning the burning need for the conservation of heritage structures in India, CSIR had taken up this Mission Mode Project on Heritage Structures. CSIR-CBRI, Roorkee being actively involved in several live projects of Heritage Conservation took lead as a Nodal Laboratory along with other six laboratories of CSIR.

List of Tasks at CSIR-CBRI:

- Classification & Categorization
  - Classification of Important Heritage Structures & Extracting Superior Features of Indian Traditional Knowledge of Building Science
- Structural Analysis & Restoration Technologies
  - Simplified Analysis Procedure for the Complex Heritage Structural Systems
  - Geotechnical Investigation of Foundation Systems
  - Structural Restoration & Retrofitting Techniques for Heritage Structures
  - Analysis of Heritage Structures: Pre & Post Retrofitting
- Non-Destructive Evaluation
  - Hybrid Non-Destructive Evaluation Techniques & Signal Processing Algorithms for Multi-Wave Imaging
  - In-Accessible Foundation Studies of Cultural Heritage Sites using Non-Invasive Techniques
- Environmental Aspects
  - Identification of Fungi on Select Heritage Structure & Development of Suitable Anti-Fungal Chemical from Medicinal Plants
- Material Development
  - Conservation & Restoration of Lime Mortars & Brickworks
  - Development of Compatible Repair Materials for Stone Masonry in Heritage Structures
- Skill Development Program
  - Skill Development, Upgradation & Training Program for Field Engineers, Technical & Non-Technical Manpower

Progress Highlights:

1. **Classification of Important Heritage Structures & Extracting Superior Features of Indian Traditional Knowledge of Building Science**
   A.K. Mittal*, Hina Gupta, Debdutta Ghosh & Amit Kush

   - There is no comprehensive database of the heritage monuments at one platform available in India. The developed database includes: significance, architectural features, construction

period, structural systems and issues, material and related issues, earthquake zone, wind speed, previous restoration constructions, sculptures, carvings/ motifs and inscription/text.

- Different search categories accessible to tourists, researchers and conservators, etc.
- The superiority features book, first of its kind, formed by accumulation and compilation of:
  - Distinct features of architectural styles and its specifications,
  - Extensive knowledge of ancient construction techniques,
  - Technique of selection of unique materials and intelligent use of them.

An Indian heritage structures database containing the structural and other information has been developed in the association with ASI.

2. Simplified Analysis Procedure for the Complex Heritage Structural Systems

Debdutta Ghosh*, Hina Gupta & A.K. Mittal

Conservation of our historic heritage and restoration of historical structures necessitates a great effort of different expertise (structural, architectural, historical, etc.). There are many challenges for understanding the behavior of historical structures under gravity and seismic loads, usually of architectural importance. Historical structures have very complex load carrying behavior due to the massive and interaction of domes, vaults, arches and pillars.

- Different modelling strategies have been adopted in this study for the modelling of complete heritage structure or the part of the structure
- It is found that the approximate analysis is capable of providing accurate results than the computationally intensive detailed modelling
- Equivalent frame modelling can be effectively used for regular opening structure
- Mazars modelling approach proved to be efficient method for obtaining the failure surface in stone masonry structure.
- Applied element modelling approach also shows promising results for the modelling of brick masonry structure (Fig. 1(a)).
- A software application is developed for circular arch systems (Fig. 1(b)).
- The software is capable of analyses the stability of the arch under gravity as well as concentrated vertical loading.

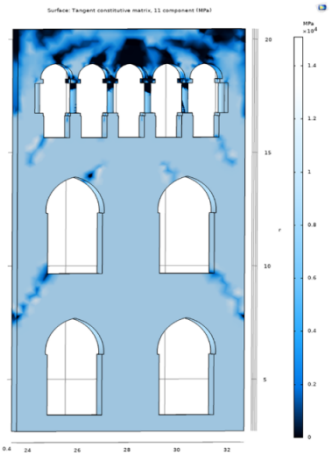


Fig. 1(a): 3D Damage Model

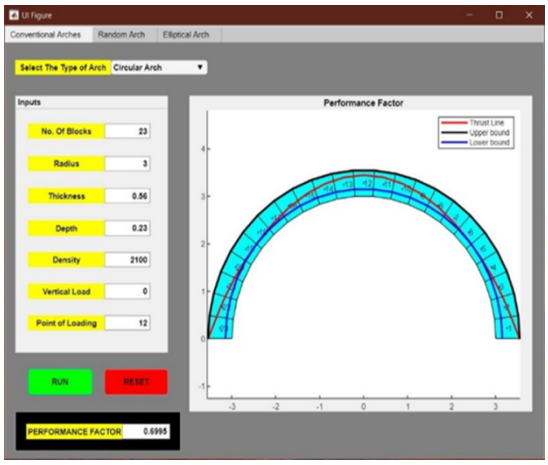


Fig. 1(b): Developed GUI of the Computer Program

3. Geotechnical Investigation of Foundation Systems

Aswathy*, M. Vinoth & A.K. Mittal

In this project, predicting the settlement induced by tunneling/excavation on soils below existing structures and adopting suitable measures to mitigate the settlement is undertaken using numerical and analytical/empirical methods (Fig. 2).

- Effect of depth of tunneling in clayey soil is carried out for depth varying from 12 m to 30 m (7 cases).
- Back-calculation of design parameters of tunneling using field data (DMRC).
- Parametric studies to study the zone of influence and effect of surcharge on tunneling in silts (18 cases).
- Ground improvement to mitigate settlement due to construction activities (3 cases).
- Settlement profile of tunnel progress has been plotted and shown in Fig. 3.

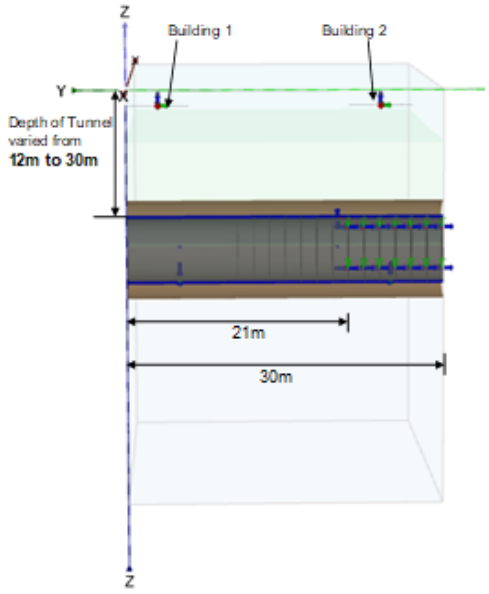


Fig. 2: Numerical Model

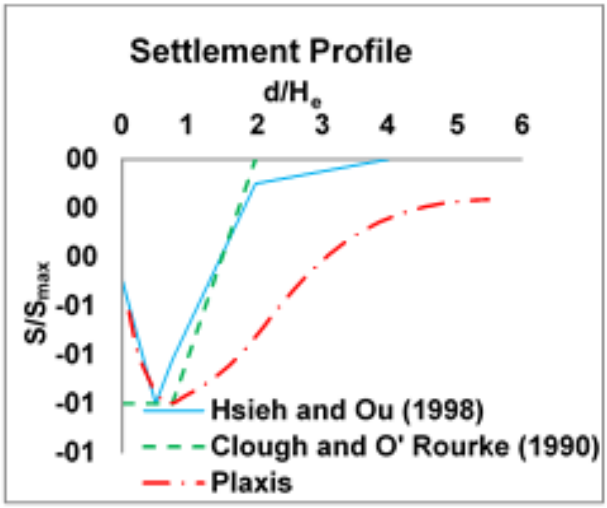


Fig. 3: Settlement Curves

Settlement prediction due to tunnelling/ excavation was undertaken for live DMRC projects

4. Structural Restoration & Retrofitting Techniques for Heritage Structures

Hina Gupta*, Debdutta Ghosh & A.K. Mittal

Several strengthening strategies (CFRP based techniques) have been applied to the brick masonry wallet (Fig. 4) and their performance has been evaluated in a laboratory-based setup.

- Dry stack archers are constructed and its performance is evaluated under static and dynamic loading. A testing setup in the form of modified diagonal testing system to assess the engineering parameters of the masonry as well as to evaluate the performance of the strengthening techniques
- State of the art testing and monitoring testing facility for heritage and masonry structures have been developed at the laboratory.
- A manual suggesting the repair and strengthening techniques for heritage structure have been prepared

- Monitoring of heritage arch and wall have been performed using the fibre optic based FBG sensor
- VWSG based monitoring strategy have been adopted for the monitoring of Shree Jagannath Puri Temple

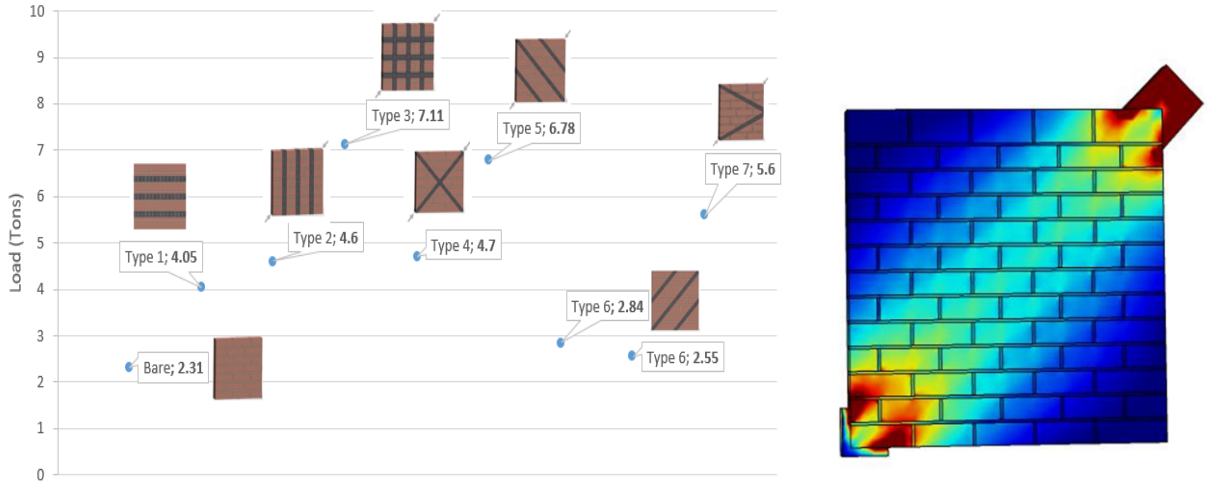


Fig. 4: Performance of FRP Retrofitted Masonry under Diagonal Compression Tests

Development of Novel Experimental Setups for Heritage Structural Testing

Developed laboratory based full scale testing techniques for Heritage Structure (Fig. 5). A full-scale dome structure has been constructed with cement-lime mortar to resemble the historic properties. Diameter of dome is 3 meters a height of the structure is around 4.5 meters (Fig. 6).

Fig. 5: Masonry Arch Settlement Setup

Fig. 6: Full-scale Heritage Structural Model

Continuous monitoring have been perfumed with the data obtained from the Vibrating Wire Strain Gauges (VWSG) installed for the monitoring of box portal frame installed in Shree Jagamohana of Puri Temple and the results are shown in Fig. 8.

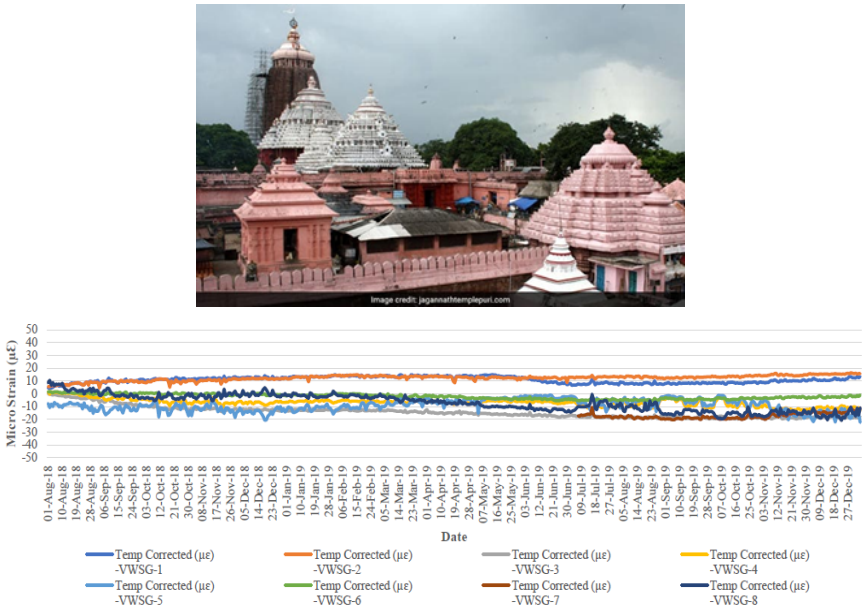


Fig. 8: Variation of Strain in Box Portal Steel Frame of Jagamohana at Puri Temple

5. Analysis of Heritage Structures: Pre & Post Retrofitting

Siddharth Behera* & A.K. Mittal

A detailed manual has been prepared on the analysis of various repair and strengthening strategies for heritage buildings. The manual covers broad understanding of various types repair and strengthening techniques/strategies practiced for heritage buildings. The methodology for modelling of historic structures using continuum-based macro modelling approach has been emphasized, since other alternatives are less reasonable for real-size structures and engineering applications. Additionally, it has also been shown how the digital documentation of heritage buildings obtained through advanced techniques can be utilized for numerical modelling. Such information/data prove to be very beneficial during creation of as-built 3D geometry for the purpose of structural analysis. The results of analysis of full-scale heritage buildings give a quick picture of the possible locations subjected to undesirable stress levels. In order to reduce such stresses experienced in any of the structural components appropriate strengthening is desired. However, before application of any strategy to existing heritage buildings, it is always recommended to study its efficacy through proper structural analysis methods. This will give confidence to the engineers and conservation experts before executing any repair and strengthening measure at site.

6. Hybrid Non-Destructive Evaluation Techniques & Signal Processing Algorithms for Multi-Wave Imaging

Debdutta Ghosh*, Hina Gupta & A.K. Mittal

The existing NDE techniques are not sufficient for heritage structures due to its material and structural complexities. Heritage Structures commonly exists in layered form and are often heterogeneous in nature. Contact and non-contact based NDE techniques have been developed in this project for the assessment of heritage structure. The detectability of individual NDE techniques have been improved by using developed signal processing techniques. The specific results are as following:

- Technique for ultrasonic imaging of defects has been developed and the technology have been transferred to the Industry (Fig. 9).
- Development of Algorithm for active thermography: phase and amplitude based thermal imaging have been carried out and defects situated at different depths have been successfully detected in a masonry specimen (Fig. 10).
- Passive thermal imaging has been used for the heritage structure inspection. Many live heritage structures have been inspected using the above technique. The appropriate timing for performing passive thermal imaging have been also decided based on laboratory experiments.
- Infrared thermography and ultrasonic technique are being used for controlled concrete specimens and its depths of penetration have been quantified.
- Combination of thermal and ultrasonic- a hybrid NDE technique has been used to detect defects inside the controlled specimens in the laboratory. Defects are embedded at the depth of 50 mm in a 600 x 600 x 100 mm concrete slab, have been successfully detected using the combined technique.
- Similarly, thermal, GPR and ultrasonic imaging, is also combined to obtain the most of the features in calibrated samples.
- Electromagnetic, thermal and ultrasonic based NDE techniques have been applied for heritage structure.
- State of the art instrumentation have been developed at CBRI and worked on several live heritage sites throughout the India.
- Delivered lectures, keynote speech and training on NDE of heritage structure.
- Published several papers in national/ international journals and symposium.
- Guided 2 M.Tech and 2 B.Tech.
- Developed techniques of NDE of historic structure in combination of thermal and ultrasonic imaging
- Field deployment of the NDE techniques at site of Archaeological Survey of India (ASI), State Archaeological Departments, Ministry of Railways India etc. Solani Aqueduct, Roorkee, UP Irrigation Workshop Roorkee, CSMT Mumbai, NAI New Delhi, Forest Research Institute Dehradun, Old Delhi Railway Station Delhi, Dam Kothi Haridwar, Sabz Burj are the name of some heritage site where we have inspected using the NDE techniques.

Firm:
M/S CANOPUS INSTRUMENTS,
#2 & 3, 'VISHWAS', KARNIK ROAD,
OFF. MURBAD ROAD,
KALYAN (W) 421 301,
MAHARASHTRA, INDIA.

Fig. 9: Technology Transfer on "Imaging of Hidden Anomalies in Concrete & Masonry Structures using Ultrasonic Pulse Velocity" to Indian MSME Firm

Hybrid Non-Destructive Evaluation (NDE) techniques were developed.

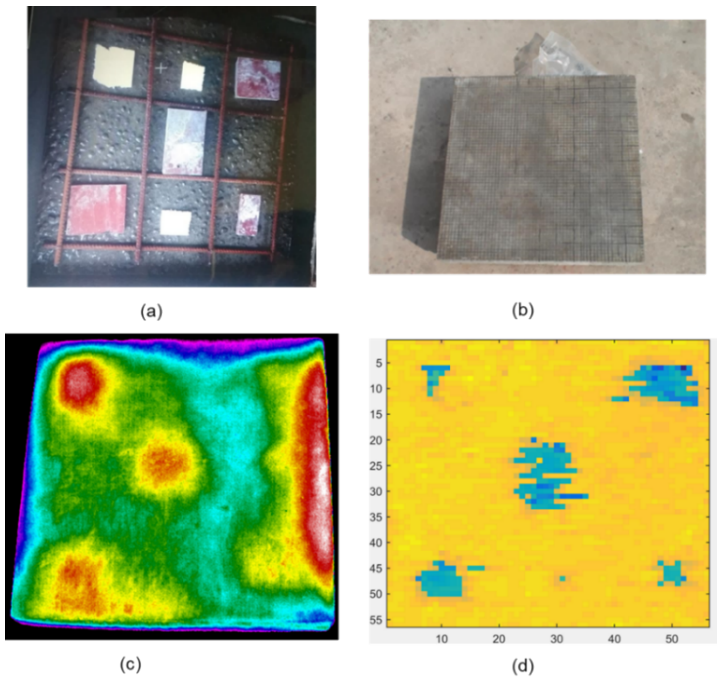


Fig. 10: Combination of Thermal & Ultrasonic Wave-Based Damage Detection was Developed

7. In-accessible Foundation Studies of Cultural Heritage Sites using Non-Invasive Techniques

P.K.S. Chauhan*, D.P. Kanungo & Zamir Ahmad

Non-invasive geophysical techniques are played an important role in the field of archaeology. They have been used for providing solutions related to different problems of heritage structures like structural problems, material degradation issues or building foundation. In the present study, only foundation delineation issue was addressed.

- ERT using inclined electrodes is a new technique evolved during this study to locate the foundation of the buildings having apron. The method was applied at two sites Swarn Jayanti Guest House at CSIR-CBRI Roorkee and Forest Research Institute Dehradun. The results were validated with GPR and past studies available.
- Guidelines on "Methods of Delineation of Foundations by Non-Invasive Geophysical Techniques" have been prepared.
- Efficacy of non-invasive geophysical methods like GPR and ERT has been established. New technique using inclined electrodes in ERT survey has been developed and validated.

8. Identification of Fungi on Select Heritage Structure & Development of Suitable Anti-Fungal Chemical from Medicinal Plants

Rajesh K. Verma*, Neeraj Jain, A.K. Mittal & L.P. Singh

Water Absorption Test

The water absorption of control specimen was recorded 3.17%. However, the water absorption of 1.40% for konex 2318, 0.56% for konex 2319 and 0.73% for zycosil-zycoprime were determined. It was confirmed that the water absorption on concrete cylinder specimens was reduced after the surface treatment.

Water Permeability Test

The water permeability on concrete cubes was reduced up to 50% (3.93 cm) in case of konex 2318 as water penetration of untreated specimen (control) was recorded 6.5cm. The concrete cubes coated with konex 2319 and zycosil-zycoprime shows water penetration of 3.83 cm and 3.13 cm, respectively.

Measurement of Advancing Contact Angle for Surface Wettablility

The results of advancing contact angle are shown in Table 1, which shows that the konex-2319 has more hybrophobicity as compare to zycosil zycoprime and konex-2318. Surface wettability is opposite of hydrophobicity of the surface and can be described by the contact angle. So, the desending order of wettability is as follows:

konex -2318 Zycosil+ zycoprime konex- 2319

Table 1: Contact Angle on Coating Surface

Coating Name	Advancing contact angle (θ0)
Zycosil+ zycoprime	140±20
Konex-2318	139±20
Konex-2319	155±20

Effect of Protective Coatings on exterior surface of the Solani aqueduct

The deterioration rating scale for all protecting coating was used for grading of degradation on field trial is shown in the Table 2. The surface coating was compared for any deterioration or destruction on treated surface due to environmental conditions such as temperature, relative humidity and colour change up to 270 days. The surface area treated with konex-2318 and konex 2319 exhibited no colour change as well as deterioration when compared with control surface area as these are penetrating silane/siloxane based coatings. However, in the case of zycosil + zycoprime slight colour change has been observed as it was a mixture of silane and acrylic content. Due to surface coating it shows dark glossy appearance. One the basis of visual observation and water hydrophobicity test performed, the order of effective protecting coating has been in order off konex -2319 > konex- 2318 > zycosil + zycoprime (Fig. 11-12).

Table 2: Deterioration Rating Scale for Field Trail

Scale	Observation	Characteristics
0	No Deterioration	No change in appearance
1	Light deterioration	Slight change in colour
2	Moderate deterioration	Appearance of dull spots and bubbles formation
3	Heavy deterioration	Loss of glossy appearance, slight precipitation of water repellent coating and surface become dark
4	Failure	Appearance of dull spots, colour changes to dark, heavy precipitation of water repellent coating on the surface.

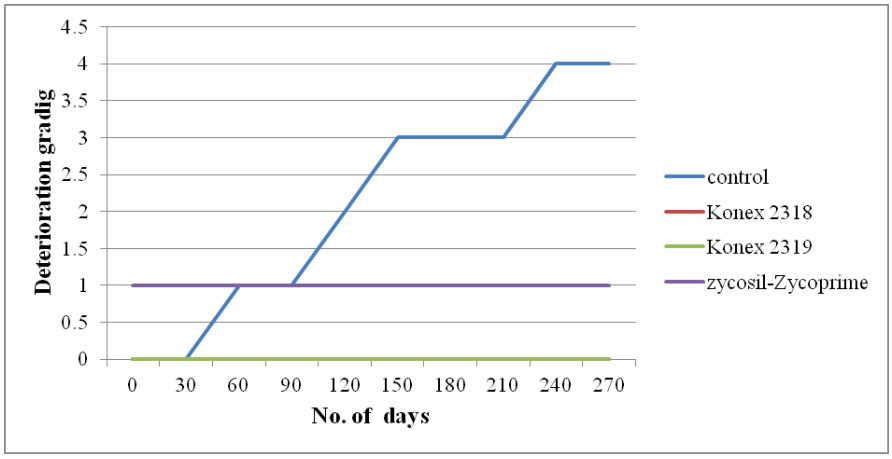
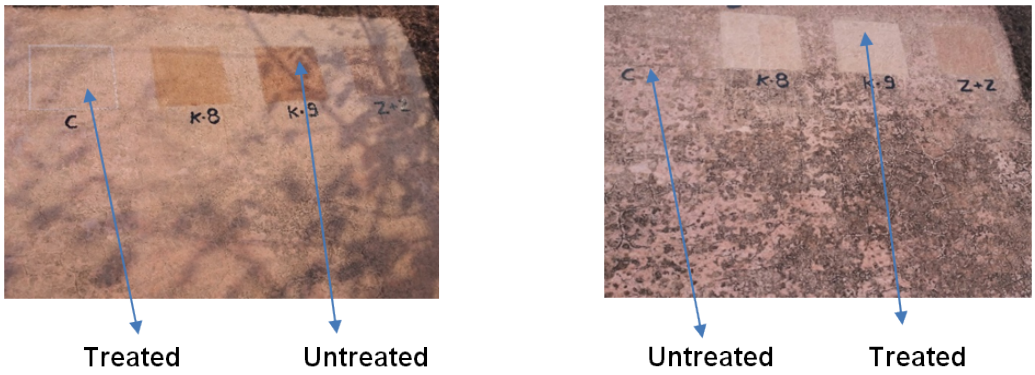


Fig. 11: Deterioration Grading on Field Trial at Exposed Surface of Solani Aqueduct, Roorkee



(a) Immediately After treatment 0 day **(b) After treatment 270 days**

Fig. 12: Field Trial on Site A of Exterior Surface of the Solani Aqueduct, Roorkee

Isolation and Identification

Five different types of fungal flora were identified. It is found that maximum percentage contribution is observed for Curvularia pallescens followed by Aspergillus niger, Fusarium equiseti. On the other hand, minimum percentage contribution was observed for Alterneria alternate, Talaromyces purpureogenus (Fig. 13).

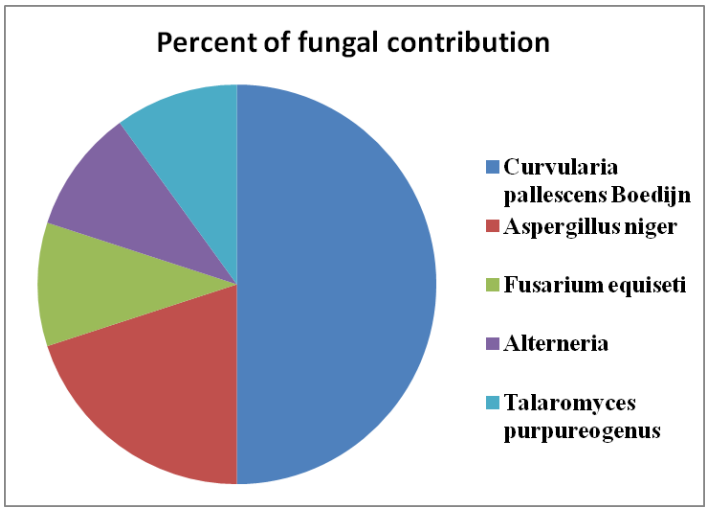


Fig. 13: Percentage of Distribution of Fungal Population in Sample Site

- Process know how for the treatment of heritage surface using transparent coating with anti-fungal essential oil" developed (Fig. 14).

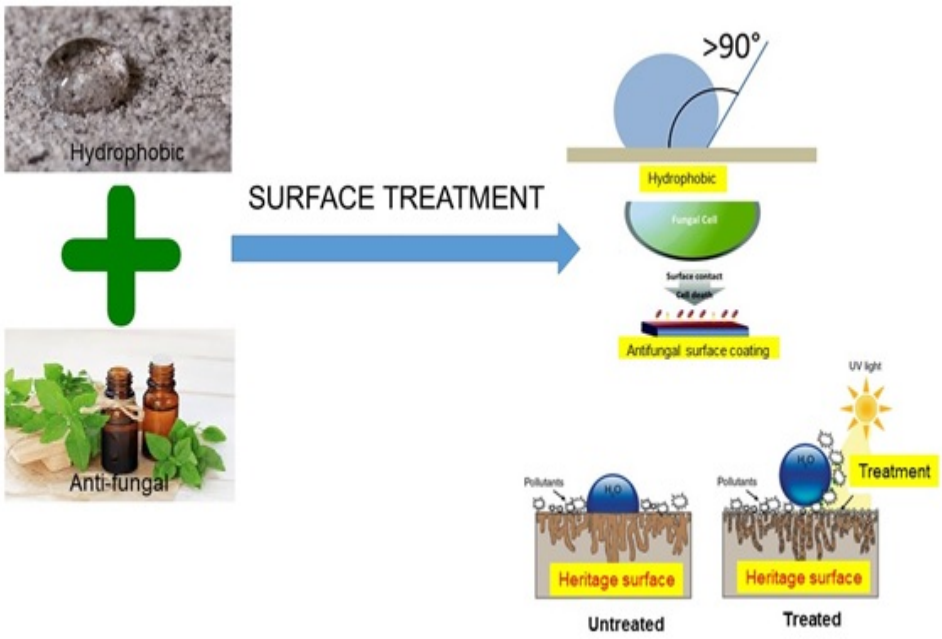


Fig. 14: Graphical summary of process know how

9. Conservation & Restoration of Lime Mortars & Brickworks

L.P. Singh*, A.K. Mittal & Srinivasrao Naik B

This research study has investigated the composition of historical mortar/plaster types, their current condition factors and processes responsible for their deterioration. Based on the characterization of mortar and plaster types, intervention technique is formulated.

- Lime has been used as the binding material for the preparation of all three buildings mortar samples.
- The higher firing temperature clay minerals are absent in B1 and B2 bricks which, confirms that bricks are fired at moderate temperature i.e. ~ 870 °C.
- The presence of calcite in mortar matrix were also confirms and cab be seen as layered form is also confirmed in FE-SEM analysis.
- The presence of protein in mortar (M1-M4) samples is confirmed by the characteristic peak of amide and CO groups. Further qualitative test also performed for confirmation.
- In mortar sample lime, surkhi, brick aggregates along with wheat straw fibers were also present in M3 samples.
- The presence of lime is confirms by XRF and XRD analysis.
- On the basis of XRD results it can be inferred that B3 bricks were manufactured by firing 850-900 °C.

- The result shows that the main mineralogical phases in M5 mortar samples are quartz (Q) and calcite (C) while anorthite (A) is present as minor phase.
- XRF analysis of bricks indicates high content of silica 59% and Al_2O_3 26 % along with 2- 4% traces of other elements.
- XRD analysis shows the peaks of quartz (Q: SiO_2) Tridymite (T), cristoballite (Cb), calcium silicate complex and fired at between 950-1000 ^oC.

Fig. 15: Transferred the technology on Nano Lime to M/s Poysha Nanotech LLP., Haridwar on May 14, 2019

Fig. 16: Pilot Plant for the preparation of Nanolime at CSIR CBRI, Roorkee

- Technology for the preparation of nanolime for heritage building conservation has been transferred to M/s Poysha Nanotech LLP., Haridwar on May 14, 2019 (Fig. 15).
- A pilot plant for preparation of nano-lime has been developed at CSIR-CBRI (Fig. 16).
- A Research Paper "Dwelling the Heritage: Characterization of lime mortars and red bricks used in Forest Research Institute and Solani Aqueduct, Uttrakhand, India" is under revision on Journal of Building Engineering.

10. Development of Compatible Repair Materials for Stone Masonry in Heritage Structures

Rajni Lakhani* & Rajesh Kumar

Based on the results obtained from experimental studies, the following conclusions can be drawn:

- There is an optimum fibre dosage i.e. 0.5% beyond which water absorption and porosity in lime-surkhi mortar registers an increase.
- Adding surkhi as mineral admixture in hydraulic lime mortar significantly improves the adhesive properties of the mortar.
- The reactivity of surkhi with lime (pozzolanic activity) is closely related to the flexural and compressive strengths of modified lime mortars.

- On the basis of these conclusions, it is possible to say that the addition of surkhi improves the mechanical properties of lime mortars.
- Addition of consolidants in lean mortar increases the strength and decreases the water absorption capacity of the mortar.
- There is an optimum fibre dosage i.e. 0.5% beyond which water absorption and porosity in lime-surkhi mortar registers an increase.
- Adding surkhi as mineral admixture in hydraulic lime mortar significantly improves the adhesive properties of the mortar.
- The reactivity of surkhi with lime (pozzolanic activity) is closely related to the flexural and compressive strengths of modified lime mortars.
- On the basis of these conclusions, it is possible to say that the addition of surkhi improves the mechanical properties of lime mortars.
- Addition of consolidants in lean mortar increases the strength and decreases the water absorption capacity of the mortar.

11. Skill Development, Upgradation & Training Program for Field Engineers, Technical & Non-Technical Manpower

A.K. Mittal*, I.A. Siddiqui & Deepak Dharmshaktu

Technical training programme has been conducted in four zones of the country: Roorkee (North), Pune (West), Kolkata (East), Chennai (South). Advertisement was published in National Newspapers. Students from India and Abroad attended the program.

PIs guided B.Tech and M.Tech students on different aspects of heritage structures

Students submitted the reports and awards were given for the best report from each zone.

Approximately 250 students were trained in the "BHAGVAN – A Search" training programme. Not only from architecture and civil engineering backgrounds but also from planning, interior designing and chemical engineering participated in the programme. B. Tech / B. Arch students from different disciplines and colleges submitted their reports on different monuments after visiting the monuments and awards were given for the best report from each zone**.**

Also a technical workshop has been conducted for ASI engineers at ASI Institute of Archaeology, Greater Noida (March 13-14, 2020)

Two-Day Workshop has been organised at Pt. Deendayal Upadhyaya Institute of Archaeology, Archaeological Survey of India, Greater Noida on **Recent Advances in Technology for Heritage Structures** by CBRI under CSIR Mission Project on Heritage Structures. (March 13-14, 2020). ASI officials: superintending archaeologists (engineers, architects) and students have attended the workshop. Faculty consisting of Dr. Achal Mittal, Dr. L.P. Singh, Dr. P.K.S. Chouhan, Dr. Debdutta Ghosh, Shri Manojit Samanta, Ms. Hina Gupta and Shri G.S. Ayappan, delivered lectures on recent issues related to conservation of heritage structure. Glimpses of this workshop are shown in Fig. 17 (a-d).

(a)

(b)

(c)

(d)

Fig. 17: Some Glimpses of the ASI Training Programme

Development of Health Assessment Techniques for Building Structures using Time & Frequency Domain Responses

S.K. Panigrahi, Ajay Chourasia, R.S. Bisht, Soju Alexander, Jalaj Parashar & Sameer

Objective:

Development of structural health monitoring algorithms for damage identification of structures.

Progress Highlights:

The objective of the present investigation is to develop a macro mode strain-based damage detection method for steel/ RC structures. Some methods have been discussed for the identification of damage from strain response. The methods are validated using electric strain gauges on damaged lab-scale beam elements and frame structures and then on real-life RC/ steel structures. It is also proposed to use fiber optics sensors/Fiber Bragg Grating (FBG) deformation sensors to acquire the strain data. Long gauge FBG with an active length of 1 m has been used to determine the damage in the structures numerically. The flow chart in Fig. 1 shows the overall summary of work done under the project.

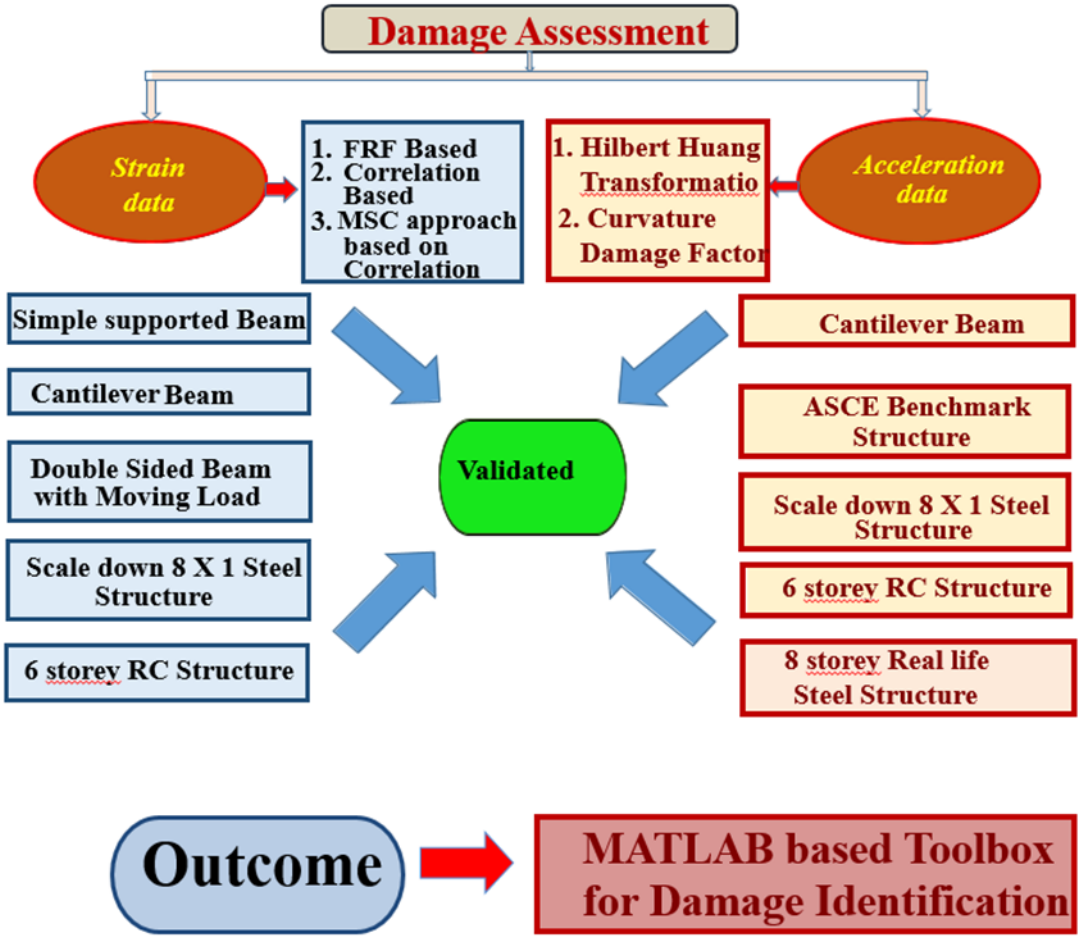


Fig. 1: Flow chart of Project Implementation

Fig. 2-3 shows the instrumented RC and steel frame structure considered for validation of the developed algorithms.

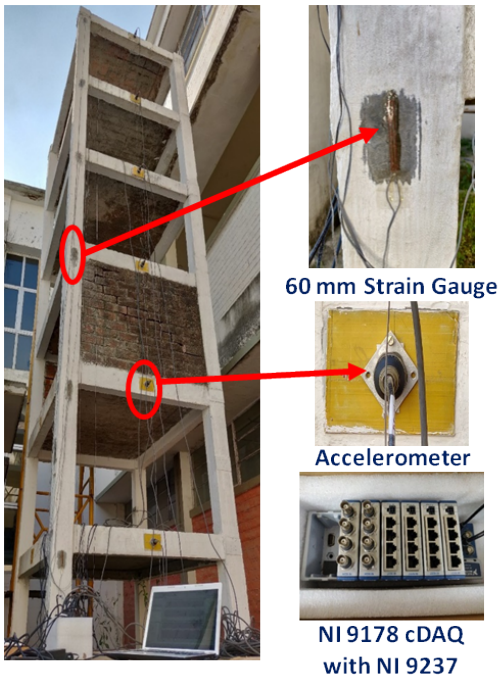


Fig. 2: Instrumented 6-Storey Scaled Down RC Structure

Fig. 3: : Instrumented 6-Storey 2-Bay Steel Structure

A tool box based on MatLab platform has been developed incorporating all the developed techniques for damage identification. MatLab compiler is required to run the software. The software can deal both strain and acceleration data. After getting the input, the user has to select the approach that he wants to use.

INNOVATIVE BUILDING MATERIALS

Development of Cost Effective Material for Sound Absorption with Air Purification Properties

Siddharth Singh, S. Maiti, Mahavir Singh (CSIR-NPL), R.S. Bisht, Soju J. Alexander & Sameer

Objective:

Development of cost effective material for sound absorption with air purification and fire retardant properties (zeolite/gypsum based).

Progress Highlights:

Development of perforated tiles with zeolite coating for air pollutant removal.

Acoustics Study of FG Samples:

Acoustic testing of the FG samples has been carried out at CSIR- National Physical Laboratory (NPL), New Delhi. For sound absorption, reflection and transmission loss measurements AED 1000 - Acousti Tube (Germany) is used. Sound transmission loss (STL) of perforated and non-perforated gypsum sample has been done in accordance with ISO 10354-2 for diameter of 100 mm and 30 mm and 10 mm thick cylindrical sample. The frequency ranges for testing of the sample in the range of 50 Hz to 6000 Hz. The obtained STL data was analysed by AED 1401 software.

The transmission loss value of non-perforated gypsum sample is approximately 20 dB at 500 Hz and shows an increasing trend with increase in frequency. The noise over the frequency range of 500-1000 Hz is the main cause of disturbances in the speech communication. The obtained sound transmission loss values should be higher to provide better insulation to outside noise and to maintain acoustic comfort in the residential areas.

Thin Film Coating of Zeolite on FG Material:

1 gm of zeolite along with 1 gm of $BaMn_{0.85}Ti_{0.15}O_3$ as photocatalyst material was ultra-sonicated in 50 ml of OKON multi-surface water repellant to suspend the zeolite and BMT particles in the solution for 30 minutes. After that solution was coated on the FG material by spin coating method as shown in Fig. 1. The zeolite-BMT layer formed on the FG tile surface was exposed to air pollutants.

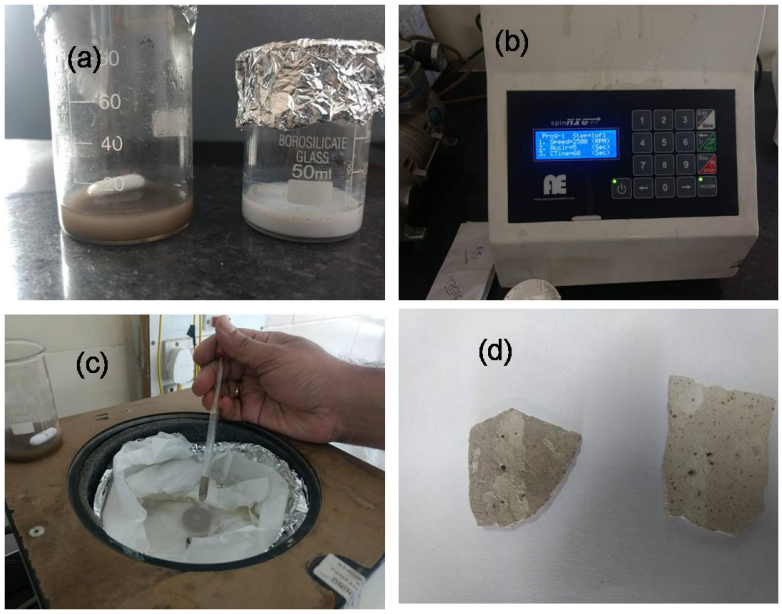


Fig. 1: Thin Film Coating of Zeolite & BMT Photocatalyst on FG Material

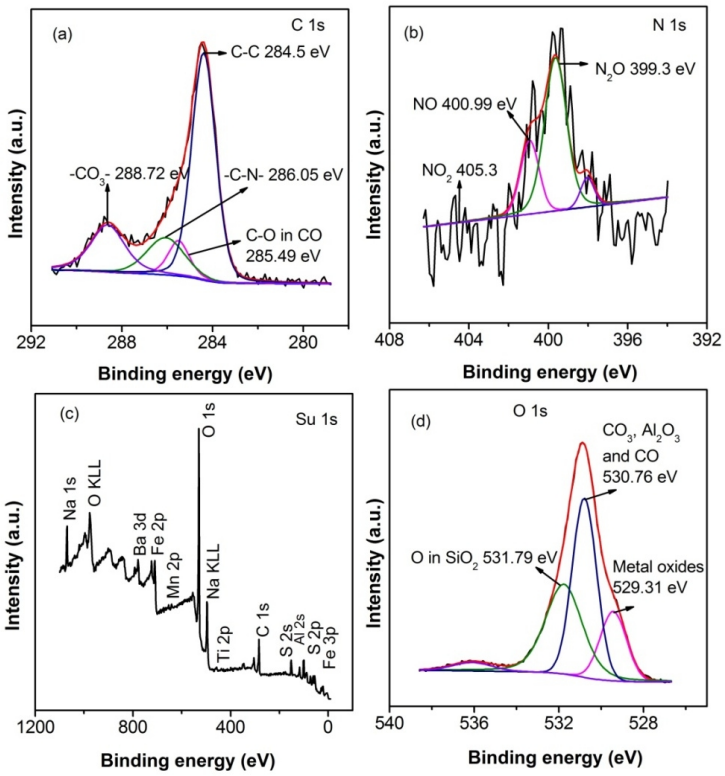


Fig. 2: Core Level Spectra of (a) C 1s, (b) N 1s, (c) Su 1s & (d) O 1s. The De-Convolution of Respective Spectrum shows the Presence of NOx & CO & Other Pollutants Adsorbed & Effect of BMT Photocatalyst on Zeolite Surface

The adsorption of CO on the zeolite surface can be verified from C 1s spectrum in Fig. 2(a). Whereas, the NO_x related impurities is shown in N 1s spectrum of Fig. 2. The degradation of NO_2 among the NO_x gases from the exhaust emission is verified by x-ray photoelectron spectroscopy (XPS) analysis and is shown in Fig. 2(b). The elemental analysis of various elements is shown in Fig. 2(c).

Development of Cement-Admixture System for Low Temperature Concreting

Jeeshan Khan, Ishwariya G. & Santha Kumar G.

Objectives:

- Study on the effect of various admixture on process of cement hydration at low temperature.
- Investigation on improvement of cement paste microstructure under low temperature hydration process.
- Performance evaluation of low temperature concrete versus controlled concrete.

Progress Highlights:

The sub-freezing temperature effects negatively on mechanical properties of fresh concrete. The Portland cement cannot harden under a freezing point without thermal protection. For this reason, fresh concrete should be protected, if it is cured below the freezing point. Chemical admixtures are routinely used to improve and enhance the characteristics of concrete mixtures. Antifreeze chemical admixtures, prevents damage to concrete due to freezing at early ages and provide curing protection to

ensure the desire strength. Antifreeze admixtures can be more effective as compared to other methods used in cold weather concreting (heating of water and raw materials). Through proper selection of chemicals and blending proportions, high quality cold weather concrete mix with characteristics of depresses freezing point, accelerated hardening and increased early-age-strength will be developed.

In the experiment OPC 43 cement was used for making cold weather concrete. Antifreezing admixture based on inorganic compound of nitrate based was prepared and used. Cement content was kept constant 390 kg/m^3 and water cement ratio was kept constant 0.40 throughout the experiments. Super plasticizer (Basf, Glemium 51) 0.75% was used by cement weight. Super plasticizer agent remains constant for all mixtures due to investigate the only effects of antifreeze admixture. Antifreeze admixture and super plasticizer agent were added in water and mixed properly. Crushed stone as a coarse aggregate of maximum nominal size of 10.0 mm was used. Locally available dry and clean natural sand was used as a fine aggregate. Mix proportions of concrete for study are given in Table 1 with 390 kg/m^3 and 0.40 water cement ratio. The one group is control mix without antifreeze admixture and the other is containing antifreeze admixture. In both mixes, fine and coarse aggregates with cement were added in a 50 litre laboratory pan mixer then mixed dry raw material for 1.5-2 min. After mixing of dry raw material mixed water containing superplasticizer was added in mixer and mixed for further 4-4.5 min. Complete mixing process is about 6 min. The cubes forms used size of 100 mm. After casting the cubes with and without antifreeze admixture mix samples have been transferred to without delay to automatic temperature controlled deep freezer at -5 ºC for cold weather curing for 28 days (Fig. 1).

Table 1: Mix-Proportions for 1M^3 Control & Antifreeze Mix Concrete

Materials	Control mix	Antifreeze mix
w/c Ratio	0.4	0.4
Cement (kg)	390	390
Antifreeze Admixture (kg)	-	37
Water (kg)	156	156
Super Plasticizing Agent 0.75% (kg)	2.92	2.92
Fine Aggregate (kg)	800	800
Coarse Aggregate (kg)	1158	1158

Fig. 1: Curing of Samples in Deepfreezer

Compressive strength results of deepfreezer curing of control and antifreeze mix shows at 7 days, control samples compressive strength is only 2.78 MPa after exposure in deepfreezer at -5 °C. However, the compressive strength of antifreeze mix samples is 12.88 MPa for the same curing conditions (-5 °C). The results show that at -5 ºC, cement hydration in control mix samples is about to stopped due to unavailibity of liquid phase water. Antifreeze admixture deepfreezes samples showed increment in the compressive strength of about 363% at -5 °C temperature, when compared to the compressive strength of control deepfreezes sample that is exposed to the same curing conditions at 7 days. The compressive strength of control mix samples cured in water at room temperature is observed 39.1 MPa at 7 days.

The compressive strength of antifreeze mix samples is 30.1 MPa, exposed at -5 ºC deepfreezer cured after 28 days. However, control mix samples compressive strength is only 5.80 after 28 days for same temperature curing (-5 ºC). Antifreeze admixture deepfreezes samples shows increment in the compressive strength of about 419% at -5 °C temperature, when compared to the compressive strength of control deepfreezes sample that was exposed to the same curing conditions after 28 days. The compressive strength of control mix samples cured in water at room temperature is observed 58.1 MPa at 28 days.

DISASTER MITIGATION

Safety of Vital Installations against Landslides

S. Sarkar, D.P. Kanungo, Manojit Samanta, Anindya Pain, K. Pandit, Ganesh Kumar, Ajay Dwivedi, Zamir Ahmad & Gayatri

Objective:

Design and development of efficient slope stabilization measures and instrumentation to mitigate landslide hazards in Uttarkashi- Gangnani region of Uttarakhand Himalayas for the safety of vital infrastructures.

Progress Highlights:

This work package of the mission mode project was undertaken to design and develop scheme of efficient, implementable and cost effective control measures as well as landslide hazard assessment in landslide prone areas which will reduce the risk of landslide hazards to infrastructures and ensure a safe built-environment catering to the needs of future development in hilly regions.

Landslide Hazard Assessment:

The geological and geotechnical investigation of landslide potential slopes along the Uttarkashi-Gangnani road were carried out to assess the landslide hazards in the region. Initially the rock slope stability assessment was carried out based on rock mass classification techniques such as Rock Mass Rating (RMR), Geological Strength Index (GSI) and Slope Mass Rating (SMR) technique. Thereafter, analysis was carried out using numerical techniques to assess the quantified stability grade of the slopes. A methodology is proposed to assess the landslide hazard in a quantifiable mode (Fig. 1).

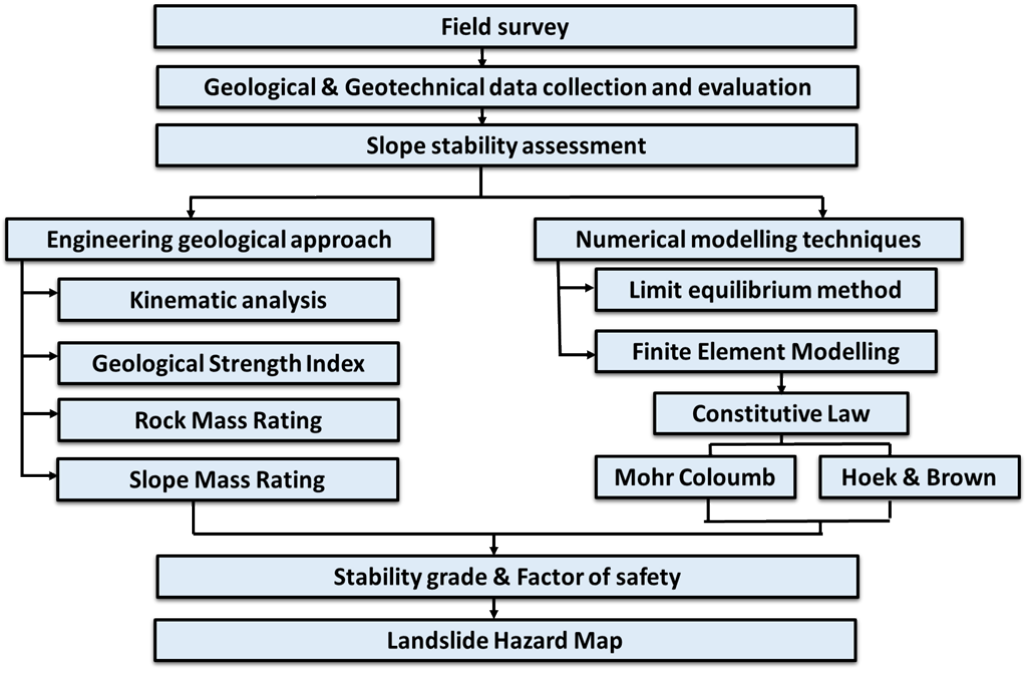


Fig. 1: Flow Diagram for Landslide Hazard Assessment

The road sector of the 40 km length has been classified into four potential landslide hazard zones containing the cluster of these susceptible slopes, which can be set off by any triggering factors like heavy rainfall, seismic activities and anthropogenic activities (Fig. 2). An attempt is made to quantify the landslide hazards associated with the studied landslide potential slopes based on the factor of

safety values. To classify each slope into different hazard classes, the FOS obtained with dry condition was considered and classified into four hazard classes as:

FOS <1.0 - very high hazard,
FOS 1.0-1.2 – high hazard
FOS 1.2-1.5 – moderate hazard and
FOS > 1.5 – low hazard

The slopes along with the hazard classes are shown in Fig. 3.

Fig. 2: Landslide Hazard Zones of the Study Area

Fig. 3: Landslide Hazard Map of Part of the Study Area with Factor of Safety Values

The study has illustrated that it is always advisable to evaluate stability grade by considering triggering factors such as rainfall and earthquake as the analysis has shown how FOS shifts from one hazard class to another when analyzed under wet and pseudo-static conditions. Such studies should be undertaken along all the major hill roads particularly in the areas known for landslide occurrences to minimize the loss of lives and property as well as less disruption to transportation and road connectivity.

Slope Stability Assessment of Bridge Sites:

Slope stability of five important bridge sites have been evaluated. The analysis is carried out to assess the possibility of landslide occurrence, which may damage the bridge (Fig. 4).

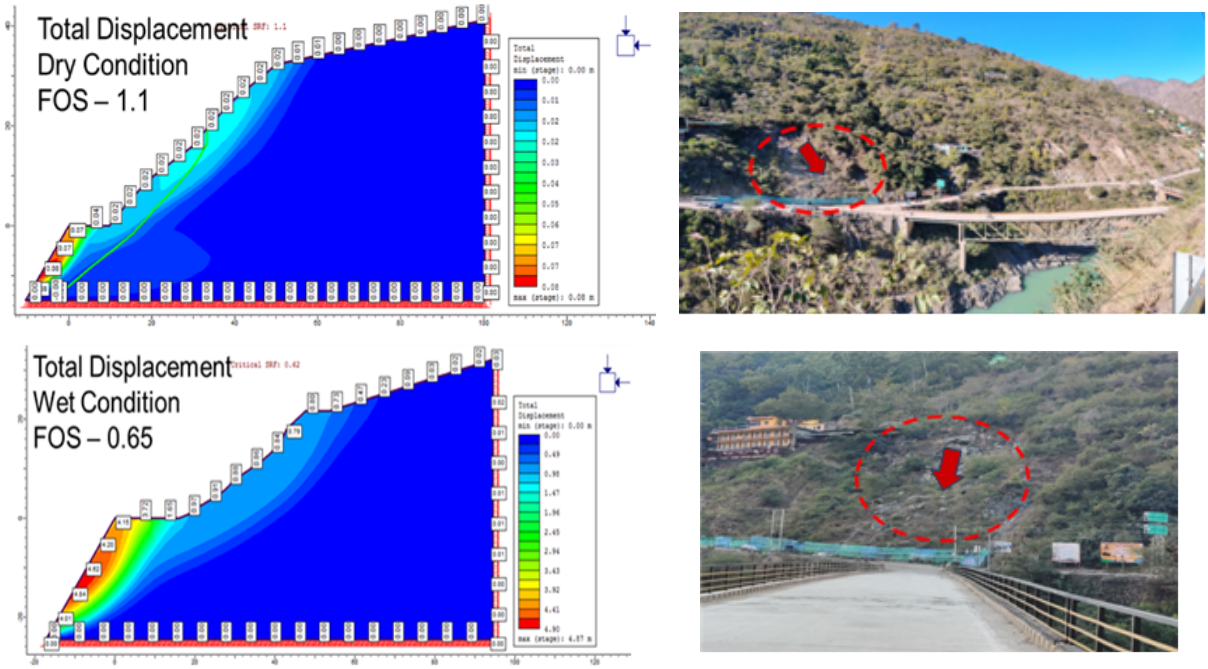


Fig. 4: Slope Stability Assessment at Devprayag Bridge Site

Geocell Retaining Structure:

The concave profiles of retaining structure (Fig. 5) show better results in stability analysis and also it decreases the required tensile strength of the reinforcement. Hence, optimal profile for the slopes having concave cross section under seismic and static conditions has been studied and a methodology has been proposed.

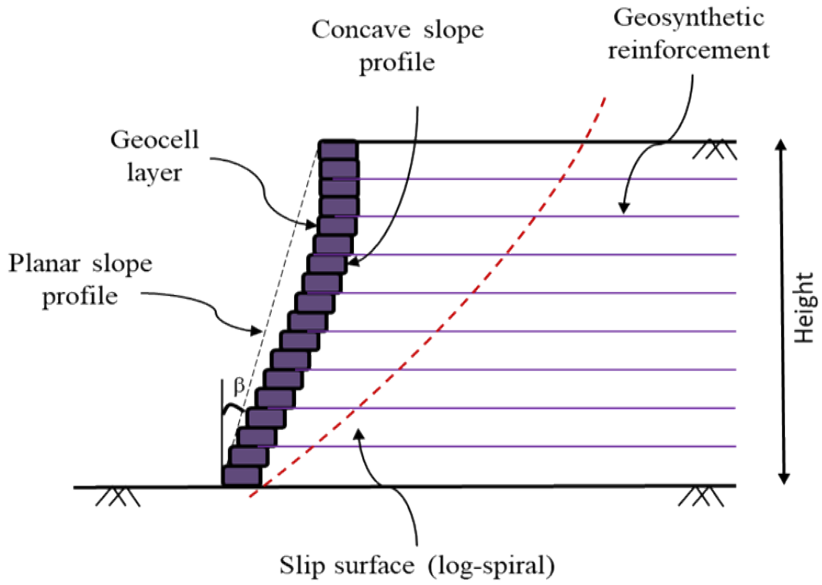


Fig. 5: Concave Geo-Synthetic Reinforced Soil Structure with Geocell Blocks as Facial Element

The results have been compared with the wall having planar facing profile and certain conclusions are drawn which are as follows:

(i) The concave geosynthetic reinforced soil retaining structure (CGRSS) is effective in minimizing the required tensile strength of the reinforcement to be used. This could be attributed to the reduced volume of soil being used in the CGRSS.

(ii) This effectiveness of CGRSS is constrained to certain favourable conditions which are dependent on the wall inclination angle with the vertical (β) and the internal soil friction angle (□).

(iii) The difference in the values of required tensile strength of the reinforcement (Td) for planar and concave facing profiles is greater for a lower value of horizontal pseudo-static seismic acceleration coefficient (kh) as compared to the higher kh values.

(iv) The effect of the height of the wall on the efficiency of CGRSS as compared to the GRSS with planar facing profile is negligible.

(v) The effect of the internal soil friction angle (□) is predominant as increasing it leads to the decrement in the value of required tensile strength of the reinforcement. Moreover, the difference in the value of required tensile strength of the reinforcement for planar and concave facing profile reduces as the value of □ increases.

(vi) The wall inclination angle with the vertical (β) also has a predominant effect on the efficiency of CGRSS. The efficiency of CGRSS decreases as the value of β increases.

(vii) After a series of parametric studies, it is concluded that the best combination of β and □ for the CGRSS to perform at its maximum efficiency is lower value of β and higher value of □.

(viii) Other geotechnical parameters such as unit weight of the soil (γ) have no effect on the required tensile strength of the reinforcement to be used in a planar and concave geo-synthetic reinforced soil retaining structure.

One such wall has been designed for a landslide site where the existing RE wall has been damaged (Fig. 6).

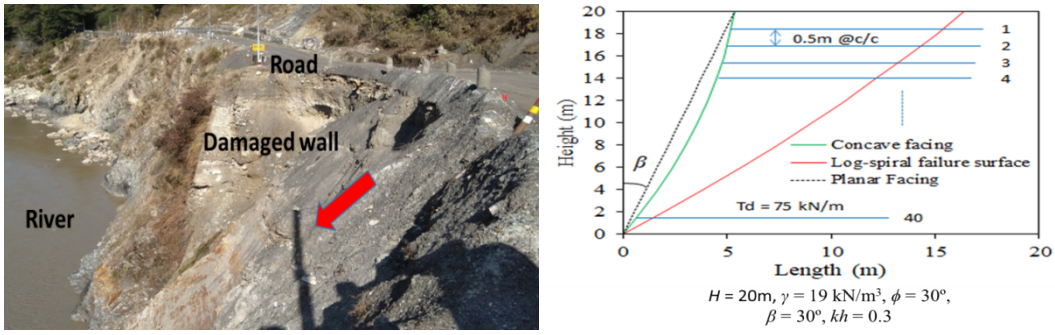


Fig. 6: Design of Concave Retaining Structure for the Section Below the Road at the Landslide

ΣTr = Required total tensile force in the reinforcement
ΣTd = Available total tensile force in the reinforcement
ΣTr = 1316 kN/m (Planar)
ΣTr = 1171 kN/m (Concave)
11 % reduction in tensile reinforcement

$$FS_t = \frac{T_D}{T_{imax}}$$
$$FS_t = 1.16\ (Planar) < 1.30\ (FHWA)$$
$$FS_t = 1.30\ (Concave) = 1.30\ (FHWA)$$

The present methodology optimizes the profile of RE wall for a cost effective solution. Such walls can be designed to protect the highways affected by landslides

Soil Nailing Technique for Slope Stabilization:

A detailed study on soil nailing has been carried out in the present study. The study mainly involved conventional soil nail and helical soil nail (Fig. 7). Some relationship between pullout capacity and different parameters of soil nail has been established experimentally. It was found from the study that performance of helical soil nails is significantly better than the conventional sol nails. Pullout capacity of helical soil nail with multiple helix has been experimentally evaluated. It has been inferred that from design consideration and effective helical nail design, interspacing between the helix should be equal or more than the four times the diameter of helix. Pullout capacity of multiple helical soil nails was also investigated through experimental studies. The test results show that no interface effect is observed when the spacing between the nails is more than three times the diameter. So, from design considerations vertical and horizontal nail spacing should be equal or more than the three times the diameter of helix. The pull-out capacity of helical soil nail increases linearly with the increase in the size of helix due to the corresponding increase in the size of failure envelope formed on the front the face of the helix. The peak pull out stress of helical soil nails is higher than the driven and grouted soil nails making it a viable economic alternative in place of conventional soil nails.

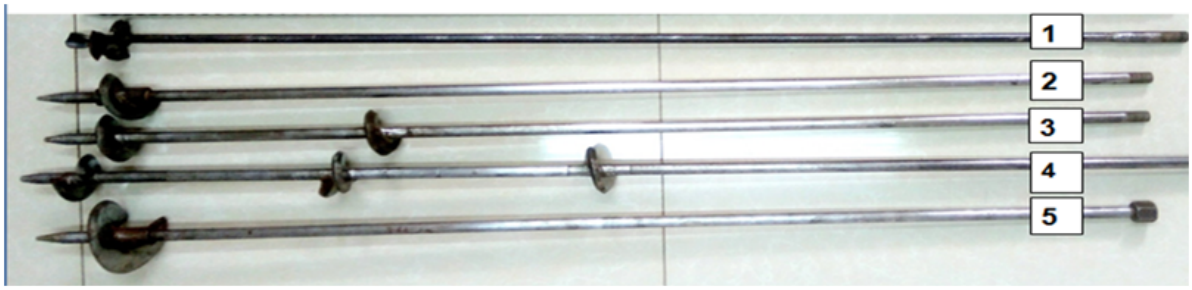


Fig. 7: Helical Soil Nails

Study has been also carried out for seismic design of soil nailed wall. A new approach known as “modified pseudo-dynamic method” has been proposed for carrying out the stability analysis under seismic conditions. A comparison has been made between the proposed method and available conventional methods.

A comparison of factor of safety values computed from the present study for three different types of soil nailed walls reinforced by driven soil nail, grouted soil nail and helical soil nail was also performed. The results of the analysis show that the factor of safety decreases with the increase in seismic acceleration. Further, factor of safety for helical soil nailed wall is significantly higher than the other two types of soil nailed walls.

Anchored Geosynthetic System:

The objective of the present study is to evaluate the reinforcing effect of anchored geosynthetic system on slope stability. Analysis has been performed with differential spacing, varying installation length of anchor and with different modulus of geosynthetic material.

- Anchor material property, geosynthetic stiffness, anchor spacing and installation angle are the prime design parameters.
- Knowing the soil parameters of landslide with varying the above parameters an optimum design of the reinforcement system can be prescribed.

Numerical modeling and slope stability analysis has been performed on a selected landslide site (Fig. 8). Analysis was performed without slope reinforcement and with anchored geo-synthetics with differential spacing, varying installation length of anchor and with different modulus of geo-synthetic material. The numerical analyses were performed with different slope angles under dry and wet conditions. It was observed that with the increase in anchor length and with closer spacing, the factor of safety of the slope increases. It was also observed that for the same anchor length with the decrease in the stiffness of the geo-synthetics the factor of safety decreases. Also, the factor of safety for the slope under wet conditions decreases when compared with that of dry conditions.

Design of an anchored geosynthetic system for an active landslide was done. Soil parameters used from geotechnical investigations were slope angle - 35°, Height - 12 m, Unit weight - 16.8 kN/m3, - 35° and cohesion - 9 kPa. The factor of safety obtained for unreinforced slope was 0.995.

Fig. 8: Proposed Anchored Geosynthetic Reinforcement at Landslide

Table 1: FOS for Different Anchor Length & Spacings

Geosynthetics – EA - 500 kN/m
Anchor – EA - 6.5×10^5 kN
Anchor length - 5 m, 10m
Anchor installation angle - 45°

	Un-reinforced	C/C 2.5m		C/C 5m	
		Anchor Length			
		5 m	10 m	5 m	10 m
FOS- Dry Condition	1.04	1.52	1.72	1.38	1.61
FOS- Wet Condition	0.94		1.41		1.31

The factor of safety of unreinforced slope was 1.04 while the FOS of the slope with reinforcement is found to be 1.61 in dry condition (Table 1).

Micro-Pile Reinforcement for Slope Stabilization:

Micro-piles are used mostly as foundation supports and as in-situ reinforcements to provide stabilization of slopes and excavations. A micropile is a small-diameter (typically less than 300 mm),

drilled and grouted as non-displacement pile that is typically reinforced. A micropile is constructed by drilling a borehole, placing steel reinforcement, and grouting the hole. Micropiles can withstand relatively significant axial loads and moderate lateral loads, and may be considered a substitute for conventional driven piles or drilled shafts or as one component in a composite soil/pile mass, depending upon the design concept employed. Micropiles are installed by methods that cause minimal disturbance to adjacent structures, soil, and the environment. They can be installed where access is restrictive and in all soil types and ground conditions. Micropiles can be installed at any angle below the horizontal using the same type of equipment used for the installation of ground anchors and for grouting projects.

- Advantages: Easy and quick installation, less disturbance to slope; length of pile can penetrate through deep seated slip surface.
- Suitability - Debris slopes and highly weathered rock slopes.

For this study, the active Netala landslide has been considered. To minimize landslide hazards in this slide which has loose overburden soil as well as highly weathered rock mass, micropile reinforcement has been attempted (Fig. 9).

Fig. 9: Proposed Location of Micro-Pile at Landslide Site

The untreated landslide slope was analysed first for various loading conditions, and safety factor of the slope for static and pseudo-static conditions were evaluated as 1.04 and 0.79, respectively. The location for micropile installations was identified (marked portion) from the contour plot of the maximum shear strain in the slope as shown in Fig. 10. Safety factor of the landslide increased from 1.04 to 1.21 by installing the micropiles.

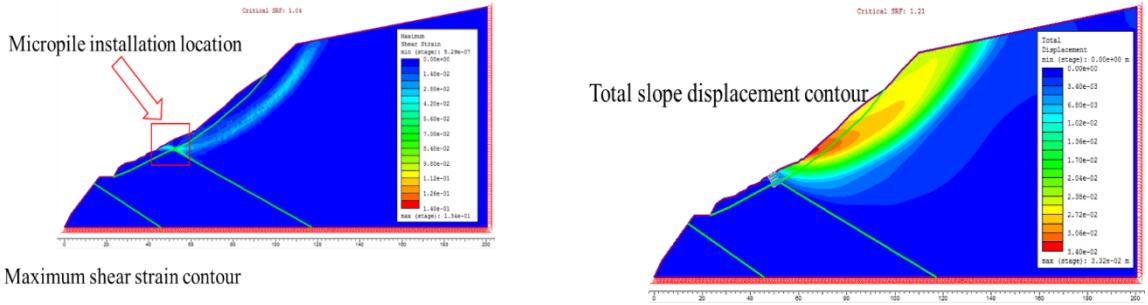


Fig. 10: Stability Analysis with Micro-Piles

Outcomes:

- A methodology for landslide hazard assessment considering relevant techniques and involving engineering geological and geotechnical parameters evaluation has been proposed. A hazard

map is prepared along the Uttarkashi-Gangnani road sector. This approach is particularly useful for the hill roads and can be employed in different hill states of the country.

- Slope stability and hazard assessment around a few important bridges has been also evaluated.
- The design methodology of a few applicable landslide mitigation measures has been evolved and has been designed for an active landslide site.
  - Concave geocell reinforced earth wall.
  - Anchored geosynthetic reinforcement.
  - Slope reinforcement using micro-piles.
  - Soil nailing.
- All these measures are applicable for soil and debris slide. The RE wall has a wider application to protect the hill roads while the other techniques reinforce the unstable slopes. These measures are designed for an active landslide in Uttarkashi region, which may be implemented by the concerned agencies in collaboration with CBRI. Similar measures can be designed for different landslides in different parts of Himalayas.

BUILDING PROCESS & AUTOMATION

Development of Mobile Sensing Device for Complex Working Environment of Civil Structures

Ravindra Singh Bisht, Narendra Kumar, Soju J. Alexander & Sameer

Objectives:

- Development of mechanism and control strategies for device locomotion in complex working environment.
- Design and development of mobile sensing device.
- Field implementation by deploying both contact and non-contact based NDE sensors.

Progress Highlights:

The prior art suggests that there is a definite need to develop mobile robotic/smart sensing techniques that can be useful for maintenance and precise inspection of tall structures even in unreachable locations. To meet the requirement, a novel hybrid climbing robotic device for remote inspection and maintenance of tall structures in a cost-effective manner has been developed at CSIR-CBRI. The robotic device can be best suitable for the maintenance of tall steel structures for cleaning/painting and visual inspection. The developed device can move and manipulate cost-effectively using various sensors by reducing the number of instrumentation required for structural monitoring. This technique will also lower the required instrumentation cost for structural monitoring.

The developed climbing robotic device can be used as a single module and two mobile-modules. The hybrid technique presents a novel model-based design of two mobile-modules connected with an arm mechanism comprises of a hybrid (wheel and arm) locomotion driven wall-climbing robot for the complex working environment of steel structures. The wheel locomotion mode, either using single module or two mobile-modules of the developed climbing robotic device can be preferred for even surface locomotion, and the arm locomotion mode of the two modules can be preferred for wall-to-wall transition, obstacle avoidance, and uneven surface locomotion of the complex wall. The arm locomotion actuation of the developed climbing technique is inspired by inchworm motion. Finally, the hybrid locomotion trials of the physical robotic device have been conducted. The successful laboratory and field trials for climbing robot motion on a vertical wall, wall-to-wall transition, and obstacle avoidance validate the feasibility of the concept of hybrid climbing robotic device. Autonomous inspection (closer visual monitoring of surface defects) field trials on steel structure have also been conducted. Further, those obtained imagery information at remote station can be beneficial for structural monitoring.

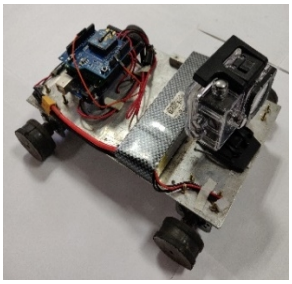
The key technical features of the developed climbing robotic device for hybrid locomotion trials in the laboratory are listed in Table 1.

Table 1: The Salient Features of the Developed Hybrid Climbing Robotic Device

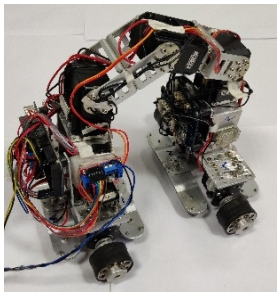
Weight	5.0 kg
Size (mm^3)	(300 extended Length) × (240 Width) × (250 extended Height)
Locomotion mechanism	Hybrid (wheel and arm) locomotion
Adhesion mechanism	Multi-layer permanent magnetic wheel mechanism, and electromagnets (optional)
Payload	4.0 kg (Approx.)

Drive motors	4 Brushed DC motors (for wheel locomotion mode), 2 Brushed DC motors (for switching mechanism) and 3 Smart servo Dynamixel MX-106T motors (for arm locomotion mode)
Power Supply	LiPo battery/tethered connections for laboratory prototype trials
Processor	ATMega 2560 microcontroller for wheel locomotion and switching mechanism, Open CM485EXP and OpenCM9.04 for arm locomotion control
Communication	RF(2.4 GHz) for wheel and switching mechanisms, Bluetooth (BT-210 module) for arm locomotion
Sensors	Ultrasonic, IMU and absolute encoders

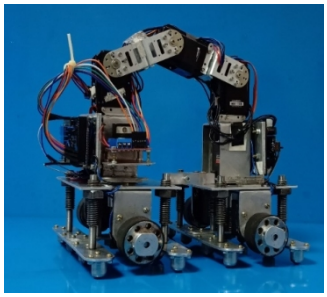
Fig. 1(a) represents instrumented prototype of autonomous climbing robotic device for its working trials, where it uses four independently actuated wheel tyre mechanisms for simultaneous locomotion and adhesion on plain/corrugated vertical wall surfaces of steel structures. Fig. 1(b) and Fig. 1(c) represent instrumented prototypes (prototype 1 and 2) of hybrid climbing device for its working trials, where it uses both wheel locomotion mode and arm locomotion mode for simultaneous locomotion and adhesion on complex surfaces (wall-to-wall transitions and obstacles) of steel structures.



(a) Single Module of Climbing Robot



(b) Two-Mobile Module Based Climbing Robot (Prototype-1)



(c) Two-Mobile Module Based Climbing Robot (Prototype-2)

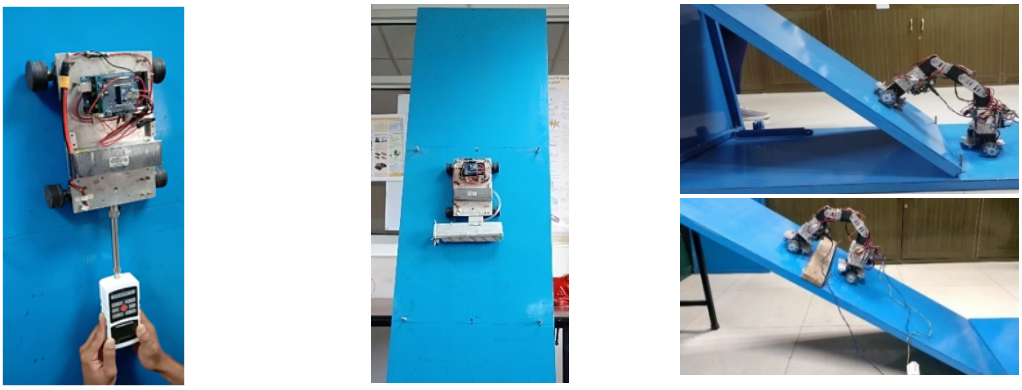
(d) Laboratory Set-Up for Locomotion Trails

Fig. 1: Various Prototypes of the Developed Hybrid Robotic Device

Prototype-2 is a more robust and improved version of the developed prototype-1. In the prototype-2, the switching mechanism precisely controls the adhesion force of the magnetic wheel by creating an air gap as compared to prototype-1. The experimental set-up presented in Fig. 1(d) has been devised for conducting the hybrid locomotion trials of the robotic device for motion along a vertical wall, wall-to-wall transition, and obstacle avoidance strategies at laboratory.

Fig. 2(a) and Fig. 2(b) represent payload carrying capacity (such as motorized roller brush, Wi-Fi camera and other NDT instruments etc.) and maneuverability (such as turning, spinning, and climbing etc.) trials of the autonomous climbing device on a vertical wall at laboratory. Fig. 2(c) represents examples of wall-to-wall transition and obstacle avoidance trials of hybrid climbing device at laboratory, where it uses both the wheel locomotion mode and arm locomotion mode under these situations. It is seen from the laboratory experiments that the autonomous climbing device and hybrid climbing device working using wheel locomotion mode have payload capacity up to 25.0 kg and 20 kg, respectively. Where, both these devices are more suitable to use in the field for high payload carrying applications such as autonomous cleaning/painting using a roller brush, and NDT/visual inspection/monitoring of corroded and other surface defects. It is also observed from the laboratory

trials the hybrid locomotion device working under arm locomotion mode has additional payload carrying capacity up to 4.0 kg. Here, the explanation for reduction in payload capacity is due to two reasons. First one is addition of the self-weight of the arm mechanism to the payload, and second is due to the use of only one mobile module also overcomes turning moments of another mobile module during obstacle avoidance and wall-to-wall/sharp angular transitions.



(a) (b) (c)

Fig. 2: Laboratory Trials, (a) and (b) Payload and Maneuverability Trials, (c) Wall-to-Wall Transition and Obstacle Avoidance Trials

Both the autonomous climbing device and hybrid climbing device are controlled remotely to operate in the field at hard-to-reach location of steel structures from a ground station with outdoor line-of-sight working range up to 800 m using different wireless communication modules such as XBee and RF transceivers. Fig. 3(a), (b) and (c) represent few examples of successful field trials of the present technique for autonomous visual inspection for the three cases such as (i) large vertical corrugated surface (ii) angle and (iii) channel of the steel structures, where Fig. 4 (a), (b) and (c) represent examples of corresponding recorded close surface defects/corroded images, respectively.

(a) (b) (c)

Fig. 3: Field Trials using Developed Robotic Device for Remote Visual Inspection, (a) Corrugated, (b) Angle and (c) Channel Type Structures

(a) (b) (c)

Fig. 4: (a-c) Corresponding Visual Inspection Recorded Close Surface Defects

Seismic Performance Enhancement of Buildings using Smart Base Isolation

Soju J. Alexander, S.K. Panigrahi, Ravindra Singh Bisht, Subhash C.B.G. & Sameer

Objectives:

To mitigate the effect of external excitation on buildings using base isolation system incorporated with semi-active device and newly developed control algorithm.

Progress Highlights:

Analytical modelling of base isolation using High Damping Rubber (Isolators) has been carried out using Simulink/Matlab to study the effect of base isolation on inter-storey drifts. It has been observed that the drifts have reduced to some extent as seen in Fig. 1.

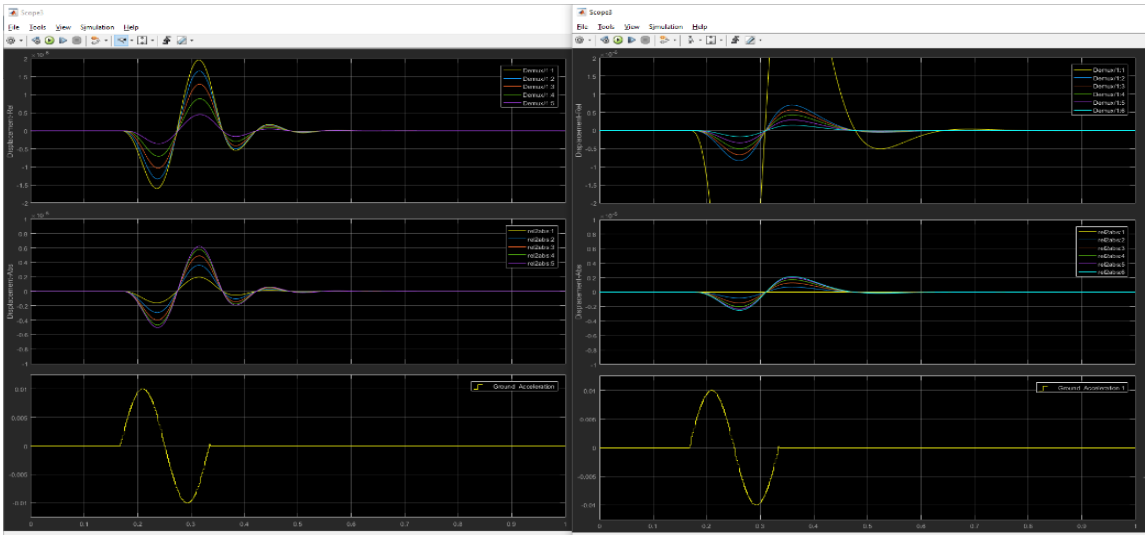


Fig. 1: Comparison of Displacements without & with Base Isolation

The controller was simulated in using Simulink for 1-DOF system for one damper as shown in Fig. 2.

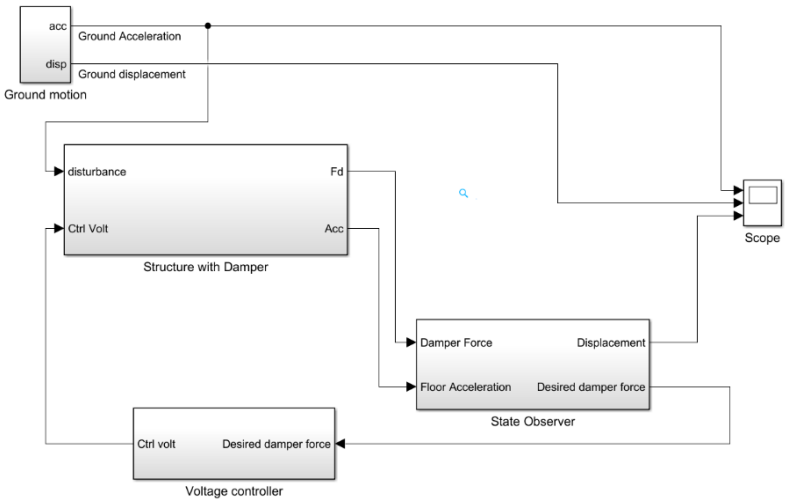


Fig. 2: Observer Based State Feedback

Using sinusoidal excitation signal to the model, the effect on the displacement of structure with base isolation, with hybrid smart base isolation, and with control algorithm is shown in Fig. 3-5.

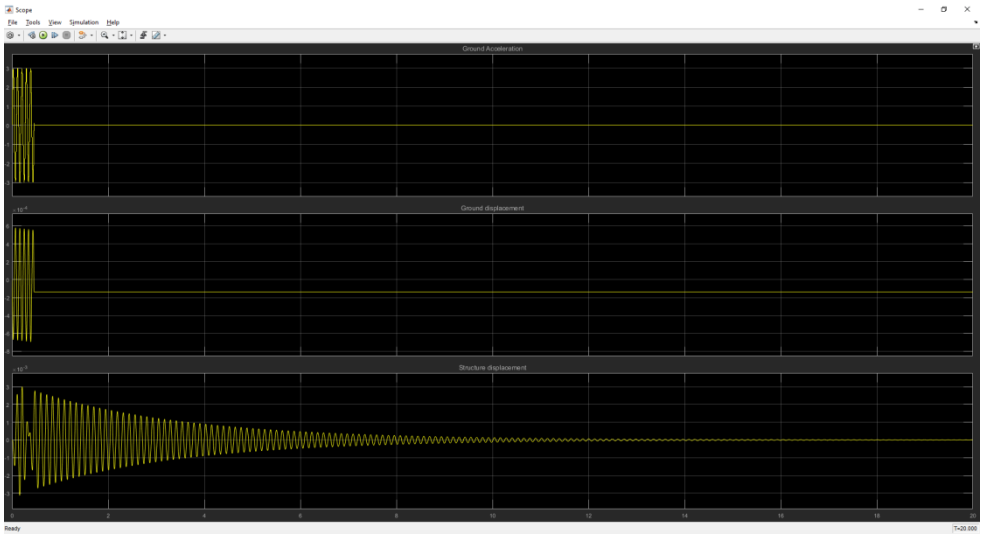


Fig. 3: Displacement of Base Isolated Structure for Sinusoidal Excitation

Fig. 4: Displacement of Hybrid-Base Isolated Structure for Sinusoidal Excitation

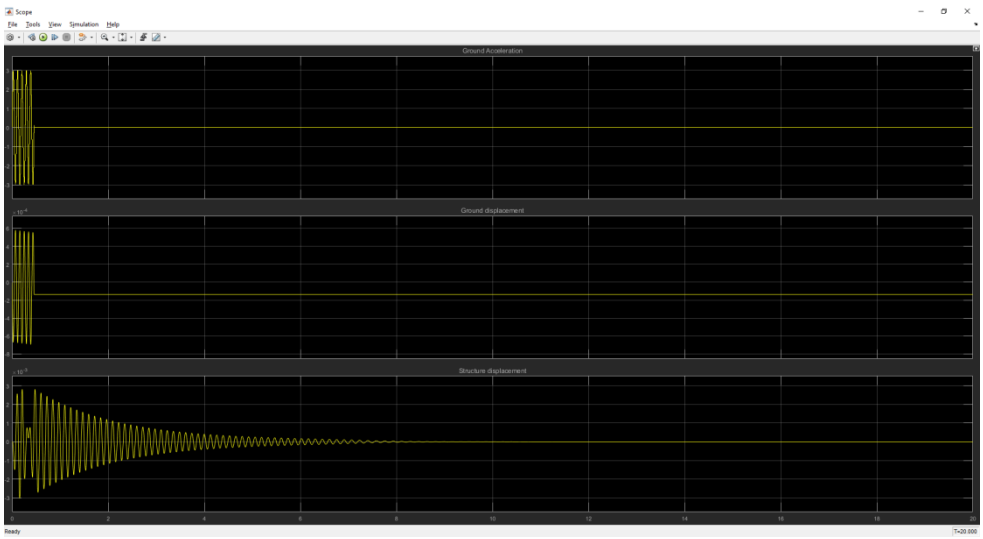


Fig. 5: Displacement of Smart-Base Isolated Structure for Sinusoidal Excitation

CSIR FAST-TRACK TRANSLATION

&

SKILL DEVELOPMENT PROJECTS

Development of Bamboo Composites Structural Elements

Hemlata

Objective:

To develop bamboo composite structural/semi-structural elements for building elements such as framing material, profile and lumber.

Progress Highlights:

Wood plastic composite manufactured from thermoplastic and bamboo fiber has advantages over natural wood and thermosetting resin bonded wood products, represents an approach with lower environmental impacts. Utilization of wood plastic composites has been immersed as building elements such as decking, siding, fencing, window and door frames. Fig. 1 represents the schematic processing of bamboo fiber. Bamboo pole is cut from nodes in to small length pieces and the electric roller is run out to extract the fiber. The long bamboo fiber passed through the hammer mill and the obtained fiber is again sieved. After chemical treatment of bamboo fiber, it is used for the reinforcement of thermoplastic polymer.

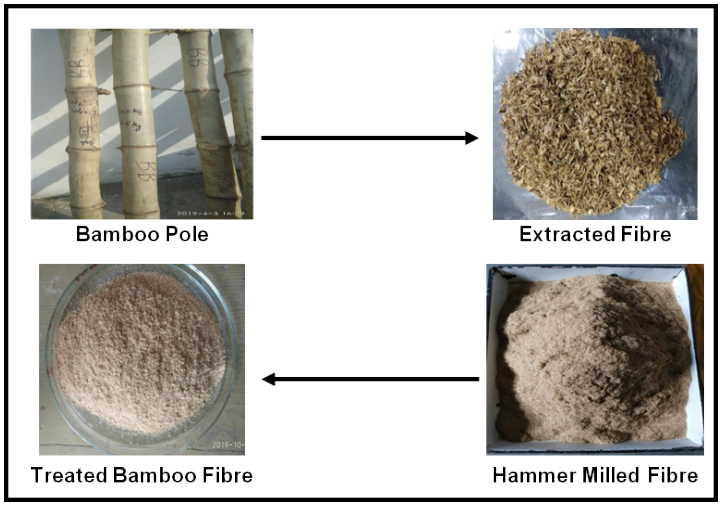


Fig. 1: Schematic Representation of the Processing of Bamboo Fiber

A series of thermoplastic/bamboo fiber composite have been prepared by melt compounding using twin screw extruder (Fig. 2) followed by injection moulding to achieve desired product.

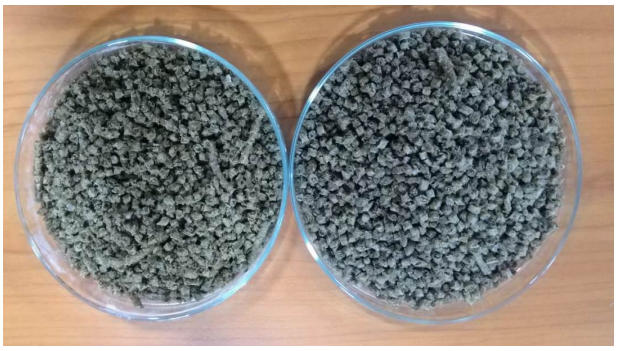


Fig. 2: Extruded Pellets of Thermoplastic Bamboo Composite

Results show that mechanical properties enhanced by the addition of bamboo fibre content as compared to pure matrix due to the reinforcing effect of bamboo fibre.

Student-Scientist Connect Programme: Jigyasa

Atul Kumar Agarwal & L.P. Singh

Objective:

To inculcate the culture of inquisitiveness and scientific temper amongst school students and teachers.

Progress Highlights:

CSIR-Central Building Research Institute, Roorkee organized various scientific programmes at the Institute premises and at various schools of Roorkee under the aegis of JIGYASA: Student-Scientist Connect Programme. The Institute, under the leadership of Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee, has taken up the responsibility to motivate the youth and develop scientific thinking in children at the school level, as a Scientific Social Responsibility (SSR).

Dr. Atul Kumar Agarwal, Senior Principal Scientist & CSIR-CBRI Jigyasa Nodal Officer coordinated the several student-scientist and scientist-teacher interactions under the programme with the aim to develop scientific consciousness in young minds. Students have been introduced to the latest innovative research and techniques of building and construction science including building materials, health monitoring and rehabilitation of the structures, disaster mitigation, fire safety, energy efficient rural and urban housing etc. Teachers have been encouraged to include interactive science learning tools such as humour, stories and experiments in classrooms to reduce monotony and encourage students to adopt a scientific approach in life.

Outcomes:

- Dr. Shekhar C. Mande, Director General, CSIR and Secretary DSIR presided over the Public Outreach Programme organized as a precursor event of 5th India International Science Festival (IISF-2019) on October 29, 2019.

- Lectures and addresses on varied aspects of building and construction science by CSIR-CBRI scientists/experts: Dr. Suvir Singh, Mr. S.K. Negi, Dr. Harpal Singh, Dr. R. Dharmaraju, Dr. Atul Kumar Agarwal, Dr. Achal Mittal and Dr. L.P. Singh.
- Lectures on varied topics of science by external experts: Dr. G.K. Mahapatro, Head, IARI Regional Centre Pune; Dr. Kulwant Singh, Scientist 'H', BARC, Mumbai; and Dr. R.K. Goel, Scientist In-charge, CSIR-CIMFR, Dhanbad Roorkee Regional Centre.
- Science Exhibitions & Seminars by Students to present their understanding of scientific concepts through models, oral presentations, survey reports etc. CSIR-CBRI experts- Dr. Atul Kumar Agarwal, Dr. Anuj Kumar, Dr. L.P. Singh, and Mr. Srinivasarao Naik B. - appraised the students' models/reports and encouraged them.
- Three-Day State-Level Students' Residential Workshop organized at CSIR-CBRI, Roorkee during August 27-29, 2019.
- Visit to National Institute of Hydrology, Roorkee laboratories was organized to educate the students on the importance of water conservation.
- Celebrating science by honoring anniversaries/contributions of scientists including Acharya Sir Prafulla Chandra Ray, Frank Friedman Oppenheimer, Nobel Prize Laureate Richard R. Ernst, Dmitri Mendeleev, Thomas Alva Edison, Charles Robert Darwin, Sir C.V. Raman etc.
- CSIR-CBRI technologies explained through technical charts at CBRI Technology Gallery and screened science films highlighting the achievements.
- Introduction to Rural Housing through demonstration models/field-level demonstration of affordable rural housing technologies at CBRI Rural Technology Park.
- Visit to CBRI Construction Technology Demonstration Park for field-level demonstration of various CSIR-CBRI technologies.
- Visit to CSIR-CBRI laboratories- Fire Research, Environment Science and Technology - Clay Products, Efficiency in Building, Organic Building Materials, Geo-Technical Engineering, Solar Panel and Structural Engineering etc. and interaction with scientists/experts.
- Motivational lectures on time, stress and memory management, perseverance etc.
- Hands-on experiments under guidance of scientists and teachers to understand STEM concepts in a simple and engaging manner.
- Guidance Programmes to discuss career opportunities in the field of science.
- Inter-school science competitions such as written science questionnaires, oral science quiz, speech competition, debate etc. to evaluate students' knowledge and encourage learning through healthy debate, interaction and discussions amongst peers.
- Science Songs and Educational Skits on Digital India, Swachh Bharat etc. by students.
- Prayer meet, thought of the day etc. to instill a positive atmosphere to the programmes.
- Plantation drives to explain the importance of environment to the students.
- Encouraged to read science magazines to keep-up on current research and scientific output around the globe.

List of Participating Schools:

Students and/or teachers from the following schools participated in the programmes:

Kendriya Vidyalaya Sangathan Schools: No. 1 & 2 Roorkee, SSB Srinagar Garhwal, Gopeshwar, Upper Camp Dehradun Cantt, Haldwani Cantt (Shift I& II), Ranikhet, Rajgarhi, Gwaldam, Joshimath, OLF Dehradun, IIP Dehradun, Kausani, ONGC Dehradun, BHEL Haridwar, Rishikesh, Almora, Bageshwar, No.2 NHPC Banbasa, Dharchula, Pithoragarh, ITBP (Shift II) Dehradun, Mathura Cantt, Kamla Nehru Nagar Ghaziabad, Punjab Lines Meerut Cantt, No. 1 Jhansi Cantt, No. 2 (Army Area) Pathankot, 3BRD AFS Chandigarh, Sector 31 Chandigarh, SAS Nagar Mohali, IMA Dehradun, New

Tehri Town Dehradun, Gole Market (Shift I) Delhi, R.K. Puram Sector 4 Delhi, AGCR Colony (Shift I) Delhi, No. 2 Delhi Cantt. (Shift II) Delhi, Pragati Vihar (Shift I) Delhi, Pitampura (Shift I) Delhi, Sector 2 R.K. Puram (Shift II) Delhi, Harsinghpura Gurgaon, NHPC Sainj Kullu, No. 3 Ambala Cantt, Karnal, GC CRPF Sonipat, Mandi, Jamuna Colliery Jabalpur, SECL Dhanpuri, No. 1 Sagar Cantt, ITI Mankapur Varanasi, Mughalsarai Chandauli, 39 GTC Varanasi Cantt, Gauchar, Raiwala, Pauri, No. 1 Hathibarkala Dehradun, Birpur Dehradun, ITBP Dehradun, Uttarkashi, Lohaghat, Kashipur, FRI Dehradun, OLF Dehradun, Mussoorie, Banbasa Cantt, ITBP Gauchar, No. 2 SOI Hathibarkala Dehradun, Ordnance Factory Dehradun, IMA Dehradun and Augustyamuni

Navodaya Vidyalaya Samiti Schools: Rajeev Gandhi Navodaya Vidyalaya, Shikarpur

Government Schools: Cantonment Board Senior Secondary School Roorkee, Sri Sanatan Dharam Prakash Chand Girls Inter College Roorkee, Arya Kanya Pathshala Inter College Roorkee, CBRI Junior High School Roorkee, Government Inter College Roorkee, BSM PG College Roorkee, BSM Inter College Roorkee, KLDAV PG College Roorkee and KLDAV Inter College Roorkee

Other Schools: Motherhood University Roorkee, Children's Senior Academy Roorkee, Dikshant International School Zirakpur Punjab, Dikshant Global School Zirakpur Punjab, Atomic Energy Junior College Mumbai, Atomic Energy Central School Kakrapar, Army Public School No. 1 Roorkee and Anand Swaroop Arya Saraswati Vidya Mandir Roorkee.

CSIR-CBRI Integrated Skill Initiative

R. Dharmaraju, S.K. Negi & Ashish Pippal

Objectives:

The main objectives are:

- To create a certified talent pool;
- To upgrade the skill set at all the levels
- To generate better earning options for masses (for e.g. from Unskilled Labor to Skilled Labor)
- To upgrade knowledge base of people at different levels
- To spread awareness among grass root workers about engineered structures.

Progress Highlights:

CSIR has mandated for the collection and dissemination of information in regard not only to research and development but to industrial matters in general. The tacit knowledge of CSIR labs along with the advanced R&D facilities has to be made available to the industry for creating a knowledge driven economy. The emphasis is given to create a robust and sustainable training module that is trans-disciplinary in nature addressing the needs of workforce among various technical areas that enhances multifaceted livelihood skilled workforce generation for industrial requirements. In tune with Government Policy on Skill Mission, CSIR has launched a major programme on CSIR Integrated Skill Initiative in 2016. The skilled/training programmes would also link to possible employment generation including small-scale technopreneurship. This ensures a sustained supply of skilled workforce in the country.

It aims to equip the target groups with the necessary technological skills, through exposure to innovative building technologies developed by the Institute to address the critical needs for the enhancement of building design/ construction/ technological skills of the individuals etc. It is planned to target the people working at all the levels in the society starting from masons to engineers/administrators etc for unified skill development to achieve the task of the programme.

With technical and scientific capability possessed by many CSIR institutions excellence in national skill mission in various identified S&T domains could be establish which will be a breeding ground for all the Skill/Training initiatives of laboratories to be taken up. It will host facilities for providing skill training to students/ industry personal/ farmers, etc. It will also envisage to be a hub to connect with industrial people for guiding the skill/ training programme. Further, the CSIR integrated Skill/ training programme will also bring in all the CSIR capabilities under one umbrella that will provide a unique knowledge driven platform under National Skill Mission. The programme also has the potential to enhance the CSIR brand image towards its Scientific Social Responsibility contributions by amalgamating its on-going and new skill/ training programmes.

CSIR-CBRI has been actively involved in providing science and technological solutions for the construction of housing in the service of the country since more than six decades. The institute has been assisting the building construction and building material industries, rural and urban housing, energy conservation, efficiency, fire hazards, structural and foundation problems and disaster mitigation. The Institute has mandate to transfer the building technologies developed by the institute to the construction industries. In this direction, the institute has been conducting short duration training programmes for engineers, supervisors, masons and unemployed youth all over the country in various vocations of building construction and production of new building materials and components. CSIR-CBRI, under CSIR Integrated Skill Initiatives has planned to regularize its skill development trainings across the country to develop skill manpower for the construction sector.

CSIR-CBRI with all its resources has provided training and skill upgradation to more than 1500 persons since the launch of this mission. The major participating agencies in this are state PWD's, State Disaster Management Authorities, MDoNER, Panchayati Raj Deptt. of state Govt., NGO's, Red Cross Societies, Nirmithi Kendras, District Administrations and Himachal Pradesh ST&E department etc. CSIR-CBRI in its each training programme keeps a balance of theory and practical skill set; in order to generate interest towards science & technology in the trainees. CSIR-CBRI, during its in house training programmes, makes the trainees visit different laboratories of CBRI and allows the participants to interact with the Scientists & Researchers.

The institute has organised several in-house and off-campus skill development training programmes during the year 2019-20 and the details of same are given below:

Sl. No.	**Sponsoring/ Collaborative Agency**	**Skill/Training Programme Title**	**No. of Person Trained**	**Date**	**Venue**
1	Department of Disaster Management & Rehabilitation, Govt. of Uttarakhand, Dehradun	Multi–Hazard Resistant Housing and Habitat for Engineers of Uttarakhand	39	Apr 22-26, 2019	CSIR-CBRI
2	Department of Disaster Management & Rehabilitation, Govt. of Uttarakhand, Dehradun	Multi Hazard Resistant Housing and Habitat for Engineers of Uttarakhand	23	May 20-24, 2019	CSIR-CBRI
3	State Centre on Climate Change & State Disaster Management Authority, Himachal Pradesh	Master Trainers on Earthquake Resistant Construction Practices for Engineers of Himachal Pradesh	27	Jun 10-14, 2019	CSIR-CBRI
4	State Centre on Climate Change & State Disaster Management Authority, Himachal Pradesh	Master Trainers on Earthquake Resistant Construction Practices for Engineers of Himachal Pradesh	20	Jun 17-21, 2019	CSIR-CBRI
5	Public Works Department, Arunachal Pradesh	Multi-Hazard Resistant Construction Practices for Engineers of Arunachal Pradesh	35	Aug 5-9, 2019	CSIR-CBRI
6	Public Works Department, Arunachal Pradesh	Multi-Hazard Resistant Construction Practices for Engineers of Arunachal Pradesh	62	Aug 19-23, 2019	CSIR-CBRI
7	Department of Disaster Management & Rehabilitation, Govt. of Uttarakhand, Dehradun	Multi–Hazard Resistant Housing and Habitat for Engineers of Uttarakhand	15	Aug 26-30, 2019	CSIR-CBRI

8	Himachal Pradesh Council for Science Technology and Environment (HIMCOSTE)	Earthquake Resistant Construction Technology for the Masons of Himachal Pradesh	25	Oct 3-5, 2019	Sundernagar, Himachal Pradesh
9	LUPIN - Human Welfare & Research Foundation, Rishikesh	Earthquake Resistant Construction for the Masons of district Haridwar	55	Nov 26-27, 2019	Rani Majra, Haridwar
10	Department of Disaster Management & Rehabilitation, Govt. of Uttarakhand, Dehradun	Multi-Hazard Resistant Housing & Habitat for Engineers of Uttarakhand	47	Dec 16-20, 2019	CSIR-CBRI
11	Department of Disaster Management & Rehabilitation, Govt. of Uttarakhand, Dehradun	Multi-Hazard Resistant Housing & Habitat for Engineers of Uttarakhand	36	Jan 20-24, 2020	CSIR-CBRI
12	Himachal Pradesh District Disaster Management Authority, Solan, Himachal Pradesh	Master Trainers on Multi-Hazard Resistant Construction Practices for officers of Himachal Pradesh	44	Jan 30-31, 2020	Solan, Himachal Pradesh
13	D.K. Nirmithi Kendra in association with D.K. Zilla Panchayath & Mangalore City Corporation	Innovative Technologies for Construction of Disaster Resilient Habitat for Architects & Engineers	248	Feb 7-8, 2020	Mangalore, Karnataka
14	Department of Disaster Management & Rehabilitation, Govt. of Uttarakhand, Dehradun	Multi–Hazard Resistant Housing and Habitat for Engineers of Uttarakhand	31	Feb 17-21, 2020	CSIR-CBRI
15	Tribal Welfare Department, Govt. of Madhya Pradesh	Innovative Technologies for construction of rural houses for the Engineers of Madhya Pradesh	29	Mar 2-7, 2020	CSIR-CBRI

Glimpses of Skill Development Training Activities:

Inaugural Ceremony

Group Discussion with Participants

Distribution of Certificate

Technical Session by Expert

Fig. 1: Training Programme on 'Multi–Hazard Resistant Housing & Habitat' organized for the Engineers of Uttarakhand during April 22-26, 2019

Inaugural Session

Group of Participants

Technical Session by Expert

Demonstration of Testing Facility

Fig. 2: Training Programme on 'Multi–Hazard Resistant Housing & Habitat' organized for the Engineers of Uttarakhand during May 20-24, 2019

Inaugural Session

Group of Participants

Technical Session by Expert

Demonstration of Testing Facility

Fig. 3: Master Trainers Programme on 'Earthquake Resistant Constructions Practices' organized for the Professionals of Himachal Pradesh during June 10-14, 2019

Inaugural Session

Demonstration of Construction Technology

Live Demonstration of Construction Techniques

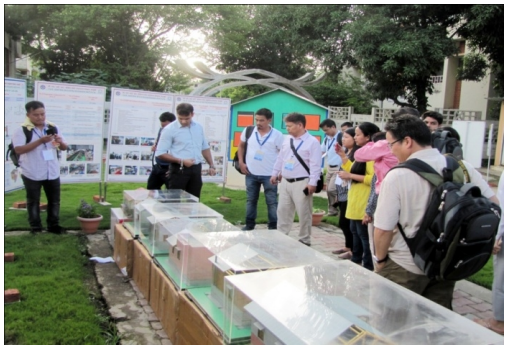
Distribution of Certificate

Fig. 4: Master Trainers Programme on 'Earthquake Resistant Constructions Practices' organized for the Professionals of Himachal Pradesh during June 17-21, 2019

Group of Participants

Witnessing Live Construction Activities at Site

Live Demonstration of Foundation Technique



Demonstrating Rural Housing Models

Fig. 5: Training Programme on 'Multi-Hazard Resistant Construction Practices' organized for the Engineers of Arunachal Pradesh during August 5-9, 2019

Inaugural Session

Technical Session by Expert

Demonstration of Construction Techniques

Distribution of Certificate

Fig. 6: Training Programme on 'Multi-Hazard Resistant Construction Practices' organized for the Engineers of Arunachal Pradesh during August 19-23, 2019

Inaugural Session

Group of Participants

Explaining the Testing Facility

Demonstration of Roofing Components

Fig. 7: Training Programme on 'Multi–Hazard Resistant Housing & Habitat' organized for the Engineers of Uttarakhand during August 26-30, 2019

Inaugural Session

Discussion with Participants

Participating in Technical Session

Live Demonstration of Construction Techniques

Fig. 8: Training Programme on 'Earthquake Resistant Construction Technology' organized for the Masons of Himachal Pradesh during October 3-5, 2019 at Sundernagar, Himachal Pradesh

Inaugural Session

Introductory Session with Participants

Technical Discussion with Participants **Live Demonstration of Walling Components**

Fig. 9: Training programme on 'Earthquake Resistant Construction' organized for the Masons of district Haridwar during November 26-27, 2019 at Rani Majra, Haridwar

Inaugural Session **Demonstration of Bamboo Model House**

Distribution of Certificate **Live Demonstration of RC Plank**

Fig. 10: Training Programme on 'Multi–Hazard Resistant Housing and Habitat' organized for the Engineers of Uttarakhand during December 16-20, 2019

Inaugural Session **Technical Discussion Session with Expert**

Demonstration of Mud House

Demonstration of Cost-effective Construction Techniques

Fig. 11: Training Programme on 'Multi–Hazard Resistant Housing & Habitat' organized for the Engineers of Uttarakhand during January 20-24, 2020

Inaugural Session

Technical Session by Expert

Live Demonstration - Casting of Stone Block

Distribution of Certificate

Fig. 12: Master Trainers Programme on 'Multi-Hazard Resistant Construction Practices' organized for the Officers of Himachal Pradesh during January 30-31, 2020 at Solan, Himachal Pradesh

Inaugural Session

Technical Session by Expert

Fig. 13: Training Programme on 'Innovative Technologies for Construction of Disaster Resilient Habitat' organized for Architects, Engineers & Students of Karnataka during February 7-8, 2020 at Mangalore, Karnataka

Inauguration of Sir M. Visvesvaraya Training Hall

Group of Participants

Demonstration of Roofing works

Distribution of Certificate

Fig. 14: Training Programme on 'Multi–Hazard Resistant Housing & Habitat' organized for the Engineers of Uttarakhand during February 17-21, 2020

Group of Participants

Technical Session by Expert

Technical Session by Expert

Demonstration of Roofing Components

Fig. 15: Training Programme on 'Innovative Technologies for Construction of Rural Houses' organized for the Engineers of Madhya Pradesh during March 2-7, 2020

OTHER R&D PROJECTS

Improving Building Energy Efficiency

Ashok Kumar, Nagesh B. Balam, L.P. Singh, Rajni Lakhani, Rajesh Deoliya, Kishor S. Kulkarni, Sayantani Lala, Anuj Kumar, Chandan Swaroop Meena, Tabish Alam, Rajesh Kumar, Srinivasrao Naik, Kshitij Jain, Vivek Agarwal & Team

Objectives:

- Development of low-energy design guides for commercial buildings in indian climatic zones.
- Development of modular thermally activated solar cooling and ventilation systems.
- Develop technology transfer, training and sensitivity plans for generating awareness on energy efficient buildings.
- Identification, study and development of building materials, novel insulation systems and components.
- Development of energy efficient lighting systems in commercial buildings.
- Technology integrated design and construction of an energy efficient demonstration building.

Progress Highlights:

(a) **Climatic Classification:** For the energy efficient building design, climatic zoning for the country is essential to differentiate the climate regions. The earlier study of CSIR-CBRI carried out during 1999 on climatic classification using climatic data of 225 station defines the country is categorised in five major types of climates viz. hot dry, warm-humid, temperate, cold and composite. Looking into the current severe climatic change scenarios, there is a need to redefine the climatic classification for India. In the present study, climatic classification is done using the latest climatic data of India for the year 1981-2010 and clustering is carried out using multivariate technique of principal component analysis. The outcome of study gives additional sub-climatic regions for India. The handbook is being prepared based on the revised classification.

(b) **High Temperature & High Efficiency Solar Collector:** Currently, the flat plate solar collectors available in the market have an efficiency of up to 30 % and generate hot water up to 75 ºC. Hence, a novel high temperature and high efficiency solar collector is developed with peak temperature of absorber plate reaching up to 140 ºC, water temperature above 95 ºC and daily average efficiency of approximately 54%. Two prototypes of double glazed flat plate solar collectors are fabricated along with insulated water storage tanks to compare the efficiency of normal solar collector with the developed solar collector.

(c) **Phase Change Materials:** Most of the researchers are preparing encapsulated phase change materials (EPCM) at lab level by chemical techniques such as spray drying, in-situ polymerization, sol-gel, interfacial polymerization etc. Hence a large scale EPCM has been developed, which has capacity of ~1 kg/day and the efficiency is about 80%. However, to meet industrial levels, systematic unit process is required i.e. jacketed agitator vessel with filtration unit. Design composition of phase transition of phase change material (PCM) has been prepared according to weather condition of particular places for application on building envelope and microencapsulation of PCM by in-situ polymerization technique.

(d) **Lightweight Interlocking Masonry Blocks:** The masonry blocks are developed using lightweight aggregates (LECA), OPC- 43 Grade, stone waste as sand replacement and latent/ active hydraulic binder. The mechanical, microstructural and durability properties of lightweight concrete products containing Class F fly ash and stone powder waste are investigated. The substitution of Portland cement with high volume Class F fly ash (up to 35%) further reduces the density of lightweight concrete by increasing the strength. Incorporation of waste materials (pozzolanic and non-pozzolanic) has showed denser microstructure as compared to the control concrete. The developed products provide better bonding with regular cement mortar; hence, there are no plaster cracks/shrinkages. The thermal conductivity (λ- value) of 0.393 W/m.K is found. The reduction of cost by 25-30% along with conservation of natural resources such as- river sand, limestone, natural coarse aggregates are other advantages.

(e) **Energy Efficient Lighting Systems:** The LED technology has higher efficiency and longer life. The operation of LED light source requires a driver circuit and the performance of LED driver circuit depends on the single, double, and triples stage circuit. As the life span of the LED driver circuit is relatively shorter in comparison of LED light sources, which is the major issue of the LED light sources. Hence a LED driver technology is developed that has long life, consumes less power, light intensity control with dimming, flickering free, and proper thermal management.

(f) **App for Integrating Daylight with Artificial Lighting:** Architects and building professionals always find difficult to design lighting systems integrating with daylight due to cumbersome simulation and complex numerical methods. To overcome this gap, an android App is developed in which a user can give predefined or user inputs for any building & rooms along with their sizes or other input and other specifications. Based on the inputs, the output is generated in the form of number of fixtures along with their wattage in the defined rooms in less than a minute. This is quite useful as a ready reckoner for any architect or designer / engineer on inspection and during the conceptual design stage.

(g) **Daylight Design using Nomographs:** CSIR-CBRI had earlier developed simple nomographs to optimize the fenestration area for a particular climate. But due to different climates and improved methods of daylight estimation, a need is always felt for upgradation of daylight integrated lighting design in India. The revised nomographs provide a simplified design methodology of calculating the amount of usable daylight entering an office space based on the sky conditions, whereas the software incorporates orientation, latitude and longitude of a given place to give a more accurate, albeit costly methodology of daylight analyses. The nomographs bridge the gap between research and implementation of integrating daylight in indoor lighting system in India. These nomographs can be an important tool at the initial stages of designing energy efficient buildings, and they can be adopted by places with same sky luminance value as India.

(h) **Technology Integrated Design & Construction of an Energy Efficient Demonstration Building:** The demo building is designed using the principles of building physics, and energy efficient building envelope to comply ECBC 2017 requirements. Majority of the technologies developed under the project or developed by CBRI are proposed with a view to integrate renewable technologies so that the building may qualify for net zero energy building.

Recycling of Silt from Storm Water Drains, Sludges from Water Treatment Plant/Sewage Treatment Plant and Ash from Waste to Energy Plant in to Useful Products

Neeraj Jain, Soumitra Maiti & R.K. Verma

Objectives:

To develop paver blocks using different wastes.

Progress Highlights:

Samples of bottom ash/fly ash from waste to energy plants (WTEPs), sludge from sewage treatment plants (STPs)/combined effluent treatment plants (CETPs) and drain silts were collected from Delhi. After required processing, these samples were analysed for various physical and chemical parameters as per standard methods. The samples of bottom ash/silt/sludge were utilized as fine aggregates for the development of building components like road paving blocks and bricks. The scope is summarized below:

- Visit and collection of samples of drain silt/sludge from WTP/STP/CETP/ash from WTE plant.
- Physical, chemical and biological characterization of samples.
- Feasibility studies for development of building and road construction materials along with suggestion regarding utilization of the silt/sludge/ash by cold process.
- Testing of Engineering Properties of the products as per Indian standards.
- Leaching studies of the products as per standard procedure (US EPA : TCLP).
- Comparison of the products developed with conventional products available in the market.
- Writing of brief techno-feasibility report.

The paving blocks are two layered building product in which top layer is made of cement and fine aggregates, while bottom layer is made of cement, fine aggregate and coarse aggregates. In present studies, the top layer is composed of cement and natural fine aggregate (stone dust) in the ratio of 1:2, while bottom layer is composed of utilization of ash/sludge/silt, as partial replacement of natural fine aggregate (stone dust). The paving blocks have been developed and tested as per IS: 15658: 2006. Mixes giving compressive strength of more than 20 MPa and water absorption of less than 6.0 % (as per IS) have been recommended for commercial production of paving blocks. Toxicity characteristics leaching procedure (TCLP) studies have also been carried out for field applications.

The cement bricks are made of cement as binder and fine aggregates. In present studies, the development of bricks have been carried out as per IS: 1077: 1992 using ash/sludge/silt as partial replacement of fine aggregate and the engineering properties have been determined as per IS: 3495: 1992. Mixes giving compressive strength of more than 5.0 MPa and water absorption of less than 20.00 % (as per IS) have been recommended for commercial production of bricks. The recommended mix compositions and results for road paving blocks using bottom ash, fly ash, CETPs and drain silt are given here under in Table 1-4 respectively:

Table 1: Mix Compositions for Road Paving Blocks using Bottom Ash from WTE Plants

Cement in Bottom Layer (%)	Fine Aggregate (%)	Bottom Ash (%)	Coarse Aggregate (%)	Compressive Strength (MPa)	Water Absorption (%)
25.00	11.25-26.25	11.25-26.25	37.50	32.50-48.00	< 6.00
22.00	10.00-23.25	10.00-23.25	44.50	30.20-45.20	< 6.00
20.00	9.00-15.00	15.00-21.00	50.00	32.50-42.00	< 6.00
15.00	17.50	17.50	50.00	36.80	< 6.00
10.00	10.00	20.00	50.00	27.00	< 6.00

Table 2: Mix Compositions for Road Paving Blocks using Fly Ash from WTE Plants

Cement in Bottom Layer (%)	Fine Aggregate (%)	Fly Ash (%)	Coarse Aggregate (%)	Compressive Strength (MPa)	Water Absorption (%)
25.00	22.50-27.50	10.00	37.50	23.50-36.37	< 6.00
22.00	20.00-23.25	15.00	44.50	28.20-36.25	< 6.00

Table 3: Mix Compositions for Road Paving Blocks using CETPs

Cement in Bottom Layer (%)	Fine Aggregate (%)	CETPs Sludge (%)	Coarse Aggregate (%)	Compressive Strength (MPa)	Water Absorption (%)
25.00	22.50-29.50	8.0-15.0	37.50	24.00-45.00	< 6.00
22.00	23.25	10.00	44.50	21.30-34.60	< 6.00

Table 4: Mix Compositions for Road Paving Blocks using Drain Silt

Cement in Bottom Layer (%)	Fine Aggregate (%)	Drain Silt (%)	Coarse Aggregate (%)	Compressive Strength (MPa)	Water Absorption (%)
25.00	22.50-27.50	10.0-15.00	37.50	21.00-47.20	< 6.00
22.00	20.00-23.25	10.00-13.25	44.50	23.20-46.50	< 6.00

Recommendations for Costing:

(i) The developed paving blocks at different cement and aggregate contents have been compared with the paving blocks available in the market. The cost estimation shows that the selling price of paving blocks in the market (cement content less than 15.0 %) is about Rs. 12.0-13.0 having a strength of less than 15.0 MPa. However, paving blocks developed in present studies using ash/sludge/silt at different cement content (20.0-25.0 %) show a compressive strength of 20-48 MPa with cost ranging from ~Rs. 12.30 to Rs. 13.50.

(ii) The cost of brick at 15.0 % and 20.0 % of cement content is Rs. 7.75 and Rs. 8.70 respectively as compared to the market selling price of Rs. 7.0 and Rs. 8.0 at 10% and 15.0 % of cement content respectively.

(iii) Cost comparison shows that the difference in the cost of market product and the product developed utilizing waste is almost negligible and the quality of the product in terms of.

(iv) The ecofriendly product developed utilizes waste as fine aggregate which not only helps to reduce the consumption of natural resources but will also it helps in conservation of the environment. Further, utilizing waste as building materials will reduce the burden on landfills, helpful keeping the cities pollution free and clean.

Development of Fluorogypsum Based Water Resistant Binder

Soumitra Maiti & Neeraj Jain

Objective:

Development of water resistant binder using anhydride gypsum- a waste from hydrofluoric acid industry.

Progress Highlights:

Fluorogypsum (FG) is a byproduct of hydrofluoric acid industry and is available in huge quantity (3.5 MT). It is acidic in nature (pH 5.5) and contains CaO; 40.2%, SO_3; 56%, F; 1.2 % and LOI; 6%. It does not easily set and hardened, thus creating disposal problems. Therefore, it is essential to convert this waste gypsum into useful products. A systematic study has been undertaken for utilization of FG in producing high strength water resistant binder for use in masonry work, plaster and development of tiles and blocks. The process includes neutralization of FG with lime and then admixed with suitable activators and inter-grinding to a fineness of 400 m^2/kg. The developed binder exhibited superior properties like high compressive strength (35 MPa), fast setting time (40 min), low water absorption (<10 %), low porosity, non-combustible and meets ASTM C-61-50 requirements.

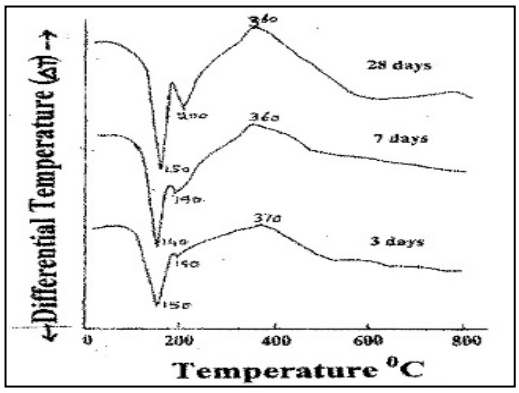


Fig. 1: DTA/TGA of Fluorogypsum

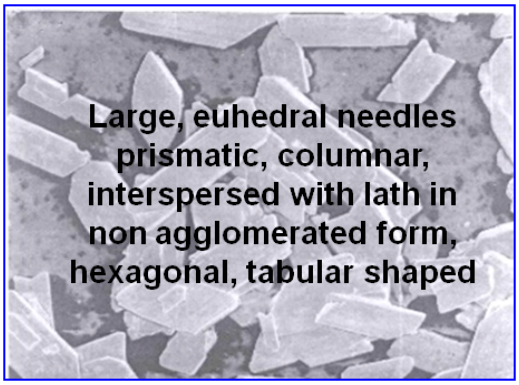


Fig. 2: SEM of Fluorogypsum

DTA (Fig. 1) and SEM (Fig. 2) studies have been carried out for characterization of Fluorogypsum binder. DTA shows increase in intensity of endotherm at 200 °C responsible for conversion of hydrated gypsum in to anhydrite. SEM shows the formation of large euhedral needles with lath in non- agglomerated form of anhydrite gypsum.

Building Products from Waste Gypsum:

The fluorogypsum binder has been used for making light weight blocks, tiles and plastering as per Indian Standards.

(i) Flooring Tiles (Fig. 3, IS: 1237-1980):

- Size : 30 mm x 30 mm x 20 mm
- Flexural Strength : 12.0 MPa
- Compressive Strength : 30-35 MPa
- Water absorption : < 6.0

(ii) Hollow blocks (Fig. 4, IS: 2849-1983):

- Size : 450 mm x 225 mm x 225 mm
- Compressive Strength : 3 MPa
- Water Absorption : < 15.0 %
- Bulk Density : 750-800 kg/m^3

(iii) Plaster (Fig. 5, IS: 1661-1972):

- Gypsum binder may be used as exterior wall plaster
- Base Coat : 1 : 2 (Binder : Sand), Thickness : 9mm
- Finish Coat : Neat Binder, Thickness : 3 mm
- Workability : 105 ± 2 mm
- Adequate strength and hardness : After 24 hours
- Texture : Smooth, hard and good adhesion with the brick

Fig. 3: FG Binder Flooring Tiles

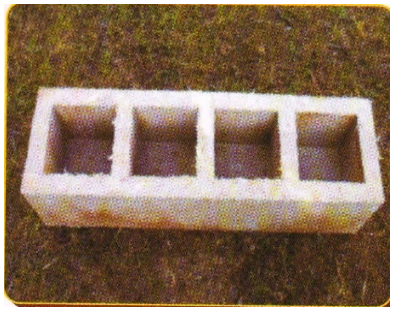


Fig. 4: Hollow Block

Fig. 5: Plastering

Evaluation of 'Arvind' Brand FRP pultruded Composite Section/Panels & their Use in Warehouse Construction

Rakesh Paswan, Chanchal Sonkar, Reyazur Rahman & Jeeshan Khan

Objective:

To study the structural behaviour of pultruded FRP profiles under axial and transverse loading conditions.

Progress Highlights:

Members Subjected to Axial Compression:

FRP pultruded profiles were tested under monotonically increasing load under compression until failure. It was found that the load carrying capacity of pultruded profiles increased with the increase in thickness and sectional area. The ultimate load at failure maximum mid span deflection and axial shortening is given in the Table 1. Typical load verses mid-span deflection curves of specimens tested under axial compression is presented in Fig. 1-2. The very first non-linear behaviour of curve is mainly due to initial adjustment of test specimen and assembly. The curves present both linear and non-linear behaviour. At ultimate load the specimen breaks suddenly without any sign of failure. The pultruded FRP specimens ultimately fail by local crushing at one end. Flange buckling and rupture of elements for most I – sections and C-Channel is also observed. Whereas the square pipes failed due to rupture of fibre matrix at one end and at mid-span of specimens. Few square pipe specimens also failed due to crushing at one end. Photo view of failed FRP specimen is presented in Fig. 3. Crushing

is not the expected mode of ultimate failure; its existence in more than one specimen shows that load transfer to the end of the specimen was not uniform. Such non uniformity arises due to geometric imperfections of specimen and mounting fixtures. Thus, designing for member resistance based on assuming uniform stress can lead to unsafe members that may fail with a mode that has not been anticipated.

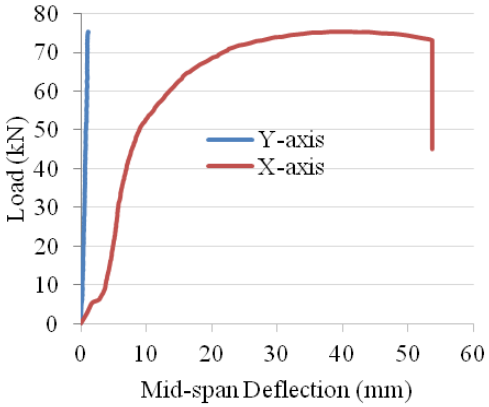


Fig. 1: Typical Load vs. Mid-Span Deflection of I-Beam (152.4 x 76.2 x 9.525) under Axial Compression

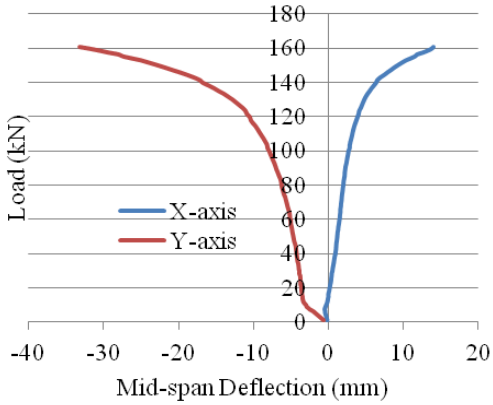


Fig. 2: Typical Load vs. Mid-Span Deflection of Square Pipe (76.2 x 6.35) under Axial Compression

Table 1: Summary of Axial Compression Test Results

Sr. No.	Profile	Profile size (mm)	Ultimate load (kN)	Max. Mid-span Deflection (mm)		Max. Axial Shortening (mm)
				X-axis	Y-axis	
1	I-Beam	203.2 x 101.6 x 9.525	163.4	49.77	0.43	7.86
2	I-Beam	152.4 x 76.2 x 9.525	75.3	53.67	1.1	3.28
3	I-Beam	152.4 x 76.2 x 6.35	67.8	49.7	0.88	4.46
4	I-Beam	152.4 x 152.4 x 9.525	347.4	2.95	18.16	13.06
5	I-Beam	152.4 x 152.4 x 6.35	-	-	-	-
6	I-Beam	101.6 x 101.6 x 6.35	117.3	9.16	4.95	24.16
7	C-Channel	355.6 x 88.9 x 9.525	-	-	-	-
8	C-Channel	300 x 75 x 12	-	-	-	-
9	C-Channel	250x100x12.5	-	-	-	-
10	C-Channel	254 x 69.85 x 12.7	-	-	-	-
11	C-Channel	203.2 x 55.5 x 9.525	361.8	2.8	6.21	20.69
12	C-Channel	200 x 100 x 10	476.1	5.72	2.94	10.9
13	C-Channel	152.4 x 42.86 x 9.525	332	5.24	2.07	13.36
14	C-Channel	152.4 x 41.3 x 9.525	400.9	47.64	2.16	20.53
15	C-Channel	250 x 50 x 4	-	-	-	-
16	Square Pipe	101.6 x 9.525	452.8	12.13	52.14	16.1
17	Square Pipe	101.6 x 8	411.3	8.96	27.99	19.35
18	Square Pipe	101.6 x 6.35	350.3	17.51	26.99	20.28
19	Square Pipe	76.2 x 9.525	180.4	2.19	48.65	6.66
20	Square Pipe	76.2 x 6.35	160.9	13.99	33.21	12.09
21	Square Pipe	88.9 x 6.35	243.6	48.97	14.47	26.36

I-Section **I-Section** **C-Channel** **Square Pipe**

Fig. 3: Failure Pattern of FRP Pultruded Profiles under Axial Compression

Members Subjected to Transverse Loads:

A third point load has been applied at the mid span of pultruded FRP profiles by a manually controlled hydraulic jack. The ends of the specimens are supported by roller to simulate simply supported conditions. Vertical supports are provided at both ends of the specimens to avoid lateral torsion. Three linear displacement transducers are used to measure the deformations at mid span and one-third of beams at each end. The channel sections are tested by connecting back-to-back. The ultimate load at failure maximum mid span deflection and maximum deflection at one-third is given in the Table 2. The typical load verses deflection graph of pultruded FRP specimens tested is given in Fig. 4-5. The figure shows linear behaviour up to ultimate failure/collapse. For few profiles the curve tends to nonlinear at near failure load due to failure of fibre matrix. The different failure pattern of FRP profiles is shown in Fig. 6. It was observed that the delamination/ crushing happens at the top surface (flange) under compression and later propagates through web or sides. Bending of an I-beam produces compression on the top flange as a result the flange buckles in local mode under or near the applied load and travels to web-flange junction. In most of I-section it can be seen that the web-flange junction was crushed, triggering the flange buckling. There was no crack propagation or delamination observed in the lower flange. For square tube sections the ultimate failure was found to occur in the compression flanges beneath the point of loading, starting with compression flange buckling and followed by delamination and shear failure of flange. In addition to local buckling of flange sections with loud cracking and rupture for few cases the failure initiated at the web-flange junctions followed by premature buckling and crushing in the web. The ultimate load in the channel section connected back-to-back was governed by local buckling of flange. Delamination of flanges and rupture along web-flange junction was observed for few cases. Local buckling and crushing of flanges away from point of loading was also observed in channel section connected back-to-back. It is observed that some specimens failed by twisting away from the centre towards one side. Due to which the failure did not occur under pure bending. The effect is not that vital since the ends are restrained against lateral torsion. Up on releasing of load, the profiles are observed to retain its original shape, leaving behind the marks of delamination and cracks.

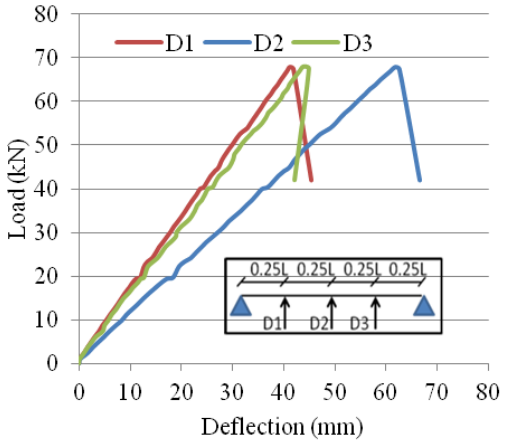


Fig. 4: Typical Load verses Deflection of I-Beam (152.4 x 152.4 x 9.525) under Three Point Bending

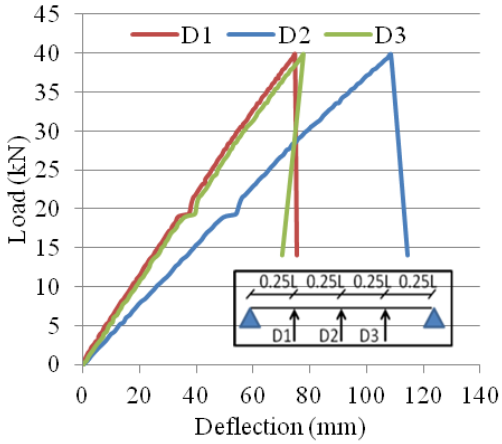


Fig. 5: Typical Load verses Deflection of Square Pipe (101.6 x 9.525) under Three Point Bending

Table 2: Summary of Three Point Bending Test Results

Sr. No.	Profile	Profile size (mm)	Ultimate load (kN)	Max. mid-span deflection (mm)	Max. deflection at one-third from end supports (mm)	
1	I-Beam	203.2 x 101.6 x 9.525	78.3	58.1	43.9	42.2
2	I-Beam	152.4 x 76.2 x 9.525	32.5	69.2	47.9	45.2
3	I-Beam	152.4 x 76.2 x 6.35	19.1	53.1	34.3	35.4
4	I-Beam	152.4 x 152.4 x 9.525	68.0	66.7	45.5	44.9
5	I-Beam	152.4 x 152.4 x 6.35	-	-	-	-
6	I-Beam	101.6 x 101.6 x 6.35	19.2	94.1	61.8	66.4
7	C-Channel	355.6 x 88.9 x 9.525	142.5	19.6	14.3	13
8	C-Channel	300 x 75 x 12	97.8	15.9	10.7	10.7
9	C-Channel	250x100x12.5	184.7	38.3	29.1	24.4
10	C-Channel	254 x 69.85 x 12.7	82.0	18.1	12.0	11.7
11	C-Channel	203.2 x 55.5 x 9.525	64.8	43.7	30.6	27.6
12	C-Channel	200 x 100 x 10	117.8	40.0	26.4	-
13	C-Channel	152.4 x 42.86 x 9.525	38.6	49.6	32.6	-
14	C-Channel	152.4 x 41.3 x 9.525	33.6	61.3	33.8	-
15	C-Channel	250 x 50 x 4	19.3	27.8	18.4	12.8
16	Square Pipe	101.6 x 9.525	39.8	114.3	75.4	77.6
17	Square Pipe	101.6 x 8	41.2	134.8	87.5	94.2
18	Square Pipe	101.6 x 6.35	22.8	94.0	68.7	-
19	Square Pipe	76.2 x 9.525	18.4	134.5	92.4	105.0
20	Square Pipe	76.2 x 6.35	15.8	140.5	96.2	104.8
21	Square Pipe	88.9 x 6.35	18.8	109.2	72.7	-

I-Section **C-Channel** **Square Pipe**

Fig. 6: Failure Pattern of Pultruded FRP Profiles under Three Point Bending

Conclusions:

(i) The pultruded FRP profiles subjected to axial compression ultimately fail by local crushing at one end, flange buckling and rupture of elements for most I-sections and channel sections, whereas the square pipes fail due to rupture of fibre matrix at one end and at mid-span of specimens.

(ii) The failure of FRP pultruded profiles under three point bending tests are governed by local buckling in compression flange beneath the loading followed by delamination and crushing of web-flange junction and premature buckling of web in case of square tube section.

Study on Rates and Ratios used in the Construction Sector and Capital Formation for estimation of Gross Value Added (GVA) of Construction

Ashok Kumar, Kishor S. Kulkarni, Navjeev Saxena, Rajesh Deoliya, S.K. Singh, Sujit Saran, H.C. Arora, Sayantani Lala, Seraj Alam, Naresh Kumar, Aditya Kumar, Simran Taneja, Arun Kumar, Shivam Tyagi, Sonu Kumar, Deepanshu Bhardwaj, Mukesh Kumar & Team

Objectives:

- To study expenditure and percentage in respect of various materials (e.g. cement and cement products, Iron and steel casting including steel bars/angles/frames etc., wood and wood products except furniture, glass and glass products, other non-metallic mineral products excluding cement (such as bricks and tiles etc.), bitumen, granite/marble/Kota-stone, tiles, aggregates, earthwork, sand, admixtures, other chemicals and other materials used in construction sector; factors related to labour, hiring charges, rentals for construction activities like machines/equipment etc. in different regions and/or states;
- To identify weights of different materials used in construction activities to arrive at the cost composition for the estimates of various types of construction activities to attain the cost composition for the construction sector;
- To estimate the percentage recycled bricks and blocks out of total bricks and blocks used in construction; and
- To estimate the consumption of various construction materials by different states for state-wise allocation of GVA of construction sector and capital formation.

Progress Highlights:

The study has been carried out by adopting a scientific methodology, splitting the teams into different groups. The first group designed & prepared the Questionnaire and conducted the preliminary

surveys, in & around Roorkee town to identify the difficulties and/or deficiencies in filling the data or gathering the information on desired format. The survey questionnaire has been designed to get a summary of information on completed buildings or under construction infrastructure projects including the construction typology, location, commencement of construction and completion year, type of construction (framed/masonry), number of storey and built -up area, construction agency (central/state govt./major agency/private contractor/petty contractors), schedule of rates (sors) followed in preparing cost estimates, bill of quantities (BoQs), materials and specifications used in different projects and their cost, cost of different types of materials and labour, cost of hiring shuttering, machines etc., cost of overheads etc., special features of the project, if any, contractor's profit etc.

The data collection Questionnaire has been used to get the information of different projects in different cities/towns of India in different states such as Assam, Chhattisgarh, Goa, Himachal Pradesh, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Puducherry, Punjab, Tamil Nadu, Uttarakhand, Uttar Pradesh, West Bengal. In each state, five cities & towns are identified for the study of residential and non- residential buildings, roads, canals, bridges, flyovers including buildings under PMAY- rural & urban schemes etc. The costs of different materials, labour, machinery in different regions, percentage of materials used in about 600 projects were studied. The study has so far helped in identifying weights of different materials used in construction activities to arrive at the cost composition for the estimates of various types of construction activities to attain the cost composition for the construction sector. This has helped in estimating the consumption of various construction materials by different states for state -wise allocation of GVA of construction sector and capital formation by the Government of India in the first phase of the identified cities & states. In the second phase, the remaining states shall be covered.

AcSIR

AcSIR

The Institute is conducting an integrated M.Tech-Ph.D. (IMP) programme under the aegis of Academy of Scientific & Innovative Research (AcSIR) since 2010 in the area of 'Building Engineering & Disaster Mitigation (BEDM)', which changed to "Building Engineering & Construction Technology" from last year. From this year, Integrated Dual Degree Programme (IDDP) has been started, in which M.Tech. & Ph.D. degree will be awarded together after completion of the course. The Institute is also taking Ph.D. students in the area of Engineering Sciences, Chemical Sciences and Physical Sciences. The details of different batches are given below:

M.Tech.

- 7th batch (2018-20) - ongoing

IDDP

- 1st batch (August 2019) - 3 students joined
- 2nd batch (January 2020) - 2 students joined

Ph.D.

- Two students joined for Ph.D. in Engineering Sciences in August 2019.
- Two students joined for Ph.D. in Engineering Sciences and one for Ph.D. in Physical Sciences in January 2020.
- Presently total 19 Ph.D. students and 5 IDDP students are enrolled in AcSIR at CSIR-CBRI.

Some of the highlights of the student activities in the current year are:

Awards received by Students:

(i) Mr. Shubham Singhal received Director's Technology Award for the year 2019-20 for "Headed Bars as Mechanical Anchorage System for RC Beam-Column Joints", as one of the co-authrors.

(ii) Mr. Rajesh Kumar Dash received the Best Paper Award at National Conference on "Geology and Natural Resources of Himalaya" at Pt. L.M.S Govt. P.G. College, Rishikesh during November 25-26, 2019 for his research paper entitled "Numerical Modelling of Debris Flow Runout using Voellmy Approach".

(iii) Mr. Mahesh Gaikwad received the Best Poster Presentation Prize in "Poster Presentation-Engineering and Geo Sciences" at the "AcSIR GYANTARANG 2020" jointly organised by

Academy of Scientific and Innovative Research (AcSIR) and CSIR-North East Institute of Science and Technology, Jorhat (CSIR-NEIST, Jorhat) during January 23-25, 2020.

Abdul Kalam Summer Trainee

1. Ms. Kinjal Rohit
2. Mr. Vivek Singh

Ph.D. Awarded

- Mr. Mahesh Sharma successfully defended his Ph.D. viva-voce examination on November 9, 2019 on his thesis entitled "Pullout Behaviour of Conventional and Helical Soil Nails in Cohesionless Soils". He worked under the supervision of Dr. S. Sarkar, Prof. Deepankar Choudhury and Mr. M. Samanta.

INFORMATION, EXTENSION & PROJECT MANAGEMENT

Publication Group

The Publication Group continued to serve as nerve centre of the Institute, conducting and coordinating multifarious activities such as collection, storage and dissemination of R&D information; handling scientific and technical enquiries; publicity and public relations; compilation, editing and publication of CSIR-CBRI Annual Report to meet the inter and intra-institutional information needs; editing and publication of CSIR-CBRI Newsletter and भवनिका (Newsletter in Hindi) periodically; publication of Building Research Notes, Project Profiles, Technical and Divisional Brochures etc.; preparation of other scientific/technical reports and filling up of questionnaires; providing inputs for CSIR Annual Report as well as for CSIR News, CSIR Samachar and CSIR in Media; reporting scientific and technical work carried out at the Institute in Hindi and English; and publicity of the Institute's R&D capabilities through print media.

- **CSIR- CBRI Annual Report:**
  (available online at https://cbri.res.in/dissimination/annual-reports/)

The annual report is a reflection of the Institute's achievements throughout the year including R&D projects and highlights, research output, glimpse of activities, honours and awards, CBRI family, student-scientist connect programmes, lectures delivered, technology transferred and MoU signed, date-line and information, extension and project management etc. It is a result of intensive efforts made in manuscript evaluation, editing, graphic design, layout, illustrations, print-production, publishing, dissemination and feedback. Considerable inputs are involved in checking the output for language, page style, consistency, clarity, factual errors, adequate visual supply, technical details, colour composition and consistency, resolution of pictures, font and so on.

- **Bilingual CSIR-CBRI Newsletters/ भवनिका:**
  (available online at https://cbri.res.in/dissimination/newsletters/)

भवनिका/CBRI Newsletter
April-June 2019

भवनिका/CBRI Newsletter
July-September 2019

भवनिका / CBRI Newsletter
October-December 2019

भवनिका / CBRI Newsletter
January-March 2020

The publication provides a glance at the Institute activities including R&D outputs, training programmes, events, staff news etc. on quarterly basis in Hindi and English. It is resultant of extensive manuscript evaluation, editing, design, layout, illustration, print production, publishing, dissemination and feedback.

- **Technology Brochure, BRNs, Project Profiles etc.:**
  Technical, information and single-sheet project profiles, building research notes (BRNs) and brochures provide technical details of developed technologies, demonstrating reliability and excellence of Institute's work for public and consumer agencies in a sustainable, cost-effective, attractive and simple way.

- **R&D Highlights/Research Output of CSIR-CBRI in CSIR Annual Report:**
  Compiled R&D achievements of the Institute and transmitted for CSIR Annual Report covering the following items:
  - Contribution to GOI Missions
    - Swasth Bharat
    - Swachh Bharat
    - Skill India
    - Digital India
  - Important Technological Contributions Against Sustainable Development Goals
    - Brief write up
    - Brief on technologies transferred/ licensed/ commercialized
  - Important Services to Rural Sector
  - Important Scientific Achievements – Academic Impact
    - Brief summary of significant scientific contributions with impact factor, if published
  - Annexure
    - Patents
    - Publications
    - Honors and Awards
    - Important Events
    - MoUs/ Agreements

- **सीएसआईआर समाचार में सीबीआरआई :**
  CSIR releases सीएसआईआर समाचार- a newslwtter in Hindi that covers various activities of all its laboratories including R&D achievements, foundation day celebrations, programmes on important awareness days, seminars, demonstrations, training programmes, etc. Inputs are sent regularly on behalf of the Institute to the Newsletter. During the year, almost each newsletter witnessed the presence of CSIR-CBRI. Seventeen inputs of CSIR-CBRI witnessed their presence in सीएसआईआर समाचार, the same also available online at http://www.niscair.res.in/periodicals/csirsamachar

सीएसआईआर समाचार में सीबीआरआई

क्र.स.	लेख	अंक	पृष्ठ	वर्ष
1.	सीएसआईआर-सीबीआरआई, रुड़की में स्नातकोत्तर शिक्षकों के लिए कार्यशाला	वर्ष 7 अंक 4	53-56	अप्रैल 2019
2.	केंद्रीय भवन अनुसंधान संस्थान, रूड़की में राष्ट्रीय प्रौद्योगिकी दिवस - निर्माण प्रौद्योगिकी का वर्ष मना रहा है भारत	वर्ष 7 अंक 5	65-67	मई 2019
3.	सीएसआईआर-केंद्रीय भवन अनुसंधान संस्थान, रूड़की में स्वच्छता पखवाड़ा आयोजन	वर्ष 7 अंक 5	78-80	मई 2019
4.	सीएसआईआर-केंद्रीय भवन अनुसंधान संस्थान, रूड़की में 'विस्मित विज्ञान सप्ताह' का आयोजन	वर्ष 7 अंक 6	86-91	जून 2019
5.	सीएसआईआर-सीबीआरआई, रुड़की द्वारा जिज्ञासा के अंतर्गत आयोजित जागरूकता कार्यक्रम	वर्ष 7 अंक 8	121-126	अगस्त 2019
6.	सीएसआईआर-सीबीआरआई, रुड़की के वैज्ञानिकों ने जिज्ञासा के अंतर्गत विद्यालयों में विद्यार्थियों को प्रेरित किया	वर्ष 7 अंक 10	161-164	अक्टूबर 2019
7.	सीएसआईआर-सीबीआरआई, रुड़की ने जिज्ञासा के अंतर्गत विज्ञान प्रदर्शनी और सेमिनार के दौरान विद्यार्थियों को प्रेरित किया	वर्ष 7 अंक 11	165-167	नवम्बर 2019
8.	सीएसआईआर-सीबीआरआई, रुड़की में त्रि-दिवसीय राज्य-स्तरीय विद्यार्थी कार्यशाला	वर्ष 7 अंक 11	185-188	नवम्बर 2019
9.	महानिदेशक डॉ शेखर मांडे ने सीएसआईआर-सीबीआरआई, रुड़की में आयोजित आईआईएसएफ 2019 पूर्ववर्ती कार्यक्रम की अध्यक्षता की	वर्ष 7 अंक 12	193-195	दिसम्बर 2019
10.	सीएसआईआर, रुड़की में सतर्कता जागरूकता सप्ताह का आयोजन	वर्ष 7 अंक 12	199-201	दिसम्बर 2019
11.	सीएसआईआर-सीबीआरआई, रुड़की ने स्वच्छता ही सेवा 2019 के अंतर्गत विद्यार्थी जागरूकता गतिविधियों का आयोजन किया	वर्ष 7 अंक 12	201-202	दिसम्बर 2019

12.	सीएसआईआर-सीबीआरआई, रुड़की द्वारा जिज्ञासा विद्यार्थी-वैज्ञानिक संयोजन कार्यक्रम	वर्ष 8 अंक 1	14-16	जनवरी 2020
13.	सीएसआईआर-सीबीआरआई द्वारा भूकम्परोधी निर्माण प्रौद्योगिकी पर प्रशिक्षण पाठ्यक्रम का आयोजन	वर्ष 8 अंक 2	18-19	फरवरी 2020
14.	सीएसआईआर-सीबीआरआई द्वारा उत्तराखंड के ग्रामीण राजमिस्त्री के लिए प्रशिक्षण कार्यक्रम	वर्ष 8 अंक 2	19	फरवरी 2020
15.	सीएसआईआर-सीबीआरआई द्वारा अग्नि सुरक्षा उपायों के डिजाइन पर लघु अवधि पाठ्यक्रम का आयोजन	वर्ष 8 अंक 2	20	फरवरी 2020
16.	सीएसआईआर-सीबीआरआई में राष्ट्रीय विज्ञान दिवस के अवसर पर व्याख्यान, प्रयोगशाला भ्रमण एवं वैज्ञानिक-विद्यार्थी संवाद आयोजित	वर्ष 8 अंक 3	40-42	मार्च 2020
17.	सीबीआरआई स्थापना दिवस समारोह 2020	वर्ष 8 अंक 3	45-47	मार्च 2020

- **CBRI in CSIR News:**

  CSIR releases newsletter carrying information on activities and accomplishments of its laboratories covering R&D highlights; new products and technologies; conferences, workshops, exhibitions; and major events such as Foundation Day, National Technology Day, Science Day, World Environment Day etc.

  Write-ups have been prepared and inputs on regular basis are provided for the same on behalf of the Institute. During the year, fourteen inputs of CSIR-CBRI witnessed their presence in the newsletter; also available online at http://www.niscair.res.in/periodicals/csirnews

CBRI in CSIR News

S. No.	Article	Volume/ Issue	Page No.	Month
1.	CSIR-CBRI Observes National Technology Day	Volume 69 No. 9 & 10	94-96	May 2019
2.	CSIR-CBRI Celebrates Vismit Vigyan Saptah	Volume 69 No. 11 & 12	115-119	June 2019
3.	CSIR-CBRI Observes “Swachhta Pakhwada”	Volume 69 No. 13 & 14	130-132	July 2019

4.	CSIR-CBRI, Roorkee Organises Awareness Programmes under JIGYASA	Volume 69 No. 15 & 16	157-159	August 2019
5.	78th CSIR Foundation Day Celebrations at CSIR-CBRI	Volume 69 No. 19 & 20	197-199	October 2019
6.	Dr Shekhar C. Mande Presides over IISF Precursor Events at CSIR-CBRI	Volume 69 No. 21 & 22	209-211	November 2019
7.	CSIR-CBRI Motivates Students during Science Exhibitions & Seminars under JIGYASA	Volume 69 No. 21 & 22	218-219	November 2019
8.	CSIR-CBRI Organises Students Awareness Activities to Observe Swachhata Hi Seva 2019	Volume 69 No. 23 & 24	231-232	December 2019
9.	CSIR-CBRI Observes Vigilance Awareness Week	Volume 69 No. 23 & 24	233-236	December 2019
10.	Training Programme on Multi-Hazard Resistant Housing and Habitat for Engineers of Uttarakhand	Volume 70 No. 3 & 4	37-38	February 2020
11.	Important Awareness Days Observed by CSIR-CBRI under JIGYASA	Volume 70 No. 3 & 4	39-40	February 2020
12.	Design & Strengthening Measures for Building Foundation Systems in Hilly Regions by CSIR-CBRI	Volume 70 No. 5 & 6	49-51	March 2020
13.	CSIR-CBRI Motivates Students on National Science Day	Volume 70 No. 5 & 6	56-57	March 2020
14.	PGT Programmes by CSIR-CBRI under JIGYASA	Volume 70 No. 5 & 6	59-60	March 2020

- **CBRI in CSIR in Media:**
  CSIR, New Delhi releases an online publication "CSIR in Media" highlighting the achievements of CSIR Labs published in Newspapers for public awareness. Inputs from CSIR-CBRI, Roorkee were provided for insertion on a regular basis and are available online at https://www.csir.res.in/news-bulletin.

- **Inputs in Electronic & Print Media:**
  (available online at https://cbri.res.in/csir-cbri-in-media/)
  Newspapers, as media of mass-communication, are capable of generating scientific consciousness and rational behaviour in public. Keeping this in view, all the daily newspapers are kept in continuous dialogue and witnessed CBRI presence on regular basis.
  Various parameters-threshold, frequency, negativity, unexpectedness, unambiguousness, personalization, meaningfulness etc- are considered while preparing the news-items to be sent for dissemination. News-items for the press are cast within a short time period, ensuring publishing of the highlights of the activities held in the next day's newspapers.
  During the year, approximately 60 news-items (a total of about 350 news clippings) about CBRI have witnessed their presence in about 6-8 regional and national newspapers including Amar Ujala, Dainik Jagran, Hindustan, Rashtriya Sahara, Punjab Kesari, Badri Vishal, Dainik Aaj, Dainik Bhaskar, Dainik Hawk, Golden Times, Swatantra Chetna, Uttar Bharat Live, Loksatya etc.

- **Press Meets – Jan Samvad:**
  Press Meets- Jan Samvads are also organized periodically to apprise the public on the latest achievements of the Institute, important events and to broaden their horizons in the field of science.
  Press Representatives from electronic & print media including Amar Ujala, Dainik Jagran, Hindustan, Rashtriya Sahara, Dainik Aaj, Dainik Bhaskar, Dainik Hawk, Punjab Kesari, Uttar Bharat Live, Swatantra Chetna, Golden Times and Badri Vishal etc. attended the meet.

- **Visibility in Conference/Souvenir/Symposium Proceedings etc:**

  Image building of the Institute by increasing visibility through advetisements etc. in Conference/ Souvenir/Symposium Proceedings etc..

- **Outreach through Articles in Magazines, Periodicals etc:**
  Articles reflecting Institute's capabilities and achievements are also published in Popular Science Magazines that are accessible to everyone including inputs in:
  - विज्ञान प्रगति, वर्ष 68, अंक 2
  - विज्ञान प्रगति, वर्ष 67, अंक 12
  - विज्ञान प्रगति, वर्ष 67, अंक 10
  - विज्ञान प्रगति, वर्ष 67, अंक 4

- **Outreach Programmes:**
  During the year, about 11,000 candidates (students and teachers) from different schools and colleges have participated in 52 programmes organized by CSIR-CBRI, Roorkee, under "Jigyasa- Quest for Curiosity Student-Scientist Connect Programme".

- **India International Science Festival (IISF 2019) Precursor Events**
  - Press Meet
  - Open Day & Science Festival

Development, Construction & Extension Group

The Development Construction and Extension Group at the Institute is involved in various activities with a main objective to disseminate outcome of the R&D of the institute among the user agencies for field implementation.

Training Programmes:

During the year 2019-2020, the group organized 15 in-house and off-campus training programmes. The group imparted training and skill upgradation to more than 1500 persons. The major participating agencies in this were State PWD's, State Disaster Management Authorities, MDoNER, Panchayati Raj Deptt. of State Govt., NGO's, Red Cross Societies, Nirmithi Kendras, District Administrations and Himachal Pradesh ST&E Department etc. In training programme, the main emphases were to keep the balance of theory and practical skill set, in order to generate interest towards science and technology in the trainees. During the in house training programmes, trainees were taken to visit different laboratories of CBRI that allowed them to interact with the scientists and researchers, with the aim to equip the target groups with necessary technological skills through exposure to innovative building technologies developed by the Institute. The Institute has been assisting the building construction and building material industries, rural and urban housing, energy conservation, efficiency, fire hazards, structural and foundation problems, and disaster mitigation. DCE Group generated the ECF of more than Rs. 45.00 lakhs from these training programmes, the details of same are given under Network Project (NWP 100) and glimpses of the activities are given below:

Group Photographs of Participants of Training Programmes

Inauguration of Uttarakhand Training

Inauguration of M. Visvesvaraya Training Hall

Site Visit at Haridwar

Practical Demonstration in Demo Park

Visit to Construction Technology Demonstration Park

Visit to Rural Technology Park

Exhibitions:

In the year 2019-2020, the group has participated enthusiastically in four exhibitions, interacted with the masses and created the general awareness about the various technical advancements of CSIR-CBRI. Details of various exhibitions are as follows:

(i) Participated in 4 days exhibition of ***"Bhopal Vigyan Mela"*** during September 13-16, 2019 at Bhopal, in which CSIR-CBRI displayed its technologies.

(ii) Participated in 2 days exhibition of ***"Uttarakhand Industrial Summit"*** during September 27-28, 2019 at Haridwar.

(iii) Participated in 4 days exhibition of ***"Indian International Science Festival"*** (IISF-2019) during November 5-8, 2019 at Kolkata.

(iv) Participated in 5 days exhibition of ***"Indian Science Congress"*** (ISC-2020) during January 3-7, 2020 at Bangalore.

India International Science Festival, Kolkata

Indian Science Congress Exhibition, Bangalore

Bhopal Vigyan Mela, Bhopal

IISF Exhibition, Kolkata

Officials from Different Organizations/ Students of Engg. /Architecture Colleges:

The Group has organized various technical visits for different organizations/colleges/schools at the Institute and a total 737 students and other officials have participated in the year 2019-2020. The participants have been briefed about all the laboratory works and various housing technologies developed by the Institute through visits of various laboratories and rural technology park of the Institute and list of the same are as follows:

S. No.	Name of Institute/Organisation	Date of Visit	Number of Visitors
1	Engineers of Uttarakhand Govt.	22.04.2019	39
2	Students of IIT Roorkee	02.05.2019	10
3	Engineers of Uttarakhand Govt.	20.05.2019	23
4	Engineers of Himachal Pradesh Govt.	10.06.2019	27
5	Engineers of Himachal Pradesh Govt.	17.06.2019	20
6	Engineers of Arunachal Pradesh Govt.	05.08.2019	35
7	Engineers of Arunachal Pradesh Govt.	19.08.2019	62
8	Engineers of Uttarakhand Govt.	26.08.2019	15
9	Students of Quantum College of Technology, Roorkee	13.09.2019	125
10	Students of IMMT Ghaziabad	29.09.2019	45
11	Students of MIET Meerut	20.11.2019	50
12	Engineers of MP & MH Govt.	03.12.2019	12
13	Engineers of Uttarakhand Govt.	16.12.2019	47
14	Engineers of Uttarakhand Govt.	20.01.2020	36
15	Students of DAV College Muzaffarnagar	05.02.2020	50
16	Engineers of Uttarakhand Govt.	17.02.2020	31
17	Students of NIIT Najibabad	27.02.2020	80
18	Engineers of Govt. of Madhya Pradesh Tribal Department	02.03.2020	30
		Total	**737**

Visit to Demonstration Park

Visit to Structure Laboratory

Visit to Geotechnical Laboratory

Visit to Rural Park

Visit to Fire Engineering Laboratory

Practical demonstration

Production of Technical Videos:

CSIR-CBRI has prepared short technical films on different building technologies, for its wider publicity among all the community through web.

- Construction Technology Demonstration Park, CSIR-CBRI Roorkee
- Post-Earthquake Reconstruction of Schools in Nepal

Non-Working Models:

CSIR-CBRI has prepared 5 non-working models on Bamboo and various housing typologies developed in the Institute for its wider publicity through exhibitions organized in different locations of the country and the exhibitions hall of the Institute.

Knowledge Resource Centre

Knowledge Resource Centre (KRC) is engaged in acquisition, technical processing, updating the collection and providing the platform for e-access of information sources to expand the horizon of information base to the scientific community. It is fully automated and RFID enabled systems and services.

Acquisition:

- **Books**: KRC purchased 123 numbers of books and received 05 numbers of books on gratis basis.
- **Journals:** The library has subscribed 52 journals (21 foreign e-journals, 14 foreign print journals and 17 Indian journals). 123 volumes of journals were got bound.

Library Statistics:

The present position of library Collection:

- Books including reports; standards; conference proceedings; theses and maps: 45,228
- Bound Periodicals: 20,877

Institutional Membership:

CSIR-CBRI is a member of four national and three international professional/learned societies. KRC receive their publications against the annual membership fees.

- **National (India):** Indian Geotechnical Society (IGS), Delhi; Institute for Steel Development and Growth (INSDAG), Kolkata; Indian Science Congress Association (ISCA), Kolkata; Indian Green Building Council (IGBC), Hyderabad; and Indian Building Congress (IBC), Delhi.
- **International / Foreign :** International Union of Laboratories and Experts in Construction Materials, Systems and Structures (RILEM), Bagneux, France; International Federation for Structural Concrete (fib), Lausanne, Switzerland; and American Concrete Institute (ACI), USA.

Exchange of Publications : Besides membership, the library received Annual Reports; News Letters; Technical Reports; Reprints and other materials in exchange from National and International Organizations.

Resource Sharing and Local Networking: CBRI-KRC is maintaining continuously good relationship with the libraries located in Roorkee viz. Indian Institute of Technology; National Institute of Hydrology; and providing resource sharing through inter library loan. Besides the local network, KRC is maintaining the liaison and relationship with the KRC's of CSIR Laboratories/DST Labs and other academic/research institutions.

Services: KRC is playing a coordinating role between users and the literature, providing personal Information service through Current Awareness (CAS) and Selective Dissemination of Information (SDI) using modern information technology. Besides the day to day circulation, reference and Xeroxing services, KRC is also rendering the following specific services:

- **Documentation:**
  a) **Paper Clipping Service (PCS):** PCS is continued through scanning nine no. of newspapers in English and Hindi. The topics of the interest of the institute under eleven major heads like-Building Materials; Structure and Foundation; Disaster Management:

Earthquake and Landslides; Shelter Planning and Policy; Environment Science and Technology; Fire Research; CSIR/ CBRI etc. The paper clipping are kept in classified order for providing current awareness service to users.

b) **List of Latest Addition:** KRC is bringing out a quarterly list of latest arrivals of books for the general awareness of library users.

c) **Bibliographic Service:** KRC is providing bibliographic service to users on demand on the subject of interest from in-house database as well as international databases.

d) **Current Contents Page (CCP)**: CCP of print journals and e-journals are providing through attachment of mass e-mail to S&T members for current awareness.

- **Web-OPAC Search:** KRC has created a bibliographic database of documents and providing search facility through computer. Users can search any document through any access point like author, class no., subject, title, keyword and combination of search (Boolean search).

- **CD-ROM:** CD-ROMs are available in KRC viz. CIB Conference Proceedings, ACI Manual, Pate state: a database of CSIR patents; heritage buildings and sites.

- **In-house Database:** KRC is maintaining in-house bibliographic database of books and bound volumes of journals.

- **Internet Facility:** KRC has internet connectivity node with PC's as well as wi-fi connectivity for users to access of e-resources.

- **Access of E-Journals:** Now, access to over 2000 full text of e-journals of leading S&T publisher's viz., ASCE, full text of ASTM Standards, Elsevier(selected), ICE (UK), IEEE, Nature, OUP, RSC, T&F, Wiley; science databases like Web of Science (WoS); and patent database viz. QPAT/ORBIT are available online under National Knowledge Resource Consortium (CSIR-DST E-journals Consortium) as well as direct subscription.

- **Knowledge Repository:** KRC has created Institutional Repository (IR) through dspace software. Large number of records has already uploaded contains full text database along with metadata of published research papers of S&T staff members of the Institute as well as all Building Research Notes (BRN), Project Profiles, Annual Reports of CSIR-CBRI since 1953 and conference proceedings volumes, organized by CSIR-CBRI. This database can be accessed at http://krc.cbri.res.in/dspace.

- **Book Exhibition:** KRC has organized a book exhibition and displayed the latest Hindi books from own collection during the celebration of 'Hindi Pakhwara' (September 2-15, 2019).

Planning & Business Development

PBD Group acts as the main facilitator of the Institute for effective planning, monitoring, evaluation and project budgeting of all R&D and Externally Funded Projects such as Consultancy Sponsored Projects, Grant–In-Aid and Technical Services, etc. Important documents, externally funded projects for MC agenda and R&D agenda for the Research Council are also dealt with by the group. Besides this, the group manages technology transfer to the industries, IPR management activities and execution of agreements and MoUs with various industries/institutes/organisations.

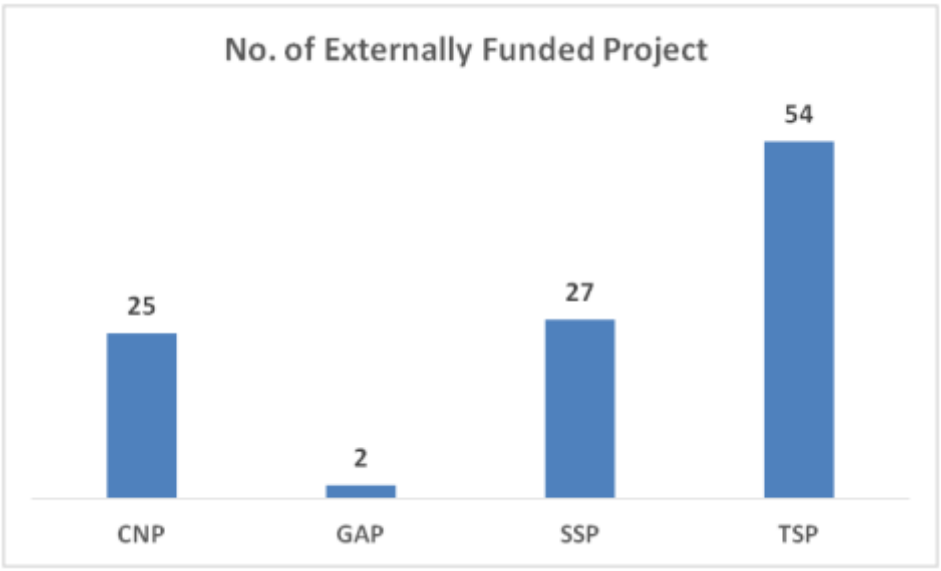
PBD Group monitors and compiles the Monthly Progress Report (MPR) and Quarterly Progress Report (QPR) of the research activities of the Institute, as well as the Research Utilization Data (RUD) for onward transmission to CSIR, New Delhi. The group regularly maintains and monitors the project records in terms of physical and financial recommendations of internal monitoring committees, Research Council (RC) and Management Council (MC).

R&D Projects:
Internal review meetings and meetings with external experts are organized for review of new R&D projects. The ongoing projects are monitored for progress and/or mid-course corrections. Comments of experts are conveyed to concern PIs and it is ensured that the same are incorporated before the projects are placed to RC. R&D projects were processed under the R&D areas of the Institute, namely, Housing-Structure & Foundation, Conservation of Heritage Structures, Innovative Building Materials, Disaster Mitigation, and Energy Efficient System & Building Process & Automation. During the 2019-2020, Institute was intensely involved in 12 In-House R&D, 3 CSIR Coordinated Mission Mode, 2 Network Projects i.e. Student-Scientist Connect Programme-Jigyasa and Integrated Skill Initiative and 2 Fast Track Translation (FTT) Projects.

Project Evaluations & Peer Reviews:
Internal and external peer review meetings and project evaluation meetings have been organized for new and on-going In-House R&D Projects as well as for the CSIR Coordinated & FTT Projects during the year. PBD group coordinated the scheduling of presentations and interacted with the project leaders for putting up the relevant documents. The inputs as an outcome of the meetings are incorporated in the projects prior to placing the same before the Research Council.

Research Council Agenda:
Research Council Meetings are held to monitor the progress of R&D projects of the Institute. The R&D agenda of 58th RC meetings has been prepared. The agenda covered the progress of ongoing projects as well as completed projects during the period and new projects taken by S&T staff. The outcome in terms of suggestion/direction/guidance are communicated to the concerned project leaders.

Externally Funded Projects:
The Institute has undertaken various externally funded projects on the basis of the expertise in different areas in the form of Consultancy, Sponsored, Grant-in Aid and Testing. The number of externally funded projects undertaken are shown in Figure:



A database of all the externally funded projects is maintained which helps in effective monitoring of these projects. Necessary record and receipts of GST/Service Tax and TDS collection are maintained. GST/Service tax is deposited with the authorities and Form-16 sent to CSIR for recoupment of tax deducted at source by the sponsors of various projects.

Institute Publication:
PBD group also prepares a list of publications, published by the S&T staff members of the Institute in journals conferences, workshops and book chapters.

Manpower Planning & Deployment:
Human Resource Management lays special emphasis on planning for optimal deployment of the scientific, technical, non-technical and administrative staff of the Institute. The group gathers information regarding deployment from various groups for the preparation of manpower planning and deployment.

Management Council Agenda & Other Documents:
Prepared agenda items related to externally funded projects and action taken for MC meeting. The group also coordinated replies to various audits (CAG, CSIR and Service Tax), attended to RTI and Parliament questions.

Events Organised:

I. International Yoga Day
II. Family Get Together with Fun & Sports
III. International Women's Day
IV. Medical Camp for Staff members & their Families

Summer Vocational Training Program for UG & PG Students of Different University & Institutions:
Vocational training of 2-6 months duration was organized and managed for 149 Under-Graduate/ Post Graduate Science and Engineering students (BE/B.Tech/B.Arch/ME./M.Tech/MCA/MSc., etc) from different institutes such as BITS, IITs, NITs, VIT, THDC, etc.

Budget & ECF

CSIR Resource Input		External Cash Flow (ECF)		
Revenue	2951.439 Lakh	Private	905.169 Lakh	***(includes 138.022 Lakh GST)***
Capital	350.521 Lakh	Govt. + PSU	3166.680 Lakh	***(includes 475.579 Lakh GST)***
Special Projects	1848.727 Lakh			
Total	**5140.687 Lakh**	**Total**	**4071.849 Lakh**	***(includes 613.601 Lakh GST)***

SPECIAL EVENTS

Swachhta Pakhwada

CSIR-CBRI, Roorkee observed Swachhta Pakhwada during May 1-15, 2019. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee inaugurated the Pakhwada by administrating "Swachhta Shapath" and planted trees at Institute premises, under "Swachh Paryavaran".



Message of Cleanliness was spread through e-mails, notice boards, banners, digital displays etc. under "Swachhta Jagrukta". Extensive cleaning of Institute premises, laboratories, colony, hostel, roads, dustbins, grounds, shopping complex, park etc. was carried out under "Swachh Parisar". Pest control and fogging were also carried out on the floors of Institute and residential areas. Group Leaders/ Division Heads supervised cleaning and inspection of their respective division/group under "Swachh Anubhag". Doors, windows, curtains, machineries, facilities, equipments etc were scrubbed and repaired. Obsolete items, old unused files, papers, newspapers, magazines etc were disposed.



Canteen and mess were inspected under "Swachh Ahaar" and emphasis was given on the practice of clean and nutritious diet, plastic restriction and use of dustbin. "Swachh Neer" was carried out for cleaning and repair of water installations, drinking water filters, faucets, tank, leaking pipes. "Swachh Prasadhan" encompassed cleaning of toilets, sewer lines and drainage systems etc.

Under the supervision of Dr. Atul Kumar Agarwal, Senior Principal Scientist & Jigyasa Programme Coordinator, CSIR-CBRI, Roorkee, several student-scientist awareness and interactive activities, as a part of "Swachh Bhawishya" and "Swachh Pratispardha", have been carried out for students during the Pakhwada, under the aegis of Jigyasa: Student-Scientist Connect Programme.



Dr. Atul Kumar Agarwal presented several lectures including "Stay Clean, Stay Healthy: Strengthen the Foundation of India" at Sri Sanatan Dharm Prakash Chand Kanya Inter College, "Jigyasa: How can India Become a Zero Waste Country" at Arya Kanya Pathshala Inter College and "Jigyasa: Value-

Added Products from Waste" at CBRI Junior High School. Slogan & Essay Writing Competition was organized for the students on the topic "Swachh Bharat" at CBRI Junior High School.



Message of Swachhta was propagated to public at large under "Swachh Samaj" with media coverage of all events through press, posts on social media etc. Events got a wide coverage in several newspapers including local dailies such as Amar Ujala, Dainik Jagran, Hindustan, Rashtriya Sahara, Dainik Bhaskar, Swatantra Chetna, Dainik Hawk, Loksatya, Uttar Bharat Live, Badri Vishal etc.

National Technology Day

CSIR-CBRI, Roorkee celebrated the National Technology Day on May 14, 2019 with great zeal and enthusiasm. Mr. V. Suresh, Chairman, Indian Green Building Council (IGBC) & Former Chief Managing Director, HUDCO graced the occasion as Chief Guest and Dr. Gopal Rai, CEO, Dhirendra Group of Companies, Mumbai graced as Guest of Honour. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee presided over the function.



Presenting a lecture on "Building the Nation – with Sustainable Appropriate Technologies", Mr. V. Suresh informed that India is celebrating the year 2019-2020 as Year of Construction Technology and discussed role of CSIR-CBRI, Roorkee in Global Housing Technology Challenge India. Dr. Gopal Rai shared his experiences on retrofitting in construction sector. In his Presidential Address, Dr. N. Gopalakrishnan assured that CSIR-CBRI, Roorkee will work with a renewed enthusiasm in its mission to develop advanced technologies in the interest of the nation.



On the occasion, two CSIR-CBRI technologies –"NANO-SILICA", developed to improve the quality of cement/concrete using nanotechnology and "NANO-LIME", developed for the purpose of conservation and repair of Heritage Structures – were transferred to M/s POYSHA Nanotech LLP for

commercialization at industrial level. The technologies were developed by team of scientists led by Dr. L.P. Singh, Senior Principal Scientist, CSIR-CBRI, Roorkee.

Under the aegis of Jigyasa : Student-Scientist Connect Programme and supervision of Dr. Atul Kumar Agarwal, Senior Principal Scientist & Jigyasa Programme Coordinator, CSIR-CBRI, Roorkee, students from Kendriya Vidyalaya No. 1, Roorkee participated in the programme and interacted with dignitaries. Latest edition of Institute's Annual Hindi Publication "Nirmanika" was also released.

Dr. Suvir Singh, Chief Scientist, CSIR-CBRI, Roorkee conducted the programme and presented a formal introduction of Chief Guest. Dr. Atul Kumar Agarwal presented a formal introduction of Guest of Honour and proposed a vote of thanks. The dignitaries visited CBRI Construction Technology Park and reviewed technologies developed by the Institute.

World Environment Day

CSIR-CBRI, Roorkee along with The Institution of Engineers (India), Roorkee Local Chapter celebrated World Environment Day on June 12, 2109. The programme aimed to create awareness on the importance of preserving our biodiversity, acknowledge the global environmental problems and discuss ways to take corrective action.

Dr. Balasubramaniam Kanda Swamy, Managing Director, Concrete Quality Concepts Private Limited & Hitesh Concrete Solutions Pvt Ltd graced the occasion as Chief Guest and Dr. Bikas Mohanty, Professor, Chemical Engineering Department, IIT, Roorkee as Guest of Honour. Dr. N. Gopalakrishnan, Director CSIR-CBRI, Roorkee presided over the function. The celebration began with planting of trees by dignitaries at CSIR-CBRI, Roorkee lawns followed by lightening of lamps.

Dr. Balasubramaniam Kanda Swamy said that scientists should research and develop environment-friendly and affordable technologies for rural masses. Dr. Bikas Mohanty discussed policies, programmes and investments to improve air quality. Dr. Achal Mittal, Chairman, The Institution of Engineers (India), Roorkee Local Chapter, discussed ways of controlling air pollution through individual efforts. In his Presidential Address, Dr. N Gopalakrishnan informed that CSIR-CBRI, Roorkee is working to develop environment-friendly building materials to face these challenges.

Mr. R S. Chimote, Chief Scientist, CSIR-CBRI, Roorkee welcomed the gathering, informed about theme of the year "Air Pollution" and presented a formal introduction of Chief Guest. Dr. Ashraf Iqbal, Honorary Secretary, The Institution of Engineers (India), Roorkee Local Chapters presented a formal introduction of Guest of Honour.

International Day of Yoga

CSIR-CBRI, Roorkee celebrated International Day of Yoga on June 21, 2019 with the aim to spread awareness on the importance of Yoga for physical, mental and spiritual well-being and healthy life. Mahamandaleshwar Advaid Anand Ji conducted the events through yogasan and lecture on stress management through yogic exercise. Mahamandaleshwar Advaid Anand Ji initiated the yoga training with the yoga prayer to create a balanced atmosphere and calm mind. The staff of CSIR-CBRI, Roorkee participated in the programme.



Independence Day

The Independence Day was celebrated with a deep sense of patriotism combined with gaiety on August 15, 2019 in CSIR-CBRI Main Lawns of the Institute. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee hoisted the National Flag, addressed the gathering and took the salute at the March Past performed by the security guards. The school children from Bal Vidhya Mandir and CBRI Junior High School presented various cultural programmes on patriotic themes.






Sadbhavna Diwas

CSIR-CBRI, Roorkee celebrated Sadbhavna Diwas on August 20, 2019 with a view to promote harmony among people of all religions, languages and states and goodwill towards everyone. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee administered Sadbhavna Pledge to staff members.

Hindi Week

CSIR-CBRI, Roorkee observed Hindi Pakhwada during September 2-16, 2019 with great zeal and enthusiasm. Dr. P.K.S. Chauhan, Principal Scientist and Officer-in-charge, Official Language Implementation, CSIR-CBRI, Roorkee coordinated the event.

The Pakhwada commenced with inauguration of Hindi Books Exhibition organized by Knowledge Resource Centre (Library) under the supervision of Dr. S.K. Senapati, Library Officer, CSIR-CBRI, Roorkee. Mr. R.S. Chimote, Chief Scientist, CSIR-CBRI, Roorkee inaugurated the exhibition. Several activities were arranged during the Pakhwada including Hindi Essay Competition on September 3, 2019; Hindi Noting-Drafting Competition on September 6, 2019; Hindi Dictation Competition on September 9, 2019; and Hindi Quiz on September 12, 2019 etc.

On September 16, 2019, Mr. Naveen Kumar Naithani, a renowned storywriter and Professor in Department of Physics, Government Degree College, Dehradun graced the Valedictory function as Chief Guest and Dr. N. Gopalakrishnan, Director, CSIR-CBRI Roorkee presided over the function.

Mr. Naveen Kumar Naithani emphasized that we should feel proud on our language and perform our all the official duties in Hindi, in the interest of the nation. In his Presidential Address, Dr. N. Gopalakrishnan said that it is our constitutional duty to do our work in Hindi Language and inspired the scientists to write scientific articles in Hindi language, so that it is easily accessible to the public.

Earlier, Mr. Suba Singh, Hindi Officer, CSIR-CBRI, Roorkee welcomed the gathering and presented description of Hindi activities and achievements throughout the year. Dr. P.K.S. Chauhan introduced the Chief Guest and presented details of activities held throughout the week.

Winners of various competitions organized during the week, including essay, noting-drafting, dictation, quiz competitions etc and winners of Incentive Schemes for Administrative Work in Hindi as well as Incentive Schemes for Scientific & Technical Work in Hindi were felicitated. Mr. Mehar Singh, Hindi Officer, CSIR-CBRI, Roorkee proposed a vote of thanks.

CSIR Foundation Day

CSIR-CBRI, Roorkee organized Foundation Day Celebrations and Open Day on September 28, 2019 to commemorate the 78th Foundation Day of Council of Scientific and Industrial Research (CSIR). Mr. Mohan Ramanathan, MD, Advanced Construction Technologies, Chennai graced the occasion as Chief Guest and Dr. Srinivasan Duraiswami, Vice President, Reliance Industries Ltd., Mumbai as Guest of Honour. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee presided over the function.



Mr. Mohan Ramanathan presented a lecture on "Status of C&D Waste in India" and appreciated the efforts of CSIR-CBRI in development of technologies such as paver blocks from C&D waste etc. Dr. Srinivasan Duraiswami presented a lecture on "Innovation-User Based Products" and said that the cycle of idea-innovate-learn-improve need to applied for development of goods/products for societal development. In his Presidential Address, Dr. N. Gopalakrishnan informed about CSIR-CBRI achievements and ongoing research in new areas/mission mode projects focusing on Affordable Housing for All and Conservation of Heritage Structures etc.



The latest edition of Quarterly Bilingual CBRI Newsletter-Bhavnika and second edition of a book and spinner on Confined Masonry were also released on the occasion.



As an important activity of the day, CSIR-CBRI laboratories were open to students and public, giving everyone the opportunity to learn about the R&D and technologies of the Institute through interactions with the scientists. The dignitaries visited the CSIR-CBRI Construction Demonstration Park and appraised the field level demonstrations of CSIR-CBRI technologies on Mass Housing.


CSIR-CBRI staff members completing twenty-five years of service in CSIR-Dr. D.P. Kanungo and Mr. Rajesh Kumar; and staff of CSIR-CBRI superannuated during the year - Dr. A.K. Minocha, Dr. Rajiv, Mr. Umesh Chand Bhatnagar and Mr. Deepak Kumar Sharma were felicitated.



As precursor events for the Foundation Day Celebrations, several competitions were organized for children of CSIR-CBRI staff. A Painting Competition was organized with the theme "Swachh Bharat", in two categories. In the, category I for students up to class II, Bhavika, Myra, Moksh Arora, Anvi and Poorvi were awarded; while in the category II for students of class 3-5, Kavya, Aarav, Aashvi Angarishi, Kaushiki, Arsh and Shraddha were awarded. An Essay Competition was also organized on the occasion for students of class 6-8 on "Housing for All" in which Ambra Angarishi, Mahalakshmi, Priyanshu and Sheetal were awarded; whereas for class 9-10 on the topic "Smart City", Uday and Simran were awarded.



Dr. Suvir Singh, Chief Scientist, CSIR-CBRI, Roorkee conducted the function and proposed a vote of thanks. The superannuated staff of the CSIR-CBRI and students of Kendriya Vidyalaya No. 1, Roorkee along with their teachers also graced the occasion besides other dignitaries.

Vigilance Awareness Week

CSIR-CBRI, Roorkee observed Vigilance Awareness Week with the theme "Integrity: A Way of Life" during October 28-November 2, 2019. Various activities were conducted during the week at Institute premises and off-campus to create awareness amongst the employees, students and public.

Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee inaugurated the programme by administrating the Integrity Pledge. Employees were also encouraged to take e-pledge by visiting the CVC website. Dr. Atul Kumar Agarwal, Senior Principal Scientist, CSIR-CBRI, Roorkee presented a lecture on

"Integrity-a Way of Life" to sensitize the employees of the Institute on preventive vigilance measures. A Debate Competition was organized for the employees on the focal theme of Integrity.



Students of Kendriya Vidyalaya No. 1, Roorkee visited CSIR-CBRI, Roorkee and pledged to stand together as a wall against corruption. Dr. Atul Kumar Agarwal presented a lecture on "Students against Corruption: Scientific Temper and Integrity". Students formed a human chain to show their enthusiasm as a soldier of integrity in the fight against corruption. A Debate Competition was organized for the students wherein they presented their ideas to fight corruption.

A team from CSIR-CBRI, Roorkee consisting of Dr. Atul Kumar Agarwal; Mr. Anil Kumar, Controller of Administration and Mr. Sushil Kumar, Senior Technical Officer visited nearby village and schools to organize various awareness activities. The team organized Gram Sabhas at Shikarpur and Hazzarpur Village, Landhora to enlighten the villagers and create awareness amongst the masses regarding gravity of the threat of corruption. Posters/banners were displayed and pamphlets/handouts on preventive activities and anti-corruption measures were distributed amongst the villagers.

The team visited Government upper Primary School, Shikarpur, Narsan, Haridwar to enlighten the students on the issue of corruption. Students pledged to maintain honesty in all their activities, to work for eradication of corruption and bring pride to the nation. Dr. Atul Kumar Agarwal presented a lecture on "Students against Corruption: Integrity and Ethical Conduct".



The team visited Rajeev Gandhi Navodaya Vidyalaya, Shikarpur and organized student awareness and interactive activities. Dr. Atul Kumar Agarwal administered the Integrity Pledge to the students. Students displayed their enthusiasm to fight corruption through awareness walks, Slogans and Skits (Nukkad Natak) on corruption awareness, and created a human chain to spread awareness on corruption and importance of integrity in daily conduct. Poster Competition and Essay Competition were organized for students of class IX-XII on "Integrity: A Way of Life".


The team visited KLDAV PG College, Roorkee and organized workshop-cum-seminar and various students' awareness activities. Major activities included creation of human chain, awareness through walks, skits (nukkad nataks) and slogans, awareness on moral values, organization of workshop-cum-seminar and inculcating scientific temper in youth. Volunteers, NCC cadets, students and teachers participated in the programme. Mr. Anil Kumar administered the Integrity Pledge. Dr. Atul Kumar Agarwal presented a lecture on "Students against Corruption: Academic Integrity". Copies of Vigyaan Pragati were distributed amongst the students.

During the Closing Ceremony, posters, slogans, banners and rangoli were displayed. Vigilance Awareness Week concluded with prize distribution to winners. Message of Integrity was spread through social media platforms, SMS/E-mail, WhatsApp, electronic and print media etc.

Dr. Shekhar C. Mande, DG CSIR Presided over IISF Precursor Events

CSIR-CBRI, Roorkee organized Public Outreach Programme for school children, college students, teachers, industry personnel, media and public as a precursor event of 5th India International Science Festival (IISF-2019) on October 29, 2019. Dr. Shekhar C. Mande, Director General, CSIR and Secretary DSIR presided over the Curtain Raiser event. The programme inaugurated with the lightening of the lamps ceremony.



While addressing the gathering, Dr. S.C. Mande, Director General, CSIR described the essence of India International Science Festival- one of the largest science marathons of the nation, and its success in bringing together students, researchers, innovators and public, from all strata and regions, on one platform for symbiotic growth of science, society and nation overall.

Interacting with the students and young researchers, Dr. Mande inspired them from the life and works of incredible Indian scientists and discussed major scientific contributions of Sir C.V. Raman, Satyendra Nath Bose, Srinivasa Ramanujam, Meghnad Saha, Prasanta Chandra Mahalanobis, C.R. Rao and J.R.D. Tata. He motivated the students to come up with next generation ideas and out-of-the-box solutions for local, national and global problems. Discussions were carried out on varied topics including light wavelength, structure of light, bosons, electro-magnetic induction, Raman scattering, formation of black holes, mathematical analysis, and application of Vedic science in the modern era.



Dr. Shekhar Mande encouraged the students to participate in the main event of IISF 2019 being held during November 5-8, 2019 at Kolkata with the theme "RISEN India – Research, Innovation, and

Science Empowering the Nation" in which various Science Expos and Book Fair would display India's Scientific & Technological prowess and new-age technology through charts, products, demonstrations and publications.

Earlier, Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee presented the Welcome Address and said that the presence of the Head of the CSIR Family has honoured, humbled and inspired the gathering. He apprised about the R&D activities and technologies developed by the Institute and said that focus is made to develop "Neutral Science" for the growth of society and nation overall. He urged the young participants to partake in the IISF-2019 events in the "City of Science-Kolkata" with open mind and enthusiasm.



Dr. Mahesh Bhatt, President, VIBHA Dehradun Region, Uttarakhand informed the gathering about VIBHA – Vijana Bharati- its history and development in promoting "science by the people & science for the people".




Dr. Atul Kumar Agarwal, Senior Principal Scientist and Nodal Officer IISF 2019, CSIR-CBRI, Roorkee encouraged the students to adopt a scientific approach of questioning and interactions, as this curious outlook towards life, leads to creativity and innovation. He also briefed about the various student-scientist connect programmes being organized by CSIR-CBRI, Roorkee, to reconnect students with STEM and research-based education, inculcate scientific temper in young minds and develop a scientific-intellectual society free of superstitions. Dr. Suvir Singh, Chief Scientist, CSIR-CBRI, Roorkee conducted the proceedings and Dr. Harpal Singh, Chief Scientist, CSIR-CBRI, Roorkee presented a vote of thanks.



Dr. Shekhar Mande also planted a tree at the Institute premises to encourage everyone to protect the environment and live in harmony with the nature. Earlier, dignitaries and participants visited CSIR-CBRI Technology Exhibition at Museum Hall and viewed the technologies developed by the Institute.

The technologies developed under energy efficient housing, organic building materials, confined masonry, fire research, conservation of heritage structures, environment science and technology-clay products, rural housing, affordable mass housing, waste management, dry construction, utilization of bamboo in construction etc., were demonstrated by CSIR-CBRI resource persons through models, demonstrations and technical charts. Science films featuring CSIR, CBRI, IISF and VIBHA scientific innovations and success stories were also screened.



The participants also had an interactive session with the Institute's scientists including Mr. S.K. Negi, Dr. L.P. Singh, Dr. Ajay Chaurasia, Mr. R.S. Chimote and Dr. Atul Kumar Agarwal. Students from various schools and colleges of Roorkee participated in the event.


Prior to the precursor events at the Institute, CSIR-CBRI scientist visited the classrooms of Kendriya Vidyalaya No. 1 & 2, Roorkee on October 21, 2019 to inform the students about the upcoming science festival-IISF 2019. Dr. Atul Kumar Agarwal presented a lecture on "IISF 2019: RISEN India" and motivated the students to participate in the main event being held at Kolkata during November 5-8, 2019. Dr. Agarwal also asked the students to participate in the precursor events at CSIR-CBRI, Roorkee.

Constitution Day

CSIR-CBRI, Roorkee celebrated the Constitution Day of the Nation on November 26, 2019 to commemorate the adoption of the Constitution of India and promote Constitution values of justice, liberty, fraternity, unity, integrity etc. amongst the Institute staff. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee administered the Reading of the Preamble of the Constitution of India to the staff.

Republic Day

The Republic Day of the Nation was celebrated with a deep sense of patriotism combined with gaiety on January 26, 2020 at CSIR-CBRI, Roorkee main lawns. Mr. R.S. Chimote, Chief Scientist, CSIR-

CBRI, Roorkee hoisted the National Flag, addressed the gathering and took the salute of the March Past performed by the guards. The school children from Bal Vidya Mandir and CBRI Junior High School presented various cultural programmes on patriotic themes.

Family Get-Together & Sports Day

A Family Get-Together & Sports Day for CSIR-CBRI Family was organized on February 7, 2020 with great zeal, excitement and frolicsome atmosphere. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee inaugurated the event and participated enthusiastically in some games. He emphasized on the importance of sports in life of an individual. The staff and their family members participated in different types of energizing games such as ball collection race, lemon race, ball throw in bucket, dodge ball, tug of war, shuttle cock throw, musical chair and three-leg race in different categories and set the tone for the rest of the event. Prizes were distributed to winners of each event.

CBRI Foundation Day

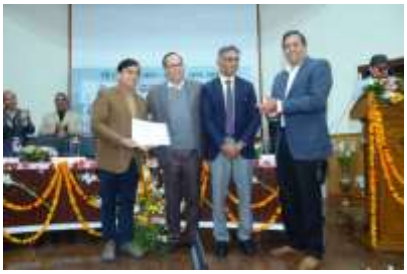
CSIR-CBRI, Roorkee celebrated 74th CBRI Foundation Day on February 10, 2020 with great zeal and excitement. Dr. V. Ramachandra, Joint President & Head (Tech Services), UltraTech Cement Ltd., Mumbai graced the occasion as Chief Guest and Prof. Kolluru V.L. Subramaniam, Professor, Civil Engineering Department, Indian Institute of Technology Hyderabad as Guest of Honour. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee presided over the function. The programme inaugurated with the ceremonial lightening of the lamps.

The programme commenced with the Message from Dr. Shekhar C. Mande, DGCSIR wherein he applauded the contributions of CSIR-CBRI, Roorkee in building construction sector and urged to develop global technologies by understanding the deep science behind building research, through brainstorming and discussions.

In his address, Dr. V. Ramachandra appreciated CBRI's commitment towards building science and the development of new-age technologies. He showed his satisfaction with CBRI's work in taking these technologies from lab to land. Presenting the Prof. Dinesh Mohan Memorial Lecture on "Fly Ash as a Binder Material", Prof. Kolluru V.L. Subramaniam discussed the effective use of fly ash in cement systems and alternate pathways. In his Presidential Address, Dr. N. Gopalakrishnan congratulated and thanked everyone for contributions to its success directly or indirectly. The latest edition of quarterly bilingual CBRI Newsletter-Bhavnika was also released on the occasion.



The Diamond Jubilee Director's Award for Best Research Paper and Diamond Jubilee Director's Award for Technology/Innovation/ Know-How having Maximum Societal Impact were presented on the occasion.



Mr. Ravinder Bisht, Mr. Narendra Kumar, Mr. Jalaj Parashar, Mr. Manoj Tyagi, Mr. Rajeev Bansal, Mr. Rajesh Kumar, Mrs. Archana, Mr. Shiv Kumar, Mr. Khushpendra Arora, Mr. Virendra Singh, Mr. Vipin Sharma, Mr. Vishwas Tyagi, Mr. B.K. Kalra, Mr. Arun Kumar and Mr. Malkhan Singh were felicitated with Best Employees Award in various categories. Winners of Essay Competition on the topic "Impact of Social Media", Mr. Saksham Bharadwaj, Mr. Arpan Maheshwari, Mr. Sushil Kumar and Mr. Nitish Raj were also felicitated. Security Officer Mr. V.P.S. Rawat was awarded as one of the winner of the 5KM Race in the category of age 50 +.

Dr. Suvir Singh, Chief Scientist, CSIR-CBRI, Roorkee presented a formal introduction of Chief Guest. Dr. P.K.S. Chauhan, Principal Scientist, CSIR-CBRI, Roorkee conducted the function and presented a formal introduction of Guest of Honour. Mr. S.K. Negi, Chief Scientist, CSIR-CBRI, Roorkee welcomed the gathering and proposed a vote of thanks. The superannuated staff of CSIR-CBRI, Roorkee also graced the occasion.

National Science Day

CSIR-CBRI, Roorkee celebrated National Science Day on March 2, 2020, to celebrate the scientific prowess of our nation. Dr. Kalachand Sai, Director, Wadia Institute of Himalayan Studies, Dehradun graced the occasion as Chief Guest and Mr. Karan Rajpurohit, Associate Director (Design), KGD - Architecture, Katra Group Company, Bengaluru as Guest of Honour.

In his address, Dr. Sai called upon the scientists to take up research projects to meet the needs of industries and the environment. Mr. Rajpurohit highlighted the benefits of precast concrete in

construction works such as quality, cost, speed of construction etc. Dr. Gopalakrishnan, Director, CSIR-CBRI, Roorkee presented an overview of the ongoing projects at the Institute and gave his views on the direction of research in the future.



Dr. S.R. Karade, Senior Principal Scientist, CSIR-CBRI, Roorkee gave a brief on the competition organized on the occasion and the winners were awarded. Dr. S. Sarkar, Chief Scientist, CSIR-CBRI, Roorkee conducted the programme and Dr. Purnima Parida, Senior Principal Scientist, CSIR-CBRI, Roorkee proposed a vote of thanks.

Medical Camp

A Medical Camp for CSIR-CBRI staff and their family members was organised on March 12, 2020 by a team of doctors of Max Hospital, Dehradun on the occasion of International Women's Day. More than 125 staff and their family members were checked up and advised by the doctors. ECG, BMD, PFT and BP tests were conducted of the staff members. Dr. Piyush Sadana, Cardiologist; Dr. Gaurav Gupta, Orthopaedist; Dr. Yogesh Yadav, Endocrinologist; Dr. Isheta Sarkar, Dentist; Dr. Ajay Bhargva were present.




Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee inaugurated the Medical Camp and emphasized on the fitness of the employees and their families. Dr. Suvir Singh, Mr. S.K. Negi, Dr. Punima Parida, Mr. Vineet Saini, Dr. P.K. Yadav, Dr. M.K. Sinha, Mrs. Archana Chaudhury etc. were present on the occasion.

International Women's Day

International Women's Day was celebrated on March 13, 2020 at CSIR-CBRI, Roorkee. In the morning, a Rangoli making competition was held for all the women of CSIR-CBRI family. Mrs. Jayashree and Mrs. Neelam Saxena were the judges for the event.




Celebration began in afternoon with Mrs. Charu Chaturvedi as Chief Guest, Mrs. Sumita Raghu and Dr. Rama Bhargava as Guest of Honour. Mrs. Jayashree presided over the function. After the motivational speeches by all the dignitaries on the dais, Mrs. Neelam Saxena presented the vote of thanks. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee congratulated all the females and emphasised that women should be given equal opportunities in all spheres of life.

Ms. Hina Gupta and Ms. Sheema Farhat were given awards in Technical and Administration respectively for their good work. The programme was followed by a cultural programme, in which staff members and children participated.

TRAINING PROGRAMMES ORGANIZED

Indo-German Workshop

Workshop on "Indo-German Collaboration in Research and Innovation towards Leapfrogging in Frontier Technologies" was organized at CSIR-CBRI, Roorkee with the theme "Sustainable Buildings R&D collaboration with the Fraunhofer Institute for Building Physics (FIBP), Germany" for the joint R&D projects between CSIR and FIBP during July 28-29, 2019.



The highlight of the Workshop was to finalize the ideas in which the industries are looking for immediate, medium -term and long -term solutions, presented by Dr. Ashok Kumar, Chief Scientist, CSIR-CBRI, Roorkee and Dr. Simon Schmidt, FIBP, Germany. This was further strengthened by Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee pin-pointing certain ideas/projects on improving the workability of geoploymerization, cooling & heating systems, proposed by NTPC, NETRA, New Delhi, and also to include water as important part of sustainable retrofitting projects, while talking about certification.



Further interactions / deliberations were held at New Delhi with several participating scientists and industry representatives regarding issues related to design, building materials, and construction technologies and collaboration with Fraunhofer. The meeting ended with vote of thanks and felicitations to German guests and participants by Dr. Shekhar C. Mande, DG CSIR.

Short Term Course on Design of Fire Protection Measures for Vital Installations & Buildings

CSIR-CBRI, Roorkee under the leadership of Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee organized a three-day short term course on "Design of Fire Protection Measures for Vital Installations and Buildings" during November 11-13, 2019 at India Habitat Centre, New Delhi.

The course aimed to develop a pool of skilled professionals in the area of Fire Protection. Cities are now facing unprecedented challenges not encountered in earlier times. The pace of urbanization is increasing exponentially. In last two decades, there have been significant changes in building typologies being constructed resulting in more complex buildings such as hospitals, high rise buildings/offices, atriums, malls, underground car parks, metro and road transport tunnels, airports, warehouses, industrial buildings posing higher fire hazards.

Recently, there have been numbers of fire incidents reported, which have raised concerns regarding fire safety in such vital installations. Therefore, it becomes essential to increase the awareness towards fire safety and to educate the concerned stakeholders for designing and implementing effective fire protection measures.

Dr. Baljit Singh, Executive Director (Security), ONGC graced the inaugural function as the Chief Guest and Shri D.K. Shami, Fire Advisor, Directorate General Fire Services, Home Guards & Civil Defence, Ministry of Home Affairs, New Delhi as the Guest of Honour.

Dr Baljit Singh appreciated and applauded the concern and efforts taken by CSIR-CBRI and relevance of this course in the present scenario. Shri D.K. Shami reinforced the views of Dr Baljit Singh and ensured to take up this issue in a big way in future with CSIR- CBRI.

Experts from Fire Research Group, CSIR-CBRI, Roorkee - Dr. Suvir Singh, Chief Scientist and Dr. Shorab Jain, Principal Scientist, imparted technical knowledge to the participants from different institutions, corporate and organisations like hospitals, ONGC, DMRC, HLL, CPWD, banks, fire services, space research organization, municipal corporations, CSIR-NAL, SERC, IGIB, private industries etc.

About 72 participants from different disciplines including doctors, engineers, academicians, entrepreneurs, researchers, architects, fire officers etc. participated in the programme.

Industrial Meet on Innovative Building Materials & Construction Technologies for Mass Housing

CSIR-CBRI, Roorkee organised an Industrial Meet on Innovative Building Materials and Construction Technologies for Mass Housing with focus on Construction Chemicals during November 25, 2019 at Habitat Centre, New Delhi.

Short Term Training Programme on Disaster Management and Sustainable Development

A short-term training programme on "Disaster Management and Sustainable Development" was organized by CSIR-CBRI, Roorkee in association with NITTTR, Chandigarh during November 11-15, 2019.

International Conference on Building Energy Demand in Global South

CSIR-CBRI, Roorkee organized International Conference on "Building Energy Demand Reduction in Global South, 2019" (BUILDER'19) with consortium partners IIT Roorkee, IIT Delhi and University of Bath, UK during December 13-14, 2019, at India Habitat Centre, New Delhi, India. Dr. Ashok Kumar, Chief Scientist and Head, Architecture & Planning and Efficiency of Building, and the Principal Investigator of the Project and the Conference Chair briefed about the conference and aim of the conference.

The conference was a part of INDO-UK Joint Research Program on Building Energy Efficiency sponsored by DST-EPSRC. The aim of conference was to share the expertise of both the countries, and to find joint solutions to the challenges in the field of building energy efficiency, reducing peak building energy demand and making clean energy more affordable to all.

Mr. Abhay Bakre, Director General, Bureau of Energy Efficiency (BEE), New Delhi, graced the occasion as Chief Guest and Dr. Sukumar Natarajan, Director, EPSRC, Dr. N Gopalakrishnan, Director CSIR-CBRI, Roorkee presided over the function as the Guest of Honour and delivered the welcome address.

In the conference six keynote speakers, nineteen distinguished lectures and more than 30 research papers were presented in eight thematic tracks viz. Sustainable and Energy Efficient Buildings, Low Carbon and Net Zero Energy Building, Climate Change vis-à-vis Energy Policy, Energy Conservation Building Codes, International Regulations, Rating Systems, Building Energy Demand Reduction in Global South, Thermal Comfort, Thermal Adaptation, IEQ and Smart Lighting Systems, Climatic Responses on Energy Systems, Smart Grids, District Cooling and Heating Systems, Life Cycle Energy Assessment of Buildings and Renewable systems and Energy Efficient Building Materials, Technologies/Systems. More than 115 participants across the world including India participated in the conference and graced the occasion.

Workshop on Recent Advances in Technology for Heritage Structures

CSIR-CBRI, Roorkee organized a Two Day Workshop on "Recent Advances in Technology for Heritage Structures" under CSIR Mission Project on Heritage Structures at Pt. Deendayal Upadhyaya Institute of Archaeology, Archaeological Survey of India, Knowledge Park II, Greater Noida during March 13-14, 2020. ASI engineers and officials attended the workshop.



PROJECTS

In-House R&D Projects

S. No.	Project No.	Title of the Project	Principal Investigator Co-Investigator	Duration
HOUSING-STRUCTURE & FOUNDATION				
1.	HCP 0015	Development of Fast, Durable and Energy Efficient Mass Housing Scheme	Dr. Ajay Chourasia Dr. Ashok Kumar	0418-0320
2.	OLP 0415	Development of Innovative Hybrid Connections for Pre-Cast Concrete Construction	Dr. S.R. Karade Dr. R. Siva Chidambaram	1117-1020
3.	OLP 0416	Prefabricated Ferro Cement Sandwich Panel based Housing System	Er. S.K. Singh Er. Subash C.B. Gurram Er. Surya M.	1017-0320
4.	OLP 0424	Development of a New Constitutive Relationship for 1D Nonlinear Site Response Analysis	Dr. Anindya Pain	0418-0320
5.	OLP 0427	Studies on Effects of the Shield-Driving on Soil Arching around the Tunnel and Long-Term Surface Settlement	Er. Vinoth	0220-0122
CONSERVATION OF HERITAGE STRUCTURES				
6.	HCP 0018	Conservation and Restoration of Heritage Structure	Dr. A.K. Mittal	0418-0320
INNOVATIVE BUILDING MATERIALS				
7.	OLP 0418	Process Technology Development of Geopolymer Concrete with varying Classes of Fly Ash for Use in Precast Building Components	Er. Md. Reyazur Rahman Er. Rakesh Paswan	1017-0920
8.	OLP 0419	Recyclability of Marble Waste in Concrete Production and Other Building Products	Dr. Rajni Lakhani Er. Rajesh Kumar	0917-0820
9.	OLP 0420	Development of Self Compacting Recycled Aggregate Concrete for Precast Building Components	Er. Monalisa Behra Er. Santha Kumar G. Md. Reyazur Rahman	1017-0919-0320
10.	OLP 0421	Development of Cost Effective Material for Sound Absorption with Partial Air Purification Properties	Er. Siddharth Er. S. Maiti	1017-0919
11.	OLP 0426	Development of Cement-Admixture System for Low Temperature Concreting	Dr. Jeeshan Khan Dr. Hemlata Er. Rakesh Paswan Md. Reyazur Rehman	0418-0321

ENERGY EFFICIENT SYSTEM & BUILDING AUTOMATION				
12.	OLP 0422	Efficient Solar Thermal Collector	Er. Nagesh B. Balam Dr. Tabish Alam	1017-0919
DISASTER MITIGATION				
13.	HCP 0017	Safety & Security of Vital Installations	Dr. Suvir Singh Dr. S. Sarkar	0418-0320
BUILDING PROCESS & AUTOMATION				
14.	OLP 0423	Development of Mobile Sensing Device for Complex Working Environment of Civil Structures	Er. Ravindra S. Bisht Dr. S.K. Panigrahi	1017-0919
15.	OLP 0425	Seismic Performance Enhancement of Buildings using Smart Base Isolation	Er. Soju J. Alexander Dr. S.K. Panigrahi	0118-1220
CSIR FAST-TRACK TRANSLATION (FTT) & SKILL DEVELOPMENT PROJECTS				
16.	MLP 0514	Pilot Scale Preparation Of Silica Nanoparticles and their Applications in cement Based Materials	Dr. L.P. Singh (PI) Er. Srinivasarao Naik B. (CO PI)	1.9.2018 to 31.08.2020
17.	MLP 0109	Development of Bamboo Composite Structural / Semistructural Elements for Building Application	Dr. Hemlata Dr. Rakesh Paswan	24.08.2018 to 31.03.2020
18.	NWP 0101	Student -Scientist Connect Programme: Jigyasa	Dr. Atul Kumar Agarwal Dr. L.P. Singh	02 Years Up to March, 2020
19.	NWP 0100	CSIR-CBRI Integrated Skill Initiative	Dr. Dharmaraju (PI) Ar. S.K. Negi (PI) Er. Ashish Pippal (CoPI)	02 Years Up to March, 2020

Externally Funded Projects

S. No	Project No.	PI	Title	Party Name
1.	GAP0806	Ashok Kumar	Improving Building Energy Efficiency	Indo-US Science & Technology Forum (IUSSTF) & DST, New Delhi
2.	GAP0657	Ashok Kumar	Zero Peak Enery Design for Buildings in India	DST, New Delhi
3.	GAP0679	Anindya Pain	Rock Mass Characterization and Numerical Modelling of Slopes subjected to Blast Loading	Defence Terrain Research Lab (DTRL), Ministry of Defence, Metcalfe House, Delhi
4.	GAP0878	S.K. Singh	Development of Newer Cementitious Materials from Ladle Furnace Slag and Improvement of Ladle Furnace Slag and Electric Arc Furnace Slag for Use as Aggregate in Concrete	DGM Research & Development, JSW Steel Limited, Dolvi Works, Geetapuram, Dolvi, Raigad
5.	SSP0029	Ajay Chourasia	Review of Structural Design and Quality Assurance of Institutional Buildings	UP Rajkiya Nirman Nigam Ltd., Dehradun Unit 2, Harrawala, Dehradun
6.	SSP0069	Ajay Chourasia	Safety Audit and Seismic Retrofit of Motilal Nehru School of Sports, School Girls Hostel Building at Sonipat	Executive Engineer, PWD, Sonipat
7.	SSP0109	H.C. Arora	Health Assessment and Suggesting Remedial Measures for Buildings of NIEPVD, Dehradun	National Institute for the Empowerment of Persons with Visual Disabilities, 116, Rajpur Road, Dehradun
8.	SSP0169	Suvir Singh	Fire Performance Assessment of Load Bearing Walls	Head-R&D, EDRC-RBU, TC-2, 4th Floor, L&T Construction, Manapakkam, Chennai

9.	SSP0219	Suvir Singh	Studies on Relative Fire Performance and Post Fire Properties of New Special Steel Product	M/s Steel Authority of India Ltd., ISPAT Bhawan, P.O. Doranda, Ranchi
10.	SSP0229	Ajay Chourasia	Post-Earthquake Reconstruction of School in Nepal: Planning, Design and Project Management for Reconstruction/ Retrofitting of 70 schools and 2 Libraries in Seven Earthquake affected Districts of Nepal	Ministry of External Affairs, Govt. of India, New Delhi
11.	SSP0279	Rajesh Deoliya	Investigation and Suggestion for Repair and Rehabilitation of Distressed DDA Flats near Dabri Mor Metro Station, New Delhi	Chief Project Manager-5, Delhi Metro Rail Corporation Ltd., Grounf Floor, Airport Express Metro Station, Dhaula Kuan, New Delhi
12.	SSP0299	Manojit Samanta	Geo-Investigation Stability Assessment and Remedial Measures for Gadora Village Landslide Area, Uttarakhand	GM (Tech), NHIDCL, Ministry of Road Transport & Highway, GoI, 4, Parliament Street, New Delhi
13.	SSP0309	S.K. Negi	Technical Support and Skill Development for Construction of Rural Housing Scheme in Odisha	Deputy Secretary, Panchayati Raj Dept., Govt. of Odisha, Bhubaneshwar
14.	SSP0349	Rajesh Deoliya	Third Party Quality Assurance and Audit (TPQA) for the Work of Construction of 120 Nos. GPRA Type VII Flats in Pocket-I at DDU Marg, New Delhi	Ex. Engineer, Vikas Pariyojana Mandal-I, CPWD, Room No. B-312, IP Bhawan, New Delhi
15.	SSP0379	H.C. Arora	Structural Audit of Buildings of Army Public School No. 2, Roorkee	Principal, Army Public School No. 2, Roorkee
16.	SSP0389	Ajay Chourasia	Health Assessment & Rehabilitation of Structures at Zuari Agro Chemicals Ltd, Goa	GM (Maintenance), Zuari Agro Chemicals Ltd., Goa

17.	SSP0419	Suvir Singh	Fire Safety Audit of New OPD Building of PGIMER	Dept. of Hospital Engineering & Planning, PGIMER, Chandigarh
18.	SSP0469	Manojit Samanta	Geotechnical Investigation and Monitoring of Victoria Memorial Hall, Kolkata	Secretary & Curator, Victoria Memorial Hall, Kolkata
19.	SSP0479	Ajay Chourasia	Testing and Evaluation of Prefab Structural Elements/ Structure to Re-establish Behaviour of various Joints under all Design Load Conditions including Seismic for High Rise Buildings	M/S B. G. Shirke Construction Tech. Pvt. Ltd., Pune
20.	SSP0599	Navjeev Saxena	Structural Safety Assessment and Suggestions of Rehabilitation Measures for Office Building of DM (South-East) Lajpat Nagar, New Delhi	Ex. Engineer, PWD, Govt. of NCT of Delhi, South-East (Building) Maintenance Division, IIT Gate, Hauz Khas, New Delhi
21.	SSP0629	R.S. Chimote	Fire Performance Evaluation / Study of BOAZ Conventional Multi-criteria Fire Detectors, Heat Detectors, Smoke Detectors, Fire Alarm Panel (Variable Zones) and Accessories such as MCP, Hooter and Response Indicators as per Indian Standard	M/s Ponmani International (I) Pvt. Ltd., Naveen Shahdara Subhash Parl (Extn.), Street No. 2, New Delhi
22.	SSP0649	Shantanu Sarkar	Scientific Studies to Investigate the Reasons of Crack Development in Buildings of Pur Village, Dist. Bhilwara, Rajasthan	Office of District Collector & District Magistrate, Bhilwara
23.	SSP0659	Shorab Jain	Fire Safety Audit of B.S. Negi Bhawan, Dehradun	GM (E) - EIC, Infrastructure Development Department, ONGC, Dehradun

24.	SSP0699	Navjeev Saxena	Investigation of Structural Distress and Suggestions for Remedial Measures for Judicial Staff Quarters at Sector-19, Dwarka, New Delhi	Executive Engineer, PWD, Shaheed Sukhdev College, Sector-16, Rohini, New Delhi – 110 089
25.	SSP0719	Ashok Kumar	Study on Rates and Ratios used in the Construction Sector and Capital Formation / Improvements in Rates and Ratios used in Estimation of Gross Value Added (GVA) of Construction Sector and Capital Formation	Dy. Director General, Ministry of Statistics & Programme Implementation, Central Statistics Office, National Accounts Division, Sardar Patel Bhawan, Sansad Marg, New Delhi
26.	SSP0799	B.S. Rawat	Termite Resistance Studies of Different Construction Materials	Saint Gobain India Pvt. Ltd., IIT Madras Research Park No. 1, FA, Phase-II, C-Block, Kanagam Road, Tharamani, Chennai
27.	SSP0829	H.C. Arora	Distress Diagnosis and Suggestions for Rehabilitation Measures of Dwarka Court Building at New Delhi	Executive Engineer, PWD, B-8, NCC Building, Safdarjung Enclave, New Delhi
28.	SSP0859	A.K. Mittal	Techno-Economic Evaluation of Partly Constructed Doon Cuber Tower at IT Park, Dehradun	Managing Director, 29-IIE, IT Park, Sahstradhara Road, SIDCUL, Dehradun
29.	SSP0899	Ajay Chaurasia	Rehabilitation of Platinum Jubilee Hostel at Indian Statistical Institute (ISI)-Delhi Centre New Delhi	Indian Statistical Institute (ISI), Delhi Centre
30.	SSP1099	Soumitra Maiti	Development of Gypsum Vermiculite Plaster (GVP) using FGD Gypsum	M/s Vindhyachal Super Thermal Power Station, P.O. Vindhyanagar, Dist. Singrauli
31.	SSP1109	Neeraj Jain	Development of High Strength Plaster using FGD Gypsum & Fly Ash	M/s Vindhyachal Super Thermal Power Station, P.O. Vindhyanagar, Dist. Singrauli

32.	CNP0039	M. Surya	Water Permeability Test of Concrete Specimens of GPRA Flats, New Delhi as DIN 1048	Executive Engineer, CPWD, Development Project Division, B-313, IP Bhawan, New Delhi
33.	CNP0079	S.K. Singh	Condition Assessment of Existing Building Blocks of Residential Colony at Shaktipuram Colony, Chinyalisaur, Uttarkashi and Suggesting Appropriate Repair / Rehabilitation / Strengthening Measures	Ex. Engineer (Civil), UJVN Limited, MB-II, H.E.P., Chinyalisaur, Uttarkashi
34.	CNP0089	A.K. Mittal	Structural Stability and Feasibility for Additional Floor on Existing ESIC Hospital Building at Bareilly	Ex. Engineer, CPWD, Bareilly Central Division, Nirman Jyoti C-18, Deendayal Puram, Bareilly
35.	CNP0129	Jeeshan Khan	Performance Evaluation of Repair Mortar / Admixtures	Sr. Division Engineer, Damodar Valley Corporation, Talaiya Konar Civil Division, PO Konar Dam, Dist. Hazaribagh (Contractor: Dynasoure Concrete Treatment Pvt. Ltd., Elagepahari, Ghaghri, PS Ramgarh, Dumka)
36.	CNP0159	S.K. Singh	Water Permeability Test of M40 Concrete Specimens of TMM, New Delhi as DIN 1048	Asst. Executive Engineer, CPWD, TM Project Division, New Delhi
37.	CNP0189	Nagesh Babu Balam	Determination of 'U' Value of Concrete Wall Sample with PVC form support	Kalzen Realty Pvt. Ltd., 4th Floor, Corporate Court, B-Wing, Sy. No. 115/1&29, Financial District, Nanakramguda, Hyderabad
38.	CNP0289	L.P. Singh	Studies on Conservation and Restoration Work on existing Heritage Building Chattar Manzil and Kothi Farhat	Aditional Project Manager, UPRNN Ltd, Vishveshwaraya Bhawan, Vibhuti Block, Gomti Nagar, Lucknow

39.	CNP0309	H.C. Arora	Technical Examination and Quality Audit of Construction of 14 Room Meerut District Court Building	Additional Project Manager, UPRNN Ltd., Agriculture University, Village Sivaya, Modipuram, Meerut
40.	CNP0319	Manojit Samanta	Geotechnical and Structural Investigations and Remedial Measures at SJVN DAV Public School, Rampur, Himachal Pradesh	Sr. Manager, PIS Dept., Rampur HPS SJVN Ltd., Bayal PO Koyal Distt., Kullu
41.	CNP0339	Ashish Pippal	Technical Assistance for Construction of Bamboo Based Structures in Timarni, Harda (MP)	Director, Madhya Pradesh State Bamboo Mission, Bhopal
42.	CNP0369	Neeraj Jain	Physical Verification of Rectangular High Draft Zig-Zag Brick Kilns in Punjab State for Issue of Adequacy Cum Completion Certificate as per CBRI design	M/s Team Energy Systems, Sector 4, 2nd Floor, Panchkula
43.	CNP0429	Reyazur Rehman	Mix Proportioning of Geopolymer Concrete for DLC and PQC including Monitoring Concrete Road along Boundary Wall in NETRA Campus	M/s NTPC Ltd. (NETRA), E-3, ECOTECH-II, Udyog Vihar, Gr. Noida (Client: M/s Neha Enterprises, 3/100, Sector-2, Rajendra Nagar, Ghaziabad)
44.	CNP0459	S.R. Karade	Health Assessment and Remedial Measures for the Residential & Other Buildings at NTPC Barauni	General Manager, NTPC Ltd. / Barauni TPS, Barauni, Bihar-851116
45.	CNP0489	A.K. Mittal	Structural Assessment of Partly Constructed Sutradhara Building at Indira Gandhi National Centre for the Arts, New Delhi	Ex. Engineer, Project Director-3, CPWD, Dr. B.D. Marg, New Delhi

46.	CNP0529	S.R Karade	Detailed Analysis of Developed Cracks in World HQ Building at Sector-29, Gurugram & Suggesting Remedial Measures	General Manager (REC Project), Telecommunications Consultants India Ltd., TCIL Bhawan, Greater Kailash, New Delhi
47.	CNP0609	A.K. Mittal	Structural Stability Issues of Building and Possible Solutions	Principal Director (Training), National Academy of Defence Production, Ambajhari, Nagpur
48.	CNP0639	Neeraj Jain	Physical Verification of Rectangular High Draft Zig-Zag Brick Kilns in Punjab State for Issue of Adequacy cum Completion Certificate as per CBRI Design	M/s Pollution Consultants and Engineers, 22C, Pocket-8, SRS Royal Hills, Sector 87, Faridabad
49.	CNP0709	Neeraj Jain	Physical Verification of Rectangular Induced Draft Zig-Zag Brick Kilns in Punjab State for Issue of Adequacy cum Completion Certificate as per CBRI Design	M/s Team Energy Systems, Sector 4, 2nd Floor, Panchkula
50.	CNP0839	Neeraj Jain	Physical Verification of Rectangular Induced Draft Zig-Zag Brick Kilns in Punjab State for Issue of Adequacy cum Completion Certificate as per CBRI Design	M/s Team Energy Systems, Sector 4, 2nd Floor, SCO 87, Panchkula
51.	CNP0849	Neeraj Jain	Physical Verification of Rectangular Induced Draft Zig-Zag Brick Kilns in Punjab State for Issue of Adequacy cum Completion Certificate as per CBRI Design	M/s Pollution Consultants & Engineers, 22C, Pocket 8, SRS Royal Hills, Sector 87, Faridabad

52.	CNP0889	Neeraj Jain	Physical Verification of Rectangular Induced Draft Zig-Zag Brick Kilns in Punjab State for Issue of Adequacy cum Completion Certificate as per CBRI Design	M/s Pollution Consultants and Engineers, 22C, Pocket-8, SRS Royal Hills, Sector 87, Faridabad
53.	CNP0959	Neeraj Jain	Physical Verification of Rectangular Induced Draft Zig-Zag Brick Kilns in Punjab State for Issue of Adequacy cum Completion Certificate as per CBRI Design	M/s Team Energy Systems, Sector 4, 2nd Floor, SCO 87, Panchkula
54.	CNP0979	A.K. Mittal	Technical Guidance on State Guest House (Dam Kothi) Haridwar	Executive Engineer, Provincial Division, PWD, Devpura, Haridwar
55.	CNP0989	Manojit Samanta	Efficacy Evaluation of Precast RCC Wall vis-a-vis Conventional Breast Wall at NH-39, Moreh in Manipur. Two Lanning Imphal - Moreh Section of NH 39 from km 350+000 to km 395+680	G R Infraprojects Ltd., 1st Floor, Mantripukhri, Opp. CRPF Camp, Near S P Building, Imphal East, Manipur
56.	CNP1009	Neeraj Jain	Physical Verification of Rectangular Induced Draft Zig-Zag Brick Kilns in Punjab State for Issue of Adequacy cum Completion Certificate as per CBRI Design	M/s Pollution Consultants and Engineers, 22C, Pocket-8, SRS Royal Hills, Sector 87, Faridabad
57.	TSP0049	Suvir Singh	Fire Performance Assessment of Fire Stopping System	M/s 3M India Ltd - Co., Concorde Block, UB City, 24, Vittal Mallya Road, Bangalore
58.	TSP0059	A.A. Ansari	Fire Performance Characteristic Studies of Raised Access Flooring	M/s Dazzle Modular Systems, Plot No. 10C, Hoskote Industrial Estate, Surve No. 85, Chokahally Kasaba Hobli, Hoskote, Bangalore

59.	TSP0119	P.C. Thapliyal	Evaluation of IPNet paints to be used by Southern Railway	Sr. Section Engineer (Bridges / MCPT), Southern Railway, Chintadripet, Chennai (Contractor: SSA Techno Construction Pvt. Ltd., 101-C, 1st Floor, Pal House, Hari Nagar, New Delhi)
60.	TSP0139	Suvir Singh	Fire Performance Assessment of Fire Door	M/s Vision Engineering, 407, Raviwar Peth, Sonya Mauruti Chowk, Pune
61.	TSP0149	A.A. Ansari	Fire Performance Characteristic Studies of Aerolam XLPE Plain Foam	M/s Aerolam Insulations Pvt. Ltd., 7th Floor, Shilp Aperia, Near Hotel Landmark, Ambli-Bopal Road, Ahemdabad
62.	TSP0179	Rajni Lakhani	To Improve the Technology of Expanded Clay Aggregate - Thermal Insulated Mortar and Preliminary Testing of ECA	M/s Rivashaa Eco Design Solutions Pvt. Ltd., Law Garden, Ellisbridge, Ahmedabad (Client: M/s Nexus Buildcon Solutions, Off NH. 8A, Bamanbor-Morvi Highway, Mesariya Road, Tal. Wakaner, Dist. Rajkot, Rangapar, Gujarat)
63.	TSP0199	A.A. Ansari	Surface Spread of Flame Studies of Some Anutone Products	M/s Anutone Acoustics Ltd, 3A, Visvesvaraya Industrial Area, Bengaluru
64.	TSP0209	Suvir Singh	Fire Performance Assessment of Fire Door	Executive Engineer, BHU Project Division -1 , CPWD, Varanasi (Client: M/s Kashyapi Infrastructure Pvt. Ltd., 12/45, Vasundhra, Ghaziabad
65.	TSP0239	Suvir Singh	Fire Performance Assessment of Fire Door	M/s Bridge and Roof Co. (I) Ltd., Head Office & Works, 427/1, G.T. Road, Howrah (Client: M/s Kunal Structure (I) Pvt. Ltd., 1755/112/A-82, W No. 34, Rabindrapally, Hijili, West Medinipur, West Bengal)

66.	TSP0249	Suvir Singh	Fire Performance Assessment of Fire Door	M/s Envirotech Systems Pvt. Ltd., B-1A/19, 1st Floor, Commercial Complex, Sector 51, Noida
67.	TSP0259	Suvir Singh	Fire Performance Assessment of Lift Doors	M/s Wittur Elevator Components India Pvt. Ltd., 45/1B, SIPCOT Industrial Park, Pondur Village Mambakkam, Sriperumpundur
68.	TSP0269	Suvir Singh	Fire Performance Assessment of Fire Sealing System	M/s Asharam Engg & Firestop (P) Ltd., Vrindavan Complex, Opp. Ravi Furniture, JSPL Road, Raigarh
69.	TSP0329	Suvir Singh	Fire Performance Assessment of Fire Door	M/s Diligent Metal, R.S. No. 5/7A, 5/7B & 5/15, Malim Main Road, Sedarapet, Pondicherry
70.	TSP0359	Suvir Singh	Fire Performance Assessment of Fire Door	M/s Vision Engineering, 407, Raviwar Peth, Sonya Mauruti Chowk, Pune
71.	TSP0399	P.C. Thapliyal	Performance Evaluation of Coating System Developed by M/s Sunanda Speciality Coatings Pvt. Ltd., Mumbai	Director (Technology), Sunshine Tower, 36th Floor, Senapati Bapat Marg, Lower Parel, Mumbai
72.	TSP0409	Suvir Singh	Fire Performance Assessment of Metal Door	M/s Ironic Infra Solutions Pvt. Ltd., Gala No. 23, Devrukhar Estates, Near Maruti School, 11th Road, MIDC, Marol, Andheri (E), Mumbai
73.	TSP0439	A.A. Ansari	Surface Spread of Flame Studies of Anutone Products	M/s Anutone Acoustics Ltd., 3A, Visvesvaraya Industrial Area, Bengaluru
74.	TSP0449	A.A. Ansari	Fire Performance Characteristic Studies of XLPE Insulation	M/s Divine Thermal Wrap Pvt. Ltd., 709 B, 7th Floor, DLF Prime Tower, Okhla Phase 1, New Delhi
75.	TSP0499	A.A. Ansari	Fire Performance Characteristics Studies of FRP material	M/s Tribeni Technocom Ltd., Plot No. 264, Rjd Interated Textile Park, Adajan - Hazira Road, Ichhpore, Surat

76.	TSP0509	P.C. Thapliyal	Performance Evaluation of IPNet Paints to be used in Bridge Number 22A and 26 between Nagercoil and Kanyakumari Railway Stations	M/s Copco Engineering Pvt. Ltd., 398, Poonamallee High Road, Chennai
77.	TSP0519	Suvir Singh	Fire Performance Assessment of Lift Landing Door	M/s Johnson Lifts Pvt. Ltd., 53, Pitamber Plaza, Ground Floor, Shastri Nagar, Hardwar Road, Dehradun
78.	TSP0539	Suvir Singh	Fire Performance Assessment of Fire Door	M/s C S Components Pvt. Ltd., 194/195/196, G.I.D.C., Umbergaon
79.	TSP0549	Suvir Singh	Fire Performance Assessment of Fire Door	M/s Simplex Infrastructures Ltd., Simplex House, 27, Shakespeare Sarani, Kolkata
80.	TSP0559	P.C. Thapliyal	Performance Evaluation of IPNet Paints	M/s Sr. Section Engineer / Bridges / MS, Southern Railway, Opp. TTE Rest House, Chennai Egmore (Contractor: BISMI Engineering Works, 63, Sivagangai Road, Melur-625106, Dist Madurai)
81.	TSP0569	Suvir Singh	Fire Performance Assessment of Rockwool Sandwich Panel Partition	M/s Svam Telecom Ltd., Plot No. 68, 69, 71-73, Sector 5, IIE, SIDCUL, Haridwar
82.	TSP0579	Suvir Singh	Fire Performance Assessment of Fire Resistance Door	M/s Asstt. Ex. Engr., NIT Durgapur Project Division, CPWD, Durgapur (Contractor: Subir Engineering Works (P) Ltd., 2/9 Suncity Chatterjee Path, City Center, Durgapur
83.	TSP0589	Suvir Singh	Fire Performance Assessment of Fire Door	M/s Alfa Peb Ltd., KIADB, Horaholi, Industrial Area, Phase-II, Bangalore
84.	TSP0619	Suvir Singh	Fire Performance Assessment of Fire Door	M/s Lauren Fabtech India LLP., 20, Adinath Shopping Centre, Pune Satara Road, Pune

85.	TSP0689	P.C. Thapliyal	Performance Evaluation of IPNet Paints to be used in Bridge Number 343 of Vizianagaram-Sambalpur Line of East Coast Railway	M/s Rahee Infratech Ltd., Plot No 62, Sector 5, Niladri Vihar, PO Chandershekharpur, Bhubaneshwar
86.	TSP0729	Suvir Singh	Fire Performance Assessment of Fire Door	M/s Supreme Metwood, 1043, Housing Board Colony, Sector 29, Faridabad
87.	TSP0739	Suvir Singh	Fire Performance Assessment of Fire Door	M/s Shakti Hormann Ltd., Plot No. 20, Sripuri Colony, Karkhana, Secunderabad
88.	TSP0749	Suvir Singh	Fire Performance Assessment of Fire Door	M/s Sharp Designer & Engineers India Pvt. Ltd., Gate No. 301/2, Nanekarwadi Chakan Tal, Khed, Dist. Pune
89.	TSP0759	Suvir Singh	Fire Performance Assessment of Fire Door	M/s Jagteq Industries Pvt. Ltd., 3, Alexio Apartment, I.C. Colony, Borivali (W), Mumbai
90.	TSP0769	Suvir Singh	Fire Performance Assessment of Fire Door	M/s Globe Engineering, SP 124, Ambattur Industrial Estate, II Street, 3rd Main Road, Ambattur, Chennai
91.	TSP0779	Suvir Singh	Fire Performance Assessment of Fire Door	M/s Selens Lift Components Pvt. Ltd., 14/144A, Sitra Road, Kalapatti, Coimbatore
92.	TSP0789	Suvir Singh	Fire Performance Assessment of Fire Door	O/o The Assistant Engineer, Hamirpur Central Sub Division, NIT Campus, CPWD, Hamirpur
93.	TSP0809	Suvir Singh	Fire Performance Assessment of Fire Door	M/s Doorwin Technologies Pvt. Ltd., Plot No. 6/2, Gandhi Nagart, Bala Nagar, Hyderabad
94.	TSP0819	Suvir Singh	Fire Performance Assessment of Fire Sealing Systems	M/s Vijay System Engineers Pvt. Ltd., 35, Chandivali Village, Off Saki Vihar Road, Andheri East, Mumbai

95.	TSP0869	Suvir Singh	Fire Performance Assessment of Fire Door	Executive Engineer, Malda Central Sub-Division, CPWD, Maheshmati, Hyderpur Street, Malda
96.	TSP0879	Suvir Singh	Fire Performance Assessment of Fire Door	Asstt. Engineer, PWD, Health (West) Sub Division-I, Sector-9, Dwarka, New Delhi
97.	TSP0909	Suvir Singh	Fire Performance Assessment of Fire Doors	M/s Greenlam Industries, E-176-179, SP-02, RIICO Industrial Area, Phase-II, Behror, Dist Alwar
98.	TSP0919	A.A. Ansari	Fire Performance Characteristic Studies of Fire X 301 on MS Surface	M/s Waseer Polymer Pvt. Ltd., 66, Pail Para First Row, Near Ashu Babu Bazaar, Kolkata
99.	TSP0929	Suvir Singh	Fire Performance Assessment of Fire Door	M/s Bhawani Fire Protection Pvt. Ltd., S-17, S-18, 1st UPSIDC Industrial Estate, Loni, Ghaziabad
100.	TSP0939	Suvir Singh	Fire Performance Assessment of Lift Door	M/s Wittur Elevator Components Pvt. Ltd., 45/1B Sipcot Industrial Park, Pondur Village Mambakkam, Sriperumbudur
101.	TSP0949	A.A. Ansari	Fire Performance Characteristic Studies of Composite Marble and Quartz Panel	M/s Asian Granito India Ltd., Marble Division, 202, Dev Ark, Opp. Iskon Temple, S.G. Highway, Ahemdabad
102.	TSP0969	Suvir Singh	Fire Performance Assessment of Partition	M/s Kingspin Jindal Pvt. Ltd., Village Souri, Swarghat Nalagarh Road, Nalagarh
103.	TSP0999	Suvir Singh	Fire Performance Assessment of Partitions	Larsen & Tourbro Ltd., India International Convention & Expo Centre, Sector 25, Dwarka, New Delhi
104.	TSP1029	Suvir Singh	Fire Performance Assessment of Fire Door	M/s Ajni Industries Pvt. Ltd., Plot No. 21 to 26, Gujarat industrial Estate, Behind Roses Nursery, Chhani Road, Navayard, Vadodara

105.	TSP1039	Suvir Singh	Fire Performance Assessment of Fire Door	M/s Kider India Pvt. Ltd., New Gat 584/2, Koragaon Bhima,Tal. Shirur, Pune
106.	TSP1049	Suvir Singh	Fire Performance Assessment of Fire Door	M/s SAM India Built Well Pvt. Ltd., 101, Dipti Classic, 32/34 Suren Road, Near Western Express Highway Metro Station, Andheri (E), Mumbai
107.	TSP1059	Suvir Singh	Fire Performance Assessment of Fire Door	M/s Trues Steel Pvt. Ltd., Village Kuranwala, Baewala Road, Derabassi, Dist. Mohali
108.	TSP1069	Suvir Singh	Fire Performance Assessment of Fire Rated Door	M/s Shreeji Woodcraft Pvt. Ltd., B-803, Western Edge II, Western Express Highway, Borivali (E), Mumbai
109.	TSP1079	Suvir Singh	Fire Performance Assessment of Fire Door	M/s NCL Industries Ltd., Vill Bhatanwalli, Paonta Sahib
110.	TSP1089	Suvir Singh	Fire Performance Assessment of Fire Door	Ex. Engineer, Delhi High Court, Civil Division (M-431), PWD, Gate No. 6, Jawaharlal Nehru Stadium, New Delhi

CBRI FAMILY

CBRI Family

Group-IV-Scientific Staff

S. No.	Name	Designation
1.	Dr. N. Gopalakrishnan	Director
2.	Mr. R.S. Chimote	Chief Scientist
3.	Dr. Suvir Singh	Chief Scientist
4.	Dr. Shantanu Sarkar	Chief Scientist
5.	Dr. Ashok Kumar	Chief Scientist
6.	Mr. S.K. Negi	Chief Scientist
7.	Dr. Harpal Singh	Chief Scientist
8.	Dr. R. Dharmaraju	Sr. Principal Scientist
9.	Dr. Pardeep Kumar-I	Sr. Principal Scientist
10.	Dr. Atul Kumar Agarwal	Sr. Principal Scientist
11.	Dr. Purnima Parida	Sr. Principal Scientist
12.	Mr. A.A. Ansari	Sr. Principal Scientist
13.	Dr. D.P. Kanungo	Sr. Principal Scientist
14.	Dr. Achal Kumar Mittal	Sr. Principal Scientist
15.	Dr. Rajni Lakhani	Sr. Principal Scientist
16.	Mr. S.K. Singh	Sr. Principal Scientist
17.	Dr. S.R. Karade	Sr. Principal Scientist
18.	Dr. Rajesh Deoliya	Sr. Principal Scientist
19.	Dr. A.P. Chourasia	Sr. Principal Scientist
20.	Mr. Nadeem Ahmed	Sr. Principal Scientist
21.	Dr. P.C. Thapliyal	Sr. Principal Scientist
22.	Dr. Navjeev Saxena	Sr. Principal Scientist
23.	Dr. B.S. Rawat	Sr. Principal Scientist
24.	Dr. L.P. Singh	Sr. Principal Scientist
25.	Dr. Shorab Jain	Sr. Principal Scientist
26.	Dr. S.K. Panigrahi	Sr. Principal Scientist
27.	Dr. Sujit Kumar Saran	Principal Scientist
28.	Dr. Rajesh K. Verma	Principal Scientist
29.	Dr. P.K.S. Chauhan	Principal Scientist
30.	Dr. Leena Chaurasia	Principal Scientist
31.	Dr. H.C. Arora	Principal Scientist
32.	Dr. Neeraj Jain	Principal Scientist
33.	Mr. Vineet Kumar Saini	Sr. Scientist
34.	Mr. Manojit Samanta	Sr. Scientist
35.	Mr. Soju Joseph Alexander	Sr. Scientist
36.	Mr. Ravindra Singh Bisht	Sr. Scientist
37.	Mr. Soumitra Maiti	Sr. Scientist
38.	Mr. Srinivasarao Naik B.	Sr. Scientist
39.	Mr. Nagesh Babu Balam	Sr. Scientist
40.	Mr. Subash Chandra Bose Gurram	Sr. Scientist
41.	Dr. A. Aravind Kumar	Sr. Scientist
42.	Dr. Anindya Pain	Sr. Scientist
43.	Mr. Mickey Mecon Dalbehera	Sr. Scientist
44.	Mr. Siddharth Behera	Sr. Scientist

45.	Ms. Ishwarya G.	Scientist
46.	Ms. Monalisa Behera	Scientist
47.	Mr. Rajesh Kumar Sharma	Scientist
48.	Mr. Rakesh Paswan	Scientist
49.	Mr. Chanchal Sonkar	Scientist
50.	Md. Reyazur Rahman	Scientist
51.	Mr. Santha Kumar G.	Scientist
52.	Mr. Koushik Pandit	Scientist
53.	Ms. Sayantani Lala	Scientist
54.	Ms. Hina Gupta	Scientist
55.	Mr. Debdutta Ghosh	Scientist
56.	Ms. Surya M.	Scientist
57.	Mr. Ashish Pippal	Scientist
58.	Ms. Shermi C.	Scientist
59.	Dr. S. Ganesh Kumar	Scientist
60.	Mr. Chandan Swaroop Meena	Scientist
61.	Dr. Banti A Gedam	Scientist
62.	Dr. Kishor S. Kulkarni	Scientist
63.	Dr. Jeeshan Khan	Scientist
64.	Mrs. Aswathy M.S.	Scientist
65.	Dr. Tabish Alam	Scientist
66.	Dr. R. Siva Chidambaram	Scientist
67.	Mrs. Hemlata	Scientist
68.	Mr. Siddharth Singh	Scientist
69.	Mr. M. Vinoth	Scientist

Group III Technical Staff

70.	Mr. Narendra Kumar	Principal T.O.
71.	Mr. Rajesh Kumar Tyagi	Principal T.O.
72.	Dr. P.K. Yadav	Principal T.O.
73.	Dr. S.K. Senapati	Principal T.O.
74.	Mr. Dalip Kumar	Principal T.O.
75.	Mr. Rajeev Kumar Sharma	Sr. T.O. (3)
76.	Mr. Sushil Kumar	Sr. T.O. (3)
77.	Mr. Zamir Ahmad	Sr. T.O. (3)
78.	Dr. M.K. Sinha	Sr. T.O. (3)
79.	Mr. Rakesh Kumar –II	Sr. T.O. (3)
80.	Mr. Vivek Sood	Sr. T.O. (3)
81.	Mr. Jalaj Parashar	Sr. T.O. (3)
82.	Mr. Ram Ashray Rai	Sr. T.O. (2)
83.	Mr. Bharat Bhushan	Sr. T.O. (2)
84.	Mr. Naresh Kumar	Sr. T.O. (2)
85.	Mr. Rajesh R. Ghadse	Sr. T.O. (2)
86.	Mr. B.K. Kalra	Sr. T.O. (1)
87.	Mr. Itrat Amin Siddiqui	Sr. T.O. (1)
88.	Mrs. Gayatri Devi	Sr. T.O. (1)
89.	Mr. Amit Kush	Sr. T.O. (1)
90.	Mrs. Deepti Karmakar	Sr. T.O. (1)

91.	Mr. Ajay Dwivedi	Sr. T.O. (1)
92.	Mr. Sameer	T.O.
93.	Mr. D.S. Dharamshaktu	T.O.
94.	Mr. Sugam Kumar	T.A. Gr. III (2)
95.	Mr. Sachin Kumar	T.A. Gr. III (2)
96.	Ms. Bhawna	T.A. Gr. III (2)
97.	Mr. Dinesh Kumar	T.A. Gr. III (2)
98.	Mr. Anil Kumar	T.A. Gr. III (2)
99.	Mr. Seraj Alam	T.A. Gr. III (2)

Group II

100.	Mrs. Saroj Rani	Sr. Tech. (3)
101.	Mrs. Neelam Gupta	Sr. Tech. (2)
102.	Mr. Sheeraj Ahmad	Sr. Tech. (2)
103.	Mr. Anil Kumar Sharma	Sr. Tech. (2)
104.	Mr. Rishi Pal Singh	Sr. Tech. (2)
105.	Mr. Sushil Kumar	Sr. Tech. (2)
106.	Mr. Himanshu Sharma	Sr. Tech. (2)
107.	Mr. Manmeet Singh	Sr. Tech. (2)
108.	Mrs. Urmila Kotnala	Sr. Tech. (2)
109.	Mr. Amar Singh	Sr. Tech. (2)
110.	Mr. B.S. Bisht	Sr. Tech. (1)
111.	Mr. Rajeev Bansal	Sr. Tech. (1)
112.	Mr. Pradeep Kr. Kapooria	Sr. Tech. (1)
113.	Mr. Arvind Saini	Sr. Tech. (1)
114.	Mr. Harish Kumar	Sr. Tech. (1)
115.	Mr. Sukhbir Sharma	Sr. Tech. (1)
116.	Mr. Arvind Kumar	Sr. Tech. (1)
117.	Mr. Sharad Kumar	Sr. Tech. (1)
118.	Mr. Mam Chand Agarwal	Sr. Tech. (1)
119.	Mr. Arvind Kumar Sharma	Sr. Tech. (1)
120.	Mr. Tahir Husain	Sr. Tech. (1)
121.	Mr. Ghanshyam Mittal	Sr. Tech. (1)
122.	Mr. Iqubal Ahmed	Sr. Tech. (1)
123.	Mr. Manoj Kumar Tyagi	Sr. Tech. (1)
124.	Mr. Jai Pal	Sr. Tech. (1)
125.	Mr. Shorab Khan	Sr. Tech. (1)
126.	Mr. Jameel Hasan	Sr. Tech. (1)

Group I Supporting Staff

127.	Mr. Rajeshwar	Lab. Asstt.
128.	Mr. Vijay Kumar	Lab. Asstt.
129.	Mr. Jagdish Pal	Lab. Asstt.
130.	Mr. Rajesh Kumar	Lab. Asstt.

Administrative Staff /House-Keeping

131.	Mr. Anil Kumar	CoA
132.	Mr. Vinod Kumar	CoA

133.	Mr. J.K. Chaurasia	F&AO
134.	Mr. Ajay Kumar Sharma	S&PO
135.	Mr. Mehar Singh	Hindi Officer
136.	Mr. Suba Singh	Hindi Officer
137.	Mr. V.P.S. Rawat	Security Officer
138.	Mr. S.K. Jakhwal	S.O. (G)
139.	Mr. Constan Kujur	S.O. (G)
140.	Mr. Lekh Raj Kaushik	S.O. (S&P)
141.	Mr. K. Arora	P.S.
142.	Mr. Satya Pal	P.S.
143.	Mr. Naresh Yadav	P.S.
144.	Mrs. Archana	Sr. Steno
145.	Mr. Arvind Kumar	Sr. Steno
146.	Mr. Dalpat Singh	Sr. Steno
147.	Mr. Dharam Singh Negi	Sr. Steno
148.	Mrs. Nisha Tyagi	Asstt. (G) Gr. I
149.	Mrs. Sarita Khanna	Asstt. (G) Gr. I
150.	Mrs. Sheema Farhat	Asstt. (G) Gr. I
151.	Mr. Sudhir Kumar	Asstt. (G) Gr. I
152.	Mr. Shiv Kumar	Asstt. (G) Gr. I
153.	Mr. Pawan Kumar	Asstt. (G) Gr. I
154.	Mrs. Mamta Sharma	Asstt. (G) Gr. I
155.	Mrs. Savita Vishwakarma	Asstt. (G) Gr. I
156.	Mr. Sushil Kumar	Asstt. (G) Gr. I
157.	Mr. Sanjay Kr. Tyagi	Asstt. (G) Gr. I
158.	Mr. Ravinder Kumar	ASO (G)
159.	Mr. Virendra Singh	Asstt. (F&A) Gr. I
160.	Mr. Aman Kumar	Asstt. (F&A) Gr. I
161.	Mr. Vipin Kumar Sharma	Asstt. (F&A) Gr. I
162.	Mr. Suraj Pal Singh	Asstt. (F&A) Gr. I
163.	Mr. Satyarth Prakash	Asstt. (F&A) Gr. I
164.	Mrs. Rubina Zaidi	Asstt. (F&A) Gr. I
165.	Mr. Sanjeev Bansal	Asstt. (S&P) Gr. I
166.	Mrs. Anju Rani Simon	Asstt. (S&P) Gr. I
167.	Mr. Arpan Maheshwari	Asstt. (S&P) Gr. I
168.	Mr. Kalam Singh Chauhan	Asstt. (S&P) Gr. I
169.	Mr. Vishwash Tyagi	Asstt. (S&P) Gr. I

Group C

170.	Mrs. Seema Ahuja	Asstt. (G) Gr. II
171.	Mr. Mukesh Kumar	Asst. (S&P) Gr. III
172.	Mr. Subhan Singh	JSA
173.	Mr. Mehraj Deen Khan	JSA
174.	Mr. Radhey Shyam	Driver
175.	Mr. Satya Pal	MTS
176.	Mr. Subhash Chand	MTS
177.	Mrs. Usha	MTS
178.	Mr. Desh Raj	MTS

179.	Mr. Rakesh Kumar	MTS
180.	Mr. Ramesh Kumar	MTS
181.	Mr. Santosh Kumar	MTS
182.	Mr. Rakesh Kumar	MTS
183.	Mr. Devendra Kumar	MTS
184.	Mr. Krishna Gopal Thakur	MTS
185.	Mr. Radhey Shyam	MTS
186.	Mrs. Prakash Kaur	MTS
187.	Mr. Rohitash Kumar	MTS
188.	Mrs. Anju	MTS
189.	Mr. Ranbeer Singh	MTS
190.	Mr. Anit Kumar Pal	MTS
191.	Mr. Pooran Vassi	MTS
192.	Mr. Kirat Pal	MTS
193.	Mr. Rajesh Kr. Yadav	MTS
194.	Mr. Jai Prakash	MTS
195.	Mr. Ranjeet Singh	MTS
196.	Mr. Satya Pal	MTS
197.	Mr. Satya Pal Singh	MTS
198.	Mr. Sunil Kumar	MTS
199.	Mr. Kiran Pal	MTS
200.	Mr. Amit Kumar	MTS
201.	Mr. Rakesh	MTS
202.	Mr. Arun Kumar	MTS
203.	Mr. Ravinder Kumar	MTS
204.	Mr. Dil Bahadur	MTS
205.	Mr. Rajinder Pal	MTS
206.	Mr. Malkhan Singh	MTS
207.	Mr. Dheer Singh	MTS

Transfer

1.	Mrs. Sangeeta Sharma	Sr. Tech. (2) From CSIR-CBRI, Roorkee to CSIR-NAL, Bengaluru	24.01.2020

Promotion

1.	Dr. Navjeev Saxena	Sr. Principal Scientist	01.01.2017
2.	Dr. L.P. Singh	Sr. Principal Scientist	27.04.2017
3.	Dr. S.K. Panigrahi	Sr. Principal Scientist	28.09.2017
4.	Dr. B.S. Rawat	Sr. Principal Scientist	01.01.2018
5.	Dr. Shorab Jain	Sr. Principal Scientist	24.09.2018
6.	Dr. Neeraj Jain	Principal Scientist	15.11.2016
7.	Mr. Subhash C.B. Gurram	Sr. Scientist	16.08.2016
8.	Dr. Anindya Pain	Sr. Scientist	02.11.2016
9.	Dr. A. Aravind Kumar	Sr. Scientist	05.09.2017
10.	Mr. M.M. Dalbehra	Sr. Scientist	02.11.2017
11.	Mr. Siddarth Behera	Sr. Scientist	02.11.2017

12.	Mrs. Saroj Rani	Sr. Tech (3) Gr. II(5)	14.10.2017
13.	Mr. Radhey Shyam	Sr. Tech (2) Gr. II (4)	21.09.2016
14.	Mr. Amar Singh	Sr. Tech (2) Gr. II (4)	01.07.2017
15.	Mr. Radhey Shyam	MTS Level III	13.07.2019

Superannuation

1.	Mr. Umesh Chand Bhatnagar	Sr. Technician	30.06.2019
2.	Mr. Kedarnath	Sr. Technician	30.09.2019
3.	Mr. Rajendra Kumar	Sr. Technician	31.10.2019
4.	Mrs. Bala	MTS	31.12.2019
5.	Mr. Gurucharan Singh	Lab Assistant	31.12.2019
6.	Mr. Pritam Giri	MTS	31.12.2019

VRS

1.	Mr. D.K. Sehgal	Principal T.O.	02.08.2019

Resignation

1.	Mr. Piyush Mohanty	Scientist	20.03.2020

RESEARCH PAPERS

Papers Published in International Journals

1. A. Chourasia, S. Singhal and J. Parashar, "Experimental Investigation of Seismic Strengthening Technique for Confined Masonry Buildings", Journal of Building Engineering, Vol. 25, September 2019, Article 100834, DOI: 10.1016/j.jobe.2019.100834.

2. A. Gaur, A. Singh, A. Kumar, K.S. Kulkarni, S. Lala, K. Kapoor, V. Srivastava, A. Kumar and S.C. Mukhopadhyay, "Fire Sensing Technologies: A Review", IEEE Sensors Journal, Vol. 19, No. 9, May 2019, pp. 3191-3202, DOI: 10.1109/JSEN.2019.2894665. (Impact Factor: 3.076)

3. A. Goyal and S.R. Karade, "Steel Corrosion and Control in Concrete made with Seawater", Innovations in Corrosion and Materials Science, Volume 10, Issue 1, 2020, pp. 58-67, DOI : 10.2174/ 2352094909666191121104836.

4. A. Verma, S. Prakash, V. Srivastava, A. Kumar, and S.C. Mukhopadhyay, "Sensing, Controlling, and IoT Infrastructure in Smart Building: A Review", IEEE Sensors Journal, Vol. 19, No. 20, October 15, 2019, pp. 9036-9046, DOI: 10.1109/JSEN.2019.2922409.

5. B.A. Gedam, "Time-Dependent Behaviour Prediction of the Prestressed HPC I-Girder, Engineering Structures", Engineering Structures, Vol. 201, December 15, 2019, Article 109763, DOI: 10.1016/j.engstruct.2019.109763.

6. B. Chauhan, G.J. Joshi and P. Parida, "Car following Model for Urban Signalized Intersection to Estimate Speed Based Vehicle Exhaust Emissions", Urban Climate, ScienceDirect, Elsevier, Vol. 29, September 2019, Article 100480, DOI: 10.1016/j.uclim.2019.100480.

7. G.S. Kumar, "Influence of Fluidity on Mechanical and Permeation Performances of Recycled Aggregate Mortar", Construction and Building Materials, Elsevier, Vol. 213, July 20, 2019, pp. 404-412, DOI: 10.1016/j.conbuildmat.2019.04.093. (Impact Factor 4.01)

8. G.S. Kumar, P.K. Saini, S.R. Karade and A.K. Minocha, "Chemico-Thermal Treatment for Quality Enhancement of Recycled Concrete Fine Aggregates", Journal of Material, Cycles and Waste Management, Springer, Vol. 21, Issue 5, September 2019, pp. 1197–1210, DOI: 10.1007/s10163-019-00874-w. (Impact Factor: 2.01)

9. J. Liu, Z. Song, Y. Lu, Y. Bai, W. Qian, D.P. Kanungo, Z. Chen and Y. Wang, "Monitoring of Vertical Deformation Response to Water Draining–Recharging Conditions using BOFDA-Based Distributed Optical Fiber Sensors", Environmental Earth Sciences, Vol. 78, Issue 14, July 2019, Article 406, pp. 1-11, DOI: 10.1007/s12665-019-8409-7 .

10. M. Behera, A.K. Minocha and S.K. Bhattacharyya, "Flow Behavior, Microstructure, Strength and Shrinkage Properties of Self-Compacting Concrete Incorporating Recycled Fine Aggregate", Construction and Building Materials, Vol. 228, December 20, 2019, Article 116819, DOI: 10.1016/j.conbuildmat.2019.116819.

11. M.K. Singh, R. Ooka, H.B. Rijal, S. Kumar, A. Kumar and S. Mahapatra, "Progress in Thermal Comfort Studies in Classrooms Over Last 50 Years and Way Forward", Energy and Buildings, Vol. 188–189, April 1, 2019, pp. 149-174, DOI: 10.1016/j.enbuild.2019.01.051.

12. N.B. Balam and A. Gupta, “A Fourth Order Accurate Finite Difference Method to Evaluate the True Transient Behaviour of Natural Convection Flow in Enclosures”, International Journal of Numerical Methods for Heat and Fluid Flow, Vol. 30, Issue 3, October 12, 2019, pp. 1233-1290, DOI: 10.1108/HFF-06-2019-0519.

13. P. Vashistha, S.K. Singh, D. Dutt and V. Kumar, “Sustainable Utilization of Paper Mill Solid Wastes via Synthesis of Nanosilica for Production of Belite Based Clinker”, Journal of Cleaner Production, Vol. 224, July 1, 2019, pp. 557-565, DOI: 10.1016/j.jclepro.2019.03.207.

14. P. Vashistha, S.K. Singh, D. Dutt and V. Kumar, “Synthesis of Nanosilica from Fly Ash and its Utilization with Lime Sludge in Concrete: an Environmentally Friendly and Sustainable Solution”, Clean Technologies and Environmental Policy, Vol. 21, Issue 9, November 2019, pp. 841–1853, DOI: 10.1007/s10098-019-01753-6.

15. P. Vashistha, V. Kumar, S.K. Singh, D. Dutt, G. Tomar and P. Yadav, “Valorisation of Paper Mill Lime Sludge via Application in Building Construction Materials: A Review”, Construction and Building Materials, Vol. 211, June 30, 2019, pp. 371-382, DOI: 10.1016/j.conbuildmat.2019.03.085.

16. P. Hou, Z. Guo, Q. Li, X. Zhang, J. Liu, S. Yang, X. Cheng, R. Kumar, B. Srinivasaraonaik and L.P. Singh, “Comparison Study on the Sulfate Attack Resistivity of Cement-Based Materials Modified with nanoSiO_2 and Normal SCMs: Pore Structure and Phase Composition”, Construction and Building Materials, Vol. 228, December 20, 2019, Article 116764, DOI: 10.1016/j.conbuildmat.2019.116764.

17. P.O. Falae, D.P. Kanungo, P.K.S. Chauhan and R.K. Dash, “Electrical Resistivity Tomography (ERT) based Subsurface Characterisation of Pakhi Landslide, Garhwal Himalayas, India”, Environmental Earth Sciences, Vol. 78, Issue 14, July 2019, Article 430, pp. 1-18, DOI: 10.1007/s12665-019-8430-x.

18. P.S. Yadav, P.K. Yadav, K.P. Yadav and S.K. Bharti, “A Hybrid Method to Augment the Efficiency of Distributed Computing System by DAG - Using Finest Task Allocation with Dual Mode Processor”, International Journal of Innovative Technology and Engineering , Vol. 8, Issue 11, September 2019, pp. 4275-4284, DOI: 10.35940/ijitee.K1974.0981119.

19. P.S. Yadav, P.K. Yadav and K.P. Yadav, “A Nobel Approach for Scheduling of Task Graph to Reduce the overall Make-Span”, International Journal of Engineering and Advance Technology, Vol. 8, Issue 5, June 2019, pp. 961-968.

20. R.S. Chidambaram and P. Agarwal, “Flexural Behavior of Reinforced Concrete Beams with HPFRCC”, Journal of Central South University, Vol. 26, Issue 9, September 2019, pp. 2609−2622, DOI: 10.1007/s11771-019-4198-0.

21. S.K. Kirthika, M. Surya and S.K. Singh, “Effect of Clay in Alternative Fine Aggregates on Performance of Concrete”, Construction and Building Materials, Vol. 228, December 20, 2019, Article 11681, DOI: 10.1016/j.conbuildmat.2019.116811.

22. S. Nimbalkar, A. Pain, S.M. Ahmad and Q. Chen, "Stability Assessment of Earth Retaining Structures under Static and Seismic Conditions", Infrastructures, Vol. 4, Issue 2, June 2019, pp. 1-15, DOI: 10.3390/infrastructures4020015.

23. S. Singh, S. Maiti, S. Rani, H. Raj, R.S. Bisht, S.K. Panigrahi, and I. Tyagi, "Ti Doped $BaMnO_3$ Perovskite Structure as Photocatalytic Agent for the Degradation of Noxious Air and Water Pollutants", SN Applied Sciences, Vol. 2, Issue 2, February 2020, Article 310, DOI: 10.1007/s42452-020-2121-9.

24. S. Singhal, A. Chourasia, S. Challapa and J. Parashar, "Precast Reinforced Concrete Shear Walls: State of the Art Review", Structural Concrete, Vol. 20, No. 3, June 2019, pp. 886-898, DOI: 10.1002/suco.201800129.

25. T. Jami, S.R. Karade and L.P. Singh, "A Review of the Properties of Hemp Concrete for Green Building Applications", Journal of Cleaner Production, Vol. 239, December 1, 2019, Article 117852, DOI: 10.1016/j.jclepro.2019.117852.

26. U. Sharma, L.P. Singh, D. Ali and C. Poon, "Effect of Particle Size of Silica Nanoparticles on Hydration Reactivity and Microstructure of CSH Gel", Advances in Civil Engineering Materials, Vol. 8, Issue 3, November 2019, pp. 346-360, DOI: 10.1520/ACEM20190007.

27. V.S. R. Annapareddy and A. Pain, "Effect of Strain-Dependent Dynamic Properties of Backfill and Foundation Soil on the External Stability of Geosynthetic Reinforced Waterfront Retaining Structure Subjected to Harmonic Motion", Applied Ocean Research, Elsevier, Vol. 91, October 2019, Article 101899, DOI: 10.1016/j.apor.2019.101899.

28. Y. Bai, J. Liu, Z. Song, Z. Chen, C. Jiang, X. Lan, X. Shi, F. Bu and D.P. Kanungo, "Unconfined Compressive Properties of Composite Sand Stabilized with Organic Polymers and Natural Fibers", Polymers, Vol. 11, Issue 10, October 2019, Article 1576, pp. 1-17, DOI: 10.3390/polym11101576.

29. Y. Wang, J. Liu, J. Chen, F. Bu, Y. Bai, D.P. Kanungo, Z. Song, and C. Qi, "Experimental Study on Compressibility and Rebound Characteristics of Sand Reinforced with Polymer and Fiber", Journal of Natural Fibers, February 10, 2020 (online), DOI: 10.1080/15440478.2020.1726251.

Papers Published in National Journal

1. A. Chourasia, J. Parashar and S. Singhal, "Confined Masonry Construction for India: A Techno Economical Solution for Improved Seismic Behaviour", Current Science, Vol. 117, No. 7, October 10, 2019, pp. 1174-1183, DOI: 10.18520/cs/v117/i7/1174-1183.

2. A. Chourasia and S. Gupta, "Influential Parameters for Headed Bars in RC Beam-Column Joint", Current Science, Vol. 16, No. 10, May 25, 2019, pp. 1666-1673, DOI: 10.18520/cs/v116/i10/1666-1673.

3. A. Chourasia and S. Singhal, "Perforated Plastic Cement Bags as Retrofit Material for Masonry Building", Nirman Sarika, A Newsletter of BMTPC, Vol. 8, Issue 3, July-September 2019, pp 31-35.

4. A. Pain, A.V.S Ramakrishna and S. Sarkar, "Seismic Stability Analysis Of Municipal Solid Waste Landfills using Strain Dependent Dynamic Properties", Indian Geotechnical Journal, Springer, Vol. 49, No. 2, April 2019, pp. 204-215, DOI: 10.1007/s40098-018-0314-6.

5. K. S. Kulkarni, S. Lala, K. Jain and A. Kumar, "Technologies Transforming Waste to Wealth for Construction Sector: An Overview", Nirman Sarika, A Newsletter of BMTPC, Vol. 8, Issue 3, July-September 2019, pp. 7-11.

6. R. Tiwari, K. Puntambekar and P. Parida, "Study of Gender Preference to Parameters of Public Transport Evaluation—A Case of Bhopal, Nagarlok", Quarterly Journal of Urban Affairs, Vol. LII, Part 1, pp. 48-56, Centre for Urban Studies Indian Institute of Public Administration.

7. R. S. Chidambaram and P. Agarwal, "Shear Resistance Behavior of Geo-grid Confined RC Elements under Static and Cyclic Loading", Current Science, Vol. 117, Issue 2, July 25, 2019, pp. 260-271, DOI: 10.18520/cs/v117/i2/260-271.

8. Sangeeta, B.K. Maheshwari and D.P. Kanungo, "GIS Based Pre- and Post-Earthquake Landslide Susceptibility Zonation with Reference to 1999 Chamoli Earthquake", Journal of Earth System Science, Vol. 129, January 2020, Article 55, pp. 1-20, DOI: 10.1007/s12040-019-1319-y.

9. Siddharth, M. Singh, S. Maiti, R.S. Bisht, S.K. Panigrahi and Sameer, "Investigation of Low Frequency Sound Absorption Property of Fluorogypsum Material for Indoor Applications", The Journal of Acoustical Society of India, Vol. 46, No. 2, April 2019, pp. 78-86.

10. S.K. Singh and S.K. Kirthika, "Effect of Elevated Temperatures on High Strength Concrete- A Review", The Indian Concrete Journal, Vol. 93, No. 10, October 2019, pp. 53-65.

11. S.K. Kirthika, S.K. Singh and S.R. Karade, "Residual Properties of Basalt and Polypropylene Hybrid Fibre Reinforced Concrete Exposed to Elevated Temperatures", The Indian Concrete Journal, Vol. 93, No. 8, August 2019, pp. 16-31.

Papers Presented/Published in Conference/Workshop/Seminar etc.

1. A.A. Kumar and R. Kumar, "Experimental and Numerical Simulation Studies for Optimization of Sprinkler Water Particle Diameter in an Enclosure Fire", Fire India 2019, September 19-21, 2019, Pragati Maidan, New Delhi.

2. A. Dewangan, G. Bhatt and C. Sonkar, "Analytical Assessment of CFS Wall Panels Sheathed with MgO Boards", Proceedings of the International Colloquia on Stability and Ductility of Steel Structures (SDSS 2019), September 11-13, 2019, pp. 337-344, Prague, Czech Republic, DOI: 10.1201/9780429320248.

3. A. Gaur, A. Singh, A. Kumar, A. Kumar and K. Kapoor, "Human Behavior and Evacuation during Fire Hazards", Abstract Proceedings of International Conference on Building Energy Demand Reduction in Global South, December 13-14, 2019, pp. 29, India Habitat Centre, New Delhi.

4. A. Joshi, J. Grover, D.P. Kanungo and R.K. Panigrahi, "Edge Assisted Reliable Landslide Early Warning System", IEEE 16th India Council International Conference (INDICON), December 13-15, 2019, pp. 1-4, Rajkot, India DOI: 10.1109 /INDICON47234.2019.9028898.

5. A. Joshi, J. Grover, D.P. Kanungo and R.K. Panigrahi, "Real-Time Landslide Monitoring, Detection and Early Warning System for Tangni Landslide", Fifth International Conference on Cyber Security and Privacy (ICCS 2019), November 29-30, 2019, ISSN 1556-5068, pp. 6-9, NIT Kurukshetra, India.

6. A. Krishna, R.S. Bisht and S.K. Panigrahi, “Dynamic Modelling and Payload Response Analysis of a 3-D Overhead Gantry Crane”, 43rd National Systems Conference (NSC 2019) on Innovative and Emerging Trends in Engineering Systems, December 6-8, 2019, IIT Roorkee.

7. A. Kumar, “Life Cycle Energy Assessment of the Building Stock in India: Current Practices and Future Directions”, International Conference on Augmenting Nature by Green Affordable New – Habitat (ANGAN), September 11, 2019, organized by BEE, New Delhi at Delhi.

8. अतुल कुमार अग्रवाल, "सशक्त देश निर्माण हेतु ऊर्जा संरक्षण में युवाओं का योगदान", अखिल भारतीय हिंदी वैज्ञानिक संगोष्ठी-2020 : ऊर्जा के क्षेत्र में भारतीय विज्ञान एवं तकनीकी प्रगति, जनवरी 9-10, 2020, पृ. 8, राजभाषा कार्यान्वयन समिति इंदिरा गाँधी परमाणु अनुसंधान केन्द्र एवं सामान्य सेवा संगठन, कल्पाक्कम।

9. A.K. Agarwal, "Environment-Friendly Rural Housing Technologies by CSIR-CBRI, Roorkee for Development of Rural India", 107th Indian Science Congress, January 3-7, 2020, Paper Id - R35, pp. 99, University of Agriculture Sciences, Bangalore.

10. अतुल कुमार अग्रवाल, "हिंदी विज्ञान लेखन : वैज्ञानिक दृष्टिकोण की ओर", अखिल भारतीय हिंदी विज्ञान सम्मेलन, नवंबर 28-30 , 2019, आमंत्रित वार्ता-5, पृ. 39-42, हिंदी विज्ञान साहित्य परिषद, भाभा परमाणु अनुसंधान केंद्र, मुंबई।

11. अतुल कुमार अग्रवाल, "खाद्य पोषण, अपमिश्रण और अपव्यय पर युवा-प्रबोधन और योगदान", राष्ट्रीय वैज्ञानिक संगोष्ठी: खाद्य सुरक्षा के विभिन्न आयाम, अक्टूबर 23-24, 2019, आमंत्रित व्याख्यान, पृ. 3, सीएसआईआर- भारतीय विषविज्ञान अनुसंधान संस्थान, लखनऊ।

12. अतुल कुमार अग्रवाल, "आधारभूत संरचनाओं के विकास में युवाओं का योगदान", राष्ट्रीय हिंदी वैज्ञानिक कार्यशाला : आधारभूत ढांचा के विकास में विज्ञान और प्रौद्योगिकी का योगदान: 21वीं सदी की चुनौतिया, सितम्बर 6, 2019, पेपर आई.डी.- एससी118, पृ. 17, सीएसआईआर - केंद्रीय सड़क अनुसंधान संस्थान, नई दिल्ली।

13. A. Sharma, Aswathy M.S. and A.K. Mittal, “Settlement Prediction in Clayey Soil Due to Tunneling Including Long Term Effects”, International Conference on Geotechnics for High Speed Corridors, July 25, 2019, Paper ID 102, pp. 305-311, Trivandrum.

14. A. Singh and A. Kumar, “Energy Performance Assessment of Houses in Hot-Dry and Warm-Humid Climates of India”, Abstract Proceedings of International Conference on Building Energy Demand Reduction in Global South, December 13-14, 2019, pp. 14, India Habitat Centre, New Delhi.

15. B.A. Gedam, S. Singh, A. Upadhyay and N.M. Bhandari, “Improved Durability of Concrete using Supplementary Cementitious Materials”, Fifth International Conference on Sustainable Construction Materials and Technologies, July 14-17, 2019, Paper ID 5151, Kingston University, London, UK.

16. C. Sonkar, A.K. Mittal, S.K. Bhattacharyya, S. Kumar, and A. Dewangan, “Experimental and Analytical Study of Cold-Formed Steel (CFS) Single-Stud Walls Sheathed with FCB, CSB and MgO under Compression”, Proceedings of the International Colloquia on Stability and Ductility of Steel Structures (SDSS 2019), September 11-13, 2019, pp. 1042-1050, Prague, Czech Republic, DOI: 10.1201/9780429320248.

17. C.S. Meena, A. Kumar and V. Aggarwal, “Reciprocal Relation between Collector Efficiency Factor and Overall Heat Transfer Coefficient of Solar Flat Plate Collector”, Abstract Proceedings of International Conference on Building Energy Demand Reduction in Global South, December 13-14, 2019, pp. 30, India Habitat Centre, New Delhi.

18. C.S. Meena, T. Alam, N.B. Balam, A. Kumar and A. Kumar, "Performance of Flat-Plate Collector of Direct Expansion Solar Assisted Heat Pump Water Heating System", Abstract Proceedings of International Conference on Building Energy Demand Reduction in Global South, December 13-14, 2019, pp. 321, India Habitat Centre, New Delhi.

19. C.S. Meena and A.K. Das, "Numerical Analysis of Boiling Heat Transfer on Horizontal and Inclined Cylinder", 25th National and 3rd International ISHMT-ASTFE Heat and Mass Transfer Conference, December 28-31, 2019, Paper ID POS 852, IIT Roorkee, India.

20. Gowtham and G. Kumar, "Shaking Table Tests on Liquefiable Sand Deposits Treated with Sand Compaction Piles", Indian Geotechnical Conference, December 21, 2019, Paper ID 16, pp. 1-4, SVNIT, Surat.

21. G. Sharma, Mohd. Shazan, K. Pandit and P. Kumar, "Stability Assessment of Pond-Ash Embankments for Static and Seismic Conditions", Geo-Environment and Sustainability Conference (Geoenvironment-2020), February 17-19, 2020, Civil Engg. Dept., IIT Delhi, sponsored by Ministry of Environment, Forest and Climate Change.

22. G. Sharma, P. Kumar, K. Pandit and S. Lala, "Codal Provisions for Foundation Design on Soils and Rocks: A Review", Indian Geotechnical Conference (IGC 2019), December 19-21, 2019, Paper ID 13-42, SVNIT Surat.

23. K. Pandit, S. Sarkar, A. Godayal and M. Shazan, "A FEM Study on Bearing Capacity and Safety of Shallow Footings on Slopes for Garhwal", Rock Mechanics for Natural Resources and Infrastructure Development – Invited Lectures, Proceedings of the 14th International Congress on Rock Mechanics and Rock Engineering (ISRM 2019), September 13-18, 2019, pp. 2607-2615, Foz do Iguassu, Brazil, DOI: 10.1201/9780367823177.

24. K. Pandit, P. Kumar and G. Sharma, "Ground Improvement of a Liquefiable Soil by Granular Piles", Indian Geotechnical Conference (IGC), December 19-21, 2019, Chapter 53, SVNIT Surat.

25. K.S. Kulkarni, K. Jain, S. Lala, E. Rajasekar and A. Kumar, "Climatic Classification of India for Building Design Using Hierarchical Clustering", Abstract Proceedings of International Conference on Building Energy Demand Reduction in Global South, December 13-14, 2019, pp. 29, New Delhi.

26. L. Chaurasia, "Desert Sand Bio-Bricks: A New Inclusion in Building Materials for Arid Region, Waste to Wealth- Sustainable Utilization", Indo-UK Workshop, August 7, 2019, CSIR-Central Building Research Institute, Roorkee.

27. L.P. Singh, U. Sharma, D. Ali and Srinivasarao Naik B., "Achieving Concrete Sustainability through Nanotechnology", 16th International Conference on Cement Concrete and Building Materials, December 3-6, 2019, pp. 251.

28. M. Behera, A.K. Minocha, S.K. Bhattacharyya and M.R. Rahman, "Rheology Study of Fresh Self-Compacting Concrete made using Recycled Fine Aggregates", 2nd International RILEM Conference, September 8-11, 2019, pp. 467-476, Dresden, Germany.

29. M. Gandhi and A. Kumar, "Shape-Stabilized Phase Change Materials or Latent Energy Storage Applications in Buildings: A Review", Abstract Proceedings of International Conference on Building Energy Demand Reduction in Global South, December 13-14, 2019, pp. 24.

30. N.B. Balam, A. Gupta, C.S. Meena, T. Alam, A. Kumar, A. Kumar and V. Aggarwal, "Natural Convection Heat Transfer and Fluid Flow Visualization in Cavities of Double Skin Facade Elements", Abstract Proceedings of International Conference on Building Energy Demand Reduction in Global South (Builders 19), December 13-14, 2019, pp. 30, New Delhi.

31. N.B. Balam, T. Alam and A. Gupta, “Transient Numerical Model for Natural Convection Flow in Flat Plate Solar Collector”, 7th International Conference on Advances in Energy Research, December 10-12, 2019, pp. 371-381, IIT Mumbai.

32. N. Jain, “Alternatives to Clay from Top Soil: Development of Building Products Using Sewage Treatment Plants (STPs) Sludge”, Workshop on National Brick Mission: Roadmap for the Brick Sector, June 24-25, 2019, organised by CSE, Delhi, at Pune.

33. N. Jain, “Potential of Waste Gypsum in Development of Value Added Building Components”, FGD Gypsum Utilization, November 21-22, 2019, organised by NTPC Ltd at RLI Vindhyachal.

34. N. Jain, “Recycling of Silt from Storm Water Drain in to Value Added Building Components”, Indo-UK Workshop on Waste to Wealth- Sustainable Utilization, August 7, 2019, CSIR-Central Building Research Institute, Roorkee.

35. नीरज जैन, सौमित्रा मैती और आर.के. वर्मा, "फ्लोरोजिप्सम द्वारा फ़र्शी टाइलों एवं भवन निर्माण सामग्रियों का विकास", पर्यावरण एवं जलवायु परिवर्तन पर हिंदी कार्यशाला, सितंबर 17, 2019, नीरी, नागपुर।

36. N. Raj, A. Kumar, A. Kumar and S. Goyal, “Indoor Environmental Quality: Impact on Productivity, Comfort and Health of Indian Occupants”, Abstract Proceedings of International Conference on Building Energy Demand Reduction in Global South, December 13-14, 2019, pp. 28.

37. P.C. Thapliyal, “Protective Coatings Contributing Towards Sustainability in Buildings”, Fifth International Conference on Polymer Processing and Characterization (ICPPC 2019), October 11-13, 2019, pp. IL10, M.G. University, Kottayam.

38. P.C. Thapliyal, Vibhrant and A. Dixit, “Effect of Plant Extracts on Surface Tension and Viscosity of Acrylic Resin”, Proceedings of National Workshop on Instrumentation Techniques for Research in Chemical Sciences (ITRCS 2019), September 6-7, 2019, pp. 1-3, Sofia Girls College, Ajmer.

39. P.K.S. Chauhan, Medha and D.P. Kanungo, “Foundation Delineation of Solani Aqueduct using Electrical Resistivity Tomography (ERT)”, First Indian near Surface Geophysics (INSG) Conference and Exhibition, November 28-29, 2019, Paper ID 27, pp. 217-221, New Delhi, India.

40. P.O. Falae, R.K. Dash and D.P. Kanungo, “Geo-Electrical Characterization of Tangni Landslide, Garhwal Himalayas, India”, First Indian near Surface Geophysics (INSG) Conference and Exhibition, November 28-29, 2019, Paper ID 31, pp. 271-278, New Delhi, India.

41. R.S. Bisht and S.K. Panigrahi, “Affordable Modular Design Concept of the Mobile Crane”, Young Scientist Conference, 5th India International Science Festival (IISF), November 5-8, 2019, Kolkata.

42. R. Lakhani, R. Kumar, P. Tomar and N. Kumar, “Study of Cement-Lime Mortars for Heritage Buildings: Micro-Structural and Physico-Mechanical Aspects”, International Conference on Advanced Materials, June 12-14, 2019, pp. 109-121, Department of Physics, Nirmalagiri College, Kannur, Kerala, India.

43. S. Ahmad, P. Bhargava and A. Chourasia, “Shear Capacity of Unreinforced Concrete Joints after Elevated Temperatures”, 12th International Symposium on Plasticity and Impact Mechanic, September 29-October 4, 2019, Busan, South Korea.

44. S. Lala, K. Jain, A. Kumar, A. Kumar and N. Goyal, “Estimation of Solar Irradiance in Indian Scenario”, Abstract Proceedings of International Conference on Building Energy Demand Reduction in Global South, December 13-14, 2019, pp. 27, New Delhi.

45. S. Maiti and N. Jain, “Development of Light Weight Building Components using Flue Gas Desulfurization Gypsum”, Indo-German Workshop on Sustainable Buildings, July 29-30, 2019, CSIR-Central Building Research Institute, Roorkee.

46. T. Alam, N.B. Balam, C.S. Meena and A. Kumar, “Parametric Analysis on the Performance of Double Glaze Flat Plate Solar Thermal Collector”, Abstract Proceedings of International Conference on Building Energy Demand Reduction in Global South, December 13-14, 2019, pp. 31, India Habitat Centre, New Delhi, India.

47. T. Jami, L.P. Singh and S.R. Karade, “Vegetal Concrete: A Foundation for Carbon Neutral Built Environment”, 16th NCB International Seminar on Cement, Concrete and Building Materials, December 3–6, 2019, New Delhi.

Papers/Articles Published in Magazines

1. अतुल कुमार अग्रवाल, "भौतिक विज्ञानी, प्रकृति-प्रेमी और प्रेरणास्रोत - सर सी.वी. रमन", विज्ञान प्रगति, वर्ष 68, अंक 2, पूर्णांक 789, फरवरी 2020, पृ. 45-47, वैज्ञानिक तथा औद्योगिक अनुसन्धान परिषद, नई दिल्ली।

2. अतुल कुमार अग्रवाल, "विमानन प्रौद्योगिकी : जमीन से आसमान छूने की चाह", विज्ञान प्रगति, वर्ष 67, अंक 12, पूर्णांक 787, दिसंबर 2019, पृ. 24-29, वैज्ञानिक तथा औद्योगिक अनुसन्धान परिषद, नई दिल्ली।

3. अतुल कुमार अग्रवाल, "खाद्य प्रदार्थों में रंग का उपयोग, कितना उचित, कितना अनुचित", विज्ञान प्रगति, वर्ष 67, अंक 10, पूर्णांक 785, अक्टूबर 2019, पृ. 36-39, वैज्ञानिक तथा औद्योगिक अनुसन्धान परिषद, नई दिल्ली।

4. अतुल कुमार अग्रवाल, "उत्तम स्वास्थ्य एवं समग्र कल्याण", विज्ञान प्रगति, वर्ष 67, अंक 4, पूर्णांक 779, अप्रैल 2019, पृ. 33 34, वैज्ञानिक तथा औद्योगिक अनुसन्धान परिषद, नई दिल्ली।

5. लीना चौरसिया, "जैब कांक्रीट-भवनो में दरारें भरने का एक विकल्प", निर्माणिका 2019, पृ. 14, सीएसआईआर-केंद्रीय भवन अनुसंधान संस्थान, रुड़की।

6. M. Surya, S.K. Singh and S.K. Kirthika, “3-D Printing in Construction: A Review”, NBM&CW, Vol. 24, No. 10, April 2019, pp. 96-102.

7. S. Lala, A. Kumar and K. Kulkarni, “Standardization in Prefabrication: Future of a Sustainable Housing Industry”, Master Builder, Vol. 21, No. 6, August 3, 2019, pp. 62-69.

8. S.K. Singh and S.K. Kirthika, “Alternative Sand: An Inevitable Resource to River Sand”, NBM&CW, Vol. 24, No. 12, June 2019, pp. 142-148.

9. S.K. Singh and S. Kundu, “Underground Transportation in Urban Built Environment”, Master Builder, July 2019, pp. 88-93.

Book Chapters

1. A. Krishna, R.S. Bisht and S.K. Panigrahi, “Dynamic Modelling and Payload Response Analysis of A 3-D Overhead Gantry Crane”, In Advances in Systems Engineering, Lecture Notes in Mechanical Engineering, Springer, Chapter 19, pp. 189-198, Singapore, 2020.

2. C. Patel, S.K. Panigrahi, A. Chourasia, T. Roy, A. Bagchi and L. Tirca, "Wavelet Transformation Approach for Damage Identification of Steel Structure Model", Recent Trends in Wave Mechanics and Vibrations, Springer Publisher, Chapter- 18, pp. 245-257, ISBN 978-981-15-0286-6.

3. K. Pandit, S. Sarkar and M. Sharma, "Optimization Techniques in Slope Stability Analysis Methods", Advances in Natural and Technological Hazards Research (Landslides: Theory, Practice and Modelling), Vol. 50, pp. 227-264, 2019, DOI: 10.1007/978-3-319-77377-3.

4. R.S. Bisht, P.M. Pathak and S.K. Panigrahi, "Development of a Climbing Robot Based on Multi-Suction Cups Mounted on Timing Belt Mechanism", Mechanism and Machine Science, Lecture Notes in Mechanical Engineering, Springer, Chapter 47, pp. 657-669, Singapore, 2020, ISBN 978-981-15-4476-7.

5. R.S. Bisht, S.K. Panigrahi, D. Kumar, N. Kumar, P. Kumar, S.S. Ali and A. Chourasia, "Dynamic Analysis of Mini Climbing Crane", In Recent Trends in Wave Mechanics and Vibrations, Lecture Notes in Mechanical Engineering, Springer, Singapore, 2020, pp. 259-269, eBook ISBN 978-981-15-0287-3.

6. S.K. Senapati, "Mobile Library Services: Present Status in India", In: Ramesh C Gaur and others (eds.), Equitable Access to Government Information and Data: Role of Government and Public Libraries in South Asia, 2019, pp. 437-447, Delhi: CGLA.

7. T. Alam, A. Kumar and N.B. Balam, "Thermo-Hydraulic Performance of Solar Air Heater Duct Provided with Conical Protrusion Rib Roughnesses", Advances in Energy Research, Springer, Vol. 2, Chapter No. 16, 2020, pp. 159-168.

Edited Abstract Proceedings of the International Conference:

1. A. Kumar, K.S. Kulkarni and E. Rajasekar, Indo-UK Conference, Abstract Proceedings on 'Building Energy Demand Reduction in Global South', India, December 13-14, 2019.

Books

1. A. Chourasia, "Confined Masonry (Concepts, Experimental Evaluation and Retrofit, Structural Analysis and Design)", 2019, CSIR-Central Building Research Institute, Roorkee.

2. A. Chourasia, "Structural Designs and Detailing for Confined Masonry EWS Houses", 2019, CSIR-Central Building Research Institute, Roorkee.

PROCESSES LICENSED
&
MoU SIGNED

The following processes were licensed/technology transferred during the year:

S. No.	Name of Technology	Name of Licensee	Date
1.	Manufacture of Paver Block and Other Building Components i.e. Tiles/Bricks from C&D Waste	M/s Disha Ecoloc Pavers Pvt. Ltd., Nagpur	16.04.2019
2.	Hybrid Rebar Coupler	M/s Jetaa Industries Pvt. Ltd., Coimbatore (TN)	03.05.2019
3.	Process Know-how for Manufacturing of Nano-Lime	M/s Poysha Nanotech LLP, Shivalik Nagar, Haridwar	14.05.2019
4.	Process Know-how for Manufacturing of Silica Nano Particles (SNPs)	M/s Poysha Nanotech LLP, Shivalik Nagar, Haridwar	14.05.2019
5.	Development of Thermal Insulated Vermiculite Tiles	M/s Ashapua Tiles & Minerals, Bewar Road, Ajmer	07.06.2019
6.	Fire Retardant Water Repellent Canvas	M/s Seghal Doors, 11/52, Subash Nagar, New Delhi – 110 027	06.09.2019
7.	Imaging of Hidden Anomalies in Concrete and Stone Masonry Structures using Ultrasonic Pulse Velocity	M/s Canopus Instruments, C/I/9, Ram Girdhar Indl. Estate, Station Road, Vitthalwadi(W) Ulhasnagar - 421003 Dist: Thane, Maharashtra	22.01. 2020
8.	Light Weight Cellular Panels for Building Construction	M/s Bharat Nav Nirman, Haridwar Road, Shyamiwala, Teh. Najibabad, Distt. Bijnor (UP) – 246 749	05.02.2020
9.	Headed Bars as Mechanical Anchorage System in RC Beam-Column Joints	M/s B.G. Shirke Construction Technologies Pvt. Ltd., 72-76, Mundhwa, Pune – 411 036	14.02.2020

The following MoUs/Agreements were executed for Contract R&D, Consultancy and Technical Services Projects during the year:

S. No.	Title of MoU/Agreement	Institute/ Industry	Date of Agreement/ MoU (DD-MM-YYYY)
1.	Development of Newer Cementitious Materials from Ladle Furnace Slag and Improvement of Ladle Furnace Slag and Electric Arc Furnace Slag for Use as Aggregate in Concrete	M/s JSW Steel Ltd., Mumbai	Agreement signed on 26.08.2019
2.	Construction and Development Rural Electrification Corporation World Headquarter Building at Sector-29, Gurugram – in Depth Analysis of Cracks and Remedial Action to Ensure Safety and Durability of the Structures	M/s Telecommunication Consultants India Ltd., TCIL Bhawan, New Delhi	Agreement signed on 16.08.2019
3.	Geotechnical Investigations and Monitoring of Vicoria Memorial Hall, Kolkata	The Secretary & Curator, Vicoria Memorial Hall, Kolkata	Agreement signed on 07.08.2019
4.	Fire Safety Audit of the said Building B.S. Negi Bhavan at Tel Bhavan, ONGC Dehradun	ONGC Ltd., Dehradun	Agreement signed on 21.10.2019
5.	Geothermal and Aero Thermal Cooling and Heating under India Cooling Action Plan (ICAP) of Govt. of India	SAP Automations India Pvt. Ltd., New Delhi	MoU signed on 27.02.2020

MoU between CSIR-CBRI and S.A.P. Automation, New Delhi

PATENTS & COPYRIGHTS

Patents & Copyrights

S. No.	Title	Inventors	Filing Date	Reference/ Application No.
		Patents Filed		
1.	An Improved Process for the Preparation of Silica Nanoparticles for Applications in Cement based Materials	Lok Pratap Singh, Srinivasarao Naik B, Usha Sharma, Dilshad Ali, Inderjeet Tyagi	14.05.2019	201911019105
2.	Method for Strengthening Coal Pillars to Improve Underground Coal Recovery	Ajay Chourasia, Koushik Pandit, Jalaj Parashar	26.11.2019	201911048284
3.	A Hybrid Robotic Device and Method for Climbing with Multiple Degrees of Freedom	Ravindra Kumar Bisht Pushparaj Mani Pathak Soraj Kumar Panigrahi	18.12.2019	201911052507
		Copyrights Filed		
1.	App for determining the Appropriate Thickness of Glass used in Buildings in Different Regions of the Country	Dr. Ashok Kumar, Dr. Rajesh Deoliya, Dr. Navjeev Saxena, Kshitij Jain, Sayantani Lala, Dr. Kishor S. Kulkarni	19.11.2019 (Granted on: 10.01.2020)	044CR2019
2.	App for Integrating Daylight with Artificial Lighting for Improving Building Energy Efficiency of Residential and Commercial Buildings during daytime in all Sky Conditions of United Kingdom	Kshitij Jain, Ashok Kumar, Anuj Kumar	03.12.2018 (Granted on: 23.05.2019)	

HONOURS & AWARDS

Honours & Awards

1. The **Diamond Jubilee Director's Award for Best Research Paper** was conferred to Dr. Banti A. Gedam for "Time Dependent Behaviour Prediction of the Prestressed HPC I-Girder"; Mr. G. Santha Kumar, Mr. P.K. Saini, Dr. S.R. Karade, and Dr. A.K. Minocha for "Chemico-Thermal Treatment for Quality Enhancement of Recycled Concrete Fine Aggregates"; and Dr. Ajay Chaurasia, Mr. Shubham Singhal and Mr. Jalaj Parashar for "Experimental Investigations of Seismic Strengthening Technique for Confined Masonry Buildings" during CSIR-CBRI Foundation Day Celebrations on February 10, 2020 at CSIR-Central Building Research Institute, Roorkee.

2. The **Diamond Jubilee Director's Award for Technology/Innovation/Know-How having Maximum Societal Impact** was awarded to Dr. Rajni Lakhani, Mr. Iqbal Ahmed, Mr. Francis Charles and Mr. Shahnawaz Khan for "Thermal Insulated Vermiculite Tiles"; Dr. L.P. Singh, Mr. Srinivasrao, Mr. Dilshad, Mr. Inderjeet Tyagi and Mrs. Usha Sharma for "Process Know-How for the Preparation of Silica Nanoparticles"; Mr. Manojit Samanta and Mr. Ajay Dwivedi for "Helical Anchors – Innovation & Applications to Infrastructure Projects"; Dr. R.S. Chidambaram and Dr. S.R. Karade for "Hybrid Rebar Couplers"; and Dr. Ajay Chaurasia, Dr. S.K. Panigrahi, Mr. Jalaj Parashar and Mr. Shubham Singhal for "Heavy Bars as Mechanical Anchorage System fr RC Beam-Column Joints". Technology on "Fire Retardant and Water Repellent Canvas" by Dr. Harpal Singh; "Process Know-How for the Preparation of Nano-Lime" by Dr. L.P. Singh, Dr. Achal Mittal and Ms. Shubhangi Shukla; "A Hybrid Climbing Robotic Device for Remote Structure Monitoring" by Mr. R.S. Bisht, Prof. P.M. Pathak and Dr. S.K. Panigrahi; and "Fire Retardant Water Based Clear Transparent Coating for Wood and Wood Based Interiors" by Mr. A.A. Ansari and Mr. Rakesh Kumar were also felicitated during CSIR-CBRI Foundation Day Celebrations on February 10, 2020 at CSIR-Central Building Research Institute, Roorkee.

3. The **National Design Award in Architectural Engineering for the Year 2019** was awarded to Dr. Ashok Kumar, Chief Scientist. The National Design and Research Forum of The Institution of Engineers (India), gave this award for his outstanding National and International contributions in the field of Engineering Design. The award was given by Dr. Tamilisai Soundarajan, Her Excellency, The Governor of Telangana, during the 34th Indian Engineering Congress of The Institution of Engineers (India) on December 27, 2019 held at Hyderabad.

4. Dr. Ashok Kumar, Chief Scientist
   - Received Second Prize for doing official work in Hindi, at CSIR-CBRI, Roorkee.
   - Nominated as Expert Committee Member of IMPRINT, Science & Engineering Research Board (SERB), New Delhi, under the Theme: Sustainable Habitat, for the year 2019-2020 and 2020-2022.

- Acted as Reviewer of International Journals: (i) Energy & Buildings, (ii) Journal of Construction in Developing Countries, and (iii) Frontiers of Architectural Research (Springer) and Indian Journal: (iv) The Institution of Engineers India (IEI) Journal (Springer)
- Acted as Jury Member for the Smart City Empowering India Awards 2019, organized by Arrucus Media Pvt. Ltd. during December 2019.
- Acted as Jury Member for the Smart City Empowering India Awards. CSIR-CBRI was also the Knowledge Partner for the event, wherein Dr. Ashok Kumar designed the evaluation criteria for the award. Hon'ble Minister Shri Hardeep Singh Puri felicitated Dr. N. Gopalakrishnan, Director and Dr. Ashok Kumar for their significant contributions as Knowledge Partner and Jury Members.

5. Dr. P.C. Thapliyal, Senior Principal Scientist and Professor (AcSIR) was part of expert committee to formulate new code IS: 17218:2019 titled ***'Solar Thermo-Reflective Exterior Coating for Cooling of Roof Top'*** which get published and contribution duly acknowledged by BIS.

6. Mr. R.S. Bisht, Senior Scientist won the Best Poster Presentation Award (cash prize and citation) under the theme of 'Make in India' during the Young Scientist Conference in India International Science Festival (IISF) 2019 during November 5-8, 2019 at Kolkata.

7. Dr. S. Ganesh, Scientist received **"Best Presentation Award"** during Indian Geotechnical Conference - 2019 held during December 19-21, 2019 at SVNT, Surat.

NEW FACILITIES

New Facilities

1. Advanced Structural Composites and Durability (ASCD) laboratory inaugurated by the DG, CSIR Dr. Shekhar Mande on October 29, 2019.
    - Fabrication of reaction wall of height 5 m with 70T lateral resistance capacity at ASCD Lab
    - Electric furnace having 1200 °C capacity of length 1.5 m at ASCD Lab

Inauguration of ASCD Lab

2. A dedicated Classroom/Lecture Hall has been developed in the Development Construction & Extension Division for effective end-to-end training program equipped with all the necessary training aids, its maintenance will be done by various sponsored training programmes being organised under CSIR Integrated Skill Initiatives.

3. Upgradation/Procurement of reverberation chamber and impedance tube for sound absorption and transmission loss measurement.

4. Full scale axial compression testing setup (1000 kN)

Axial Compression Test Setup

5. Full scale flexure testing setup (500 kN**)**

Axial Compression Test Setup

LECTURES DELIVERED

Lectures Delivered

1. Dr. Ashok Kumar, Chief Scientist delivered invited & keynote lectures on:
    - "Smart Cities and Smart Infrastructure-Research Challenges and Future Possibilities", AICTE sponsored Faculty Development Program, June 22, 2019, Indian Institute of Technology Roorkee.
    - "Pest Prevention by Design: Existing Buildings and New Build", Workshop on Challenges of Structural Pest Management, October 3, 2019 CSIR-Central Building Research Institute, Roorkee.
    - "Frontier Technologies as a Tool for Sustainable Habitat: Current Practices and Way Forward", Habitat Day 2019, October 7, 2019, CSIR-Central Building Research Institute, Roorkee.
    - "Building Science and Technology: Past, Present and Future R&D and Roadmap for Collaboration", Workshop on Academia-Research-Industry Interface on Challenges in the Built Environment, October 11, 2019, Department of Architecture & Planning, Indian Institute of Technology Roorkee.
    - "Sustainable and Energy Efficient Buildings", November 15, 2019, CSIR-Central Building Research Institute, Roorkee.

2. Dr. Atul Kumar Agarwal, Senior Principal Scientist delivered lectures on:
    - "A Scientific Journey of CSIR and CBRI with Emphasis on Building Material from Past to Future", April 16, 2019, Motherhood University, Roorkee.
    - "World Earth Day 2019: Protect Our Species", Vismit Vigyan Saptah: World Earth Day 2019, April 22, 2019, Children's Senior Academy, Roorkee.
    - "Inclusion of Humor & Fun Facts in Science Education", Vismit Vigyan Saptah: State-Level Scientist-Teacher Interactions, April 23, 2019, CSIR-Central Building Research Institute, Roorkee.
    - "Our Scientists-Our Inspiration", Vismit Vigyan Saptah: State-Level Scientist-Teacher Interactions, April 24, 2019, CSIR-Central Building Research Institute, Roorkee.
    - "Mosquitoes, Malaria and More", Vismit Vigyan Saptah: World Malaria Day 2019 & International Girls in ICT Day 2019, April 25, 2019, Cantonment Board Senior Secondary School, Roorkee.
    - "Building Material-Past, Present & Future: Scientific Journey of CSIR and CBRI", Vismit Vigyan Saptah: World Intellectual Property Day 2019, April 26, 2019, Kendriya Vidyalaya No. 1, Roorkee.
    - "Successful Invention: A Series of Failed Experiments", Prayer Meet, April 27, 2019, Kendriya Vidyalaya No. 1, Roorkee.
    - "Journey of CSIR & CBRI : Building Materials from Waste", Vigyan Se Vikaas, April 30, 2019, CSIR-Central Building Research Institute, Roorkee.
    - "CSIR: Infinite Career Opportunities in Science", Guidance Programme for KV Tarunotsav Students, April 30, 2019, CSIR-Central Building Research Institute, Roorkee.
    - "Stay Clean, Stay Healthy: Strengthen the Foundation of India", Swachh Bhawishya, May 10, 2019, Sri Sanatan Dharm Prakash Chand Kanya Inter College, Roorkee.
    - "JIGYASA: How can India Become a Zero Waste Country", Swachh Bhawishya, May 13, 2019, Arya Kanya Pathshala Inter College, Roorkee.

- "JIGYASA: Value-Added Products from Waste", Swachh Pratispardha, May 15, 2019, CBRI Junior High School, Roorkee.
- "Internet for Intellectual Development not Destruction", World Telecommunication & Information Society Day, May 17, 2019, Sri Sanatan Dharam Prakash Chand Girls Inter College, Roorkee.
- "International System of Units: New Definitions", World Metrology Day, May 20, 2019, Arya Kanya Pathshala Inter College, Roorkee.
- "Science against Terrorism", National Anti-Terrorism Day, May 21, 2019, Children's Senior Academy, Roorkee.
- "CSIR: Fulfilling the Aspirations of Modern India", Lecture to PGTs of 7 Regions attending the In-Service Course, June 14, 2019, Kendriya Vidyalaya No. 2, Roorkee.
- "CSIR-CBRI Technologies for Pollution Control", Pollution Awareness Pakhwada with NCC Cadets, July 11, 2019, Cantonment Board Senior Secondary School, Roorkee.
- "Scientific Temperament: Catalyst for Skill Development", Students Programme on World Youth Skills Day, July 16, 2019, CSIR-Central Building Research Institute, Roorkee.
- "Role of Students to Fight against Corruption", Students Programme on World Youth Skills Day, July 16, 2019, CSIR-Central Building Research Institute, Roorkee.
- "Skill Development & Career Opportunities", Students Programme on World Youth Skills Day, July 17, 2019, Cantonment Board Senior Secondary School, Roorkee.
- "Career Opportunities in Science", Acharya P.C. Ray's 158th Anniversary of Birth, August 2, 2019, Kendriya Vidyalaya No. 1, Roorkee.
- "Science for a Brighter Future", Student-Scientist Connect Programme, August 14, 2019, Rajeev Gandhi Navodaya Vidyalaya Shikarpur.
- "Scientific Journey of CSIR & CBRI", Three-Day State-Level Students' Residential Workshop, August 27, 2019, CSIR-Central Building Research Institute, Roorkee.
- "Career Opportunities", Three-Day State-Level Students' Residential Workshop, August 28, 2019, CSIR-Central Building Research Institute, Roorkee.
- "Inculcating Scientific Temper: 3 Ks of Jigyasa", Three-Day State-Level Students' Residential Workshop, August 28, 2019, CSIR-Central Building Research Institute, Roorkee.
- "Secrets to Success", Three-Day State-Level Students' Residential Workshop, August 29, 2019, CSIR-Central Building Research Institute, Roorkee.
- "Jigyasa: A Scientific Approach to Life", Science Exhibition, September 2, 2019, Kendriya Vidyalaya No. 2, Roorkee.
- "Jigyasa: Sustainable Development Goals", Children's Science Congress, September 3, 2019, Kendriya Vidyalaya No. 2, Roorkee.
- "Jigyasa: Conservation of Himalayan Ecology", Science Exhibition & Himalaya Day 2019, September 9, 2019, Kendriya Vidyalaya No. 1, Roorkee.
- "Jigyasa: CSIR-CBRI Contributions towards Disaster Mitigation in India", State-Level Students' Science Awareness Programme, September 19, 2019, CSIR-Central Building Research Institute, Roorkee.
- "Jigyasa: Key to Awaken Scientific Consciousness in Students", State-Level Scientist-Teacher Interactions Programme, September 20, 2019, CSIR-Central Building Research Institute, Roorkee.

- "Swachhata Hi Seva: Eradicate Single-Use Plastic", Students for Swachhta Programme to observe Swachhta Hi Seva 2019, October 1, 2019, CSIR-Central Building Research Institute, Roorkee.
- "Swachh Bharat: 5 R's of Waste Reduction", Swachhta Hi Seva : Swachhta Programme to observe 150th Birth Anniversary of Mahatma Gandhi, October 3, 2019, CBRI Junior High School, Roorkee.
- "Importance of Student Science Festivals & Outreach Programmes", Student-Scientist Interactions, October 16, 2019, Kendriya Vidyalaya No. 2, Roorkee.
- "IISF 2019: RISEN India", Students Awareness Programme, October 21, 2019, Kendriya Vidyalaya No. 1 & 2, Roorkee.
- "Integrity in Studies, Science & Research", Inter-School Debate Competition, October 25, 2019, Kendriya Vidyalaya No. 1, Roorkee.
- "Jigyasa: Student-Scientist Connect Programm at CSIR-CBRI, Roorkee", Dr. Shekhar C. Mande, DGCSIR Presided over IISF Precursor Events, October 29, 2019, CSIR-Central Building Research Institute, Roorkee.
- "Integrity-a Way of Life", Vigilance Awareness Week, CSIR-Central Building Research Institute, Roorkee.
- "Students against Corruption: Scientific Temper and Integrity", Student Awareness Activities during Vigilance Awareness Week, November 4, 2019, CSIR-Central Building Research Institute, Roorkee.
- "Students against Corruption: Integrity and Ethical Conduct", Student Interactive Activities, November 5, 2019, Government Upper Primary School Shikarpur.
- "Students against Corruption: Academic Integrity", Student Workshop-cum-Seminar, November 6, 2019, KLDAV College, Roorkee.
- "Jigyasa: Aspirations & Career in Science", CSIR-CBRI Scientists Encouraged Students, November 20, 2019, KV FRI, Dehradun.
- "Jigyasa: Importance of Soil", World Soil Day, December 5, 2019, Government Upper Primary School, Khanjarpur, Roorkee.
- "Flying High with Science & Jigyasa", CSIR-CBRI Scientists Encouraged Students, December 6, 2019, Government Primary School, Khanjarpur.
- "Jigyasa: Education, Science & Development", Vijay Diwas, December 14, 2019, J.P. International Public School, Landhaura.
- "Jigyasa: Reconnecting Students with Science", PGT Workshop, December 26, 2019, CSIR-Central Building Research Institute, Roorkee.
- "Edison or Curie – Science Does Not Discriminate", International Day of Women and Girls in Science & Birth Anniversary of Thomas Alva Edison, February 11, 2020, CSIR-Central Building Research Institute, Roorkee.
- "Darwin & Evolution: Survival of the Fittest", International Darwin Day, February 12, 2020, CSIR-Central Building Research Institute, Roorkee.
- "Our Inspiration- Nobel Laureate Sir C.V. Raman", Student-Scientist Connect Programme on National Science Day, February 28, 2020, CSIR-Central Building Research Institute, Roorkee.

3. Dr. P.C. Thapliyal, Senior Principal Scientist and Professor (AcSIR) delivered invited talk on "Protective Coatings contributing towards Sustainability in Buildings" and Chaired one technical session in ICPPC 2019, on October 12, 2019 held at M.G. University, Kottayam.

4. Dr. S.R. Karade, Senior Principal Scientist delivered keynote lectures on
    - "Protection Measures for Corrosion of Steel Reinforcement and Other Durability Issues in Concrete", Training of Master Trainers on Multi Hazard Resistant Construction Practices, June 18, 2019, CSIR-Central Building Research Institute, Roorkee.
    - "Corrosion of Steel in Concrete-Issues and Protection", ICI Lecture, July 25, 2019, Institution of Engineers (I), Roorkee.
    - "Durability Issues in Buildings: Corrosion of Steel in Concrete and its Protection", August 6, 2019, National Academy of Defense Production (NADP), Nagpur.
    - "Cement Bonded Composites from Agro-Forestry Wastes", Training Programme on Multi Hazard resistant Construction Practices for Engineers of Arunachal Pradesh, August 21, 2019, CSIR-Central Building Research Institute, Roorkee.
    - "Corrosion and Other Durability Issues in RCC Structures", Workshop on Innovative Construction Machineries, Materials and Methods (ICMMM-2019), November 9-10, 2019, organized by Indian Institute of Technology Jammu.
    - "Corrosion and Other Durability Issues in RCC Structures", Short Term Training Program on Disaster Management and Sustainable Development, November 11-15, 2019, CSIR-Central Building Research Institute, Roorkee.
    - "Sustainable Building Materials", 3rd International Conference on Innovative Technologies for Clean and Sustainable Development (ITCSD2020), February 19-21, 2020, NIITR, Chandigarh.

5. Dr. Neeraj Jain, Principal Scientist, delivered lectures on
    - "Alternatives Brick Manufacturing Technologies with Low Emission and Reduced Energy Consumption", Training Programme on Inspection and Monitoring of Brick Kilns, February 13-14, 2020, Organized by CSE at Delhi.
    - "Experiences from Monitoring of Brick Kilns in Punjab", Training Programme on Inspection and Monitoring of Brick Kilns, February 13-14, 2020, Organized by CSE at Delhi.

6. Dr. R. Siva Chidambaram, Scientist delivered lectures on
    - "High Performance Materials and its Applications in Structural Engineering", July 5, 2019, Saveetha School of Engineering, Chennai.
    - "Sustainable Building Materials", DST-NIMAT Sponsored Workshop, March 2-4, 2020, CCMM-SR University, Warangal.

WORKSHOP ATTENDED

Workshop Attended

Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee and Dr. Ashok Kumar, Chief Scientist, participated in a Deep Dive Mission Innovation IC7 Program on **"Low Carbon, Affordable Heating and Cooling of Buildings", Focus Area: Thermal Comfort**, on November 6, 2019 at New Delhi.
Dr. N. Gopalakrishnan briefed on the R&D carried out by CBRI in developing Tropical Summer Index (TSI) for thermal comfort of Indian objects, and recent developments on affordable heating and cooling of buildings in India and the future perspectives of research in CSIR-CBRI.

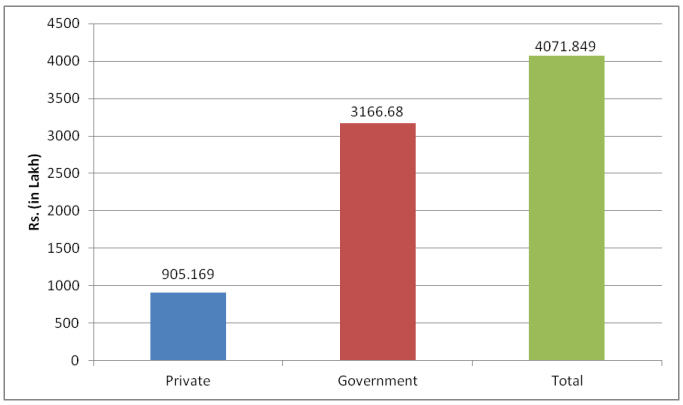
DATE LINE

Date Line

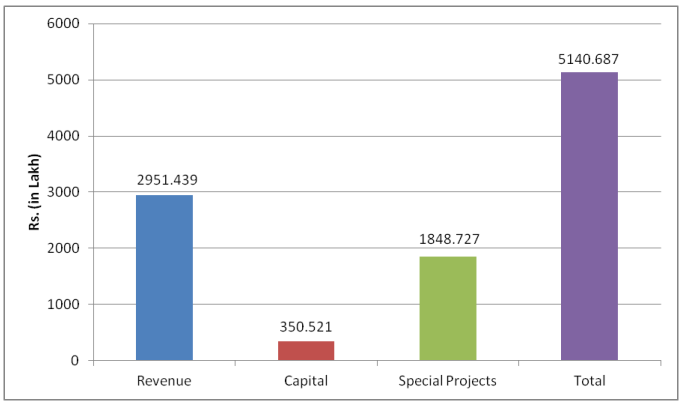
S. No.	Date	Event
1.	May 1-15, 2019	Observance of Swachhta Pakhwada at CSIR-CBRI, Roorkee
2.	May 2, 2019	Students of IIT Roorkee visit CIR-CBRI, Roorkee
3.	May 14, 2019	National Technology Day Celebrations at CSIR-CBRI, Roorkee
4.	May 20-24, 2019	Training Programme on Multi Hazard Resistant Housing and Habitat for Engineers of Uttarakhand at CSIR-CBRI, Roorkee
5.	June 10-14, 2019	Training Programme for Master Trainers on Earthquake Resistant Construction Practices for Engineers of Himachal Pradesh at CSIR-CBRI, Roorkee
6.	June 17-21, 2019	Training Programme for Master Trainers on Earthquake Resistant Construction Practices for Engineers of Himachal Pradesh at CSIR-CBRI, Roorkee
7.	June 21, 2019	Observance of International Day of Yoga at CSIR-CBRI, Roorkee
8.	July 28-29, 2019	Workshop on "Indo-German Collaboration in Research and Innovation towards Leapfrogging in Frontier Technologies" at CSIR-CBRI, Roorkee
9.	August 2, 2019	Acharya P.C. Ray's 158th Anniversary of Birth at Kendriya Vidyalaya No. 1, Roorkee
10.	August 15, 2019	Independence Day Celebrations at CSIR-CBRI, Roorkee
11.	August 19-23, 2019	Training Programme on Multi-Hazard Resistant Construction Practices for Engineers of Arunachal Pradesh at CSIR-CBRI, Roorkee
12.	August 20, 2019	Observance of Sadbhavna Diwas at CSIR-CBRI, Roorkee
13.	August 26-30, 2019	Training Programme on Multi–Hazard Resistant Housing and Habitat for Engineers of Uttarakhand at CSIR-CBRI, Roorkee
14.	September 2-16, 2019	Observance of Hindi Pakhwada at CSIR-CBRI, Roorkee
15.	September 13, 2019	Students of Quantum College of Technology, Roorkee visit CIR-CBRI, Roorkee
16.	September 28, 2019	CSIR Foundation Day Celebrations at CSIR-CBRI, Roorkee
17.	September 29, 2019	Students of IMMT Ghaziabad visit CIR-CBRI, Roorkee
18.	October 3-5, 2019	Training Programme on Earthquake Resistant Construction Technology for the Masons of Himachal Pradesh at Sundernagar, Himachal Pradesh
19.	October 28- November 2, 2019	Observance of Vigilance Awareness Week at CSIR-CBRI, Roorkee
20.	October 29, 2019	Dr. Shekhar C. Mande, DGCSIR Presided over IISF Precursor Events at CSIR-CBRI, Roorkee
21.	November 11-13, 2019	Short Term Course on "Design of Fire Protection Measures for Vital Installations and Buildings" at India Habitat Centre, New Delhi
22.	November 11-15, 2019	Short Term Training Programme on "Disaster Management and Sustainable Development"
23.	November 20, 2019	Students of MIET Meerut visit CIR-CBRI, Roorkee
24.	November 25, 2019	Industrial Meet on Innovative Building Materials and Construction Technologies for Mass Housing with focus on Construction Chemicals at Habitat Centre, New Delhi
25.	November 26, 2019	Observance of Constitution Day at CSIR-CBRI, Roorkee
26.	November 26-27, 2019	Training Programme on Earthquake Resistant Construction for the Masons of District Haridwar at CSIR-CBRI, Roorkee
27.	December 3, 2019	Engineers of MP & MH Govt. visit CIR-CBRI, Roorkee

28.	December 13-14, 2019	International Conference on "Building Energy Demand Reduction in Global South, 2019" (BUILDER'19) at India Habitat Centre, New Delhi
29.	December 16-20, 2019	Training Programme on Multi-Hazard Resistant Housing and Habitat for Engineers of Uttarakhand at CSIR-CBRI, Roorkee
30.	January 20-24, 2020	Training Programme on Multi-Hazard Resistant Housing and Habitat for Engineers of Uttarakhand at CSIR-CBRI, Roorkee
31.	January 26, 2020	Republic Day Celebrations at CSIR-CBRI, Roorkee
32.	January 30-31, 2020	Training Programme for Master Trainers on Multi-Hazard Resistant Construction Practices for officers of Himachal Pradesh at Solan, Himachal Pradesh
33.	February 2, 2020	Students of DAV College Muzaffarnagar visit CIR-CBRI, Roorkee
34.	February 7, 2020	Family Get-Together & Sports Day Celebrations at CSIR-CBRI, Roorkee
35.	February 7-8, 2020	Training Programme on Innovative Technologies for Construction of Disaster Resilient Habitat for Architects and Engineers at Mangalore, Karnataka
36.	February 10, 2020	CBRI Foundation Day Celebrations at CSIR-CBRI, Roorkee
37.	February 17-21, 2020	Training Programme on Multi–Hazard Resistant Housing and Habitat for Engineers of Uttarakhand at CSIR-CBRI, Roorkee
38.	February 27, 2020	Students of NIIT Najibabad visit CIR-CBRI, Roorkee
39.	March 2, 2020	National Science Day Celebrations at CSIR-CBRI, Roorkee
40.	March 2-7, 2020	Training Programme on Innovative Technologies for Construction of Rural Houses for the Engineers of Madhya Pradesh at CSIR-CBRI, Roorkee
41.	March 12, 2020	Medical Camp at CSIR-CBRI, Roorkee
42.	March 13, 2020	International Women's Day Celebrations at CSIR-CBRI, Roorkee
43.	March 13-14, 2020	Workshop on "Recent Advances in Technology for Heritage Structures" at Pt. Deendayal Upadhyaya Institute of Archaeology, Archaeological Survey of India, Knowledge Park II, Greater Noida

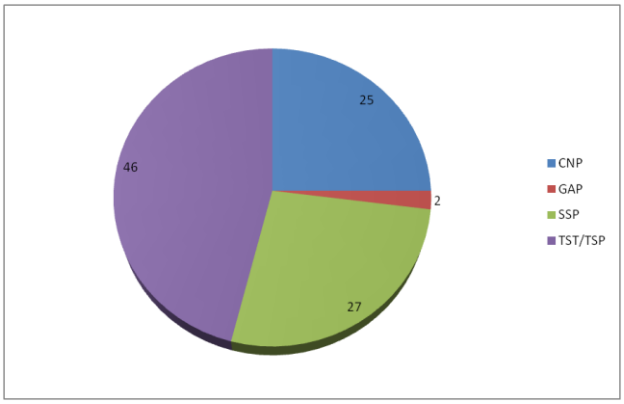
Performance/ Projects/ Human Resource



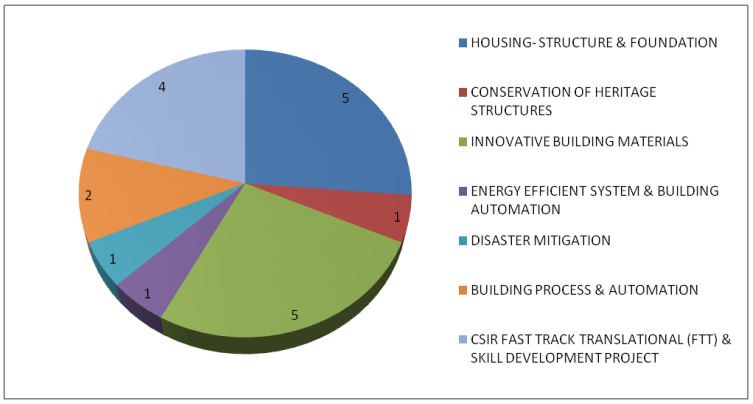
ECF



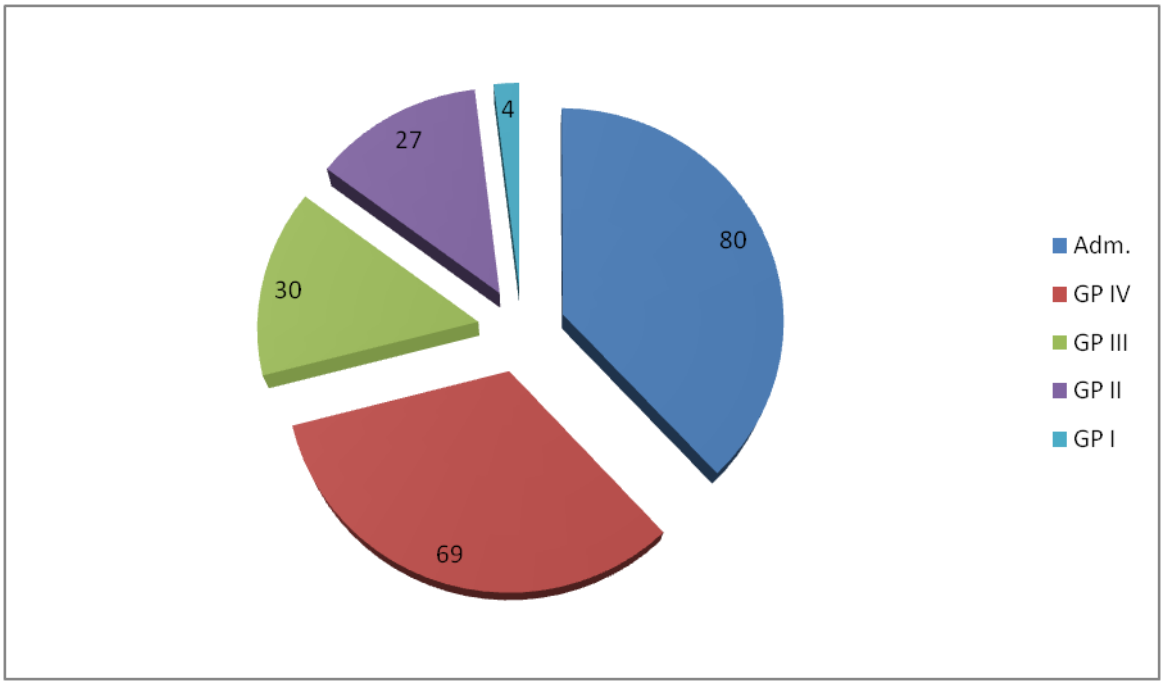
CSIR Resource Input



Externally Funded Projects



In-House R&D Projects



Human Resource

सीएसआईआर-केंद्रीय भवन अनुसंधान संस्थान, रुड़की

CSIR-Central Building Research Institute, Roorkee

Phone: +91-1332 272243; Fax: +91-1332 272272, 272543

E-mail: director@cbrimail.com; director@cbri.res.in

Website: http://cbri.res.in