Member of CISQ Federation
RINA
ISO 9001:2008
Certified Quality System

50
1965-2015
Excellence Through Innovation

CSIR-SERC
ENGINEERING SUSTAINABLE STRUCTURES

excellence

that nurtures innovation

CSIR-SERC

the golden legacy continues . . .

1965 - 2015

endurance
that inspires progress ...


Ranga river
Lakhimpur
Luhit
Dihing river
Dikhow river
Jhanji river
Jorhat
Disoi River

technology IN A NEW PERSPECTIVE

Panoramic view of the CSIR-SERC campus

TOWER TESTING
RESEARCH STATION

CSIR - Council of Scientific & Industrial Research

(Established 26th September, 1942)

CSIR - Structural Engineering Research Centre

(Established 10th June, 1965)

CSIR-SERC
Golden Legacy 1965 - 2015

WHAT'S INSIDE WHAT'S INSIDE WHAT'S INSIDE

A JOURNEY
OF EXCELLENCE

A commemorative volume in the form of a coffee-table book detailing events and moments of the past is not only exciting and compelling but also, at times, challenging. I looked around and found only three or four of us, who are in service, have witnessed and participated in some of the splendid moments qualifying for the record and yet unable to narrate in factual terms. I accepted this challenge and made sure that the documentation is based on facts and evidence that can re-create those moments! The more I collected and compiled such details, the more I was convinced that it has been a glorious and illustrious past and a legacy has been created that paved the way for admirable challenges to continue and build upon. The saga of 50 years is narrated analogous to the form of a river - the river source, the main river, the meander and flood plain, the river mouth and, the tributaries. Such is the story of CSIR-SERC. Her footprints on the sands of time are etched by untold tales of sweat and perseverance, hard work and steadfastness, courage and conviction, undaunted spirit and dogged determination. CSIR-SERC has had the blessing of being steered by men of high caliber with visionary zeal and meticulous planning, informed decision making and forecasting trends, staying abreast but thinking ahead of the times, leap-frogging many a times driven by a desire to innovate and be a pioneer in more ways than one. Altogether, CSIR-SERC's is a protracted tale of agony and ecstasy!

The River Source, also known as the headwaters, marks the humble beginnings of a mighty river. Often located in a mountain range, the source is likely to be fed by an underground spring or at times, by runoff from rain, snowmelt or glacial melt. In a somewhat similar fashion, an institution starts off as a fledgling, is guided into its growth

> *"The 50-year saga of CSIR-SERC is narrated analogous to the form of a river - the river source, the main river, the meander & flood plain, the river mouth and the tributaries."*

path by visionaries down the timeline, grows step by step, accumulates experience and knowledge and, becomes a full-fledged institution which brings to bear a definitive and distinctive impact on its specialist domain. The day in 1965 - 10th June - in history marks the establishment of CSIR-SERC to initiate its operations in providing for the very best of expertise in Structural Engineering to benefit this great nation of ours... yes, we were born out of ideals as high as the mountains, to fulfil a great legacy of landmark achievements and core competencies.

As the heart of the river system, the main river is the motherhood of the system, amply providing for the livelihood of the populace that dots either side of the water, on the banks. The support is as long and as ample as the length that the river traverses before ending its journey into the sea or the ocean. Much like evolving from a few drops to a voluminous river, we were to grow from strength to strength, gaining from the pool of great minds and tireless human spirit. This would enable us to gather ourselves into a unified force that will stand the test of time for several years to come. Rather than traversing in a straight line, sometimes the river takes a winding path much like a snake when seen from above. The greatest advantage of this detour is that more human communities stand to benefit from the river system. Having completed the process of consolidation, we were to move onto fields and milieu that were hitherto unknown or never ventured. This attribute would thus enable us, then, to churn out path-breaking innovations and never-before methodologies that would stand the test of time to benefit the field of

Structural Engineering and inter- and trans-disciplinary areas. The last stage of the river system - the estuary as it is popularly known - the mouth of the river segments the land mass here into island-like places, sometimes amounting to several tens of hundreds of them like the famous 24 Parganas - the estuary of the voluminous Brahmaputra. This land mass is rich in mangroves and spawns a wide variety of honeybees that rampantly colonise many tree trunks to produce natural honey - one of the most vital foods known to man. The last two decades or so would see us grow into a colossus that would embrace the Indian engineering industry in general and also the global Structural Engineering arena, redefining the very thought process that sustains them. Fifty years and several milestones later, we stand tall not only in our achievements but also in our unflinching commitment to showcase

“A Legacy that leaves us awestruck...”

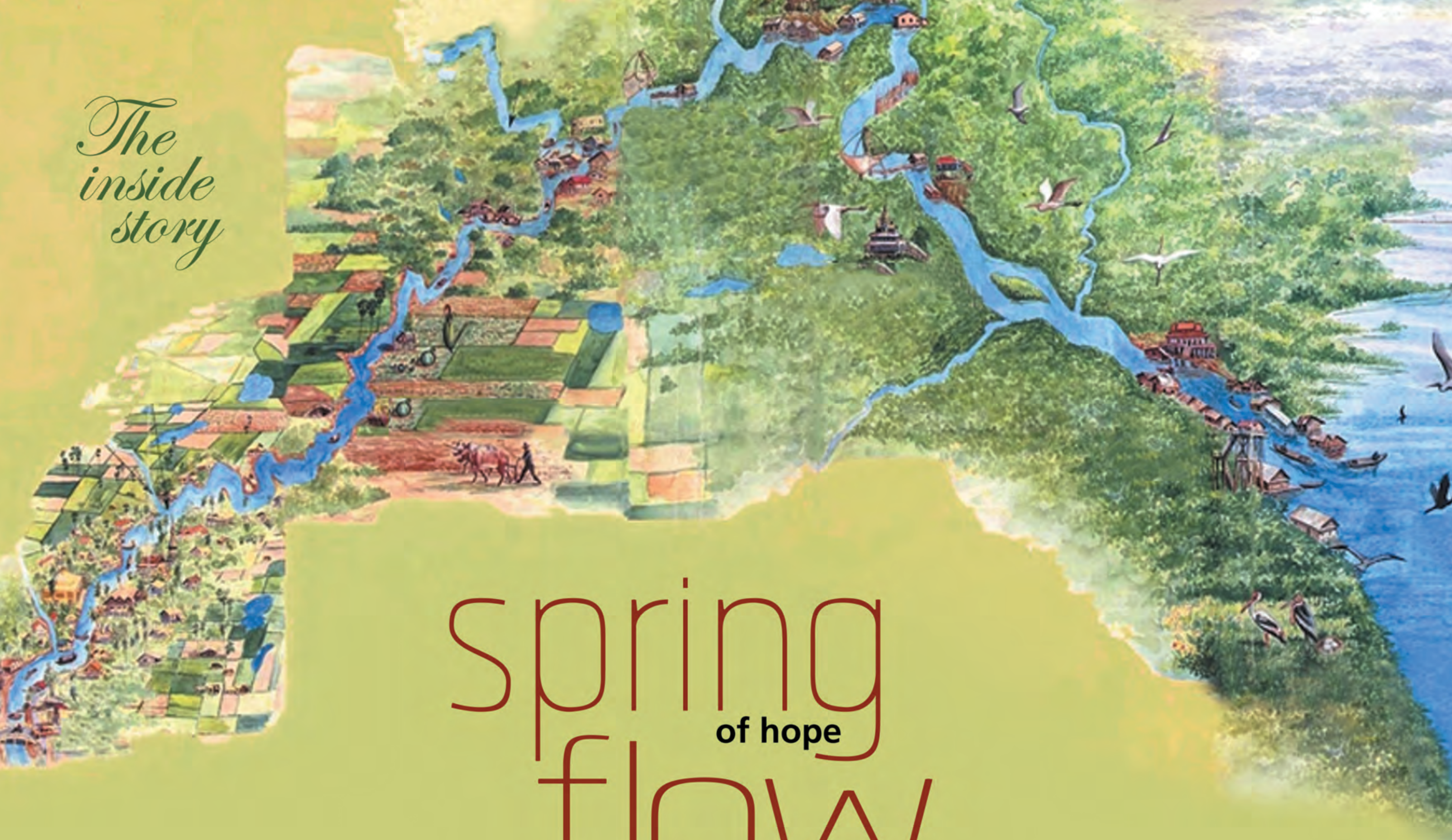
our dear motherland by providing for the highest levels of structural engineering excellence that technology has ever witnessed. We have thereby merged ourselves into the spirit of the engineering fraternity with a pledge to never waver from this focus in the coming decades. The intermediary stage in the river system is the collection of various branch-outs of the main river body termed as the tributaries. Mostly found in the upstream section of the river and, to a lesser extent in the downstream section as well, some of these tributaries are voluminous enough to be significant rivers by themselves. Most of them, though, are what are called rivulets or tiny river bodies that have their own banks and still support a fair proportion of human communities in agriculture and fisheries. Today, even as global technological advancements reach dizzying heights, we are abreast in keeping pace with these trends to plan, innovate, design, experiment and deliver with a great degree of consistency and the highest levels of quality, solely to the advantage of all who source our expertise in several related yet new areas of engineering. Attempting to recount the significant landmarks of the origins and growth of the institution, that CSIR-SERC is beset with a unique challenge of its own... one can never be fully satisfied as to whether each and every important step taken, landmark achieved, trials and tribulations undergone, have been done justice as they deserve. Nevertheless, in this document, both of archival and knowledge dissemination value, we have taken pains to assemble as many important milestones as we possibly could, still making this a handy reference compendium of manageable proportions and commemorating the completion of 50 years of significant presence of CSIR-SERC.

I wish to place on record the contribution in this endeavor by my colleagues Prof. K. Ravisankar, Prof. G. S. Palani, Ms. S. Vijayalakshmi, Dr. Mymoon Moghul and Mr. V. Srinivasan who dug through the past and logically built this entire saga in such an eloquent form! I derive great pleasure in presenting this golden jubilee compendium on CSIR-SERC with all humility and admiration, dedicating the work and the glory to all the past and present members of staff of CSIR-SERC. The participation from Directors, Scientists, Scientific and Technical staff, Infrastructural staff, all the members of Administration, Finance and Accounts, Stores and Purchase and, Research and Post-Graduate scholars, has been overwhelming. Besides the CSIR, the Directors-General of CSIR, distinguished peers of the Research Councils and Performance Appraisal Boards, the UNDP have all contributed to the making of CSIR-SERC into what it is today - a shining beacon of knowledge and expertise that stands as a veritable asset both nationally and internationally.

Prof. Nagesh R. Iyer
Director, CSIR-SERC

23rd October 2014

The inside story



spring

of hope

flow

of excellence

Waves


BOARD ON AWARDS FOR
IMPORT SUBSTITUTION
Awarded To
Structural Engineering Research Centre
Roorkee
For Developing Indigenous Know How for the Manufacture of
Grip Bars for Concrete Reinforcement


1999
अभियान्त्रिकी प्रौद्योगिकी पुरस्कार
PRIZE FOR ENGINEERING TECHNOLOGY
AWARDED TO THE TEAM AT SERC, MADRAS FOR
ADVANCED COMPUTATIONAL METHODOLOGIES,
MODELLING TECHNIQUES AND SOFTWARE
FOR ANALYSIS & DESIGN OF
COMPLEX STRUCTURES
DR. NAGESH R. IYER - TEAM MEMBER


2000
अभियान्त्रिकी प्रौद्योगिकी शील्ड
SHIELD FOR ENGINEERING TECHNOLOGY
AWARDED TO THE WIND ENGINEERING GROUP AT SERC, MADRAS
FOR DEVELOPMENT OF ADVANCED ANALYTICAL &
COMPUTATIONAL METHODOLOGIES, EXPERIMENTAL
FACILITIES AND TECHNIQUES FOR WIND ENGINEERING
AND CYCLONE DISASTER MITIGATION
DIRECTOR
STRUCTURAL ENGINEERING RESEARCH CENTRE
CHENNAI


CSIR TRANSFORMATION &
ICT INTERVENTIONS
PROJECT
OUR NEW ENTERPRISE
CSIR-INDIA
Outstanding Achievement Award
CSIR - STRUCTURAL ENGINEERING RESEARCH CENTRE


Corrosion Awareness Award
2014
NIGIS
Excellent Laboratory Award
CSIR – Structural Engineering
Research Centre, Chennai


CSIR - INDIA
CSIR Transformation &
ICT Initiatives
Bronze Icon Award
CSIR Foundation Day 2012
CSIR @ 70


नगर राजभाषा कार्यान्वयन समिति (कार्यालय) चेन्नै
Town Official Language Implementation Committee (Offices), Chennai
सत्यमेव जयते
संयुक्त राजभाषा समारोह - वर्ष 2013
केन्द्र सरकारी कार्यालय - बृहत्
तृतीय पुरस्कार
संरचनात्मक अभियांत्रिकी अनुसंधान केन्द्र


भारत सरकार
राजभाषा विभाग, गृह मंत्रालय
हिंदी गृह पत्रिका पुरस्कार
वर्ष : 2013-14
'ग' क्षेत्र
प्रथम पुरस्कार
'स्पन्दन'
सी.एस.आई.आर., चेन्नै
को प्रदत्त
हिंदी गृह पत्रिका पुरस्कार
प्रथम पुरस्कार

Created

CSIR
TRANSFORMING OUR ENTERPRISE
CSIR CELEBRATING 70 Years
Award For Exemplary Performance
CSIR acknowledges with immense appreciation, the exemplary work and commitment that has been demonstrated by Team **CSIR-Structural Engineering Research Center** in the preparatory realm of population of the data bases and priming the ERP Application with the configuration of data, for the commencement of seamless integrated online operations under the CSIR Transformation & ICT interventions Project.
In recognition of such outstanding work as trail blazing fore-runners in the transformation to an arena of digital collaborative workspace, for the progressive strides they have taken in contributing to the promotion of electronic work culture and to the cause of green growth, **CSIR-SERC** is awarded the **Bronze Icon Award** this day the 25 Sept 2012, on the occasion of the 70th CSIR Foundation Day 2012.
(Dr. G Radhakrishnan)
Project Leader
(Dr. K. Jayakumar)
Joint Secretary & Head IT
(Dr. Nagesh R Iyer)
Chairman PCTB
(Dr. Gangan Prathap)
Director NISCAIR
(Prof. Samir Brahmachari)
Director General

CSIR-Structural Engineering Research Centre
Honoured With
A Thicket of 5 Trees
At Dwarka, Jamnagar,
Gujarat, India
November 12, 2014
By NACE International Gateway India Section
CORCON 2014
Appreciate your support for NACE mission to protect people, assets and the environment from corrosion
NACE INTERNATIONAL GATEWAY INDIA SECTION
GROW-TREES.com
greet with trees · offset with trees
Certificate No.: 367121

सत्यमेव जयते
Department of Scientific and Industrial Research
Ministry of Science and Technology
Government of India
Outstanding Achievement Award
CSIR STRUCTURAL ENGINEERING RESEARCH CENTRE
For their Inspiring Institutional Leadership
Demonstrated in Championing
the Transition to an Electronic Work Culture,
embracing performance driven evidence based operations
& transcending beyond conventional confines
Members of the Champion Team
As an Expression of placement in High Esteem and in recognition of noted Professional Accomplishment,
this Outstanding Achievement Award is Conferred upon
the Champion Team of CSIR SERC on the 71st Foundation Day of CSIR, 26 Sept 2013
One CSIR
OUR NEW ENTERPRISE
Prof Samir K Brahmachari
Secretary

NACE INTERNATIONAL GATEWAY INDIA SECTION
NACE International Gateway India Section
CORROSION AWARENESS AWARD - 2014
for
Excellent Laboratory Award
presented to
CSIR – Structural Engineering Research Centre, Chennai
In recognition of meritorious contribution to the field of Corrosion Science and Technology
Dr. Samir Degan
Chairman, NIGIS
Dr. A J V Prasad
Joint Secretary, Department of Chemicals and Petrochemicals
Ministry of Chemicals and Fertilizers, Govt. of India

Partners *in progress*

International

- BAM — Federal Institute for Materials Research and Testing
- cnrs
- DAAD — Deutscher Akademischer Austauschdienst — German Academic Exchange Service
- UNDP

Industry

- adani
- AFCONS — AFCONS INFRASTRUCTURE LIMITED — A Shapoorji Pallonji Group Company
- ASHOK LEYLAND
- bajaj group
- BGR ENERGY
- CAIRN — Energy for India
- CPCL
- FREYSSINET
- GAMMON — Builders to the Nation
- godrej
- JAYPEE GROUP
- JINDAL STEEL & POWER
- KALINDEE — RAIL NIRMAN (ENGINEERS) LIMITED
- LARSEN & TOUBRO
- LARSEN & TOUBRO LIMITED — Engineering Construction & Contracts Division
- OBEROI THERMIT PVT.LTD. — AN ISO 9001:2008 COMPANY
- Patil Rail Infrastructure Pvt. Ltd — Smarter track Solutions-Safer Mobility
- Rane — Expanding Horizons

RAYBAN METALS

RELIANCE Infrastructure

sesa sterlite
a vedanta company

SHELBA CONSTRUCTIONS

SPML Engineering Life

Synergy Thrislington

TATA STEEL

TVS

RINL VIZAG STEEL Pride of Steel
A Navratna Company

WHEELS INDIA LIMITED
You Name it... We Make it

Government

AERONAUTICS RESEARCH & DEVELOPMENT BOARD AR & D B

Govt. of India
Department of Atomic Energy (DAE)
Board of Research in Nuclear Sciences (BRNS)

CMDA
சென்னைப் பெருநகர் வளர்ச்சிக் குழுமம்
Chennai Metropolitan Development Authority

CPWD

CBRI

CSIR-CENTRAL ELECTROCHEMICAL RESEARCH INSTITUTE

EDS

CLRI Central Leather Research Institute
Council of Scientific and Industrial Research

CSIR-CMERI

CSIR CRRI

CHENNAI METRO RAIL LIMITED

C-WET

DAE

सत्यमेव जयते
Department of Telecommunications
Ministry of Communications & Information Technology
Government of India

Department of Science & Technology
Ministry of Science & Technology

Societal

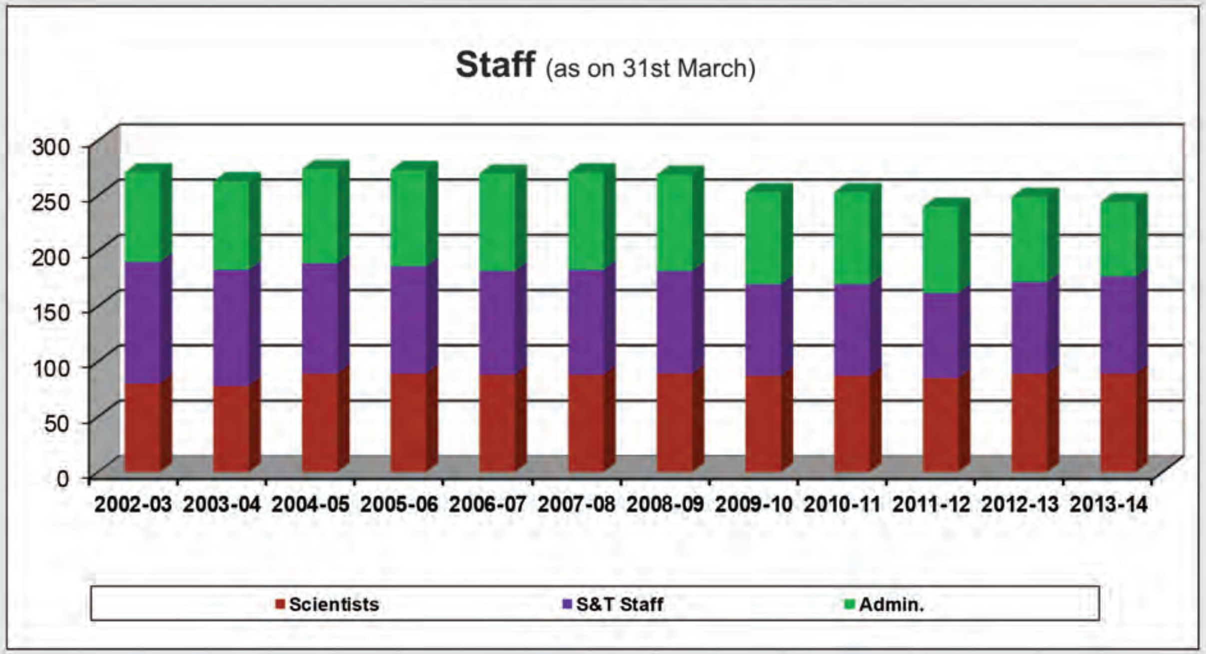
Public Sector

and many more ...

The Performer

PERFORMANCE THAT SPAWNS COMMITMENT ...

The METRICS



Sections	No. of Staff	Average Age
General Cadre	16	46.19
Finance & Accounts	10	41.94
Stores & Purchase	10	47.88
Stenographic	16	50.23
Others	13	50.48
Class IV Non-Tech	2	49.38
Total	67	48.18

Administrative Staff

Sanctioned = 98

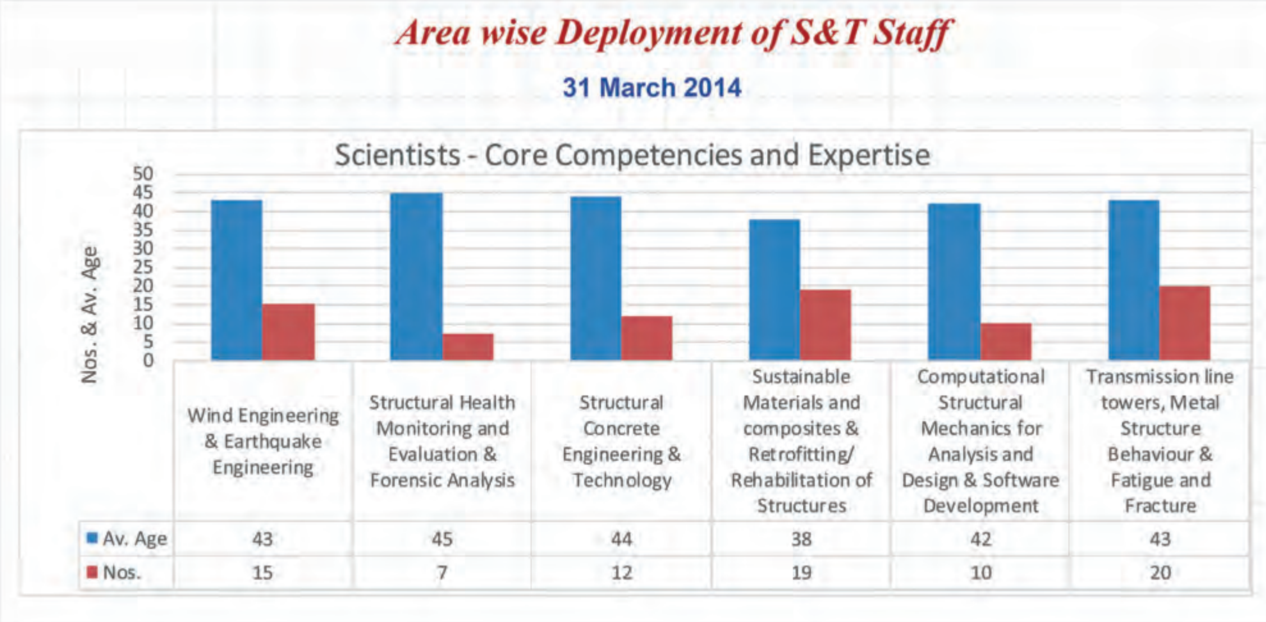
Redeployment = 03

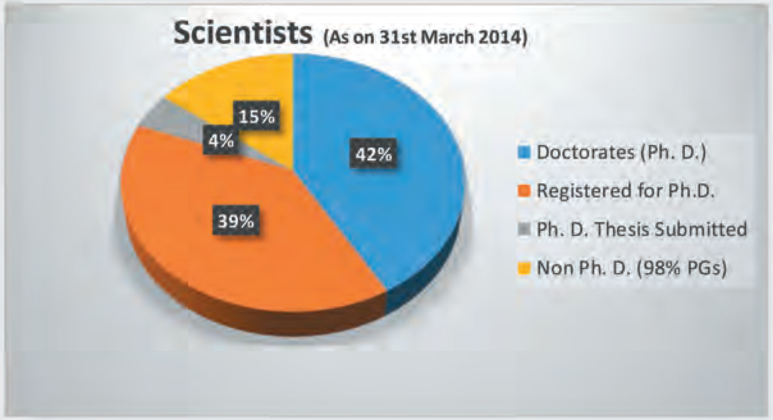
Vacancy = 34

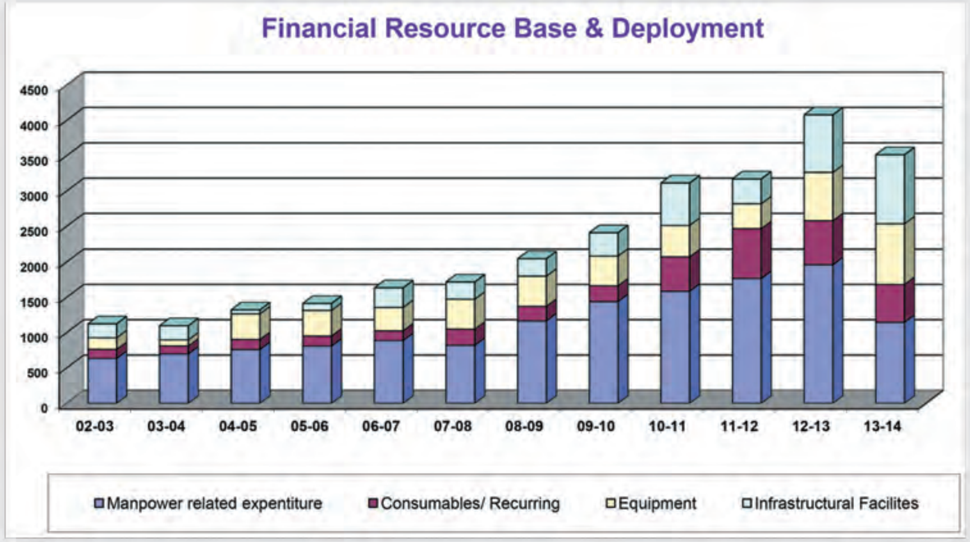
Ave Age = 46.19

(Including Redeployment/ Transfer)

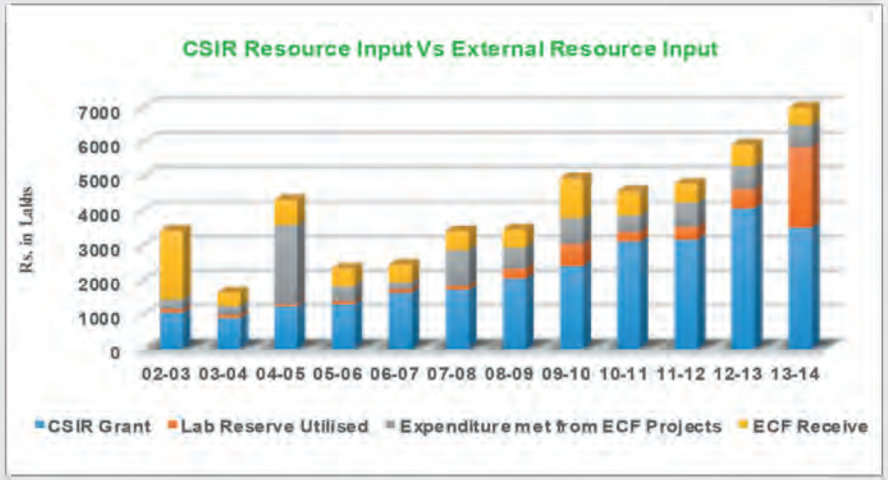
The METRICS

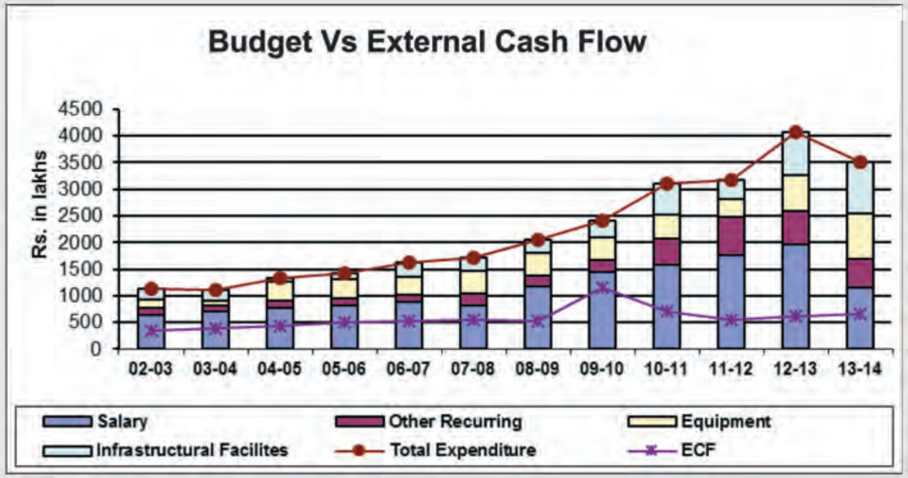

Area wise Deployment of S&T Staff
31 March 2014
Scientists - Core Competencies and Expertise
Nos. & Av. Age
50
45
40
35
30
25
20
15
10
5
0
Wind Engineering & Earthquake Engineering
Structural Health Monitoring and Evaluation & Forensic Analysis
Structural Concrete Engineering & Technology
Sustainable Materials and composites & Retrofitting/ Rehabilitation of Structures
Computational Structural Mechanics for Analysis and Design & Software Development
Transmission line towers, Metal Structure Behaviour & Fatigue and Fracture
Av. Age 43 45 44 38 42 43
Nos. 15 7 12 19 10 20

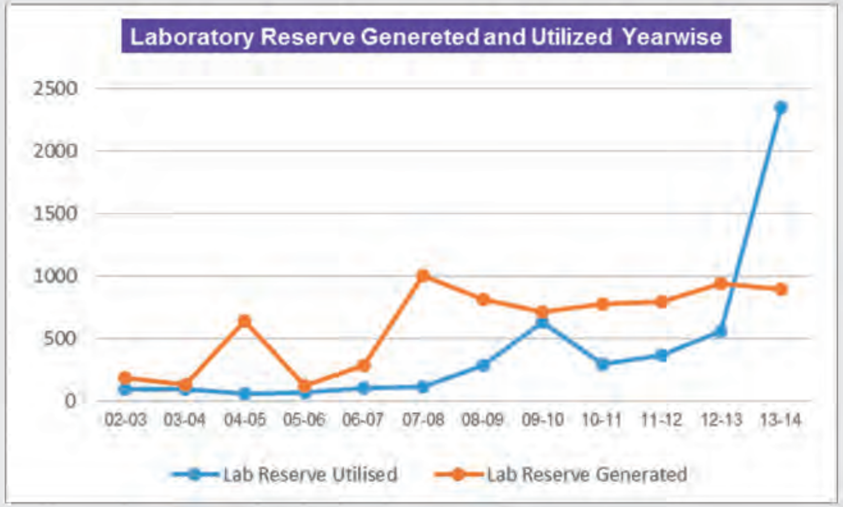

Scientists (As on 31st March 2014)
15%
4%
42%
39%
Doctorates (Ph. D.)
Registered for Ph.D.
Ph. D. Thesis Submitted
Non Ph. D. (98% PGs)

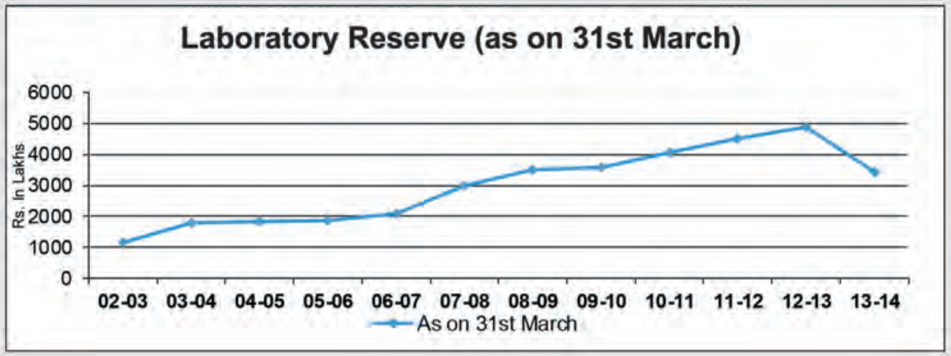

Financial Resource Base & Deployment
4500
4000
3500
3000
2500
2000
1500
1000
500
0
02-03
03-04
04-05
05-06
06-07
07-08
08-09
09-10
10-11
11-12
12-13
13-14
Manpower related expentiture
Consumables/ Recurring
Equipment
Infrastructural Facilites

The METRICS

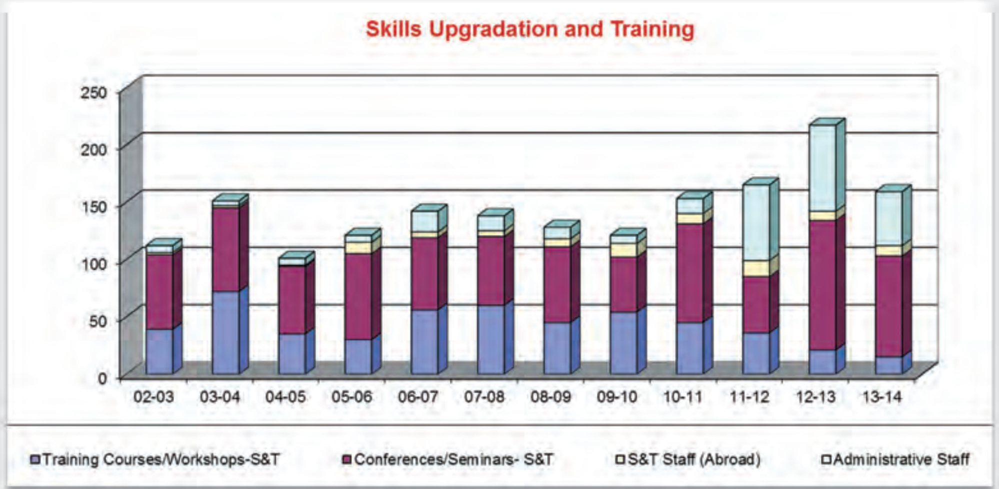

CSIR Resource Input Vs External Resource Input
Rs. in Lakhs
0
1000
2000
3000
4000
5000
6000
7000
02-03 03-04 04-05 05-06 06-07 07-08 08-09 09-10 10-11 11-12 12-13 13-14
CSIR Grant
Lab Reserve Utilised
Expenditure met from ECF Projects
ECF Receive

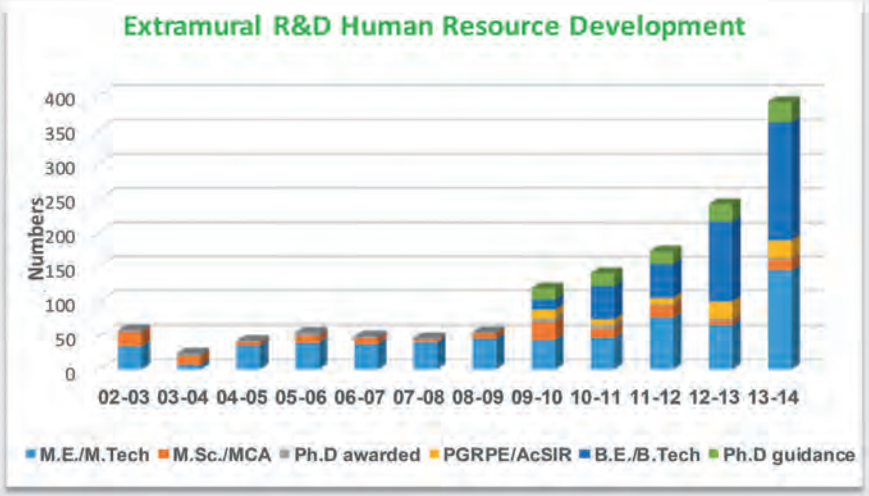

Budget Vs External Cash Flow
Rs. in lakhs
0
500
1000
1500
2000
2500
3000
3500
4000
4500
02-03 03-04 04-05 05-06 06-07 07-08 08-09 09-10 10-11 11-12 12-13 13-14
Salary
Other Recurring
Equipment
Infrastructural Facilites
Total Expenditure
ECF

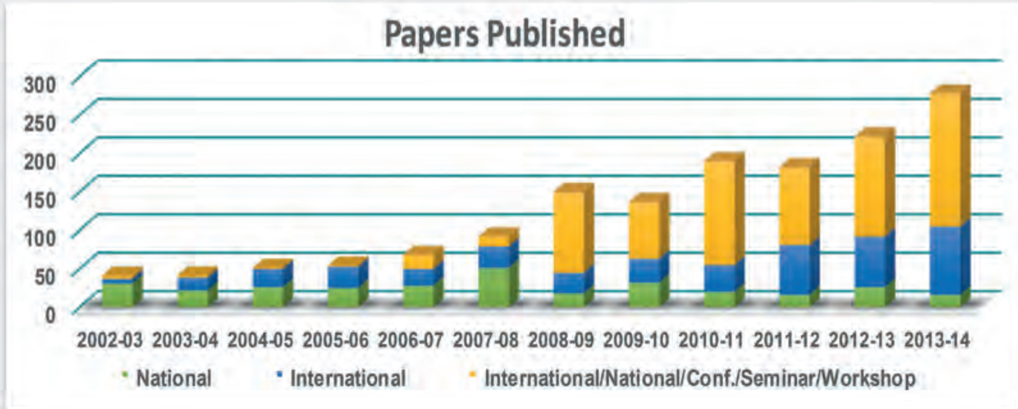

Laboratory Reserve Genereted and Utilized Yearwise
0
500
1000
1500
2000
2500
02-03 03-04 04-05 05-06 06-07 07-08 08-09 09-10 10-11 11-12 12-13 13-14
Lab Reserve Utilised
Lab Reserve Generated

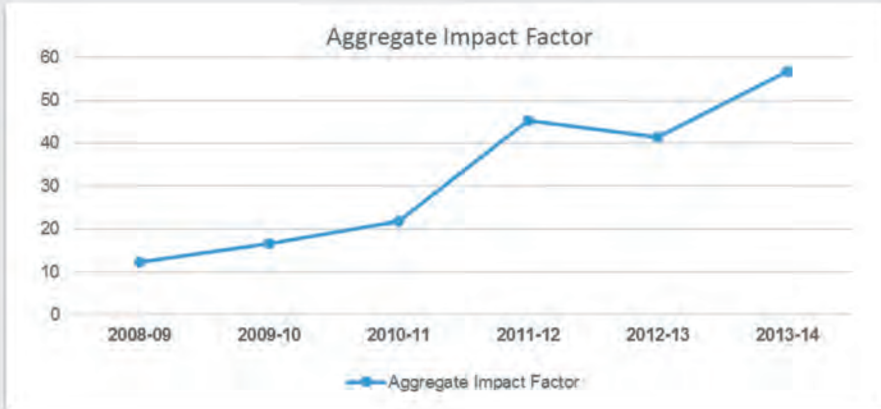

Laboratory Reserve (as on 31st March)
Rs. in Lakhs
0
1000
2000
3000
4000
5000
6000
02-03 03-04 04-05 05-06 06-07 07-08 08-09 09-10 10-11 11-12 12-13 13-14
As on 31st March

The METRICS


Skills Upgradation and Training
Training Courses/Workshops-S&T
Conferences/Seminars- S&T
S&T Staff (Abroad)
Administrative Staff


Extramural R&D Human Resource Development
Numbers
M.E./M.Tech
M.Sc./MCA
Ph.D awarded
PGRPE/AcSIR
B.E./B.Tech
Ph.D guidance


Papers Published
National
International
International/National/Conf./Seminar/Workshop


Aggregate Impact Factor
Aggregate Impact Factor

from a few drops

A TRICKLE THAT STARTED IT ALL ...

ESTABLISHMENT

OF THE STRUCTURAL ENGINEERING RESEARCH CENTRE

AD 1965… the year in history that marked the establishment of SERC to initiate its operations in providing for the very best of expertise in Civil Structural Analysis to benefit this great nation of ours... yes, we were born out of ideals as high as the mountains, to fulfil a great legacy of not just achievements but in becoming the core of expertise from which India as a nation benefits as well.

"In pursuance of the decision of the Board of Scientific and Industrial Research and the Governing Body of the Council of Scientific and Industrial Research taken at their special session held on 14th January 1965, the Structural Engineering Research Centre came into being as an independent National Laboratory on the 10th June 1965, at Roorkee.

The Centre was set up to meet the felt demand for an organization which can make the country self-sufficient in structural engineering skills of a high order in design as well as construction, covering Plain and Reinforced Concrete; Prestressed Concrete; Shell Structures, Folded Plates and Space Frames; Prefabrication; Steel and Light Metal Structures; Bridges; Structural Dynamics; Multistoreyed Structures and Digital Computation. "

Prof. G. S. Ramaswamy
First Director, SERC

...Although the Centre came into being only in June 1965, it is already making very rapid strides to establish itself as one of the major centres of civil engineering research in this country and abroad...

G. Pande
Vice Chancellor, University of Roorkee
and
Chairman
Executive Council
STRUCTURAL ENGINEERING RESEARCH CENTRE

(excerpted from the Foreword to The First Annual Report of SERC, 1965-66)

Organisation of a Regional Centre
of the SERC at Madras (1966)

At the seminar on "Cost Reduction in the Design and Execution of Industrial Buildings" held at Madras in January 1966 under the auspices of the Madras Productivity Council, a resolution requesting the Council of Scientific and Industrial Research to set up a Regional Centre of the SERC at Madras was adopted. As a first step in implementing the proposal, the Director set up a Cell of the SERC in the premises of the College of Engineering, Guindy in August 1966.

The Executive Council, at its 3rd meeting held on 30th August 1966, strongly recommended that the Extension Cell be elevated to a full-fledged Regional Centre as early as possible. The Governing Body of the CSIR, at its meeting held in November 1966, approved of this proposal in principle.

Prominent engineers, architects and contractors of Madras have come forward to raise one lakh of rupees as their contribution to this project. The proposal, as it emerged as a result of these discussions and consultations, envisages the setting up of a Regional Centre of the SERC at Madras as part of the composite campus of the CSIR housing the regional units of various national laboratories, in about 60 acres of land adjacent (on the south) to IIT Madras.

The Regional Centre started functioning from the CSIR Campus early 1969. The buildings of the Regional Centre have been designed and built with a dual purpose in view. They have been so planned that, apart from housing the laboratories, they serve as demonstration structures incorporating the findings of research carried out at the Structural Engineering Research Centre. The object is to motivate engineers and architects visiting the Centre to use these new techniques in their works. The Concrete Laboratory, which has been completed and occupied, is roofed over by precise funicular shell units which form a waffle-shell system. The waffle shell system is superior to the waffle slab in that it is much stiffer; and hence, it is suitable for carrying heavy loading.

Structural Testing Laboratory (STL)

The buildings on the Campus have been designed keeping in mind the dictum of the famous engineer-architect Nervi that an aesthetically-acceptable solution will always result if the structural form has been logically chosen to meet all functional requirements. Such structures according to Nervi will need no external embellishments. It is our hope that the buildings on the Campus represent structural engineering research in action. These buildings are an effort to carry the results of research to the doorstep of the engineer and the architect and, this project will succeed as a pace setter only if the techniques demonstrated find wide practical application.

Concrete Testing Laboratory (CTL)

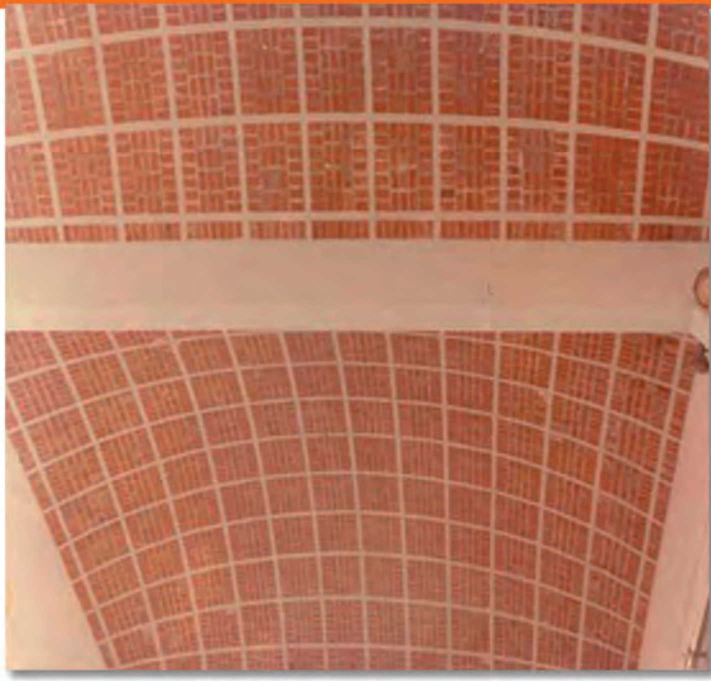
HTL / STL & CTL front view alongside hexagonal braced dome

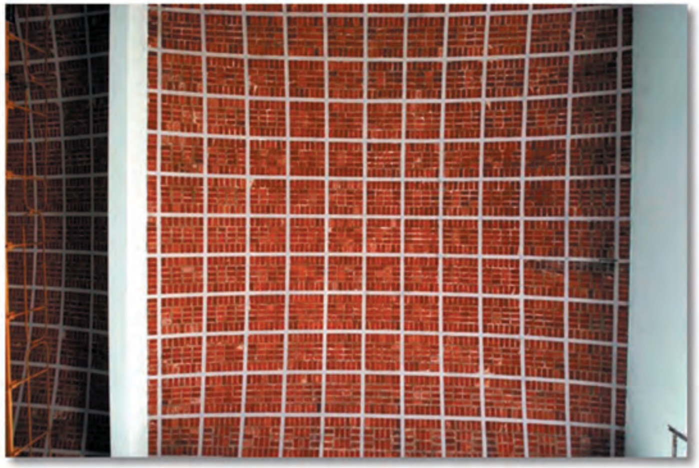
Structural Testing Laboratory (STL) / Heavy Testing Laboratory (HTL)

The Heavy Testing Laboratory, now called the Structural Testing Laboratory (STL) has been completed in 1970. The heavy-duty floor size is 30m x 8.8m and each anchor point is capable of carrying a vertical load of 40 tonnes. The floor is designed as a twin box with wall and slabs 50cm thick. The loading plant installed on the floor can apply a static load of 480 tonnes and a dynamic load of 240 tonnes.

In the brick shell roofs built over the Heavy Testing Laboratory then and, now called Structural Testing Laboratory, the funicular principle has been pushed to its logical limit. As these shells carry loads by pure compressions, bricks can be used instead of concrete. Each of the three shells roofing the Laboratory and measuring 12.6m x 12m is built of brick approximately 11cm thick. These shells do not need any reinforcement to carry loads. However, nominal reinforcement is provided to take care of shrinkage and temperature stresses. It is concentrated in small concrete ribs, at 1-metre intervals, to prevent possible corrosion. Such shell roofs had been built earlier at the National Institute of Design, Ahmedabad. They offer an economical and attractive means of providing large column-free areas especially for factories. The laboratory is equipped with an E.O.T. crane to handle heavy structural components. The heavy duty floor is designed as a twin hollow box. These facilities are adequate to test full-scale bridge or building components to destruction. The heavy-duty floor is reinforced with deformed grip bars developed by the SERC and then commercially produced by the Tata Iron and Steel Company (TISCO) which made a generous gift of 50 tonnes of this steel for use on this work.

The Concrete Testing Laboratory (CTL) building that is roofed over by a special precast unit known as the funicular shell, developed at the CSIR-SERC. This technique had found extensive application on a number of projects. In Chennai itself, such units had been employed earlier at the Port Trust to build transit shed floors to carry heavy industrial loading of over 2000kg/m^2. The shape of the shell has been so chosen that it develops a state of pure compression; hence little or no reinforcement need be provided in the body of the shell. The Waffle-shell system employed for the roof and floors of the concrete testing laboratory is an improvement over the Waffle-slab construction widely used in the USA for carrying office and warehouse loadings. It is far more stiff because of the use of shells in place of slabs. Structural design for this 8-metre span, three-storeyed building was done by the ultimate load method in the late 60s & early 70s and, high-strength deformed bars were used wherever possible. This resulted in large quantities of steel being saved. The building - including columns, lintels, and foundations - consumed only 14.15kg/m^2 of mild steel and 28.7kg/m^2 of deformed bars. The use of these shells on the campus buildings has led to their large-scale adoption for slum clearance projects by the Government of Tamil Nadu, and for the residential quarters at the Bharat Heavy Electricals Ltd., Tiruchirapalli.



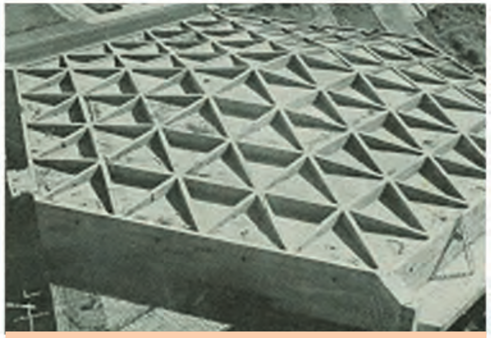


Funicular Shell Roof

BRACED DOMES

Since the early 1970's, there has been a great demand for light portable shelters that are easily assembled out of factory made units which necessarily have to be of as few types as possible. Such portable shelters may serve as mobile canteens and hospitals in forward areas and in remote locations. These can also be used as enclosures for exhibition halls and circus arenas and, can be air-dropped if necessary. The sphere is the most economical means for covering large areas. However, since the sphere cannot be prefabricated, we have to think of a structural scheme with the icosahedron the largest of the group of platonic polyhedra as a starting point. The icosahedron has 20 faces made up of members which are equal and is, therefore, ideally amenable for prefabrication. However, when large domes have to be built, the size of the members tends to be too long. To prevent buckling, large members will have to be used which will make the structure uneconomical. This problem has been solved by the celebrated American designer, Fűller, by sub-dividing the icosahedrons. CSIR-SERC, evolving different scheme of sub-division has found a substitute for the Fűller dome. A 12.2m-diameter dome employing this scheme was built out of light aluminium alloy tubes at the Indian International Trade and Industries Fair held at Chennai in 1968. This scheme has been patented by CSIR-SERC. The dome which served as the focal point of the CSIR cluster of pavilions attracted a large number of visitors. This dome weighs only 575kg., which works out to a consumption of 1lb, of aluminium per sq.ft. of area covered. The dome can be air-dropped using a helicopter. The CSIR-SERC developed computer programmes by which braced domes of diameters up to 60 metres (200ft.) can be generated and work out the stresses induced in such domes by different loads applied to them. The dome which is made of aluminum tubes, is clad with triangular funicular units made of polyester reinforced with fibre glass. The dome which has been patented was developed as an indigenous substitute for the well-known Fűller's Geodesic Dome. The point of departure in both cases are the icosahedrons. But the scheme of subdivision developed at the CSIR-SERC for subdividing the icosahedrons is basically different from that of Fűller.

The main building of the Campus has incorporated partially prestressed concrete beams produced at the casting yard

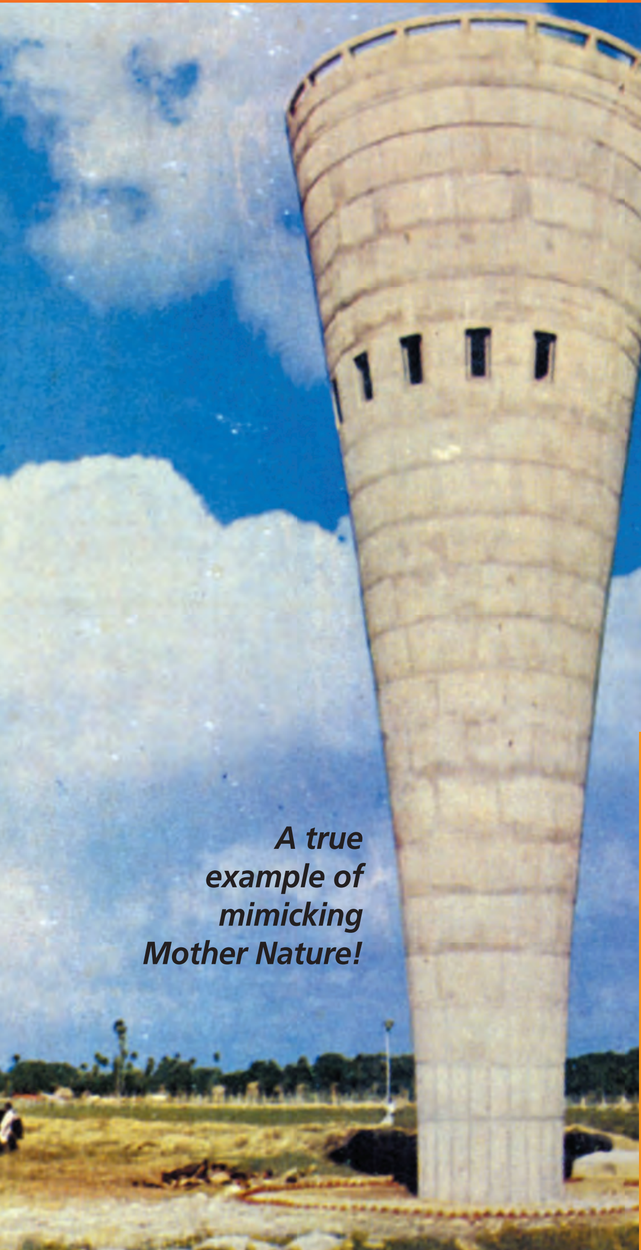


Central Complex Auditorium, Bhabha Atomic Research Centre, Trombay, Bombay - Structural Design by CSIR-SERC.

Braced dome of aluminium with glass fibre reinforced polyester cladding unit at the Indian International Trade and Industries Fair Madras, 1968 - Structural Deisgn by CSIR-SERC.

The hemispherical braced dome of 21.2m diameter is patented by CSIR-SERC. The structural frame made up of light aluminum tubes weighs just 576kg. The cladding is made of glass-fibre reinforced polyester panels moulded into funicular shells.

THE SHELL
Structures



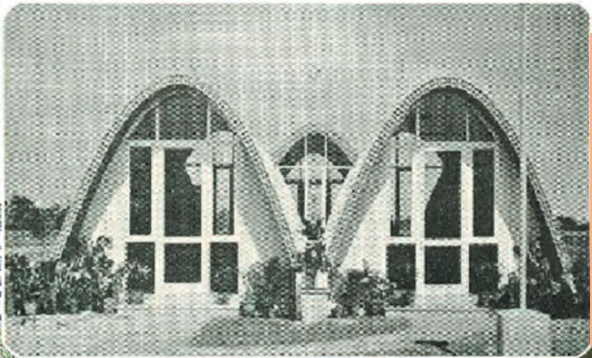
A true example of mimicking Mother Nature!

The next thing, needless to say, is the pride passion of CSIR-SERC - the "shell structures". Though a complex form and geometry with multiple challenges, CSIR-SERC has provided novel, unique, simple yet powerful wholesome solutions! Perhaps the focal point of the campus is the **mushroom-shaped water tank of 140000-litre capacity**, designed as a hyperboloid of revolution, it gives the illusion of growing out of the ground as it were, with no support! Rising to 21m above ground level, it has already become a well-known landmark in the area.

Hyperboloid 8m dia at base 2m at top resting on 6 precast V-shaped equally spaced columns on a circle of 9.6m dia Structural Skeleton-32mm dia GI pipes, taking advantage of the doubly-ruled characteristic of surface. Nominal reinforcement - 6mm bars at 30cm centres one layer mesh tied to pipes to form surface of the shell cast worked out in 1972-73 at ₹110/- per sq.m.

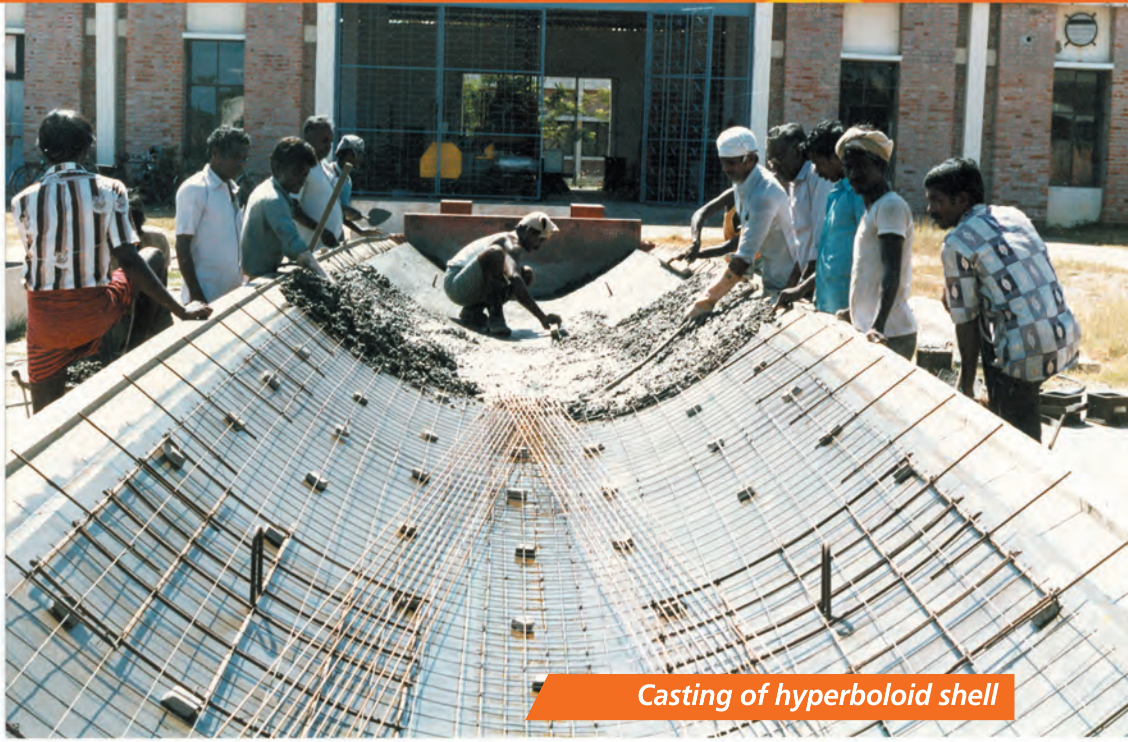
The world's first scaled micro-concrete containment vessel model

The pagoda structure



An experimental shell-type building inaugurated by Hon'ble Sri C. Subramaniam, Minister for Industrial Development and Science & Technology

The stores building is roofed over by precise prestressed hyperboloids. Another economical structural form employed in the construction of the campus is the prestressed hyperboloid shell unit used to roof the stores building. The hyperboloid of revolution of one sheet has the interesting property of being entirely made up of straight lines called rulings. Taking advantage of this property, a segment of a hyperboloid, only 6cm thick, was pre-tensioned along its rulings. The shells were picked up by a simple derrick and placed on two masonry walls with saddles for seating them to form a roof of 14m span. The transverse curvature of the units facilitates easy drainage. The steel consumed by this form of roofing amounted to only 1.65 kg/m^2 of pre-stressing steel and 3.6 kg/m^2 of mild steel. Where adequate number of repetitions is involved, this system of roofing will prove very economical. Where good day-lighting is desired, north-light arrangements are possible. The shell units may be suitably tilted and glazing provided between them. As a result of the promotional work carried out by the CSIR-SERC, this new form of shell has already been used in Chennai to roof a footwear factory.


Casting of hyperboloid shell


Hyperboloid shell roof of the stores building

The tower crane and pretensioning bed installed in 1969 were used to produce the precast prestressed hyperboloid shell units for roofing the stores unit. Outdoor pretensioned bed of about 61m (200 feet)

Gathering strength

Momentum that results in fullness...

Consolidating ourselves ...

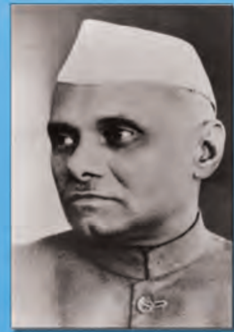
Much like evolving from a few drops to a voluminous river, we were to grow from strength to strength, gaining from the pool of great minds and tireless human spirit. This would enable us to gather ourselves into a unified force that will stand the test of time for several years to come.

CSIR

Dr. S.S. BHATNAGAR
Director
1942 - 1954

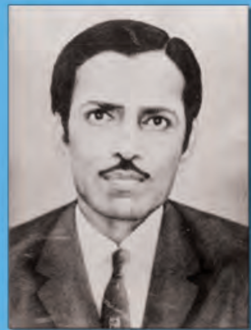
Prof. M.S. THACKER
Director-General
3.8.1955 - 1.8.1962

Dr. S. HUSAIN ZAHEER
Director-General
1.9.1962 - 21.8.1966



Dr. ATMA RAM
Director-General
22.8.1966 - 21.8.1971

Dr. Y. NAYUDAMMA
Director-General, 27.8.1971 - 27.7.1977



Dr. A. RAMACHANDRAN
Director-General, 27.7.1977 - 9.10.1978

Prof. M.G.K. MENON
Director-General, 9.10.1978 - 4.5.1981

Dr. G.S. SIDHU
Director-General
5.5.1981 - 4.5.1984

Dr. S. VARDARAJAN
Director-General
22.6.1984 - 27.1.1986

Dr. G. THYAGARAJAN
Officiated for 7 days in
1986

Prof. P .K. JENA
Officiated for 7 days in
1986

THE ILLUSTRIOUS DIRECTORS-GENERAL OF CSIR

Dr. A.P. MITRA
Director-General,
26.2.1986 - 16.4.1991

Prof. S.K. JOSHI
Director-General
18.4.1991 - 30.6.1995

Dr. R.A. MASHELKAR
Director-General
1.7.1995 - 31.12.2006

Dr. V. PRAKASH
Director-General Designate Dec '06

Prof. S.R. MEHRA
(Officiated during deputation abroad of DG.)

Dr. MAHARAJ KISHAN BHAN
Secretary DBT (Addl. Charge)
05.01.2007 - 06.03.2007

Dr.T.RAMASAMI
Additional Charge, 07.03.2007 - 11.11.2007 &
01.01.2014 - 30.4.2014

Prof. SAMIR K. BRAHMACHARI
Director-General
12.11.2007 - 31.12.2013

Dr. P.S. AHUJA
Officiating 1.4.2014 till date

Our Visionary Leaders

G.S. Ramaswamy

M. Ramaiah

N.V. Raman

T.V.S.R. Appa Rao

N. Lakshmanan

Nagesh R. Iyer

we owe it to our
RESEARCH COUNCILS

The broad R&D policy guidelines and overall directions for charting the growth and evolution of SERC have been outlined and meticulously overseen over the years since its inception by eminent scientists, engineers and academicians in the field of civil and structural engineering in India who advised in their capacity as Chairmen of Executive Council / Research Advisory Council / Research Council of SERC. This list, reading like the who's-who of the leading luminaries, includes Shri G Pande, Vice-Chancellor, University of Roorkee, Prof. M.S. Thacker, Member, Planning Commission, Dr. T.N. Subba Rao, Managing Director, Gammon India Ltd., Prof. K.T.S. Iyengar, Professor of Civil Engineering, Indian Institute of Science, Dr. O.P. Jain, Professor & Chairman, Civil Engineering, University of Roorkee, Prof. V.N. Gupchup, Pro Vice-Chancellor, University of Bombay, and Principal & Secretary (Retd.), VJT Institute, Mumbai and Prof. N.Rajagopalan, Consultant, L & T Ramboll and formerly Dean & Professor of Civil Engineering Department, IIT-M.

Shaheed Bhagat Singh, RAJ GURU & SUKH DEV Memorial (1965-66)

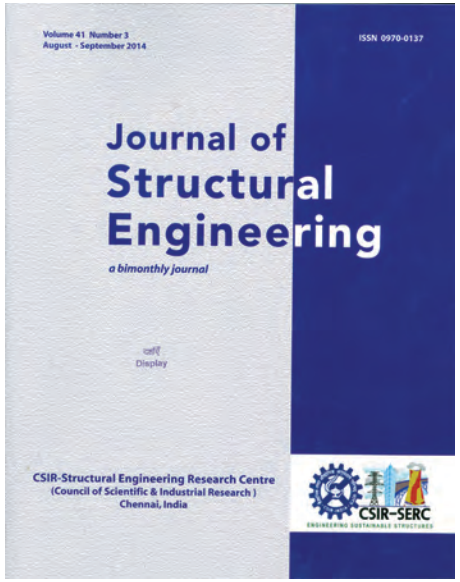
The Centre undertook the analysis and design of the Shaheed Bhagat Singh, Raj Guru and Sukh Dev Memorial at the urgent request of the Punjab P.W.D. The monument, as visualized by the architect, is a free-form shell supported on three legs symbolically representing the Three Martyrs. The shell covers an area of nearly 232m^2. The thickness of the monument is restricted to 10cm at the edges and no sharp lines are permitted; thus a ribbed structure is ruled out. Rough longitudinal and cross sections were supplied to define the underside of the shell which had to be corrected by trial and error to obtain a smooth surface.

The monument has been designed using a numerical technique programmed on the IBM 1620 computer available at the Centre in 1965. A 1/10 scale model has been constructed in microconcrete with wire reinforcement. This project is a typical example of the utilization of theoretical analysis with the help of high speed computer and experimental analysis, to arrive at an efficient design of a free-form structure in a short time span.

journal of STRUCTURAL ENGINEERING (JoSE)

The need for a journal in India, devoted exclusively to activities in the field of structural engineering with special emphasis on research and development had been felt since long. To meet this demand and to provide a medium for structural engineers in India and abroad and to document, discuss and debate current trends in design, research, and development relating to all areas of structural engineering, SERC decided to undertake the publication of a quarterly journal titled **Journal of Structural Engineering** (JoSE). The first publication came out in April 1973.

From 1993 onwards, the first issue in each volume has been dedicated to a special topic of current R&D interest. From the year 2005 onwards, the JoSE has been converted into a bi-monthly journal to meet the enhanced responses received from prospective authors, national and global alike. Today, with over four decades of existence, current and futuristic trends are portrayed in the articles.



prestressed
CONCRETE REACTOR CONTAINMENT
(1970-74)

Work was started at the Regional Centre to conduct a 1/12-scaled structural model test of the containment vessel proposed to be built at Kalpakkam, Madras. This project was sponsored by the Power Projects Engineering Division of the Department of Atomic Energy. This model study was intended to predict the response of the prototype structure under prestressing forces and pressure load.

The Centre successfully carried out the test on the 1/12-scale micro-concrete model of the prestressed concrete secondary containment pressure vessel. This model has six openings in its perimeter wall to represent the six major openings of the MAPP containment. The 12/8mm Freyssinet cables of the prototype are represented in the model by 4mm diameter high tensile wires for the purpose of circumferential and vertical prestressing of the perimeter wall, and by 2mm diameter high tensile wires for prestressing the dome. A total of about 580 wires had to be prestressed in the model.

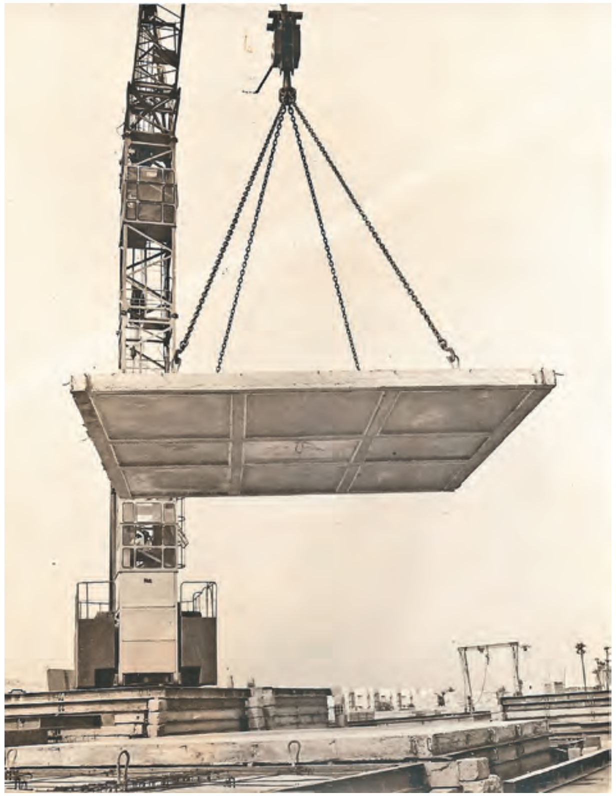
The 1/12-size model of the containment was instrumented with 191 electrical resistance strain gauges for measurement of strains on the inside and outside surfaces. All the gauges were connected to a 500-channel digital data-logging system for measurement and recording of strains by automatic scanning. In addition to the electrical strain gauges, pellets were pasted on the outside surface for mechanical measurement of strains with Pfender gauges. Dial gauges and Bourdon-type pressure gauges and, thermometers were employed for measurement of deflections, internal pressure, and temperatures, respectively. The perimeter wall of the model was prestressed with 133 vertical and 198 hoop prestressing wires (4mm dia), while the dome was prestressed using three layers of 2mm diameter wires with 84 wires in each layer. Prestressing was done in stages similar to those planned for the prototype. A detailed report on the model test was prepared and submitted to the Department of Atomic Energy, which sponsored the test. The report contains the analysis of the test results and predictions of the behaviour of the prototype containment.

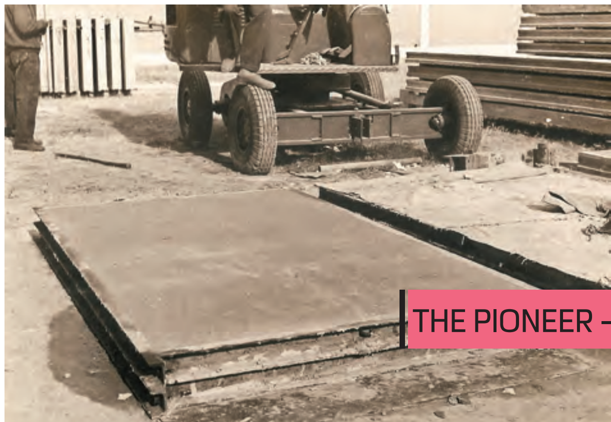
The test was one of the most complex ever organized by the Structural Engineering Research Centre calling for concerted action and team work on the part of SERC and the Department of Atomic Energy.


500 CHANNE
DATA LOGGIN

large panel
ON-SITE PREFABRICATION
(1972-76)

Working in close collaboration with the Tamil Nadu Housing Board, SERC developed a prefabrication system involving the use of storey-sized wall panels made up of hollow clay blocks set in concrete and room-sized funicular shell waffle panels which consume very little steel. The aim of the project was to develop indigenous skills and techniques of on-site pre-fabricated construction of residential buildings, using locally-available materials. With financial support from the National Buildings Organization, the Tamil Nadu Housing Board started this pace-setting project of building 144 flats employing full-fledged prefabrication.





The project has generated considerable interest in many construction agencies and public sector undertakings. One hundred and forty-four flats, in 6 blocks of 24 flats each, have been constructed by the TNHB. A 35mm black and white documentary movie was produced for the benefit of technical personnel engaged in construction, policy makers and construction agencies dealing with housing.

SOFTWARE PACKAGES FOR STRUCTURAL ANALYSIS, DESIGN & DRAFTING

CSIR-SERC, Madras, offers several general-purpose software packages for analysis and design of structures. The packages developed over the years are available for ready use, under license agreement.

INFRAN (INteractive FRame ANalysis):
This software package allows the users to interactively analyse two dimensional rigid jointed plane frame systems under different static load conditions. This performs analysis for nodal forces and moments in addition to member loads in the form of concentrated, uniformly distributed and trapezoidal load condition. Interactive sessions are possible to change member properties or coordinates of the nodes.

INTRAN (INteractive TRuss ANalysis):
This software package allows the users to interactively analyse two and three-dimensional pin-jointed truss system for static nodal load condition. Interactive sessions are possible to change boundary condition, connectivity, member properties and coordinates of the nodes.

INGRID (INteractive GRID analysis):
This software package allows the user to interactively analyse rigid jointed grid systems subjected to lateral loads. Interactive sessions are possible to change connectivity, member properties and coordinates of the nodes.

INSPACE (INteractive SPACE frame analysis):
This Software package allows the users to interactively analyse three-dimensional rigid-jointed space frame systems under static load condition. It performs analysis for nodal forces and moments in addition to member loads in the form of concentrated, uniformly distributed and trapezoidal load conditions. Interactive sessions are possible to change boundary conditions, connectivity, member properties and coordinates of the nodes.

INCYSHELL (INteractive CYlindrical SHELL analysis):
This software package has the capability to analyse circular shell

roofs (barrel shells) with or without edge beams for given uniformly distributed loads. It is based on the classical procedure developed by Gibson. Single shell with edge beams which may be prestressed or a feather-edge shell can be analysed with this program and the stress resultants at the chosen longitudinal and transverse sections may be obtained.

INFOLD (INteractive FOLDed plate analysis):
This software package permits the user to interactively analyse simply supported folded plate structures under uniformly distributed load, line loads and moments. Finite strip method is used in modelling and analysing the folded plate structure.

RC SLABS (G) (Reinforced Concrete SLABS design):
This software package allows the users to interactively design RC slabs with different boundary conditions. The design by limit state approach follows the provisions of IS:456-1978. In addition to the design, this generates the reinforcement details on the screen which can be plotted on plotter/dot matrix printer. Interactive session is available to change the design variables.

RC SLABS:
This is a non-graphics version of RC SLABS (G). All features of RC SLABS (G) are available in this except the graphics display and drafting.

RC FLAT SLABS (G) (Reinforced Concrete FLAT SLABS design):
The programme package allows the user to interactively design RC flat slabs. The design follows the provisions of IS:456-1978. In addition to the design, this generates the reinforcement details on the screen which can be plotted on a plotter / dot matrix printer.

RC FLAT SLABS:
This is a nongraphics version of RC FLAT SLABS (G) and does not feature graphics display and drafting.

RC BEAMS (G) (Reinforced Concrete BEAMS design):
This software package allows the users to interactively design reinforced concrete beams of rectangular, T and L shapes. The design by limit state approach follows the provisions of IS:456-1978. In addition to the design, this generates the reinforcement details which can be displayed on the screen and subsequently plotted. Interactive session is available to change the design variables.

RC BEAMS:
This is a nongraphics version of RC BEAMS (G) without the graphics display and drafting capability.

RC COLUMNS (G) (Reinforced Concrete COLUMNS design):
This software package allows the users to interactively design

reinforced columns. The design follows the provision of IS:456-1978. Design can be carried out for columns of square and rectangular sections with axial load and uniaxial or biaxial moments. In addition to the design, this generates the reinforcement details on the screen which can be plotted on a plotter/dot matrix printer. Interactive session is available to change the design variables.

RC FOOTINGS (G) (Reinforced Concrete FOOTINGS design):

This software package allows the users to interactively design RC Isolated Footings. The design by limit state approach follows the provision of IS:456-1978. In addition to the design, this generates the reinforcement details on the screen which can be plotted on a plotter/ dot matrix printer.

RC FOOTINGS:

This is a non graphics version of RC FOOTINGS (G) and does not feature graphics display and drafting.

RC COMBINED FOOTINGS (G) (Reinforced Concrete COMBINED FOOTINGS design):

This software package allows the users to interactively design RC combined footings. The design follows the provisions of IS:456-1978. In addition to design, this generates the reinforcement details on the screen which can be plotted on a plotter/dot matrix printer.

RC COMBINED FOOTINGS:

This is a nongraphics version of RC COMBINED FOOTINGS (G) and does not feature graphics display and drafting.

RC STRIP FOOTINGS (Reinforced Concrete STRIP/ Continuous Footings design):

This software package allows the users to interactively design RC Strip footing. Both axial load and uniaxial / biaxial column moments can be considered for analysis. The design follows the provisions of IS:456-1978.

WINFRAN (WINdows based FRame Analysis system):

This package helps the user to interactively generate the geometry of two dimensional rigid jointed plane frame systems and carry out their analysis under different load conditions. This has been developed in C/C++ and the graphics is supported by MS WINDOWS. The package is leased as load module and can be installed in IBM PC AT 386 and more advanced Intel-based systems, with EGA/VGA/SVGA monitor and mouse.

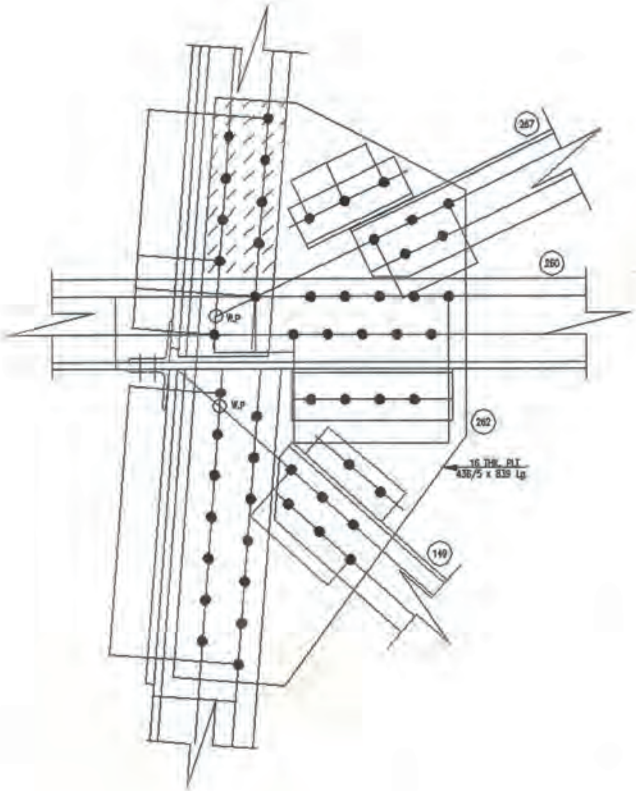
RC INTZE TANK (Design of RC Intze Water Tank):

This package helps the user to interactively design RC Intze type water tanks. The design follows the provisions of relevant I.S. codes of practice for concrete structures for storage of liquids.

In addition to the design, the program generates the reinforcement details which can be viewed on the screen or can be plotted on a plotter / dot matrix printer.

INDROOS (Analysis of INDustrial ROOf Systems):

This package helps the user to interactively analyse industrial trussed roof systems. The following roof trusses are available in the program library: King Post, Howe, Pratt, Fan, North light and Fink. The analysis is menu driven with extensive graphic support.



– NATIONAL HERALD –

Ships to be designed by computer

NEW DELHI, April 7 (PTI). —Indian shipyards will now be able to design ships with the help of computer.

A software package for computer aided analysis and design of ships and ship structures (CODES) has for the first time been developed under a joint project of Hindustan Shipyards Limited (HSL) and the Structural Engineering Research Centre (SERC) in Madras.

CODES can be used to design bulk carriers and container or container-oriented cargo vessels. Its application in ship design will save time and cost of ship building.

According to Dr S Varadarajan, chief of the Council of Scientific and Industrial Research, "this is the first indigenous effort in computerisation of ship design."

He hoped that it would contribute to the modernisation of ship design in the country and enhance design capabilities.

SERC director Dr M Ramaiah said the CODES system consisted of two packages, one dealing with the naval architectural design of ships and the other with the analysis and design of hull structures.

The software system has been tested and implemented on the prime-750 computer system at SERC. It can be with IBM-370 and computer

– THE HINDU –

Computer aided ship design and analysis package

CODES (COmputer-aided analysis and DEsign of Ships and ship structures) is an integrated software system for analysis and design of bulk carriers, containers, or container-oriented cargo vessels. The software package is the result of a project undertaken by the Structural Engineering Research Centre (SERC), Madras, of the Council of Scientific and Industrial Research (CSIR) sponsored by and in collaboration with Hindustan Shipyard Ltd., Visakhapatnam. The project was fully financed by HSL.

The software system is intended to serve the long-felt need of HSL and other shipyards in the country to computerise their design activities for saving time and for achieving economy. HSL has taken the initiative to make a beginning in this direction. The CODES system consists of two packages:

—ship design package consisting of nine basic programmes dealing with naval architectural design, developed by HSL, and

—structural design package consisting of nine programmes dealing with analysis and design of ship hull structures, developed by SERC.

The ship design package and a few programmes of the ship structural design package will find application in the first stage of ship design normally called the conceptual (preliminary) or project design stage.

The maximum utility of both packages will be in the second stage of design during which the classification drawings are prepared. Before commencement of detailed drawings in the third stage of design, the programmes of both the packages can be used effectively in the finalisation, to some extent, of basic design of the ship and some of the major structural classification drawings such as midship section, shell expansion, and longitudinal sections.

Computers to design ships

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SERC director Dr. M Ramaiah said the CODES system consisted of two packages, one dealing with the naval architectural design of ships and the other with the analysis and design of hull structures.

The software system has been tested and implemented on the Prime-750 computer system at SERC. It can be also used with IBM-370 and other comparable computer systems, he said.

– TRIBUNE –

New system developed for ship design

From our Madras bureau

The Structural Engineering Research Centre, Madras, has successfully developed an integrated software system "codes" for computer-aided analysis and design of ships and ship structures. This first indigenous effort in the computerisation of ship design was sponsored and financed by the Hindustan Shipyard Ltd., Visakhapatnam.

The software system is intended to serve the long-felt need of HSL and other shipyards in the country to computerise their design activities for saving time and for achieving economy. Mr S Varadarajan, Director-General, CSIR and Secretary, Department of Science and Technology, has hailed the achievement and expressed the hope that it would contribute to the modernisation of ship design in the country.

The codes system consists of two packages Ship design package consisting of nine basic programmes dealing with naval architectural design, developed by the HSL, and structural design package consisting of nine programmes dealing with analysis and design of ship hull structures

– NEWSTIME –

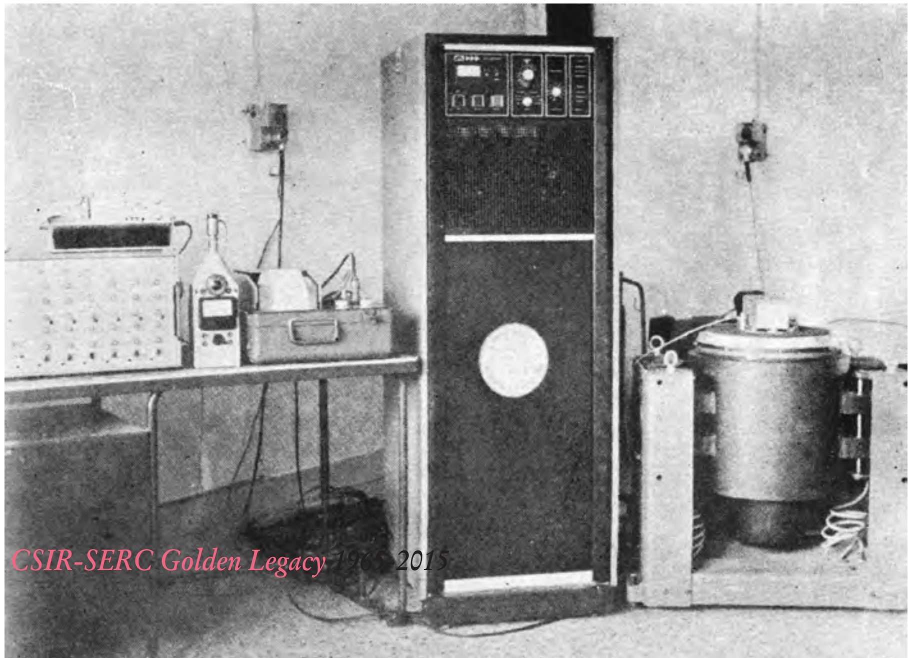
Projects at Madras Centre get UNDP SUPPORT (1972-76)

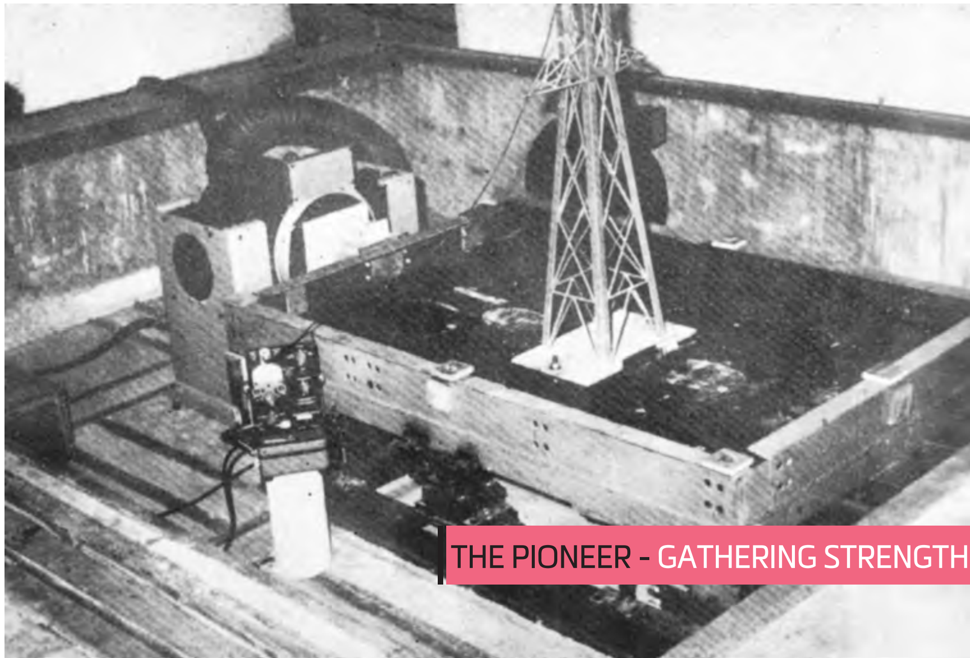
Most of the projects in progress at the Madras Centre have received assistance from the **United Nations Development Programme (UNDP)** in the form of experts, consultants, equipment, and fellowships for training of staff in advanced countries of the world. The projects covered under the programme include prefabrication and industrialized building, structural dynamics and machine foundations, steel and light metal structures, digital computation, nuclear structural engineering, polymer concrete, and the installation of facilities for testing of transmission line towers.

Structural Dynamics Laboratory (1976-77)

The aim of the project is to build up adequate facilities and expertise in the country for the rational analysis of complex machine foundations and other dynamically-loaded structures, leading to economy in their construction.

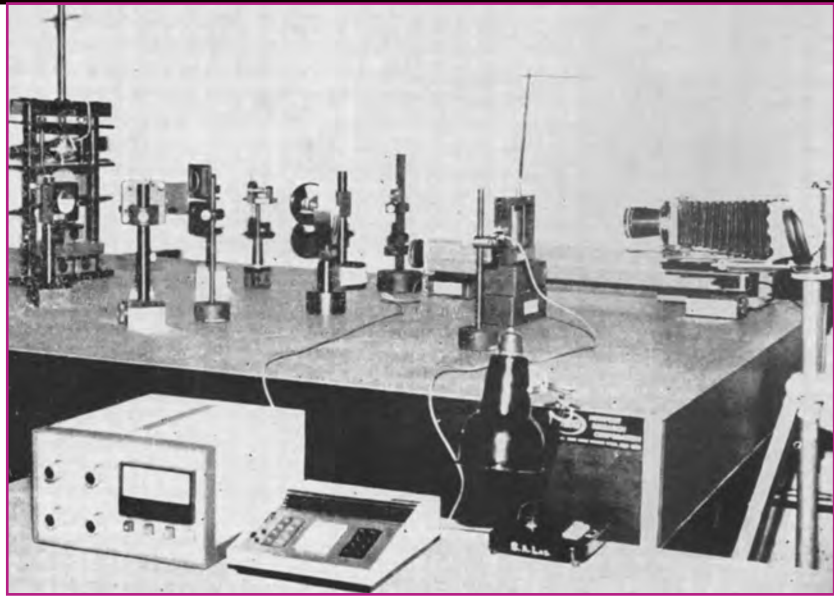
A structural dynamics laboratory capable of undertaking dynamic tests on large models was constructed and some of the major equipment needed for this laboratory had been received as part of the UNDP assistance.



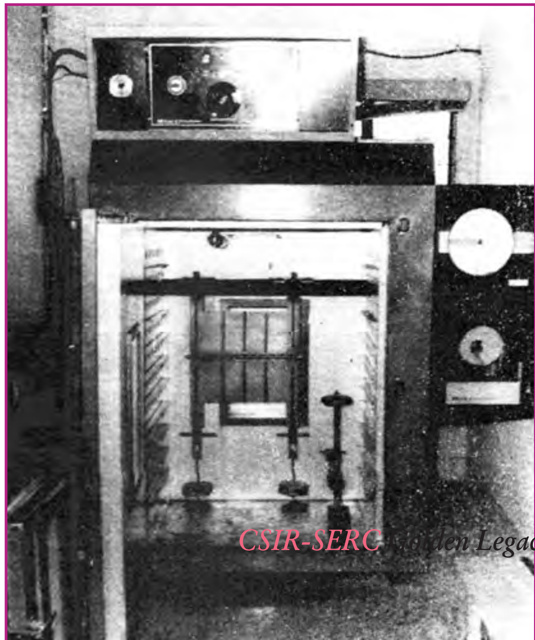


setting up of a laboratory for MODEL ANALYSIS OF STRUCTURES (1976-77)

Initially established as the **Laboratory for Model Analysis of Structures**, this later came to be known as **Stress Analysis Laboratory** and then **Experimental Mechanics Laboratory**. The objective of this laboratory was to develop techniques for the experimental stress analysis of structures using 3-dimensional photoelasticity, moiré strain analysis and laser holography and, to build up research and development capability for handling problems involving model investigations.



Steps taken for setting up facilities for carrying out experiments using optical and laser holography techniques were completed during the year. Setting up of facilities for reproducing gratings by reflection process using a concave mirror is nearing completion.



The following facilities were also established for conducting experiments:

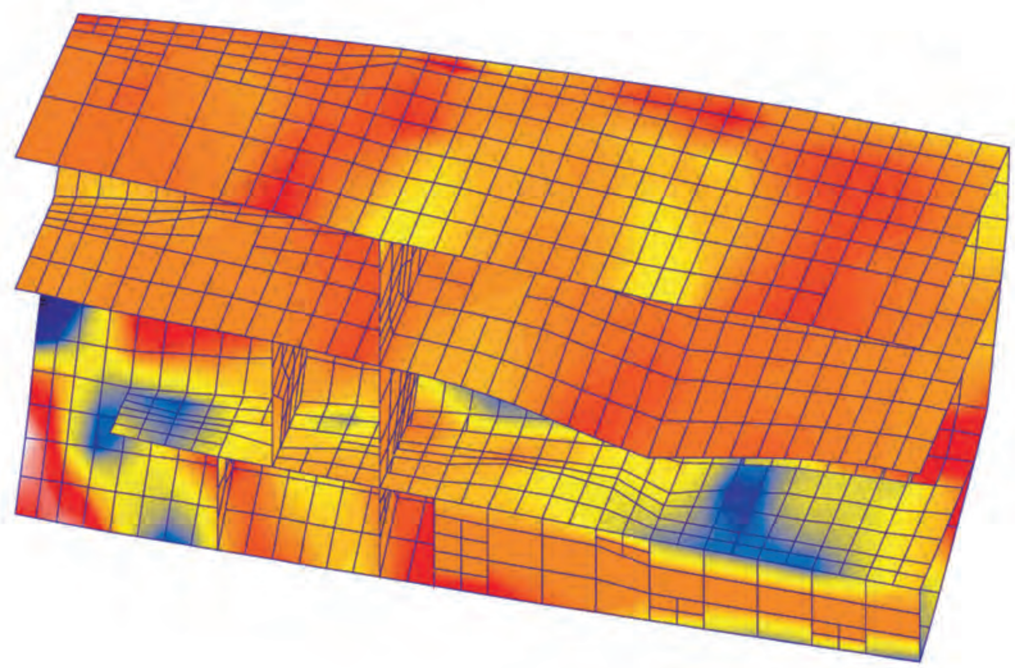
- Shadow moiré and Lightenberg
- Optical bench elements
- Loading frame for holographic interferometry
- Reproduction of gratings

COMPUTATIONAL STRUCTURAL MECHANICS
for analysis and design/software development

1965-2015
CSIR-SERC Golden Legacy

CSIR-SERC's EXPERTISE

CSIR-SERC has built up considerable expertise in the area of computer-aided analysis and design of structures and structural elements and also in development of software for general use as well as for special applications. Scientists of the Centre have been helping the industry by providing advisory and consultancy services to solve complex structural analysis and design problems, and imparting training to practising engineers by conducting workshops and advanced training courses. The Centre has been in the forefront of development of software for structural engineering applications and its propagation to various user groups in different Government departments, public and private sector organisations and academic institutions by leasing of software packages and undertaking specific software development projects. The Scientists of the Centre serve as members in prestigious Professional Bodies / Societies and in select Committees interested in computer applications in structural engineering.



Mid-ship region of a hull structure - deformed shape superposed with stress contour using FINEART

Thrust Areas / Activities

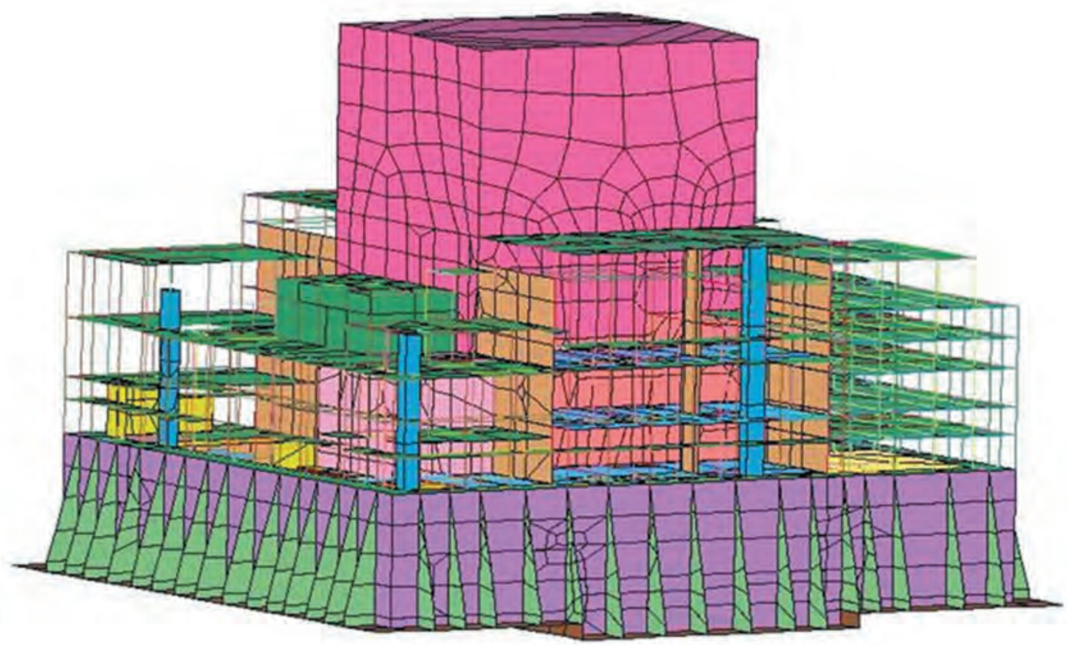
The expertise and major activities of CSIR-SERC in the field of computer-aided structural analysis and design may be categorised under:

- Advanced Computer-aided Structural Analysis
- Computer-aided Design of Structures
- Application of AI Techniques in Structural Engineering
- Software Development and Dissemination
- Consultancy Services and Sponsored R&D
- International Collaboration
- Training Programmes and Interaction with Academia

Advanced Computer-aided Structural Analysis

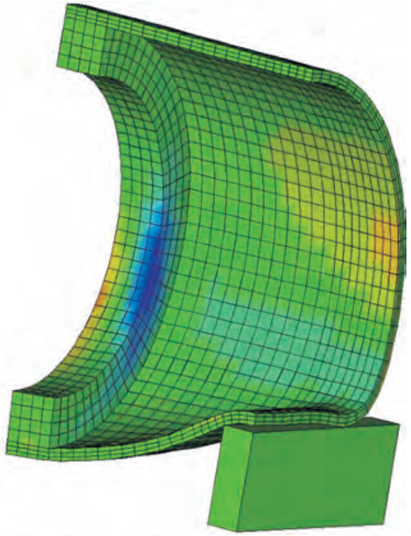
Scientists of CSIR-SERC have developed improved methodologies and computational techniques for solving different problems of structural analysis including vibration, dynamic response, and nonlinear analysis of structures, by using the Finite Element Method and other numerical methods such as the Boundary-Element method. Some of the computer programs developed by CSIR-SERC (based on the R&D work carried out in related areas) listed below will give an idea about the expertise built up by Scientists of CSIR-SERC in wide ranging topics of advanced structural analysis.

- OSTA - Offshore/Onshore Structural Analysis system (consisting of program modules in Fortran for deterministic / stochastic dynamic analysis of skeletal as well as plate structures)
- FINEART- FINite Element Analysis using Adaptive Refinement Techniques
- 3D frame and torsional analysis of ship hull structures
- TGFNDN -Software for the static and dynamic analysis of framed-type foundations supporting turbo generator machines
- PGDYN -Software for the dynamic analysis of pile groups in layered soils
- Seismic analysis of 3D framed buildings
- TATWIN -Temporal analysis of towers subjected to wind effects
- Stochastic analysis of RC chimney stacks under wind loading



Nonlinear & Dynamic Response Analysis

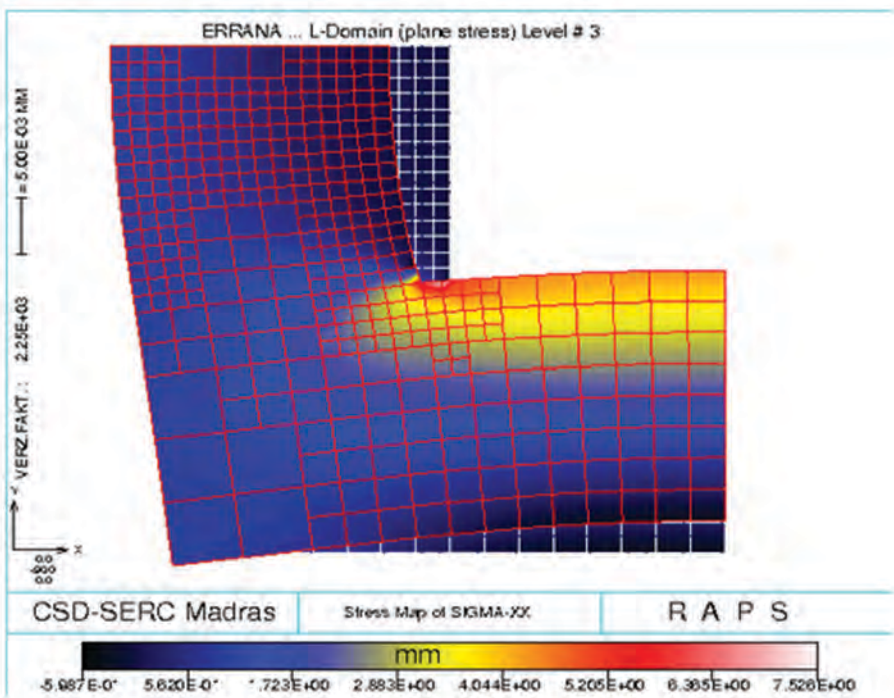
Structural response analysis of frames, plates and shells, in both linear and nonlinear ranges under time dependent loads such as impact, blast and seismic loads, can be investigated by using the computer programs developed by CSIR-SERC. Soil-structure interaction can be included in evaluating the response. Computer programs have been developed to analyse reinforced concrete shell structures, in particular hyperboloid natural draught cooling towers, taking into account inelastic behaviour of concrete including cracking.



Error Estimation & Adaptive Mesh Refinement

The Centre has been actively carrying out R&D work in the area of adaptive finite element modelling for dynamic analysis of structures. The highlights of expertise built up include:

- Development of *'a posteriori'* error estimator for static and dynamic analysis of structures using FEM
- Development of h-adaptive refinement procedures and suitable iterative solvers
- Application of these procedures to solve specific problems of dynamic analyses of ship hull structures and offshore deck platform structures

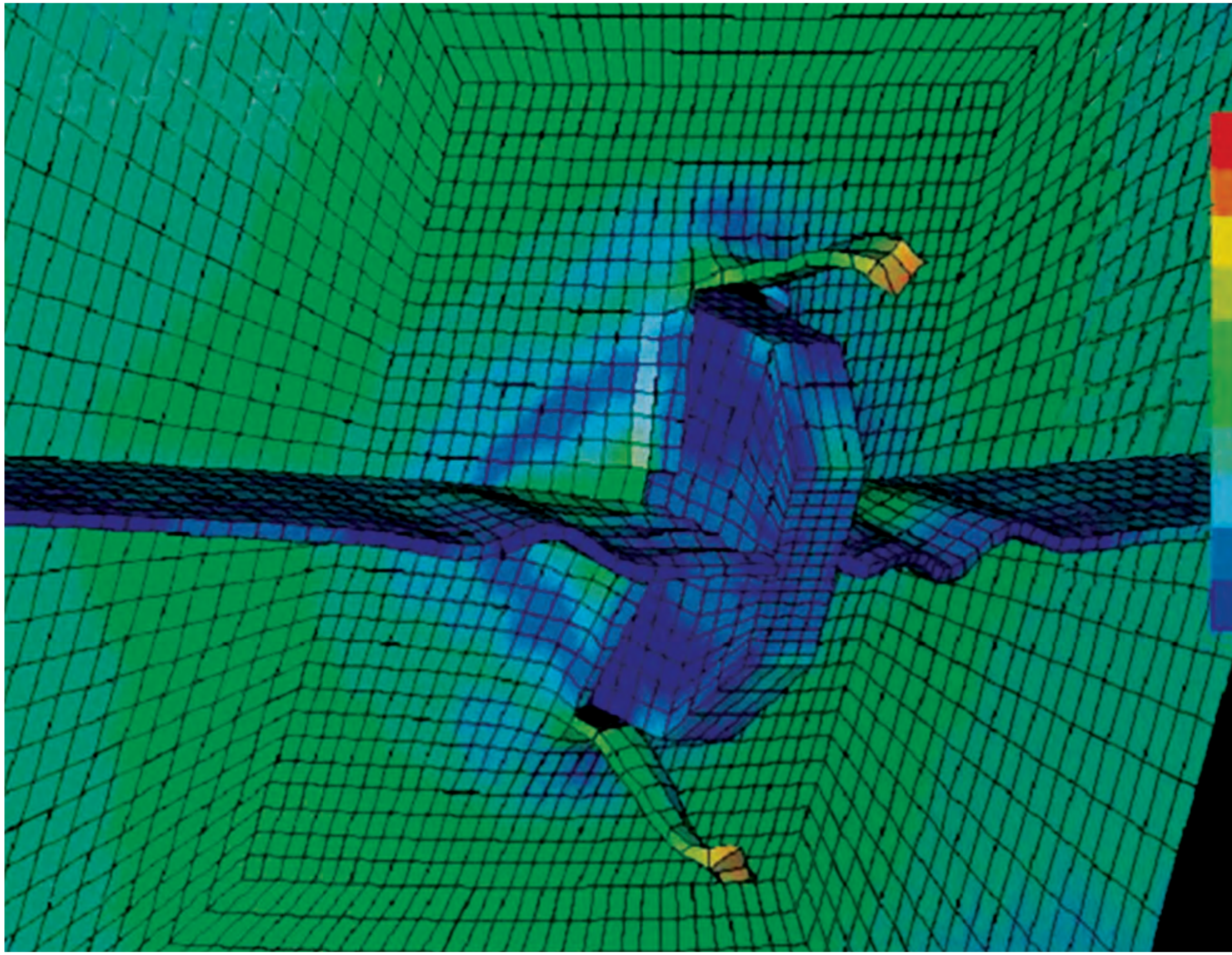


Parallel Processing

The Centre has been developing algorithms using parallel processing concepts that would enable solving of large and complex problems of structural analysis by making use of a cluster of Workstations instead of very expensive and highly powerful Supercomputers. Computer software for some of the complex problems of structural analysis and design have been developed.

Some of the software packages developed in this area are:

- **X-DOM** - An Interactive Preprocessor for Parallel Finite Element Computations
- **PASTA** - PArallel STatic Analysis
- **PARADYN** - PARAllel linear DYNamic analysis
- **CODYN** - COncurrent nonlinear transient DYNamic analysis
- **PAROPT** - PARallel design OPTimisation



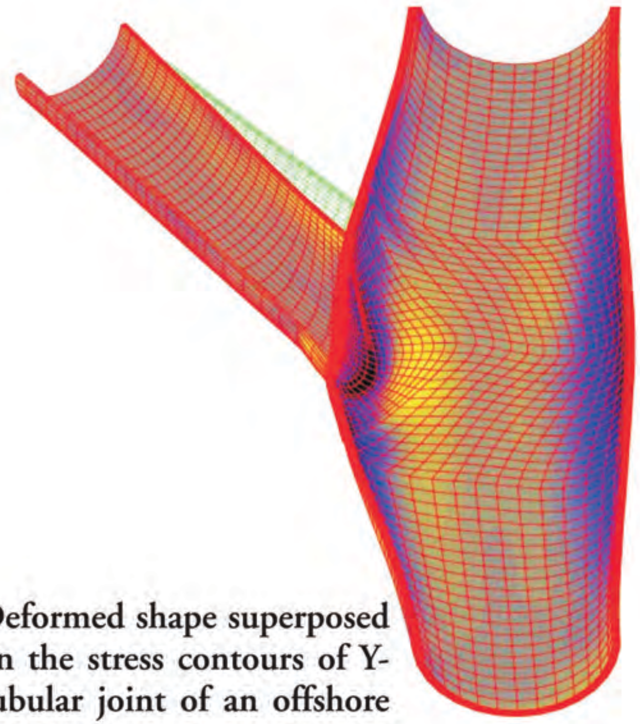
Computer-aided Design of Structures

High-level expertise has been developed in the area of Computer-aided Design and Drafting of different types of structures and structural components. Graphic pre-and post-processing as well as integrated approaches have been adopted to develop software, including the use of AutoCAD.

Special-Purpose Software for Design & Optimisation of Structures

CSIR-SERC has developed special-purpose software packages to suit the requirements of the industry for solving some of the complex problems of structural analysis and design including optimisation. This effort includes computer-aided design of ship-hull structures, steel grillages, transmission line and microwave towers, and bridge girders, besides development of special purpose software for design using knowledge-based optimisation and object oriented programming. Some of the packages developed are :

1	**CODES-I**	Interactive COmputer aided analysis and Design of Ships and ship structures
2	**SACS**	Shaft Alignment Computer Software
3	**AANAND**	Automatic ANalysis ANd Design of bridge girders
4	**GRANDEX**	GRillage ANalysis and Design EXpert
5	**TAPS**	Finite element software package for nonlinear static, dynamic and buckling analysis of guyed towers (masts)
6	**TANDS**	Tower ANalysis and Design System
7	**TRALTAND**	TRAnsmission Line Tower ANalysis and Design
8	**KNODSS**	KNOwledge Driven software for finite element modelling in Structural Synthesis
9	**KNOPT**	KNowledge based OPTimum design program
10	**PARAGAN**	PARAbolic Grid ANtenna structure analysis and design package



Deformed shape superposed on the stress contours of Y-tubular joint of an offshore structure

international seminar on MODERNISATION OF CONCRETE CONSTRUCTION (1982)

An international seminar on Modernisation of Concrete Construction was organised at Madras in January 1982, sponsored by CSIR-SERC and 16 other national organizations. This event, which was supported by the United Nations Centre for Human Settlements (UNCHS), the Committee on Science and Technology in Developing Countries (COSTED), and the TOKTEN Programme of UNDP and CSIR, was attended by over 500 delegates from 15 countries. Several interesting construction techniques were displayed in the exhibition which had participation from three European countries, besides a large number of construction firms in India.

preservation & renovation of **DECAYED STONE MONUMENTS** (1981-82)

Experimental investigations were performed on the sand stone samples from the **Kailasanatha Temple** at Kancheepuram and the granite samples from the **Shore Temple** at Mahabalipuram to understand the mechanism of their decay and deterioration and, to develop suitable preservation techniques using polymer concrete concepts.

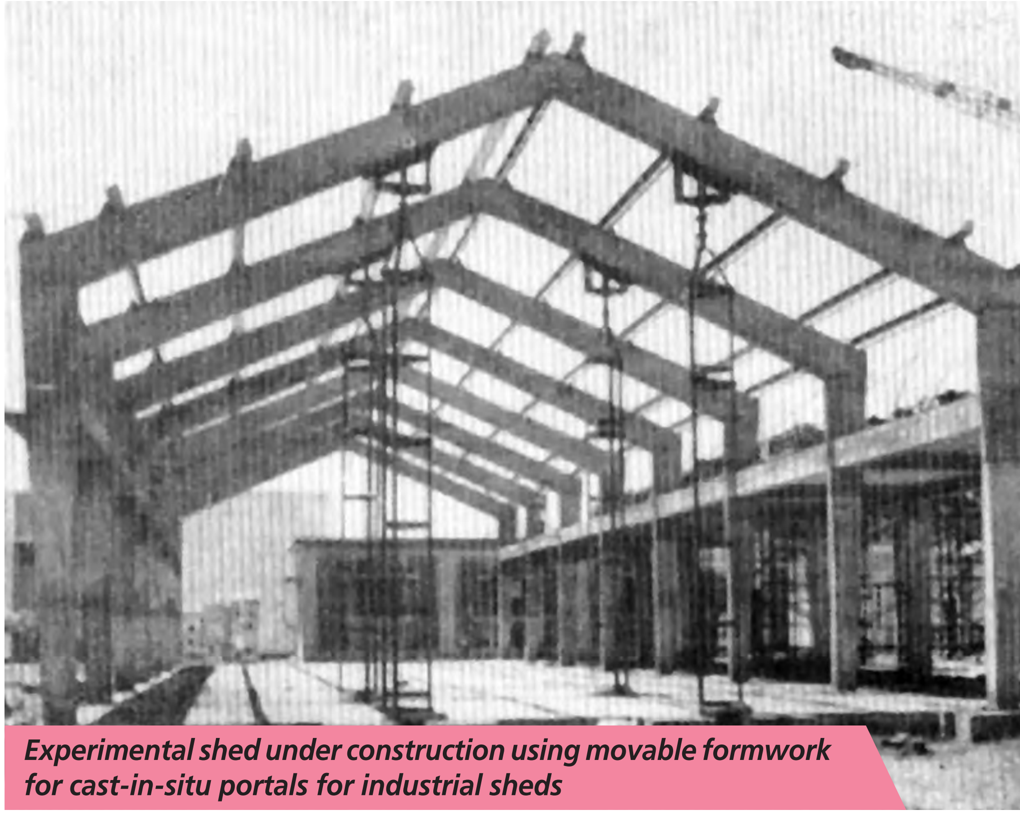
non-linear elastic/inelastic analysis of framed structures

MATRI-MANDIR
(1982)

SERC carried out analysis and design aspects of **MATRI-MANDIR**, a monumental, complex, reinforced concrete Space Structure of 38m height and 36m diameter for the Auroville Project of Aurobindo Ashram, Puducherry.

STRUCTURAL
CONCRETE ENGINEERING & TECHNOLOGY

The Concrete Engineering Laboratory now known as **ADVANCED CONCRETE TESTING & EVALUATION LABORATORY (ACTEL)** was the first to be established in the campus. The concrete laboratory is roofed over by precast funicular shell units which form a waffle-shell system similar to the well kown waffle-slabs widely used in the USA. The waffle-shell system is superior to the waffle-slab as it is much stiffer; and hence, it is suitable for carrying heavy loading. CSIR-SERC is carrying out pioneering research and development work in the area of construction materials, products and techniques, since the decade of the sixties. It had developed cost-effective concrete products and construction techniques for residential, institutional, and industrial buildings. Since 1966-67, in collaboration with Tata Iron & Steel Company Ltd., Jamshedpur, CSIR-SERC has spearheaded the introduction of high strength deformed bars in concrete construction and also popularised the method of ultimate strength designs for reinforced concrete (RC) structures.



Experimental shed under construction using movable formwork for cast-in-situ portals for industrial sheds

ACCELERATED CARBONATION TEST FACILITY

A walk-in type accelerated carbonation test facility has been created in the laboratory, with a chamber of dimensions 12′ x 12′ x 8′. It is built of a triple-wall frame, with the inner chamber made of stainless steel and proper insulation.

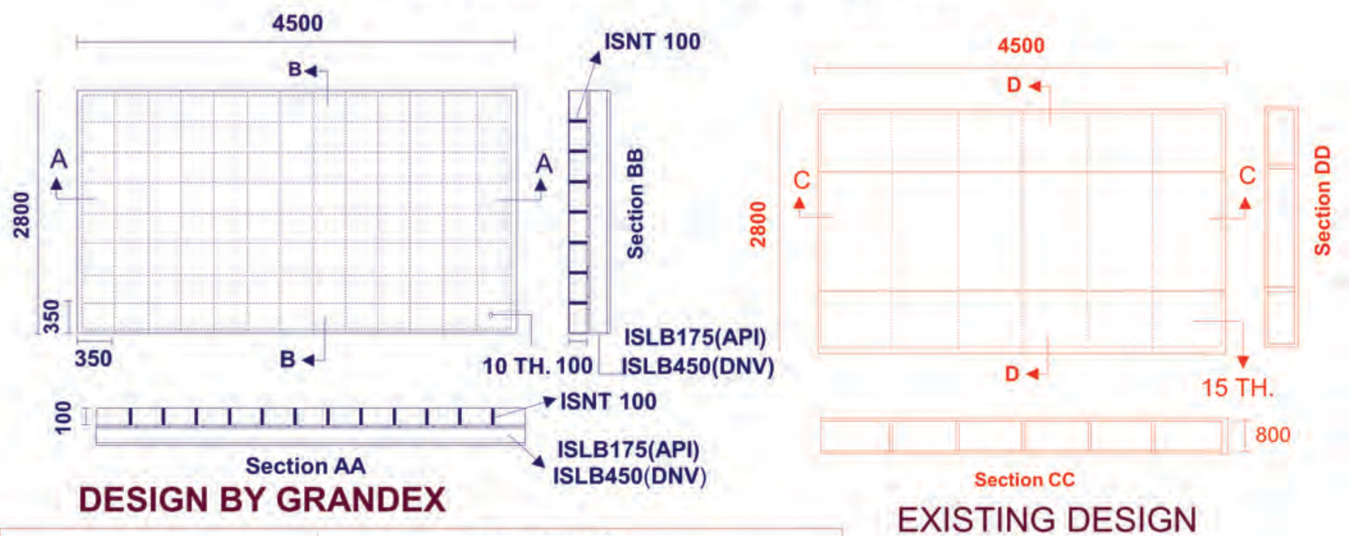
While the temperature inside can be controlled in the range of 25°C to 40°C with a tolerance of ± 2°C, the humidity can be maintained in the range 45 to 65% ± 2%, and CO_2 range of 1 to 5%.

One of the largest in the world

ARTIFICIAL INTELLIGENCE(AI)
Techniques in Structural Engineering

CSIR-SERC has developed computer software for knowledge-based design of steel transmission line towers. A knowledge-based optimisation procedure has been used to generate preliminary design and subsequent improved designs of towers considering them as free standing or as a line consisting of three or four towers. Similarly, a knowledge-based software package has been developed for preliminary design of natural draught hyperboloid cooling towers. Grillages in steel have also been addressed in a software package GRANDEX where knowledge bases on design of plates, stiffeners and girders, are used to obtain minimum weight design, using **SerShell**.

Comparison of Designs



Component	Weight in Kg		
	Results from KBES		Existing Design
	DNV Rules	API Rules	
Plating	987	987	1460
Orthogonal stiffeners	976	976	1473
Girder	1119	808	667*
Total weight of Grillage	3082	2771	3600

* made of built-up sections

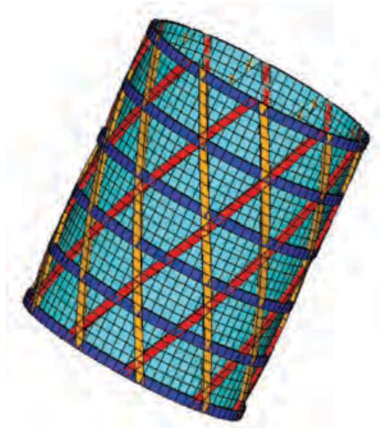
Engine supporting grillage
Engine weight 17.5 t
Speed 175 rpm

Sketch not to scale
Dimensions in mm

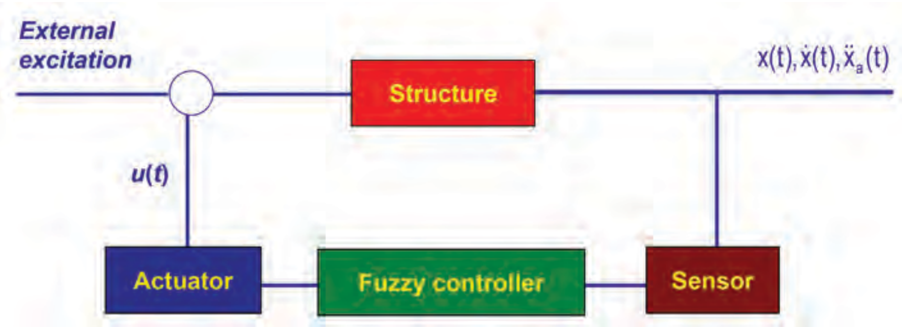
ARTIFICIAL INTELLIGENCE(AI)
Techniques in Structural Engineering

Artificial neural networks, fuzzy logic and probabilistic analysis have been applied for damage assessment and vulnerability analysis of industrial structures subjected to extreme winds in cyclone-prone areas. Object Oriented Programming and artificial neural networks are being applied for design of structural components such as, columns, beams and plate panels. Application of genetic algorithms for optimisation is also an area of current interest.

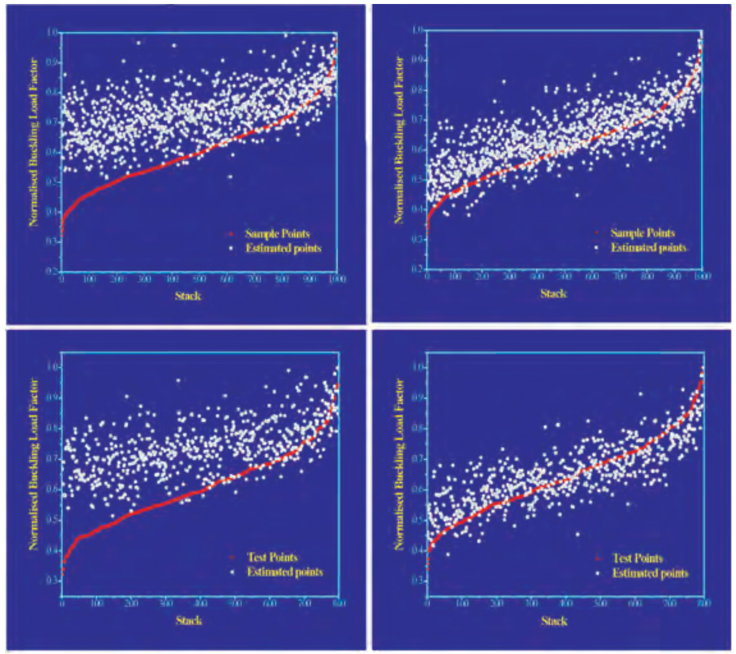
Laminate composite stiffened cylindrical shell



The close-loop of the structural fuzzy control system



Performance of polynomial base functions



ADVANCED MATERIALS **LABORATORY** (AML)

Initially known as **Polymer Concrete Laboratory**, this was set up to develop indigenous capability for producing different types of polymer composites such as polymer concrete, polymer cement concrete and polymer-impregnated concrete for specific applications. The project received assistance from UNDP and a full-fledged laboratory was set up in consultation with UN consultants on polymer concrete and experts from Lehigh University, USA

The prospective areas for application of polymer-modified composites include precast flooring tiles for chemical and abrasion resistance, pipes for transport of chemicals and industrial effluents, mortar formulation for patching and quick repair of damaged structures, overlays and markings for industries, ornamental tiles, and towers and structures for service in marine and coastal environments. The applications also include spillways for dams, airport runways, structures in marine or corrosive atmosphere, industrial floors, railway sleepers, structures in chemical plants and pile foundations.

Utilizing the technology developed, a prefabricated, polymer-impregnated ferro cement light beacon tower was developed for the department of lighthouses and lightships.

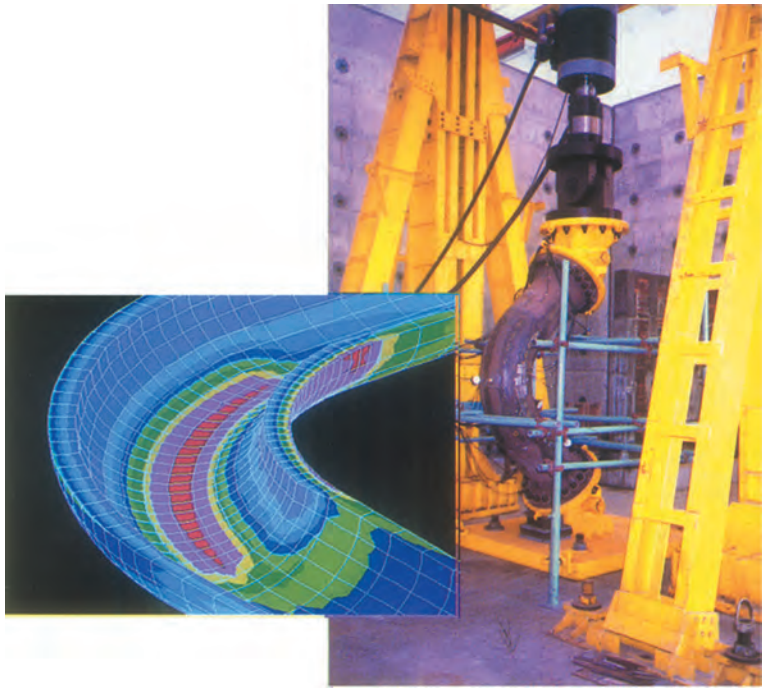
A 6m high tower was fabricated and tested under lateral and gravity loads.

A six-metre high light beacon tower, fabricated with precast polymer concrete components, under test

FATIGUE & FRACTURE **LABORATORY** (FFL)

FFL has a heavy-duty test floor of overall size 36.36m x 10.50m together with two reaction walls 10.50m wide and 7m high, erected mutually perpendicular on the floor. The test floor and the reaction walls are structurally separated from the laboratory building to facilitate fatigue and dynamic tests to be carried out without affecting the building. The testing facility includes loading frames designed for dynamic loads up to 1000kN.

Fatigue tests on model structures and structural components can be conducted with cyclic loads applied through servo-hydraulic actuators of capacities ranging from ±50kN to ±1000kN. These actuators are computer-controlled and can simulate constant amplitude and random loading conditions through software control. A computer-controlled fatigue rated ±500kN capacity Universal Testing Machine is also available for carrying out material property evaluation including fracture toughness. FFL also houses other related testing facilities and a number of measuring instruments for a range of applications in fatigue and fracture studies.



TOWER TESTING & RESEARCH STATION (TTRS)

Towers and tower-like structures are literally the pillars for transmission of power and for communications. Sustained industrial throughput and the well-being of vital sectors of the national economy depend enormously on safe and reliable availability of power and communication lines. Against this backdrop, the contributions of CSIR-SERC ever since 1965 and, its world-class **Tower Testing and Research Station** (TTRS) facility since its establishment in 1984, have been truly significant.

The TTRS facility, situated in a horse-shoe shaped erstwhile granite quarry located at Tirusulam, opposite to the Chennai Airport, ranks among the best of its kind in the world today. TTRS has been collecting extensive research data on the behaviour of Towers for Power transmission towers under various loading conditions and has conducted full-scale (proof) testing of towers for the tower industry since 1984, thereby contributing to the development of more reliable and economical towers not only for power transmission but also for communications. Such full-scale testing services have become almost indispensable in view of inherent limitations of analysis and design procedures, and also uncertainties involved in quality of materials, fabrication/assembly and erection of towers. The experience gained by CSIR-SERC through years of R&D, design and testing activities, has enabled the Scientists to develop improved / optimal designs of towers for different applications. TTRS has proven capability to conduct tests on towers conforming to various international standards.

Construction work in progress at the Tower Testing and Research Station at Tirusulam

There is a growing need for high power density and compact lines in transmission and distribution of electrical power worldwide. This is due to technical considerations as well as the greater emphasis being laid on the preservation of rural and urban natural environment. This will require the transmission voltage to be increased to ultra-high voltages (UHV) and extra high voltages (EHV) during the years to come. In order to cater to these upcoming and future demands, CSIR-SERC had recently upgraded the facilities at the Tower Testing and Research Station to cope with the demand for testing very heavy towers of larger base widths.

Since its commissioning in the year 1985, the Tower Testing & Research Station has conducted full-scale tests on several transmission line towers and tower-like structures. The structures tested include: single circuit gantry towers, double circuit towers, multi-circuit towers, guyed towers, switchyard structures, insulators of I and V types, tower hardware and the like. The present modernisation will equip the station to undertake tests on large and heavy UHV/EHV towers with wide base width and increased loads. The tests have been conducted for many tower fabricators across the length and breadth of the country as well as from abroad. Microwave and communication towers required for the Department of Telecommunication have also been tested.

CSIR-SERC has a high level of expertise for designing towers for power transmission and telecommunications. State and Central Government organisations and several public and private sector undertakings avail of the services of this Centre for the analysis and design of these structures. In recognition of CSIR-SERC's expertise in tower design, many tower designers / consultants / fabricators have had their tower designs proof-checked by CSIR-SERC. Tests have been conducted on towers from different tower manufacturers from abroad and India for their use in East Asia and the Middle East regularly. The Centre has recently developed analysis and design capabilities for 740kV transmission line towers for the first time in India. A sponsored research project was also completed on the use of hollow sections for transmission line towers, sponsored by M/s Tata Iron & Steel Company, Jamshedpur.

1965-2015

CSIR-SERC Golden Legacy

major features of the TOWER TESTING FACILITY

The test tower is erected and held down using prestressed rock anchors to the test pad located on the granite rock. The test pad can now accommodate towers having base dimensions up to 22.5m x 22.5m and cross arm width of up to 40m.

The hydraulic actuators that apply the transverse loading on the test tower have now an increased capacity of 12000kN and are anchored firmly to a cellular box type reinforced concrete foundation structure located on the hill at approximately 46m above the test pad level and behind a crest tower of 24m height. The longitudinal ram station on the hill, at 65m above the test pad level, consists of three main anchor blocks and a 37m long crest structure in front. Eleven actuators are connected to the main anchor blocks which can impart an increased load up to 5500kN. The vertical ram station is located at the ground level in front of the test pad at a distance of 50m and has loading capacity of 5000kN.

A custom-built special type four-way manually-operated direction control valve has been installed with new actuators as an integral part of hydraulic actuator which is very useful to manually control the applied loads.

A four-storeyed building near the vertical ram station houses the air-conditioned control room at its top floor so that the tower under test can be monitored. The 21-channel control system provides continuous monitoring of the magnitude of applied loads and direction of their application. This has been augmented with an additional 10-channel, PC-based loading, control and data acquisition system.

Oil at high pressure (up to 300bar) required for the working of the rams is supplied from a central pumping unit comprising a variable delivery pressure compensated piston pump of 125hp housed in a building at the foot of the hill. The oil is passed through an on-line filtering system continuously to maintain the quality. The high-pressure oil is conveyed to the various ram stations through high-strength, special-quality seamless pipes.

HEARTBEATS

"It has been a very good time here, I really enjoyed the explanations from the various experts and scientists. I hope to be a good ambassador for SERC in my country."

Emmanuel Y. I., Terna Oil Refinery, Ghana

WIND ENGINEERING **LABORATORY** (WEL)

The boundary layer wind tunnel testing facility at CSIR-SERC, Chennai, is a world-class facility established in 1992-95, under the UNDP Programme. Today it is probably the largest boundary layer wind tunnel in our country, which has a large test section of 2.5m x 1.8m x 20m with a maximum wind speed of about 55m/s that can be generated. As high as 1.1m depth of boundary layer can be satisfactorily developed.

Special features of the Development

Model fabrication and instrumentation plays a major role in wind tunnel experiments. The wind engineering team has succeeded in in-house fabrication of rigid models of high-rise buildings using acrylic material. Model portions with curved faces can also be satisfactorily fabricated. This includes, for example, model of a hyperbolic paraboloid cooling tower with raker columns for pressure measurement investigations. Similarly, the dynamic characteristics of the pressure tubing system are very crucial for pressure measurement tests in the wind tunnel. A pressure calibrator was in-house designed and fabricated which is being used to perfect the required length of the tubing system inclusive of restrictors, in every wind tunnel test using pressure measurements.

S & T Challenges overcome

The complex geometric shape and dimensions of any given prototype building significantly influence the model dimensions and its fabrication. Consequently, selection of proper combination of locations and number of pressure taps on the model, connection between pressure taps to pressure sensors at different levels, placement of pressure sensors within the model, calibration of pressure sensors, recommended tubing length from response characteristics poses challenges in every pressure measurement experiment.

With the capability of the boundary layer wind tunnel (BLWT) at CSIR-SERC for generating boundary layer depth even up to a large height of 1.1m (which is difficult in most of the wind tunnels in India and abroad) it becomes now possible for testing high-rise buildings to a reasonable model scale ratios of 1:100 to 1:250, without sacrificing required detailing on the models.

Further, acrylic material is generally preferred at CSIR-SERC for fabrication of models since it is amenable for machining and it is transparent and enables detection for kinks on the pressure

tubes. With the devotion and expertise of our technicians, we have been successfully able to fabricate several high-rise buildings and other structural models within the laboratory. Dedicated in-house software has also been developed which can automatically perform calibration of pressure sensors, data acquisition, analysis of large quantum of raw data into pressure coefficients and presentation of pressure coefficients in the form of tables. The above fabricating, testing and data handling capabilities have significantly improved in recent years, leading to improvements in the quality and efficiency of wind tunnel testing on high-rise buildings. Presently, BLWT experiments are the only reliable design tools for evaluating the wind induced interference on a given building / structure due to surrounding structures. Particularly in all the wind tunnel experiments being undertaken for several projects of national importance, on high rise buildings/tall chimneys/cooling towers, including the three examples included in this report, experimental determination of interference factor is an invaluable design input for the clients for their structural designs, for which required aerodynamic loading information is otherwise seldom available.

Impact

Considering the actual cost of buildings / power plant structures (which are tested in the wind tunnel) which runs to several hundreds of crores of rupees, results from the wind tunnel experiments, provide rational and scientific aerodynamic loading information to the designers. This helps in achieving safe and economic design of structures. The beneficiary is the society at large.

Current codes of practice on wind loads do not give adequate information for determining aerodynamic loads on tall buildings / structures, particularly for interference conditions. Based on thumb rules and subjective judgment, the interference factors are presently assumed, which might be over-conservative or deficient. However, by conducting wind tunnel experiments, which are internationally accepted as rational and scientific methods for evaluation of aerodynamic loads, the structure can be designed from both economic and safety considerations.

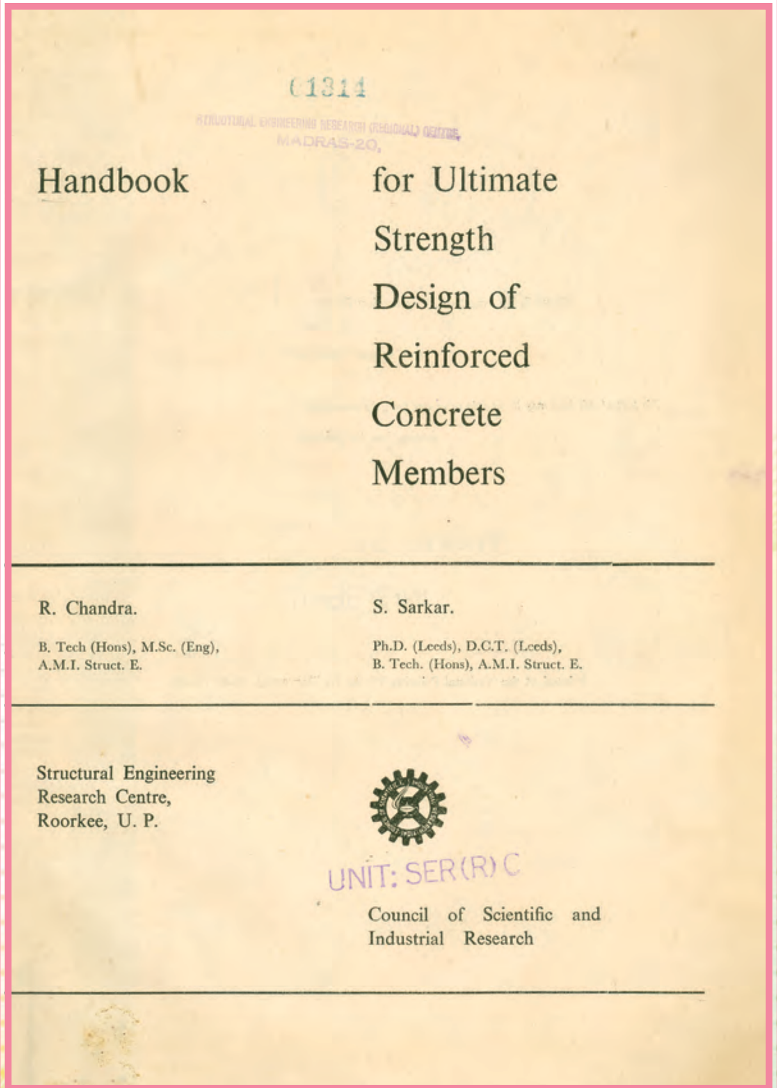
HEARTBEATS

"For the first time, I saw and was introduced to the wind tunnel facility at the Wind Engineering Laboratory, reputed to be one of the best in the world. It is truly a great scientific marvel. NANDRI!"

Seth Pepra, Ghana National Petroleum Corporation, Ghana

Handbook for ultimate strength design of reinforced concrete members (1966-67)

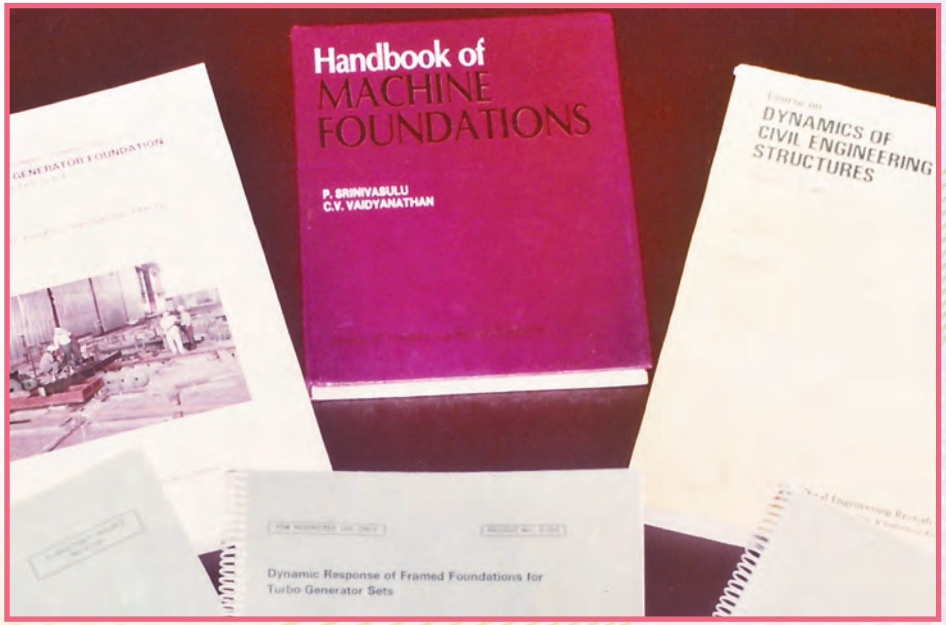
The **Handbook for Ultimate Strength Design of Reinforced Concrete Members**, authored by R. Chandra and S. Sarkar, was brought out by CSIR-SERC. It is generally based on the recommendations of Indian Standard Code of Practice for Plain and Reinforced Concrete - IS 456 of 1964 with some extensions and modifications where considered necessary. The use of the ultimate load method results in savings in steel consumption to the extent of 21% for mild steel and 42% when high strength deformed bars are used. The method is characterised by simplicity of approach and better prediction of the behaviour of structures. There are over 100 time-saving and labour-saving charts and tables included in the handbook. These have been compiled on an electronic digital computer. Two grades of steel, namely, mild steel and medium tensile steel, conforming to IS 432 of 1966, have been considered in preparing the charts and tables. But the use of these can be easily extended to other grades of steel. The handbook is in great demand by design engineers in India and abroad as well.



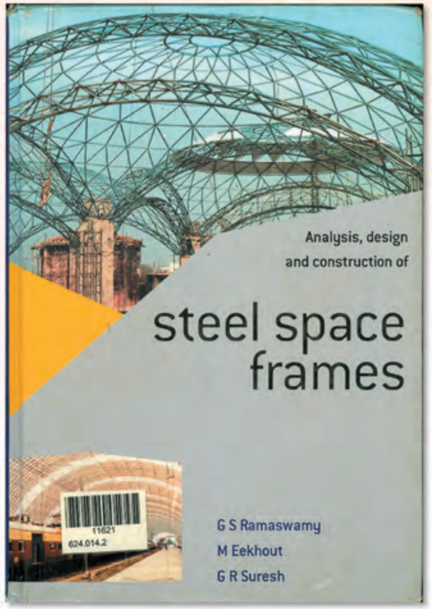
handbook of MACHINE FOUNDATIONS

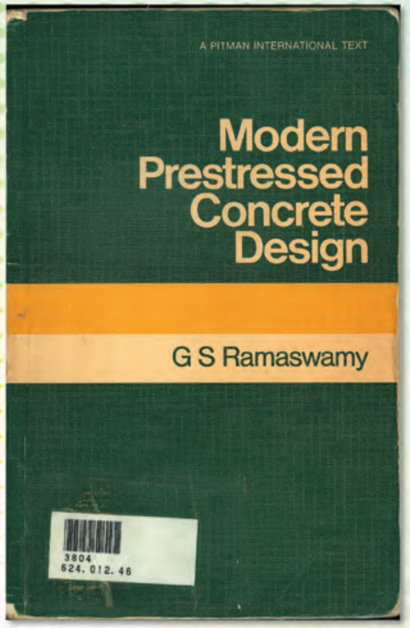
During the year (1972-73), a **Handbook of Machine Foundations** was compiled with guidelines and examples for the benefit of the design engineer specializing in this field. Authored by Dr P. Srinivasulu and Shri C.V. Vaidyanathan, the book has been published by Tata McGraw Hill.

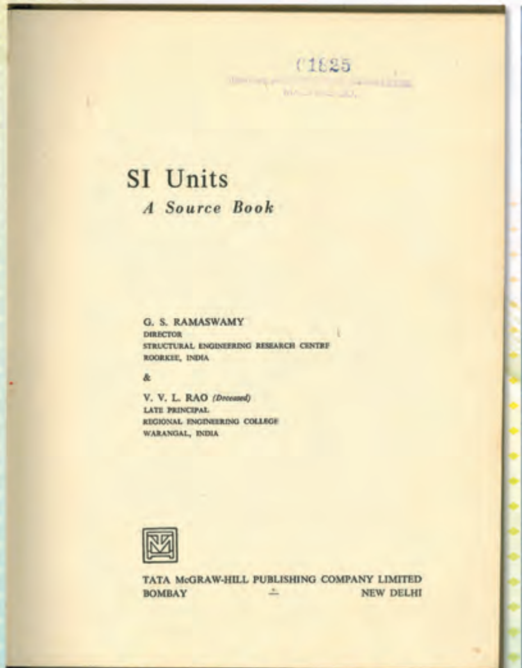
Rapid industrialization of the country involves the installation of machines of various types in industrial establishments. The design of foundations for such machines calls for specialised knowledge. The effort of the authors of this book has been to present the principles of analysis, design and construction of machine foundations of different types in sufficient detail. Elements of structural dynamics are presented in one chapter. A feature of the book which the designers would specially welcome is the inclusion of numerical examples. A chapter each is devoted to the design of block and framed foundations. Vibration isolation and construction details have also received adequate attention. The book has been very well received and is in demand both in India and abroad. It has seen several reprints, with royalty flowing to SERC/CSIR till date.

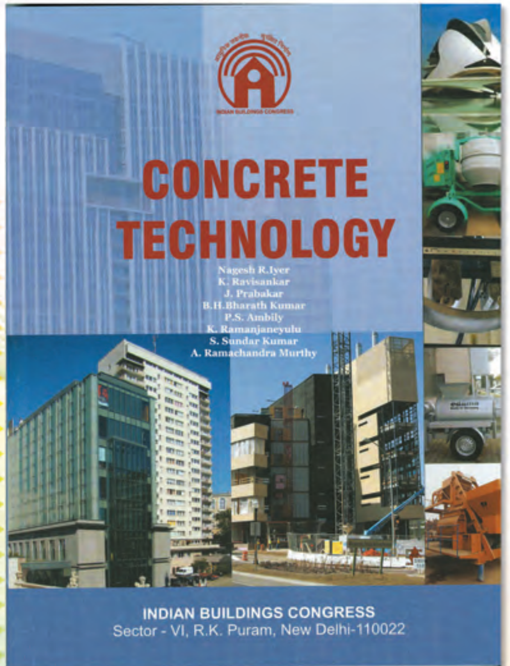


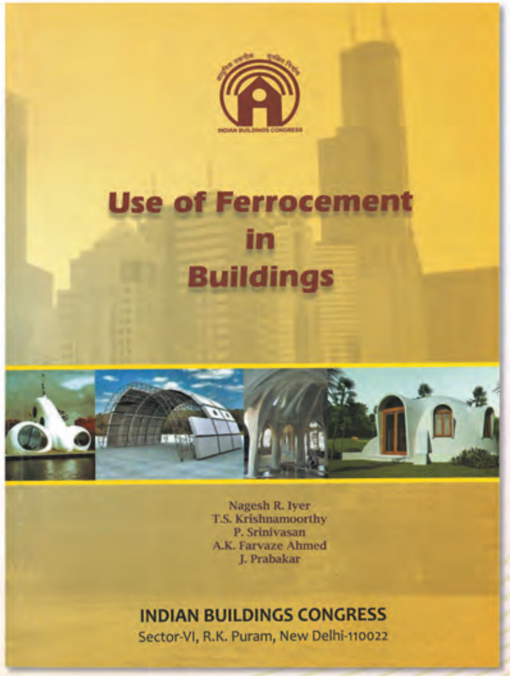
KNOWLEDGE DISSEMINATION











making FORAYS

The last two decades or so would see us grow into a colossus that would embrace the Indian engineering industry in general and, the Civil and Structural field in particular, redefining the very thought process that sustains them. Fifty years and several milestones later, we stand tall, not just in our achievements but in our unflinching commitment as well to our dear motherland in providing for the highest levels of engineering excellence that technology has ever witnessed. We have thereby merged ourselves into the spirit of the engineering fraternity with a pledge to never waver from this focus in the coming decades.


Meandering to frontiers
Excellence that permeates

PRESTRESSED
Concrete Sleepers (1970-73)

As part of their scheme to modernize track and to get over the problem of replacement of timber and also to carry higher axle loads, the Indian Railways proposed to use prestressed concrete sleepers on a large scale. The estimated demand (in 1970) was over a million sleepers per annum. The immediate problem faced by the factories engaged in the manufacture of sleepers was to effect improvements in the design and production techniques and to reduce the cost of sleepers. The Regional Centre took up, at the instance of the Research Designs & Standards Organization of the Ministry of Railways, a comprehensive investigation on the design and production aspects of sleepers. The scope of the study included development of techniques for ensuring that desired concrete strengths are obtained consistently, assessment of transmission length and loss of prestress, optimum cycles for steam curing, and determination of resistance to static bending and to impact and dynamic loads. Fifty-two sleepers had been cast on the long-line pretensioning bed with different concrete strengths, with different types, numbers, and arrangements of high tensile wires, and with and without mild steel reinforcement. Both plain and crimped wires have been used and gradual and sudden releases of prestress have been tried out. The sleepers developed 70 - 80 percent of the designed 28-day compressive strength of concrete within 24 hours after casting.

Sleepers with crimped wires met the specifications laid down in the draft Indian Railway Standards with sufficient margin of safety. Dynamic tests were conducted on a few sleepers prestressed with crimped wires, keeping a load range of 3-12 tons. The sleepers were subjected to 2 million load cycles at a frequency of 400 cpm.

Pre-stressed concrete mono block railway sleepers made at Kosikalan, U.P, with the know-how developed by CSIR-SERC

The technology developed has been passed on to the National Research Development Corporation of India for being licensed to industry. The indigenously developed technology obviates the need for importing technology from abroad.

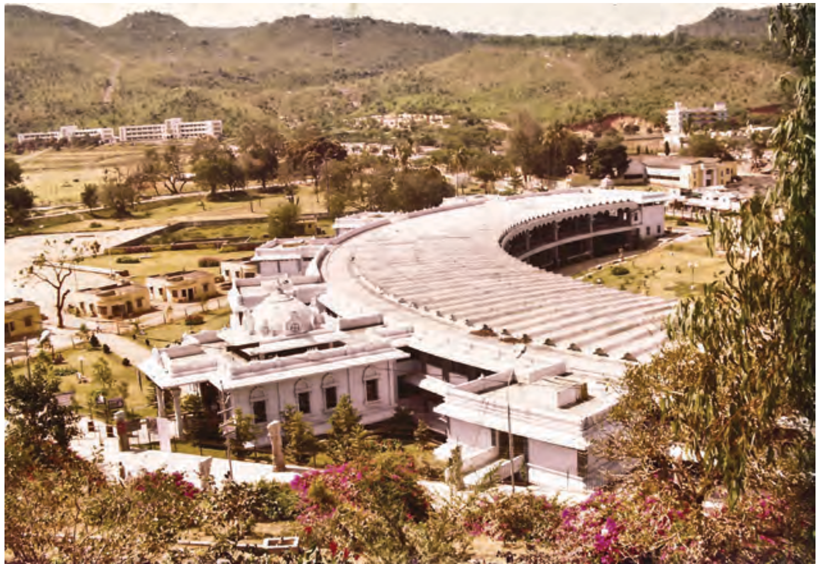
Prestressed concrete mono-block railway sleepers was produced by Jay Prestressed Products, New Delhi (1977) and, the royalty per sleeper for five years was given to CSIR-SERC

DESIGN CHALLENGES
Prestressed Concrete Pipes

Prestressed concrete pipes were compacted by a vaccuum process and gaskets were specially designed for pipe joints. The pipes were produced by different compacting methods such as spining, high frequency vibration and vacuum. A "ro-tap" cover coating machine was developed to provide the necessary coatings. It is understood that these pipes have been utilized in large numbers to bring potable water to the city of Chennai from different locations.

Hon. Shri Ravindra Varma, Union Minister for Labour and Parliamentary Affairs, inspecting the test set-up for large-diameter prestressed concrete pipes at CSIR-SERC

DESIGN CHALLENGES
Queue Complex at TTD



Q Complex at Tirupati designed by CSIR-SERC (1982)

HEARTBEATS

"World-class facilities... Keep it up!"

George Aidoo, Terna Oil Refinery, Ghana

FLY-ASH Buildings (1973-74)

Construction of the 2-storeyed experimental building using fly ash in concrete and mortar was completed, with the floor and roof being made up of channel units in reinforced and prestressed concrete, resting on load-bearing walls. Precast channel-shaped floor slabs prestressed by the electro-thermal method have been erected in position. Tests on high-strength deformed bars having a yield strength of about 6000kg/cm^2 were done and, a proposal to use these bars and a few test beams to ascertain their relative performance and cost-wise merits over bars having a proof stress of 4250kg/cm^2 was done. **A patent on the technique of electro-thermal prestressing has also been filed.**

Units measuring 7.5m in length were made of prestressed concrete and shorter units in reinforced concrete. The use of fly ash concrete structural components in this building created considerable interest in several construction agencies and housing boards. It is only recently (2008) that the use of fly ash has been recommended by CPWD while CSIR-SERC had envisaged and used fly ash way back in 1973-74.

HEARTBEATS

"The $2\frac{1}{2}$-hour visit of various labs and interaction with the scientists has been a good experience. Feel proud to know that SERC is dealing with special projects for big organizations of national and international importance. The team is a dedicated and committed one. Our institute looks forward to interact further with this great research centre."

Dr. Soundara Rajan, Director, Velammal College of Management & Computer Studies, Chennai, India

This is the first flyash building in the country and is standing tall to this day!

The catenary shell roof system consists of a catenary-shaped shell structure, built with hollow clay blocks that need no reinforcement. The other advantages for the system are the speed of construction and the low cost. In order to evaluate the system and its merits, an experimental building consisting of three shell units and measuring about 100 sq.m. in area was put up on the CSIR Campus. Five types of machine-made hollow clay blocks, contributed by M/s Shellcons, were used in the construction. Each shell has a span of about 4.1m and a rise of about 2.9m. The construction of an entire shell unit of 4.1m span and 7.6m length was completed in about 8 hours with the help of only four masons and three unskilled workers. The cost of constructing this building with teakwood and glazed window and door openings and a reinforced raft foundation (which was found necessary owing to poor soil conditions at the site) worked out to around ₹160 per sq.m. The total cement consumption for the building inclusive of foundation was only 50kg/m^2, as compared to 100kg/m^2 required for traditional brick-wall and reinforced concrete slab construction.

LATOBLOCK - A NEW BUILDING BLOCK **from Lateritic Soil (1976-77)**

The Centre has developed a process for the manufacture of building blocks from lateritic soils. Blocks having compressive strengths of the order of 80-100kg/cm^2 can be produced by this process. These **Latoblocks** have a pleasing appearance and regular shapes. They show no efflorescence and have a moisture absorption of 10-12%.

A machine for the production of latoblocks was designed by CSIR-SERC in collaboration with MERADO, Madras. The future programme includes the assembly of the prototype machine and release of the know-how for commercial exploitation. Efforts are also underway for the development of a simpler machine which will be relatively cheap and suitable for use on small projects and in rural areas.

HEARTBEATS

"I have enjoyed my visit to the institute. It has been an educative experience. My only wish is to see your work benefit the community – research must reach the common people – all my good wishes to all of you"

Margaret Alva, MP, Karnataka

LOW-COST FUNICULAR Shell House using Latoblocks

The house was one of the two demonstration houses built by CSIR-SERC at the Housing Exhibition held at Madras in connection with the International Seminar on Low Cost Housing. The model house had a number of innovative features such as the use of latoblocks for the walls and for the unreinforced funicular shell roof and the use of a moveable steel formwork suitable for row housing. The house was adjudged as the best entry by an International Jury commissioned by Seminar authorities and was awarded the first prize.

Low unit cost (plinth area cost being ₹198.10 per sq.m), less consumption of cement and steel, and speedier construction are some of the advantages of the techniques used in the construction of the house. The latoblocks used in its construction can be produced using less energy as compared to bricks.

HEARTBEATS

"Very important measurement / study-purpose equipment are available here... will help many industries solve their problems."

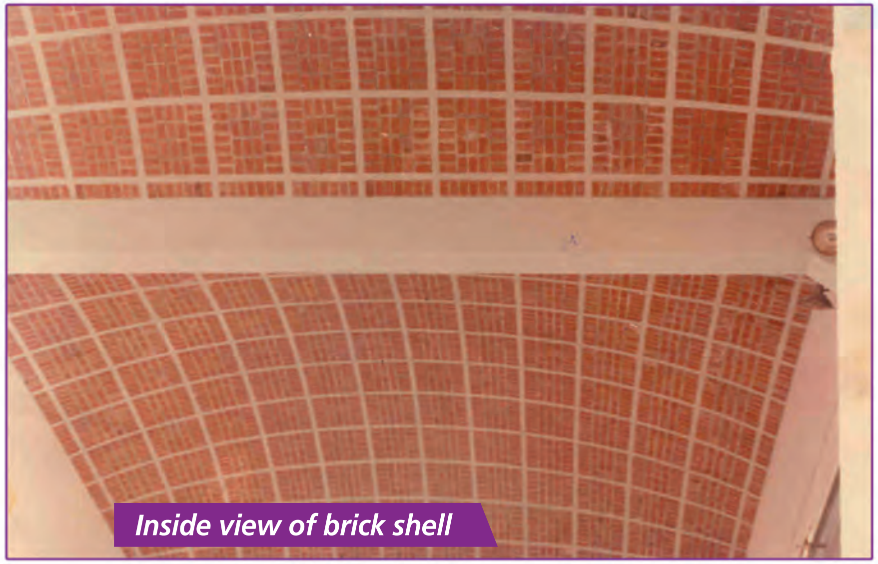
S.K.Basu, JGM, Hirmi Cement Works, L&T Limited, Raipur, India

"Very informative to our students - especially roofing systems and ferro cement applications in construction."

Prof. Adhiseshan & Dr.Charulatha, Bharath Institute of Science & Technology, Chennai, India

BRICK FUNICULAR shells for roofing

Mould for shell



Inside view of brick shell

Row of houses

Concept of funicular shape was extended to brick shells as:

- ♦ The ultimate design load applied produces pure compression
- ♦ The stress at the junction of shell and edge beam is very much lower (5 to 7kg/cm^2)
- ♦ First class bricks (50 to 70kg/cm^2) can safely be used.
- ♦ In order to maintain the shape of the shell, nominally reinforced edge beam all round is the requirement

- **Formwork for the shells being costly, a novel formwork**
- **Movable depending on foldable all-steel or steel-timber composite has been developed (5m x 4.20m) plan**
- **Based on the requirement, formwork can be designed**
- **This technology has been transferred to:**

  - APPHC, TNPWD, FEDO and other agencies.
  - NID and SERC have constructed 12m x 12m shells using in-situ formwork

HEARTBEATS

"Very good testing and research facilities are available with latest information & technology."

J.N.Asati, Prakash Industries Ltd., Chempa, India

Applications:

- Laboratory buildings (roofing, test floors)
- Markets (continuous stalls)
- LIG Housing
- Mass Housing (row-type houses)

Advantages:

- Savings in cement
- Savings in steel
- Speedier construction, if movable formwork is adopted
- Overall cost reduction; greater savings

HEARTBEATS

"In the limited time available I could go round a few laboratories of my immediate interest and had general discussions with the Director and the scientists I was very impressed with the quality and devotion of work being carried out. Quite a few things were new to me. The equipment is modern. Overall a very interesting and inspiring visit. I was also happy to see the beautiful garden and dust-free atmosphere in the laboratories!"

N.V. Merani, Retd. Principal Secretary, PWD, Govt. of Maharashtra, Mumbai, India

PRECAST CONCRETE FUNICULAR SHELLS FOR ROOF AND FLOORS

Funicular shells are:

- Doubly curved - strength through shape
- State of pure compression develops in the shell under the action of uniformly-distributed loads
- Ideally suited for concrete construction
- Extensively used for warehouse flooring, roofs/floors of buildings: Slum Clearance Board, large panel prefabricated constructions
- Architecturally appealing ceiling: Conference halls, Temple corridors and the like
- Shells do not have any steel in their body, but require reinforcement (shrinkage) for large shells
- The edge beams all-round need nominal reinforcement to contain the funicular shape
- Can be cast easily on masonry moulds (reuse potential: more than 200-500)

Advantages:

- Savings in steel
- Partial or complete elimination of shuttering for roofs/floors and rendering of the soffit (depends on scheme)
- *Precast RC battens and precast shells*
- *In-situ centering and precast RC funicular shells*
- Architecturally pleasing ceiling pattern
- Saving in total cost up to 20% as compared to conventional RCC slab
- Economical for large spans: 9m onwards
- For roofs and floors of Government Sponsored Housing:
- *Slum Clearance Boards*
- *Housing Boards*
- In large panel prefabrication constructions
- Individual dwelling units and apartment complexes
- Successfully transferred to TNHB, TNSCB, NID, Nirmithi Kendras of HUDCO, HR&CE (Tiruchendur temple)

PRECAST PLATE ELEMENTS FOR ROOF AND FLOORS

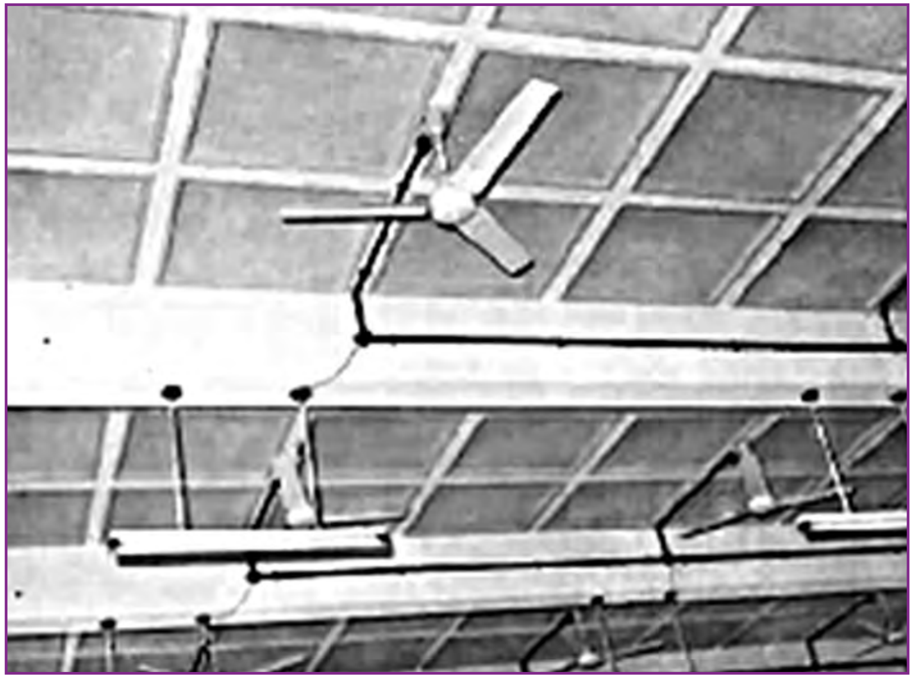


Plate Floor System

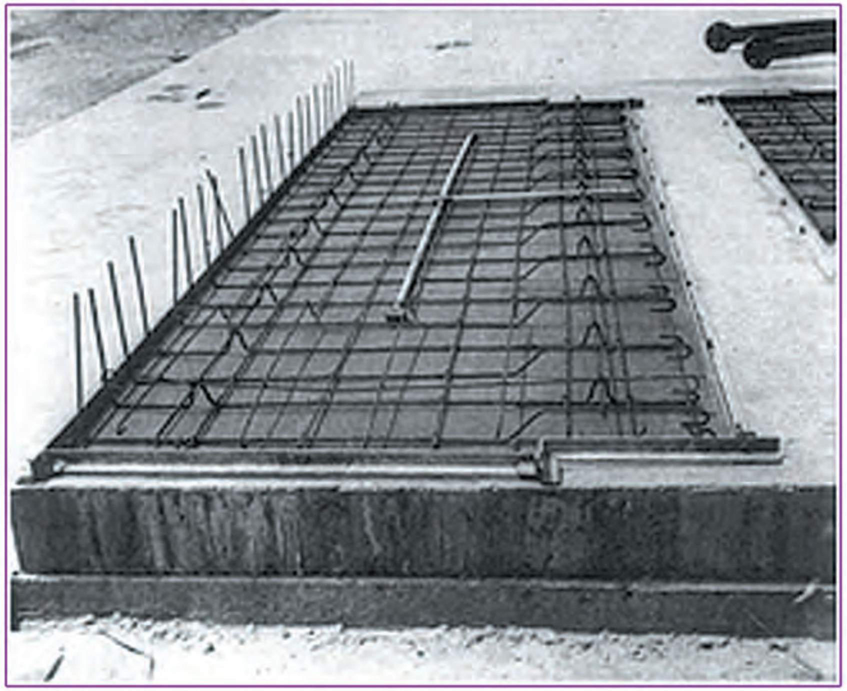
System consists of:

Thin precast RC plate elements generally 40-50mm thick containing tension reinforcement, used as lost formwork in conjunction with insitu concrete forming a slab for use in roofs and floors

Elements are cast on smooth platform (steel or masonry finished smooth) to obtain as cast smooth finish for ceiling ready for painting (plaster eliminated)

Intermediate line supports are provided by runners and props at intervals of 1.2m - 1.5m

- Plate elements are kept side by side with their short ends kept over supports (walls/beams)
- Lateral reinforcement provided in the plate elements are overlapped across the joint, along the length for continuity
- If designed, this reinforcement can also provide
- *two way reinforcing for the slab*
- *After placing the required negative reinforcement over supports, in-situ screed is laid above the plate elements to complete the construction of the slab*



HEARTBEATS

"I am delighted to see the excellent work being done by SERC and other labs of CSIR in their campus. I went round the various facilities of SERC, the wind laboratory, fatigue testing laboratory and the concrete research laboratory. They are helping industrial houses by solving their problems, by advanced research equipment and methods. I congratulate Dr Appa Rao and his team of dedicated scientists for their highly commendable work which will make our country great."

Dr. K. Ramalingam, MD & Former Dean, Madurai Medical College; Member, National Commission for Safai Kharamcharis, Govt of India, New Delhi

PARTIALLY PRESTRESSED CONCRETE POLES
Using Portable Stressing Bed

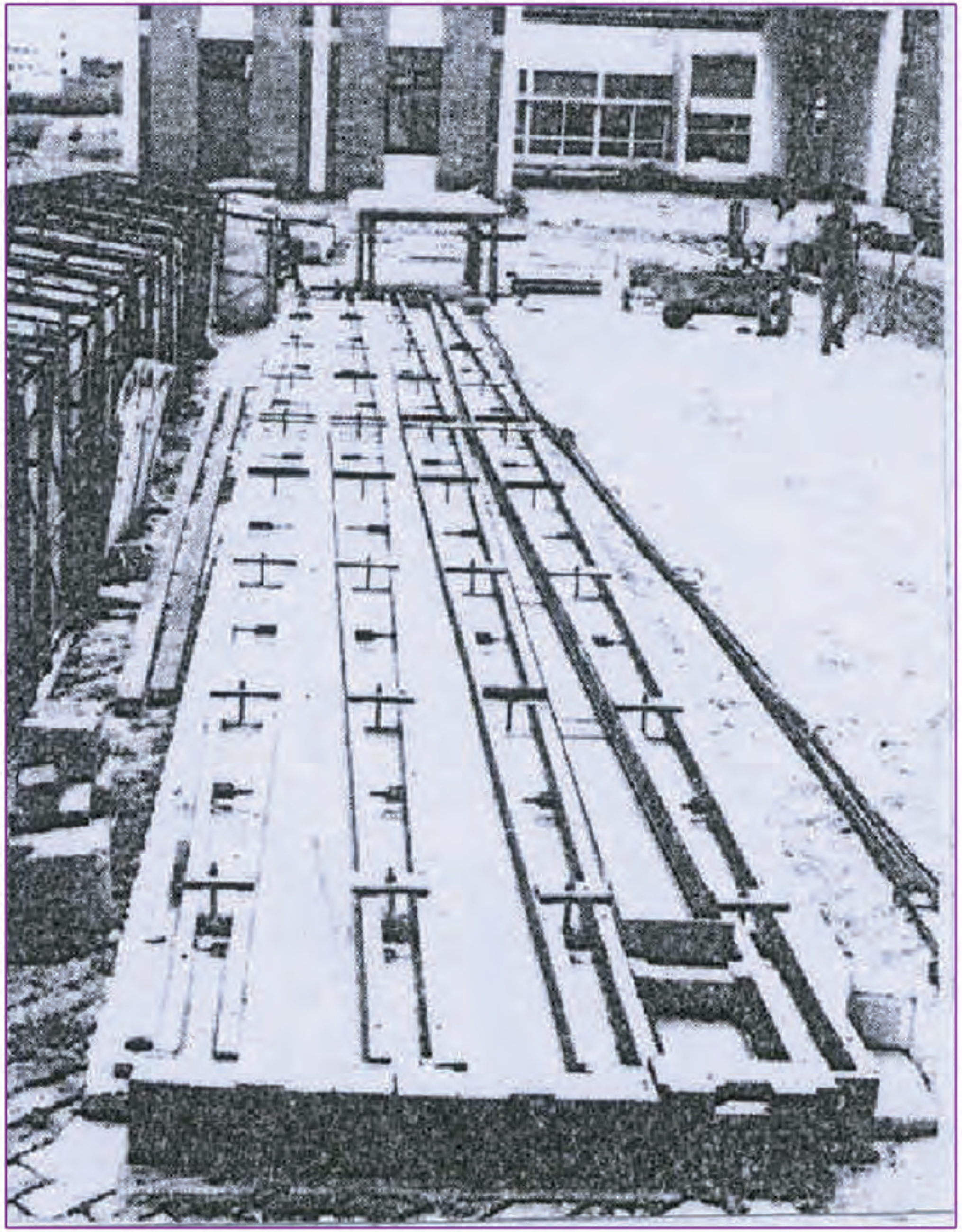
Concrete poles are used for carrying transmission lines of electricity and communication and also as lighting columns. They are traditionally made of reinforced concrete with mild steel bars or high strength deformed bars as passive reinforcement; alternatively, they are made of prestressed concrete with high tensile steel wires as active reinforcement. The poles made by the former method are generally heavier than those made by the latter method and are liable to crack, resulting in corrosion of reinforcement. The prestressed concrete poles are lighter and free from cracks, but are brittle and call for the use of high tensile steel wires, a scarce and costlier commodity. They also call for installation of heavy fabricating facilities like prestressing beds, resulting in a limited radius of operation due to the cost of transport of products. The new system eliminates the disadvantages of the existing systems for producing poles.

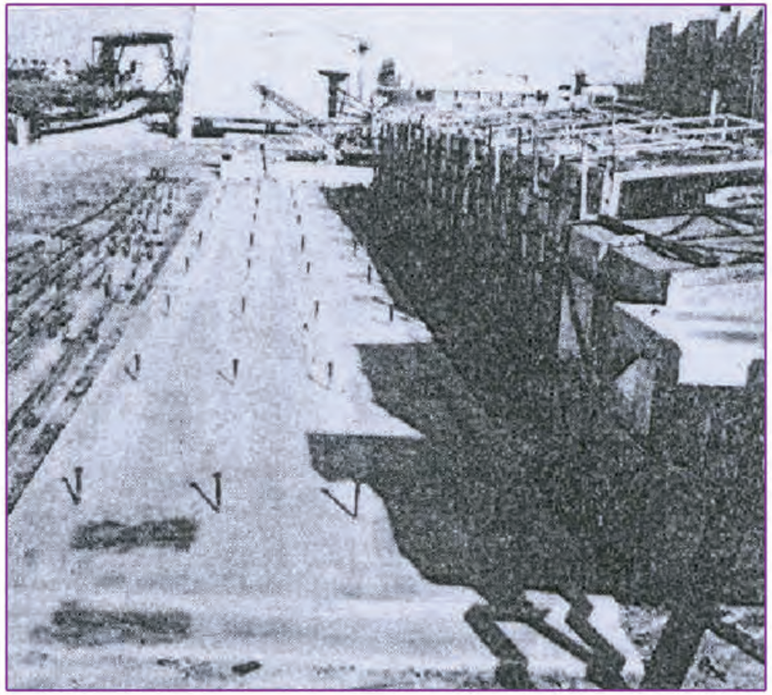
- Portable disposable stressing bed can be installed at convenient locations. Hence, reduces the cost of transportation of poles.
- Normally available high strength deformed bars of yield strength 415 - 500N/sq.mm. are used as active reinforcement.
- Hot-formed rivet heads or welded rings at both ends of bars are used as anchorages.
- Stressing of bars is achieved by means of simple hydraulic jacks and detachable connecting rods; alternatively, by tightening nuts over a threaded bar in turn connected to tendons by simple couplers.
- The cut-off length, which is often a wastage, is reduced to minimum in this system.
- Stressing operations are made simpler and the connections can be used several times as compared to the limited use of barrel and wedge anchorages used in HTS wires.
- The poles have adequate ductility and are free from cracks because of partial prestressing.
- The number of stirrups is less when compared to RC poles.
- The higher bond strength of HSD bars makes it possible to use a lower strength concrete (M35) at transfer.
- The system can be used to manufacture poles for transmission lines, telecommunication lines and for street lighting.

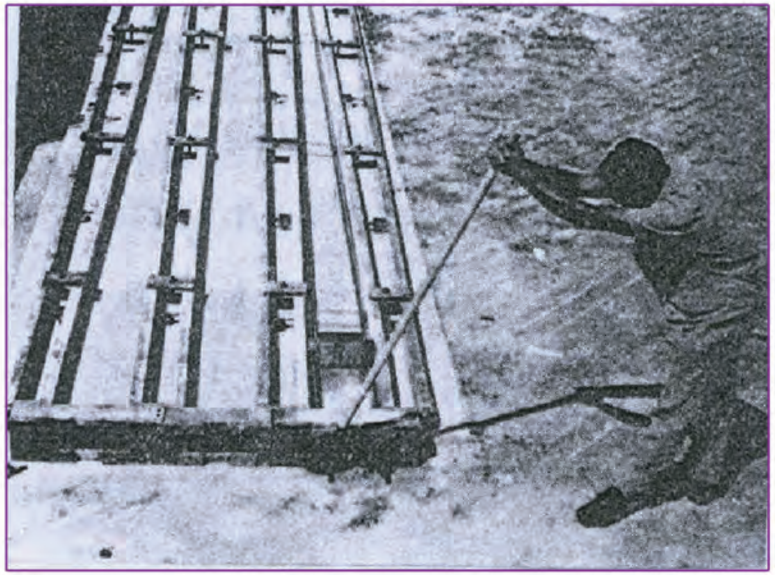
HEARTBEATS

"In a full day it was not possible to see all the very interesting facilities of SERC. It was very impressive to see the work done here on a very scientific basis. The technical discussions with the Director and the scientists were excellent and promoted the understanding of the philosophy behind the work. Aside the visit a very important fracture mechanics test that was carried out on a cracked pipe to understand better the LBB."

Eberhard Roos, Material Testing Institute, University of Stuttgart, Germany







FERROCEMENT
- the wonder substitute for WOOD

Ferrocement is a highly versatile form of mesh-reinforced cement mortar that possesses unique quality of strength and serviceability. This versatile construction material can be used for variety of products, such as, service core units (toilet / bath units), cupboards, rafters and trusses as an alternative to timber to realize termite-proof, and fire-proof properties in addition to other advantages mentioned below:

- *Structures can be thin and light*
- *They can be easily precast*
- *They are amenable to repairs in case of local damage*
- *Considerable saving in formwork particularly for complex shapes; savings in cost*

WATER TANKS:

800, 5000, 7500,10000-litre capacities have been successfully adopted

Service core Units: Sites and Services Schemes

Application and Use

- Individual dwelling units
- Apartment complexes
- To serve community in rural areas

Cost : ₹ 2.50 - ₹ 3.00 per litre storage

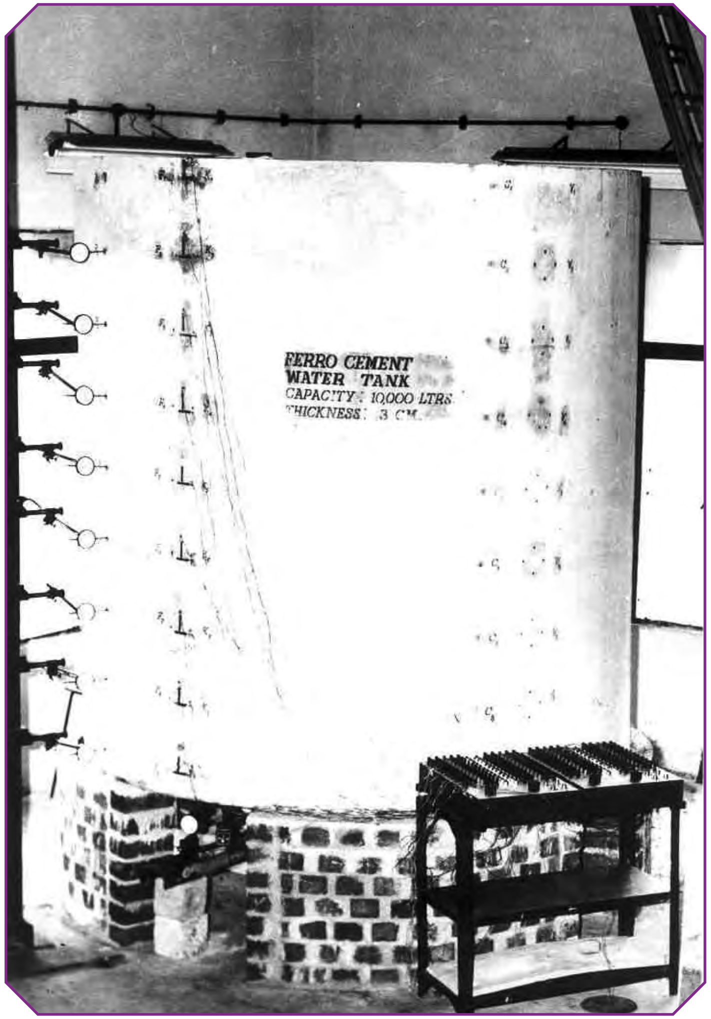
Ferrocement water tanks of rectangular or circular type can be economically adopted for storage of drinking water in individual dwelling units / apartment complexes and also for serving community in rural areas. Designs have been developed by CSIR-SERC for tanks of 800, 5000, 7500 and 10000-litre capacity.

These tanks are economical compared to the traditional brick-walled water tanks, by up to 30%. They have been successfully used in many places in India. For small capacity tanks of up to 1000 litres, a wall thickness of 20mm in cement mortar 1:2 is recommended. The reinforcement cage consists of one central layer of 10G x 10G - 100 x 100mm welded wire mesh and two layers of 22 G - 13mmX13mm chicken wire mesh. The thickness and reinforcement details for higher capacity tanks depend on the size, shape and height of the tank.

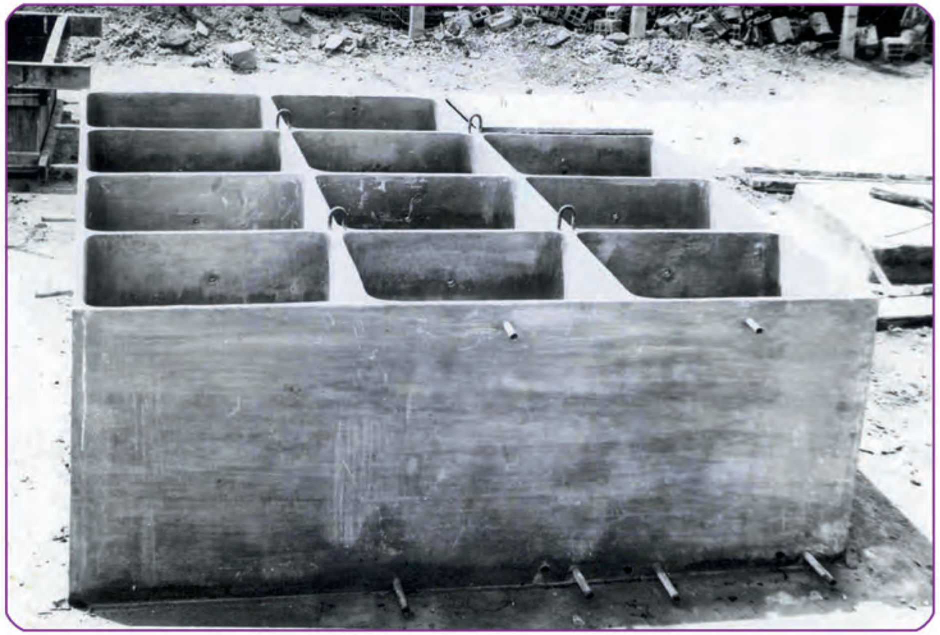
It is estimated that about 5000 ferrocement water tanks are being produced per annum in Chennai alone in the public and private sectors, using CSIR-SERC technology.

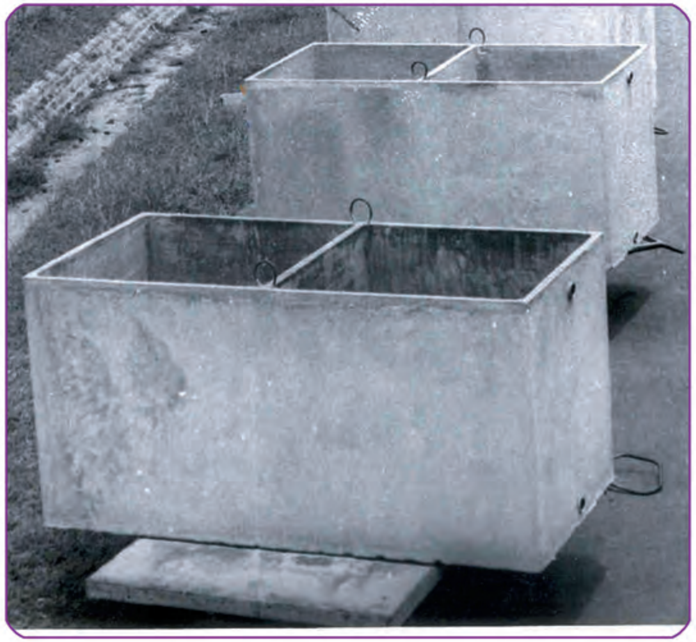
Ferrocement truss with Mangalore/Kavelu tiles

Weld mesh & Completed unit of Double 'T'



Cylindrical tank - 5000 litres





Multiple water tanks

Ferrocement cupboard

Service core units (Bath & Toilet)

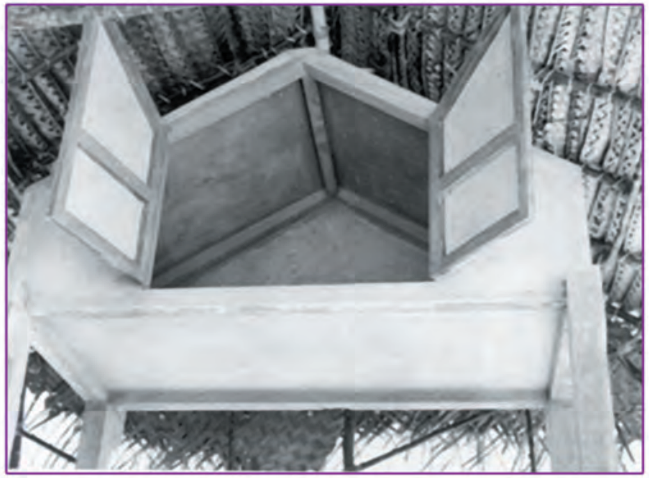
MISCELLANEOUS
Products

Pressed concrete paving blocks for heavy-duty floors

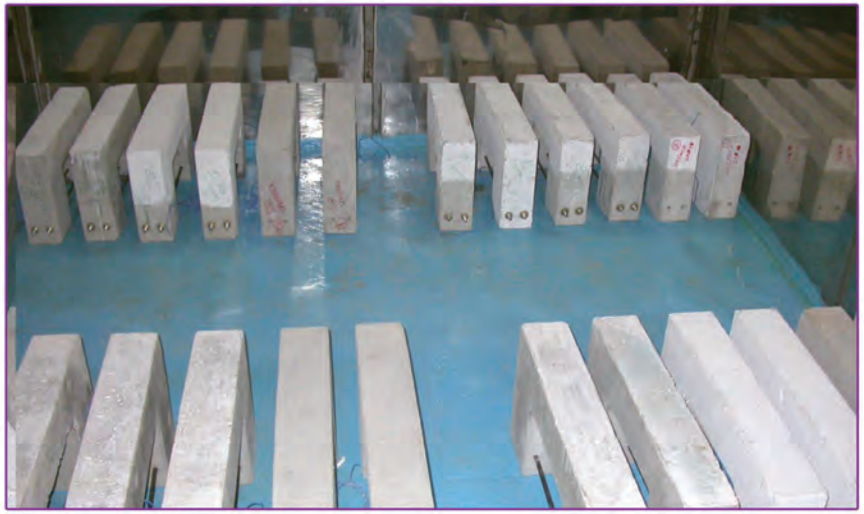
Carbonation Depth as Measured by Phenolphthalein Spray

(a) without fly ash *(b) with fly ash*

Water Tank

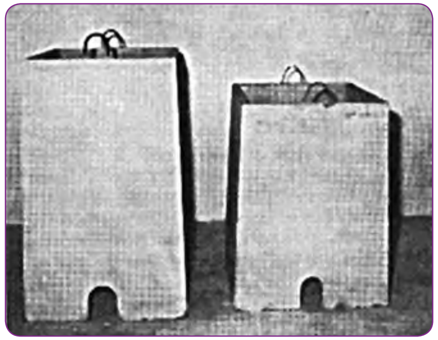


Ferrocement Trusses



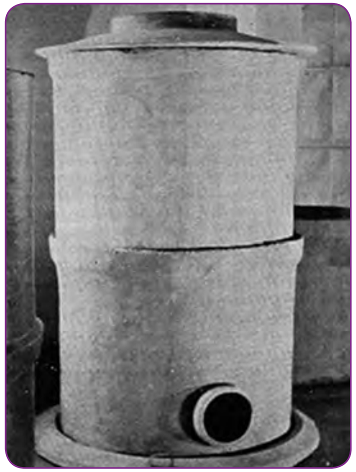
RC Test Beams in CO_2 Environment

FERROCEMENT PRODUCTS



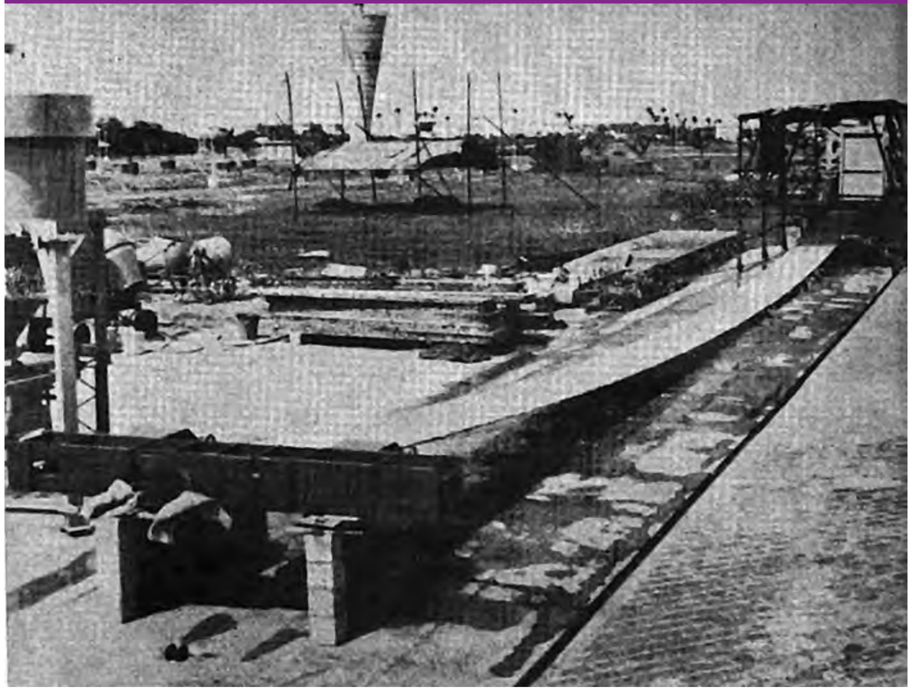
Meter Boxes

CSIR-SERC has also developed ferrocement meter boxes for housing water meters in domestic water supply schemes. These are light in weight compared to concrete meter boxes, presently in use. The installation of these meter boxes is relatively simple. They are cheaper than concrete or masonry units by 30%.



Two-tonne capacity grain storage bin made of ferrocement

Longest Ferrocement Ribbon



A ***ferrocement tension ribbon*** 30m span, 0.9m wide and 2cm thick, as an element for long span roof successfully tested for natural dip and composite action. Recommended for roofing solutions for large-span structures such as auditoria and hangers. To the best of our knowledge, this is the largest experimental ferrocement ribbon cast in the world till date.

FERROCEMENT SERVICE CORE UNITS - Sites and Services Scheme (1978-79)

The development of three-dimensional service-core units in ferrocement for the 'sites and services' scheme of the Madras Metropolitan Development Authority was completed. Three types of units with different combinations of bathrooms and water closets were cast, tested and found to be suitable for mass construction. On the basis of the system developed by the Centre, the Tamil Nadu Housing Board initially took up the construction of 40 units at their sites and services project at Villivakkam in Madras.

HEARTBEATS

"India is a nation who has seen many disasters. Now time has come to take holistic approach and national policy with legislative support. Save from these disasters most important approach will be preventive measures. SERC, Chennai is unique organization which is doing very useful work and research in this area. This is possible just because of dedicated scientists and technocrats. I was really happy and impressed after visiting this organization. My congratulations to all whose vision, devotion and hard work has brought such reputation to this organization."

Sharad Pawar, Member of Parliament, India

FIBRE-REINFORCED Concrete Manhole Covers

Salient Features

- Circular in shape with a diameter of 60cm
- Use of medium strength concrete, reinforced with HSD bars and high tensile steel fibres
- Produced by adopting pressure cum vibration technique using steel moulds
- Provided with recesses or lifting hooks and other special features to suit standard masonry or concrete supporting frames

Advantages

- Pilfer-proof, durable and long-lasting
- Possess greater impact and wear resistance
- Ductility and energy absorption is far superior
- Suitable for mass production at site or in a factory with less capital investment
- Up to 40% savings in cost compared to cast-iron man-hole covers

Demand

- Corporations, Municipalities, Apartment Complexes
- Heavy-duty manhole covers - Streets and Highways
- Medium-duty manhole covers - By lanes, Pavements
- Light-duty manhole covers - Building Complexes

Cost of Heavy-duty manhole covers ₹ 1,200 - ₹ 1,500

CSIR-SERC, Chennai

- Provides technology for new factory setup
- Provides technology for existing precast factories that may require modifications.

SPACE-GRID
Roof Structures (1978 - 80)

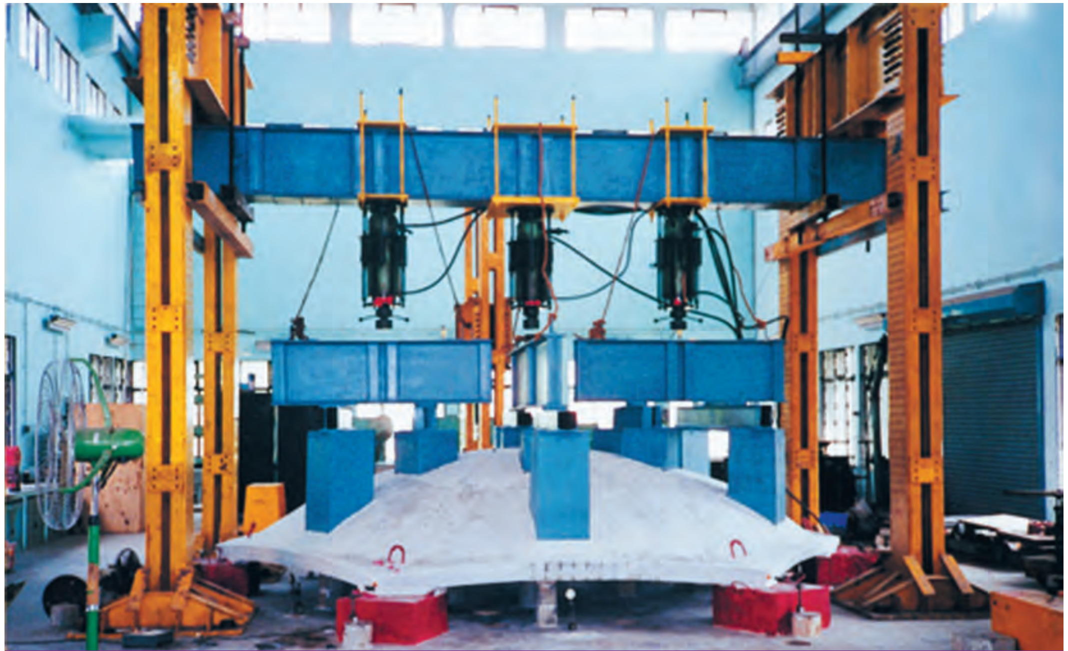
A detailed study was made on space-grid roof structures which can be used to advantage in industrial buildings. A new jointing system was developed to enable the roof to be assembled easily at site from pre-fabricated modules. A preliminary test was carried out on a model of the roof using triangular modules. An experimental prototype structure, 15m x 16.5m in plan was designed using a diagrid-type space grid roofing scheme. The modules required for the roof structure were fabricated. The construction of the concrete supporting structure made of four concrete twin columns was taken up. High strength friction grip bolts were used to connect the space frame modules. Asbestos cement sheets were used for the roof. A design handbook in the form of charts and tables for space-grid roofs was prepared and made available to designers as a nominally-priced publication.

BUBBLE-TYPE Elements for Roofing

- CPWD, New Delhi, sponsored the project
- Steel fibre-reinforced HPC, M60 grade was selected and designed.
- The concrete mixture was designed with CRM level of 40% (having a blend of 35% GGBS and 5% Silica Fume) and with Dramix steel fibres at 0.75% by volume of concrete.
- Naphthalene-based superplasticizer was used
- The water-binder ratio adopted was 0.35
- The maximum size of coarse aggregate was limited to 10mm.
- To improve the shrinkage resistance of fresh concrete and the tensile strength of hardened concrete (so that the possibility of microcracking of concrete is minimised besides enhancing the toughness), steel fibres were added.

HPC mix designs have already being provided to many clients through consultancy and sponsored project mode. ASTAR lab has been constructed at CSIR-SERC using 50% slag as cement replacement (3000 cu. concrete). A HPC mix was designed for CPWD to construct the roof of parliament library building at New Delhi

Prototype Bubble-type Dome Unit undergoing Strength Evaluation Test



Mould and Reinforcement Arrangement for the HPC Shell Unit for Parliament Library Building

Panoramic View of the Parliament Library Building with the Bubble-Type Dome Units

SPECIAL-PURPOSE SOFTWARE

CODES & CODES-I (1984 & 1991)

COmputer-aided analysis and DEsign of Ships and ship structures and Interactive Computer Software for Analysis and Design of Ships and Ship Structures (**CODES-I**)

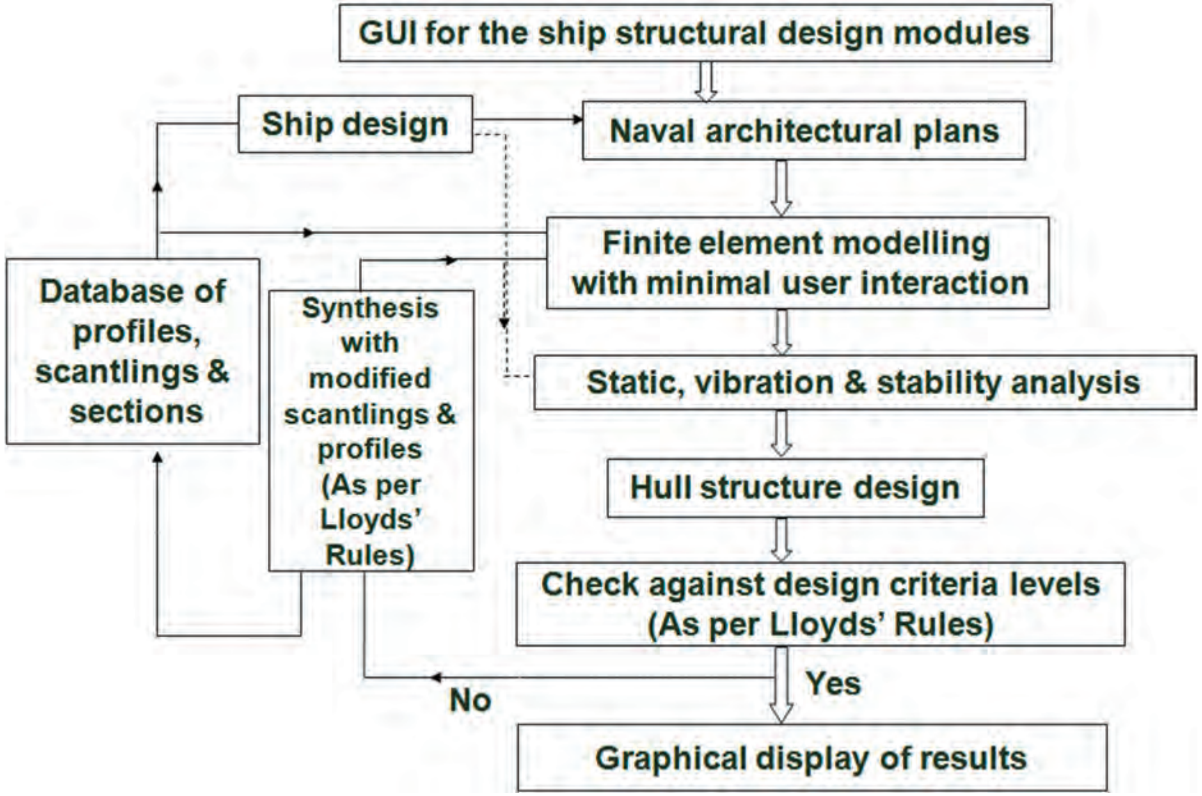
Objective

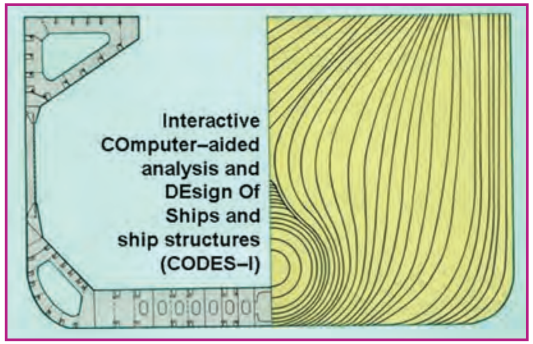
To develop an interactive & user-friendly software for analysis & design of ships and ship structures

Sponsor and Collaborator

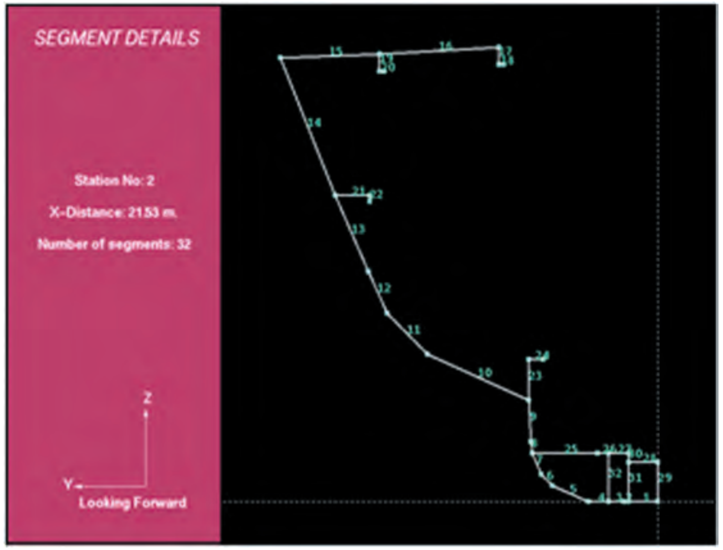
Hindustan Shipyard Limited, Visakhapatnam

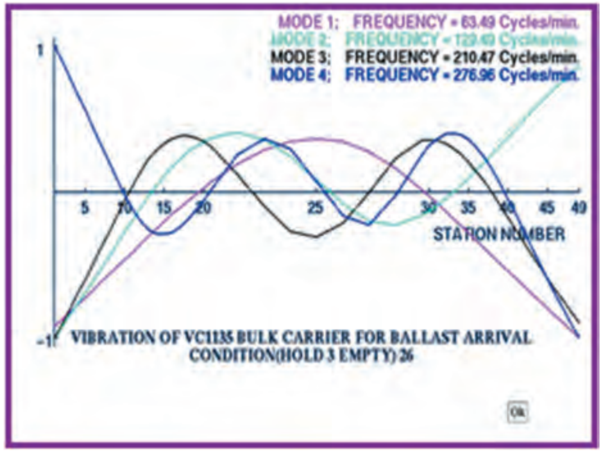
Organisation of Ship Structural Design Modules

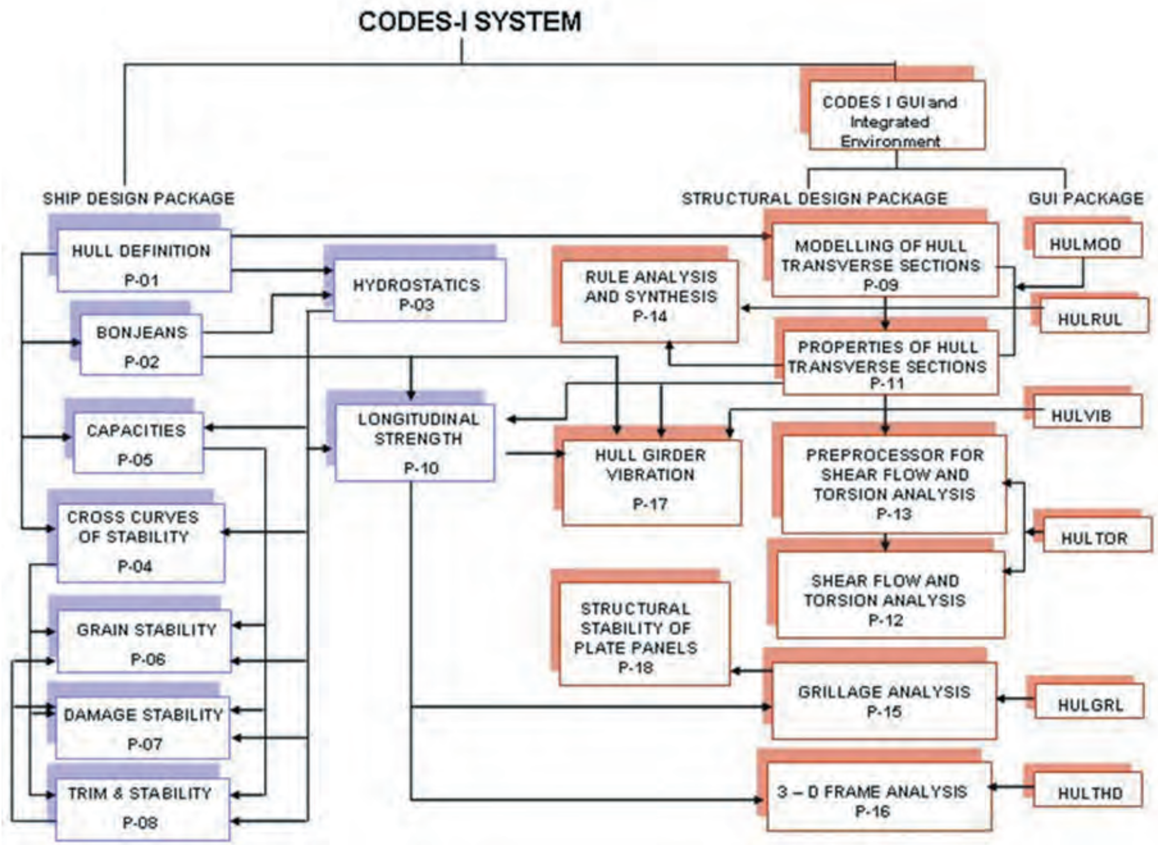




FE Modelling & Typical Output


SEGMENT DETAILS
Station No: 2
X-Distance: 21.53 m.
Number of segments: 32
Z
Y
Looking Forward


MODE 1; FREQUENCY = 63.49 Cycles/min.
MODE 2; FREQUENCY = 129.49 Cycles/min.
MODE 3; FREQUENCY = 210.47 Cycles/min.
MODE 4; FREQUENCY = 276.96 Cycles/min.
STATION NUMBER
VIBRATION OF VC1135 BULK CARRIER FOR BALLAST ARRIVAL CONDITION(HOLD 3 EMPTY) 26

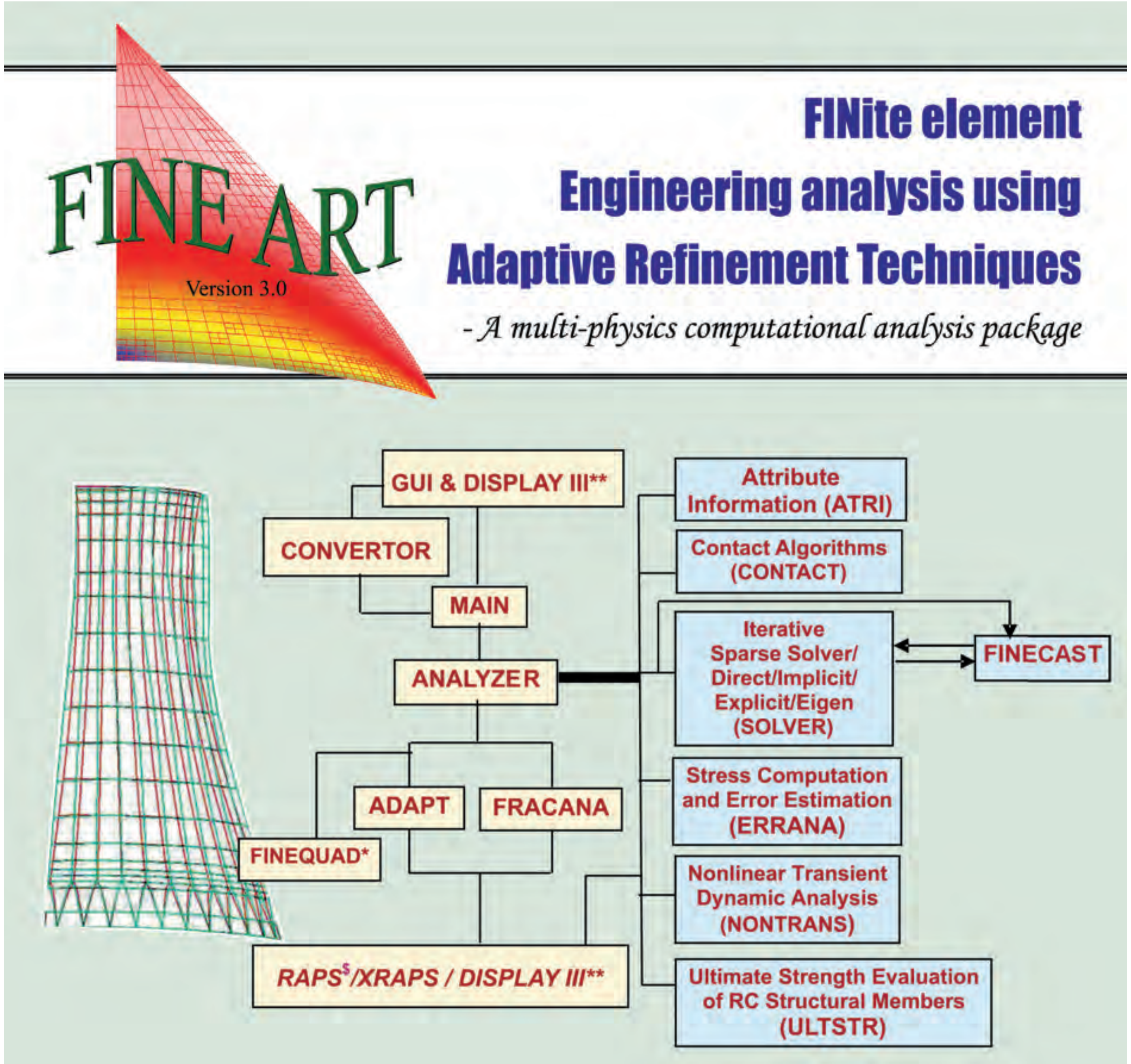

CODES-I SYSTEM
CODES I GUI and Integrated Environment
SHIP DESIGN PACKAGE
STRUCTURAL DESIGN PACKAGE
GUI PACKAGE
HULL DEFINITION P-01
BONJEANS P-02
HYDROSTATICS P-03
CROSS CURVES OF STABILITY P-04
CAPACITIES P-05
GRAIN STABILITY P-06
DAMAGE STABILITY P-07
TRIM & STABILITY P-08
MODELLING OF HULL TRANSVERSE SECTIONS P-09
LONGITUDINAL STRENGTH P-10
PROPERTIES OF HULL TRANSVERSE SECTIONS P-11
SHEAR FLOW AND TORSION ANALYSIS P-12
PREPROCESSOR FOR SHEAR FLOW AND TORSION ANALYSIS P-13
RULE ANALYSIS AND SYNTHESIS P-14
GRILLAGE ANALYSIS P-15
3 – D FRAME ANALYSIS P-16
HULL GIRDER VIBRATION P-17
STRUCTURAL STABILITY OF PLATE PANELS P-18
HULMOD
HULRUL
HULVIB
HULTOR
HULGRL
HULTHD

A multi-physics

computational analysis package

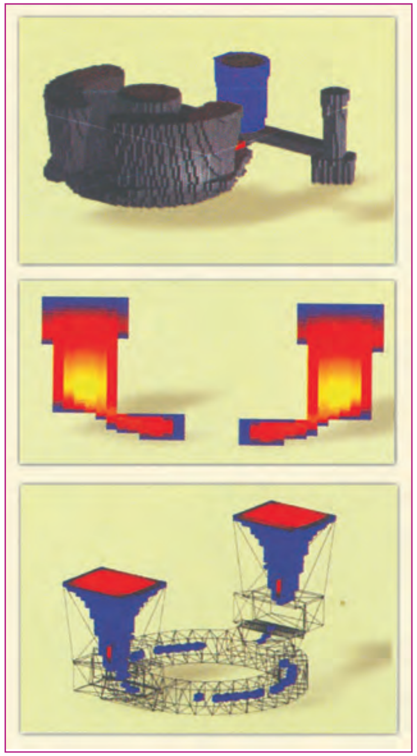
with the following features:

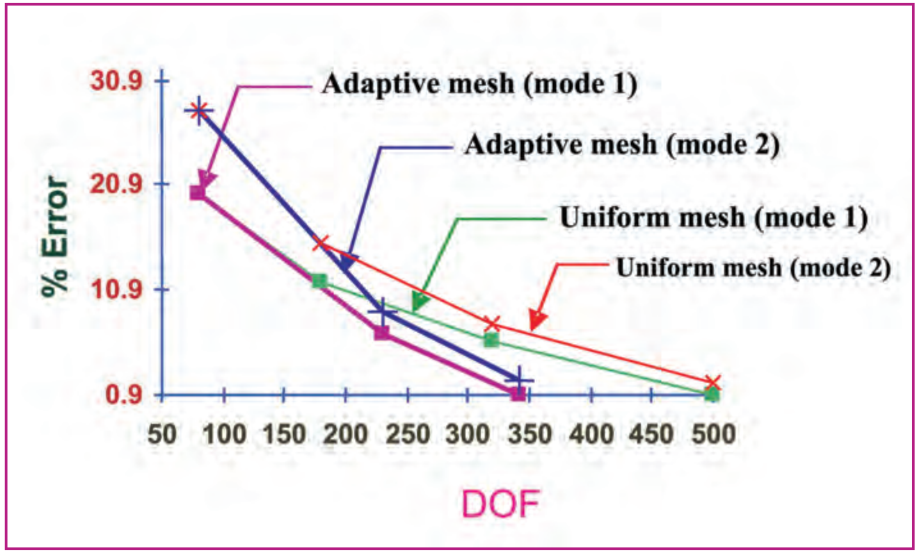
- Advanced finite element analysis (FEA) software
  - *To provide solutions to engineering problems*
  - *To illustrate performance of different types of elements and modeling methods*
- A tool for solutions to real life industrial problems involving engineering analysis and design.
- A research and/or applications environment to address new problem areas or analysis requirements



The salient features of basic FINEART are

- FINEART is modular and coupled to function in an integrated manner
- Developed primarily for LINUX OS using C and Fortran
- Computation of element stiffness matrices & assembly of stiffness matrices in non-zero single column form
- Solution using iterative sparse solver
- Capable of solving plane stress, plane strain, axisymmetric, plate bending, and 3-D problems. Static analysis, linear, non-linear free vibration and dynamic analyses can be conducted
- Uses stress (energy norm) based error analysis procedures and h-adaptive mesh refinement techniques using bi-section and unstructured meshing (only for 2-D in present release) approach to arrive at the reliable mesh and solution
- Different models for material representation
- Derives the final reliable mesh based on multi-level concepts from the starting (basic) mesh
- Can be used to build a finite element model of structure and to evaluate reliable structural responses by satisfying the minimum specified tolerance on error
- Graphical and numerical output of results
- Has a reasonably good pre-processor of its own that can help/aid the user to develop data in an interactive manner. Further, the commercially available pre-processor, DISPLAY III can be used for modeling and the data can be ported to FINEART solver
- Provided with interfaces for post-processing s/w such as RAPS /XRAPS/ DISPLAY III for graphical visualization of results of an analysis



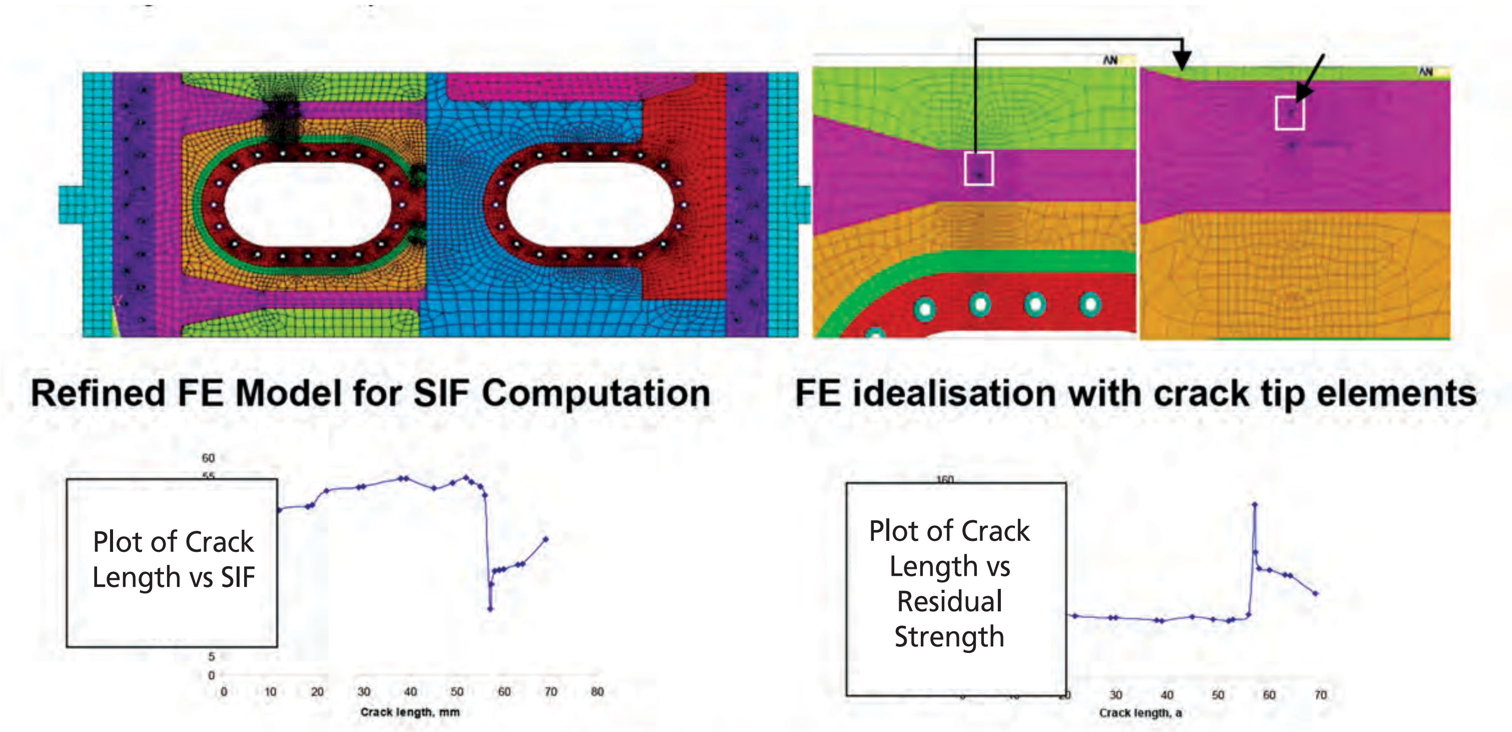


ADVANCED
Computational Structural Mechanics

Some important achievements in brief on the Inter Lab Project on Damage Tolerant Evaluation of Critical Components/ Structures of SARAS Aircraft (April 2001 – December 2004)

Collaborator: National Aerospace Laboratories (NAL), Bangalore

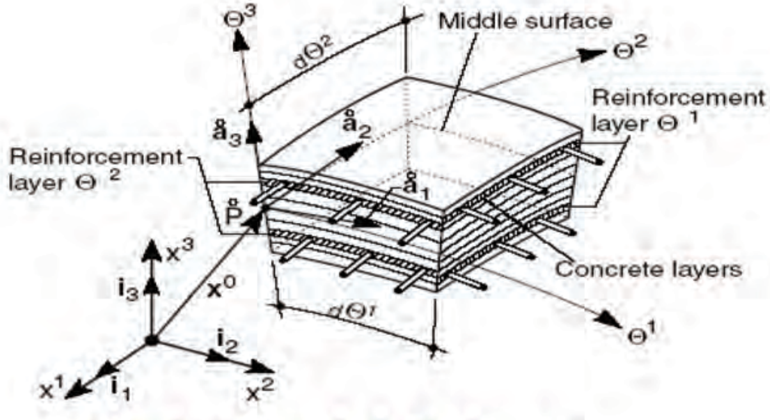
CSIR-SERC has been involved in conducting finite element analysis (FEA) of critical components/structures of SARAS aircraft and testing of these components. This work has been taken up for Centre for Civil Aircraft Design and Development (C-CADD) of the National Aerospace Laboratories (NAL), Bangalore. As a part of this project, various critical structural components such as wing, fuselage, empennage, stub wing and the like of the SARAS aircraft are being evaluated for their damage tolerance qualities.



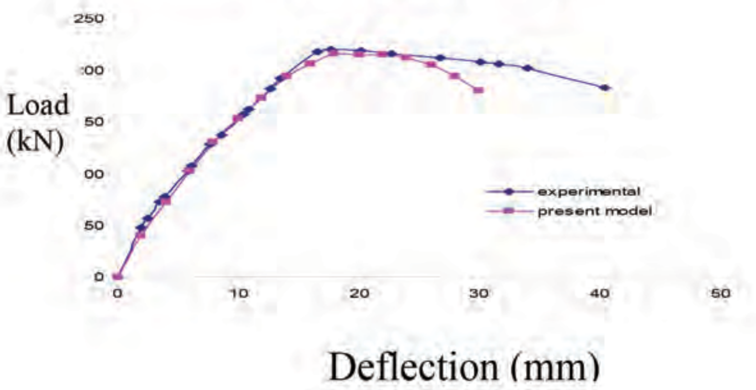
Wing Bottom Skin Panel

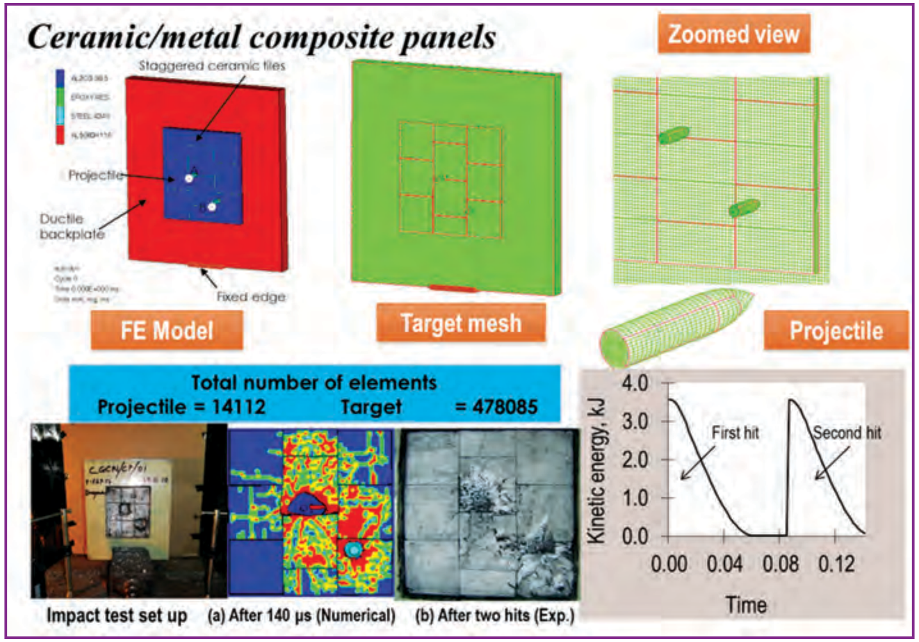
Advanced Analytical Tools for **Performance Assessment of RC Structures / Components**

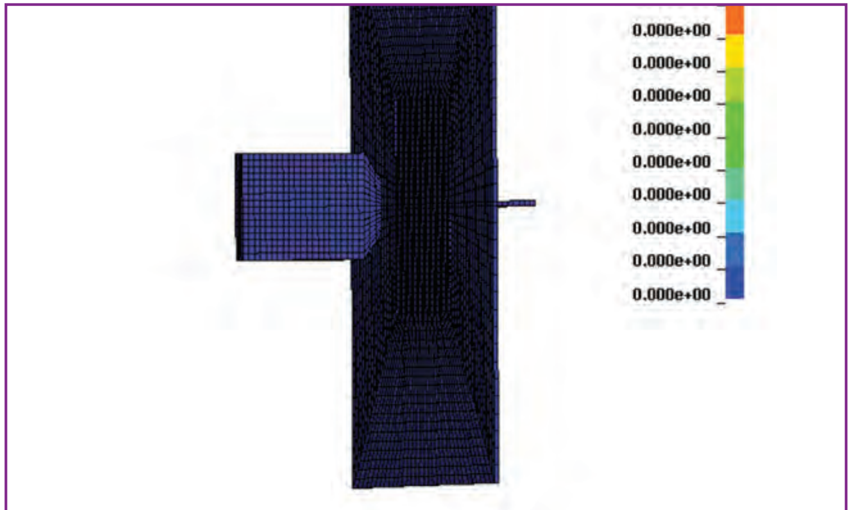
- Composite layered approach with smeared reinforcement
- Reinforcement is modelled as bilinear material with strain hardening



Multi-layered shell element



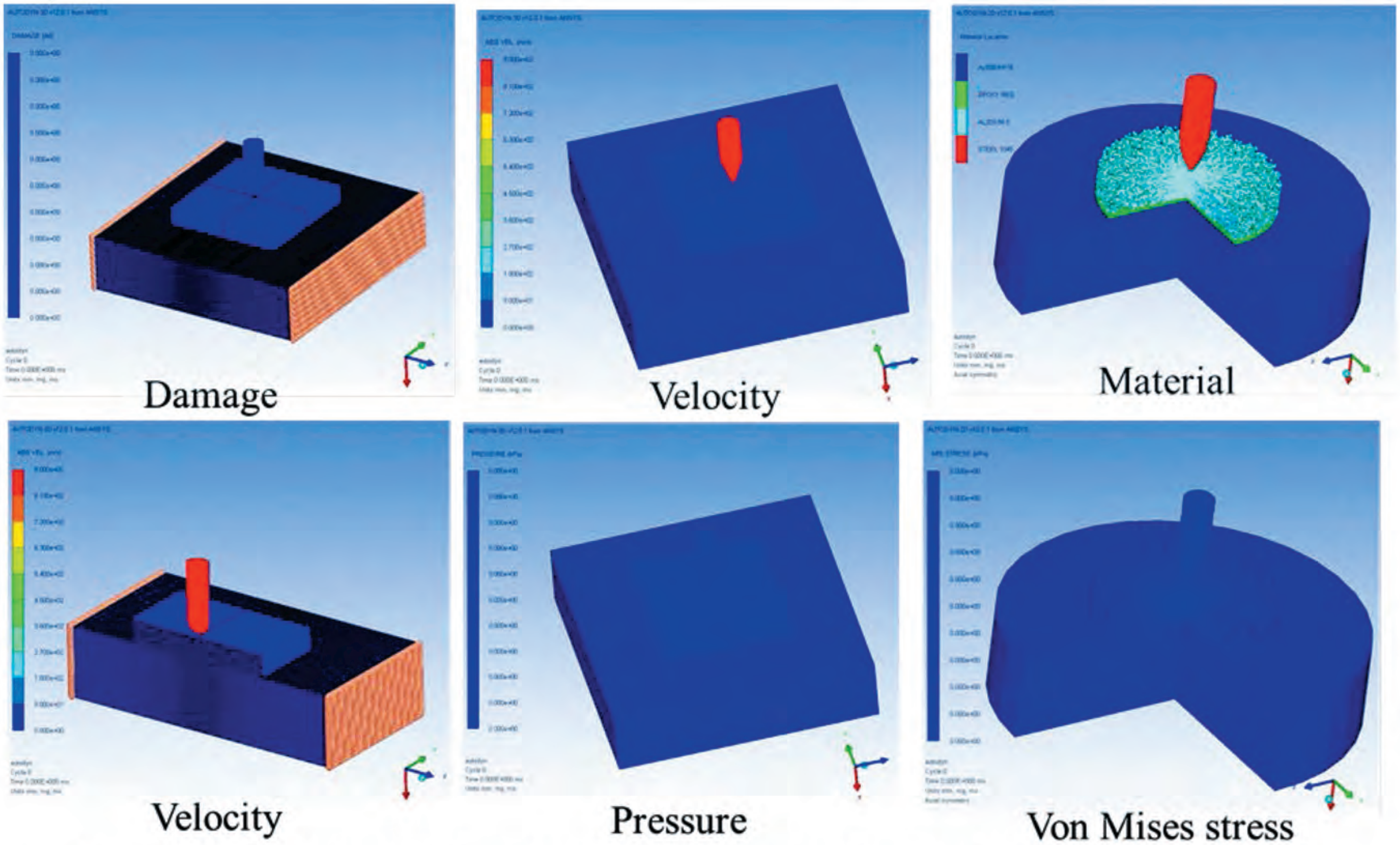




Penetration of Stiffened Plate

ANIMATION

SPH simulations



Spalling and fragmentation phenomenon are simulated using meshless method

INTEGRATED SOFTWARE FOR Analysis and Design of Towers

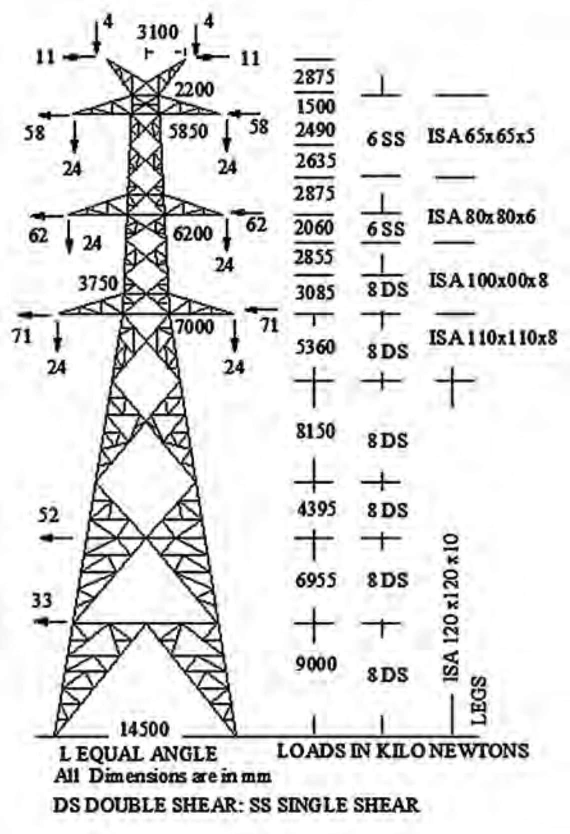
Features:

- User-friendly Program
- 3D Visualisation
- Incorporated several bracing patterns
- Single angle, star angle, plus angle, tubular sections (CHS, SHS,RHS)
- Automatic Wind load calculations as per IS codes, BS code
- Automatic Design as per IS codes, BS Code, AISC code

Type of Towers

- Roof-top tower
- Ground-base tower
- Delta tower
- FM Tower
- Lead-in-light tower
- Telescopic tower
- Angular tower
- Tubular tower
- Hybrid Tower
- Triangular tower
- Square tower

Finite Element Model



Configuration of 400kV DC "A" type tower

CONCRETE
Technology and Products

Distressed Concrete Structures - Repairs and Rehabilitation

A comprehensive methodology has been developed for investigation of distressed concrete structures in order to formulate recommendations for appropriate and economical repair and rehabilitation. This is a unique capability of this laboratory which has been applied in a large number of cases of distressed structures that have been referred to this Centre.

Different types of buildings and other structures investigated include, framed buildings of institutional and industrial type, power plant structures, such as, Turbo Generator Pedestals, Mill Block Foundations, Coal Crusher Foundations, Chimneys and Cooling Towers, Harbour Structures, Bridges, Water and Liquid retaining structures, and Monumental and historical buildings. The Centre has advised on rehabilitation or repair of more than 65 buildings and other structures located all over India.

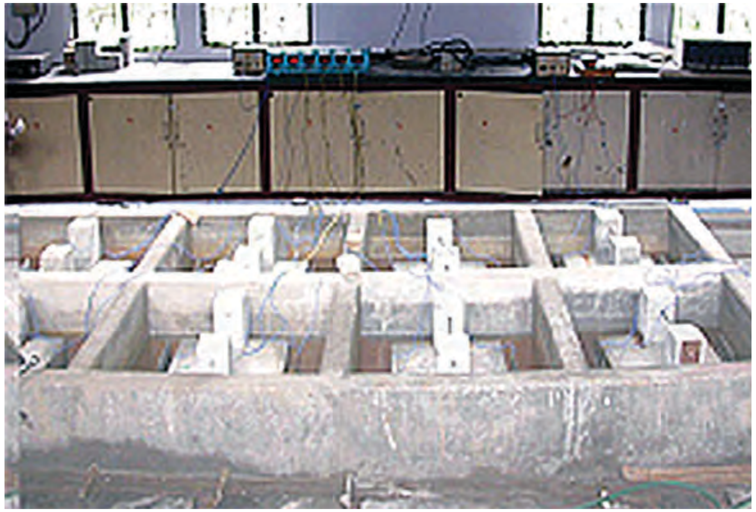
The in-situ testing expertise has also been applied to evaluate the quality of newly built structures as part of overall quality assurance measures for the construction industry.

Corrosion-affected Concrete Structures

While there could be several causes that may be contributing to distress and deterioration of concrete structures, affecting their durability, corrosion of reinforcement has been recognised as one of the major and menacing problems. Based on field investigation covering physical, chemical, and electrochemical properties of concrete, as well as on extensive data created through in-house R&D, this Laboratory has established a comprehensive methodology for condition assessment, monitoring, and evaluation of service life of corrosion-affected concrete structures. R & D experiments have been carried out on the following aspects of reinforcement corrosion.

- Effect of cover thickness and bar diameter on cracking due to corrosion
- Behaviour of reinforced concrete beams affected by corrosion with regard to strength and serviceability limits
- Effect of corrosion on bond between reinforcement and concrete
- Accelerated electrochemical method for determination of diffusion coefficient of different types of concrete with regard to chloride ions

- Methodology for estimation of initiation time for chloride-induced corrosion based on Fick's law and in-situ chloride measurement
- Evaluation of performance of concrete coatings and corrosion inhibitors using polarisation methods in the laboratory.



Pull-out specimens under accelerated corrosive conditions

HEARTBEATS

"I enjoyed a highly interesting visitation in CSIR-SERC, with a visit to most of the laboratories. The impression the visitor gets is that in this institution a group of highly skilled and dedicated researchers is working in an excellent working environment including the good food in the guest house. Congratulations to all achievements and special thanks to the Director, Dr. N. Lakshmanan."

Friedemann Wenzel, University of Karlsruhe, Germany

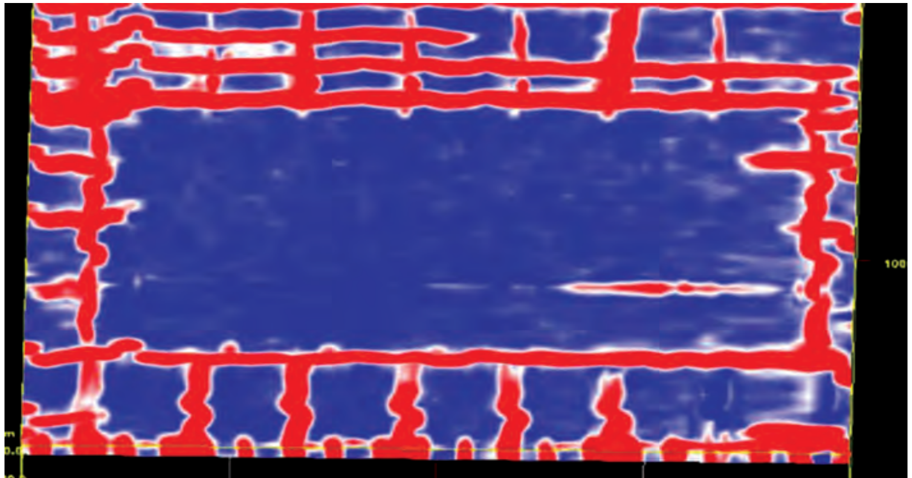
NON-DESTRUCTIVE Testing & Evaluation [NDTE]

Non-destructive testing of concrete structures is one of the essential tasks for estimating or assessing quality. As of now, the rebound hammer and the ultrasonic pulse velocity tests are being used for assessing the quality and integrity of concrete. Advanced non-destructive test methods such as Ground Penetrating Radar (GPR), Impact Echo and Ultrasonic Pulse Echo are being implemented at CSIR-SERC as for applying to reinforced/pre-stressed concrete structures. In order to validate these methods and to study their capabilities in detecting various parameters, a unique large-scale reinforced concrete specimen was cast at CSIR-SERC.

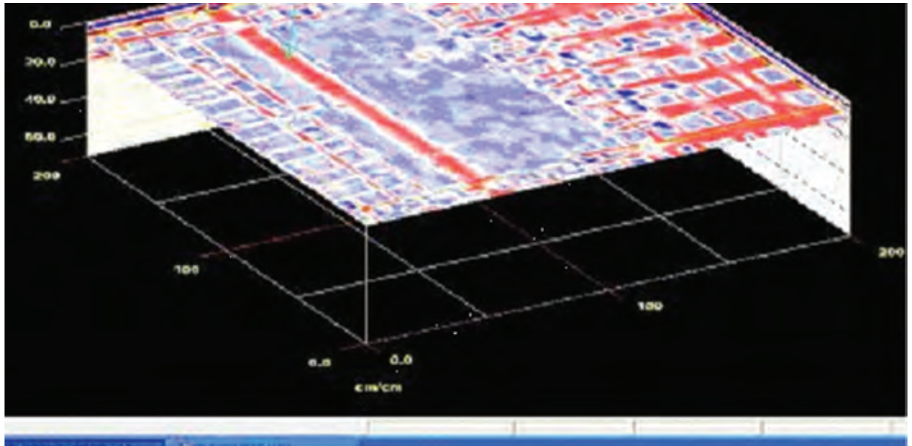
Large-Scale Test Specimen

Measurement with 1.6GHz antenna

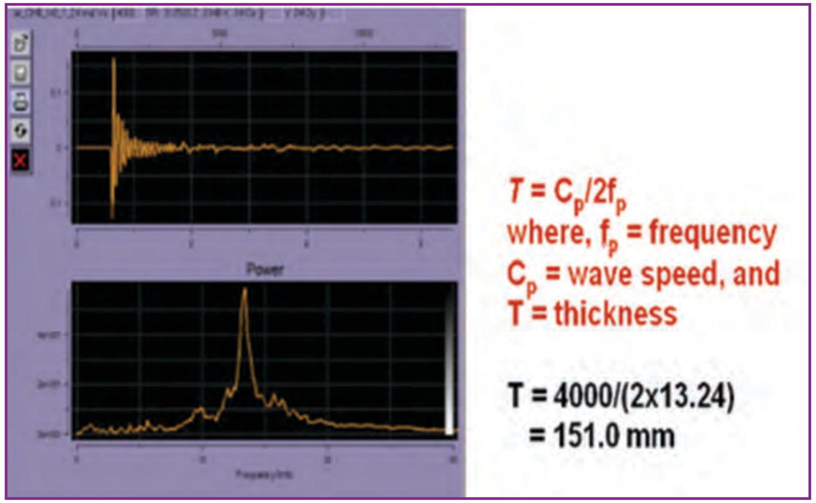
The figures below show the C-scan, which give the reinforcement details by the radar method and is comparable to the reinforcements provided. The presence of steel box and the PVC pipe is seen.



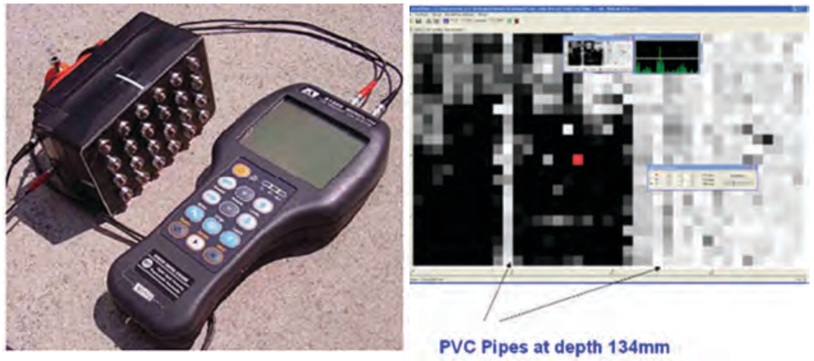
C-scan at 45mm form top face



C-scan at 70mm from top face

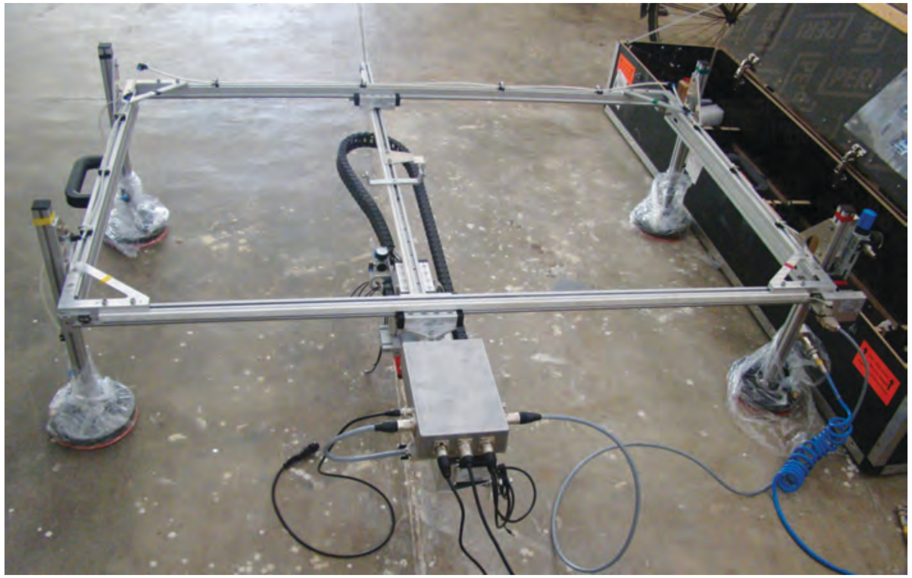


Wave form and frequency spectra - Impact Echo Method



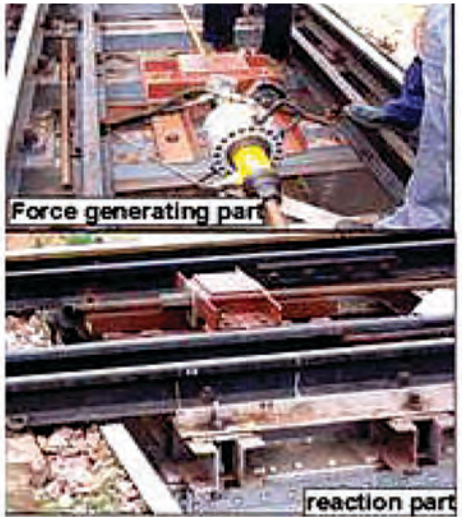
Typical Ultrasonic Pulse Echo Equipment and Measurement (C-Scan)

Automated Scanner



Performance Evaluation of Prototype Steel & Concrete Bridges

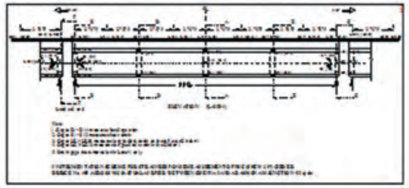
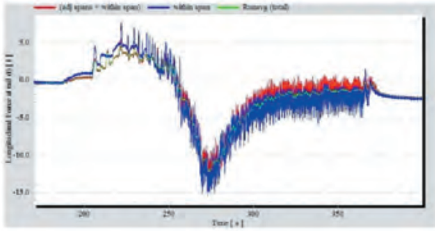
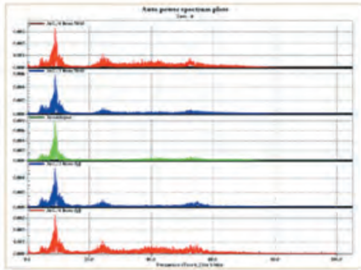
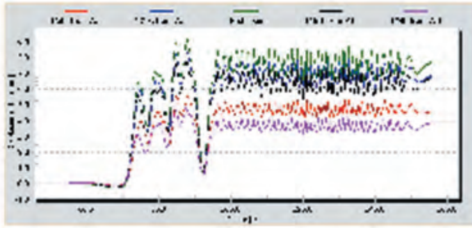
- Railways require advice on performance of existing bridges under increased axle loads of iron ore.
- CSIR-SERC, Chennai conducted static and dynamic tests on number of typical railway bridge spans.
- The test train (Two front locos + 58 BoxN wagons with CC+8+2T + Brake van + rear loco) was run at different speeds
- A unique methodology to calibrate / validate the technique adopted to determine the longitudinal force has been evolved







Full-scale testing and evaluation of
HIGHWAY & RAILWAY BRIDGES


Different Bridge Types

DYNAMIC STRAIN MONITORING using flat jack

HEALTH MONITORING & Safety Audit of Structures

- Many infrastructural facilities in India are old and need attention
- Repair & rehabilitation - CFRP, GFRP wraps techniques Beam-Column joints - Improved joint detailing
- Various repair schemes proposed
- SERC developing remote structural health monitoring techniques to monitor many facilities/structures concurrently and suggest measures wherever necessary

Reinforcement Details for Concrete Jacketing

Micro Concrete

Instrumented Sensors in the Box Girder C

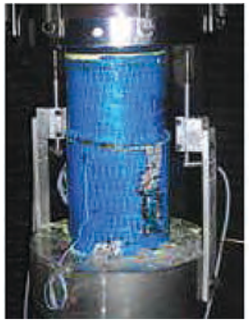



Deflection monitoring using Total Station

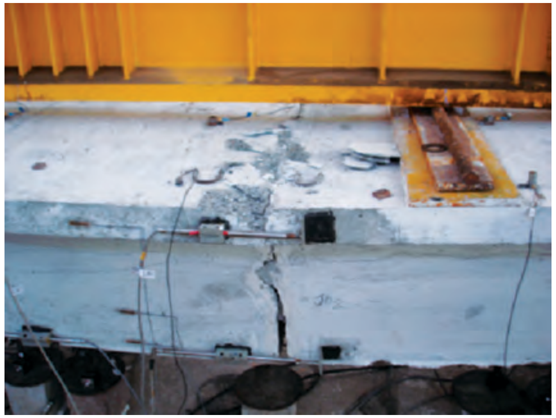
Forced vibration testing on the bridge using multiple shakers


Corrosion of tower leg member

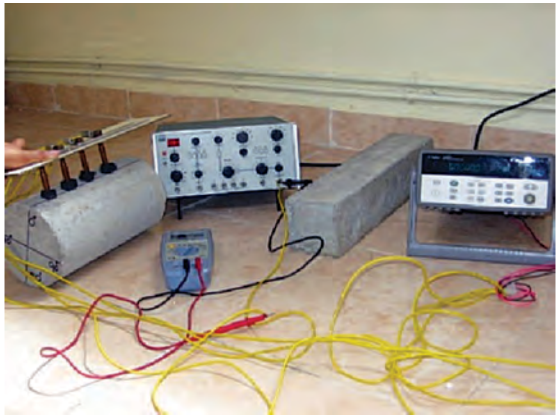
Failure pattern of FRP wrapped cylinder




Static test up for epoxy jointed segmental box girder



Specimen at failure load



Forced vibration testing on the bridge using multiple shakers

Fatigue investigation for structures exposed to aggressive environment

FATIGUE & FRACTURE STUDIES of Structural Components

AREAS OF EXPERTISE

Among the major structures which have been acknowledged as being prone to fatigue crack problem are aerospace structures, bridges, offshore platforms, ships, welded rails, cranes, earth moving and handling equipment, impellers, machine parts in manufacturing and processing plants and, piping systems in power plants. This situation has thrown up great challenges for design engineers who are required to deal with complex structural forms, new materials and joints and, jointing techniques for the purpose of evolving appropriate design of such structures. For example, offshore tubular joints are not only subjected to fatigue loads but are also exposed to harsh / corrosive environmental factors.

CAPABILITY HIGHLIGHTS

The centre has built up considerable R&D capability and knowledge on several aspects of fatigue and fracture mechanics of structures and structural components. These include:

- Fatigue behaviour and fatigue strength evaluation of structural, automobile and other components
- Corrosion fatigue life estimation of structures and structural components both under freely corroding conditions and with cathodic protection
- Stress concentration evaluation by employing finite element analysis
- Fracture mechanics studies for evaluating stress intensity factor and fatigue crack growth in structural components
- Techniques for improvement of service life of components subjected to fatigue loads
- Static strength and fatigue behaviour evaluation of new materials by testing under load, displacement and strain control
- Remaining life estimation and life extension methodologies
- Assessment of existing structures to determine damage / serviceability including remaining life evaluation, suggestions for repair and requalification for continued operation.

HEARTBEATS

"I am delighted to be here and see the activities that are taking place here. I am thankful to everyone here for their contributions to atomic energy programme. I wish all of you all success in your respective endevours. My compliments to you all."

Anil Kakodkar, Chairman, AEC, India

Industry Interaction

Several investigations have been carried out on fatigue and fracture behaviour of structural components such as welded steel tubular joints of offshore platforms, including corrosion fatigue and remaining life evaluation of tubular joints of a Bombay High platform using fracture mechanics approach, studies on thermit-welded rail joints, leaf springs, axles and piston rods of earthmoving equipment, oil field chains, micro-fatigue crack development for leak simulators in power plants, investigation of steel tubular Tee junction and elbows of the primary heat transport system, fracture behaviour of circumferentially cracked straight pipes, and evaluation of new types of reinforcement bars under static and fatigue loading for application to concrete structures.

A close-up of the instrumentation during ratcheting test

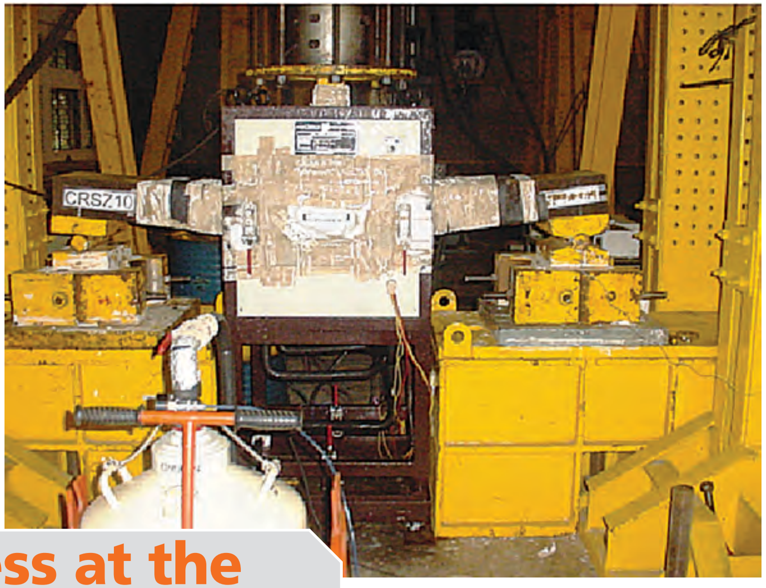
Achievements in Fatigue and Fracture Studies on Structural Components and Materials

Large-scale experimental investigations on structural components, in the area of fatigue and fracture, are being carried out at the Fatigue and Fracture Research Laboratory of SERC. Some selected R&D studies of specialised nature carried out in the laboratory in the recent months include fracture studies on piping components with through-wall notch under internal pressure, fracture studies on carbon steel pipes at elevated temperature, fracture studies on cruciform specimens at sub-zero temperature, ratcheting studies on a stainless steel pipe subjected to internal pressure and bending, application of beach marking technique for fatigue crack growth measurement in steel plate specimens and fatigue life evaluation of a tyre curing press.

HEARTBEATS

"It was a most enlightening experience visiting the labs and seeing the activities here. It makes me very proud to be part of this organisation. I hope that my visit will help me serve you better."

Rama Murali, Financial Advisor, CSIR, New Delhi, India



Tests under progress at the Fatigue & Fracture Laboratory

TRANSMISSION & Communication Tower Systems

The R&D topics of study relating to towers and tower-like structures at CSIR-SERC may be listed as:

- Structural analysis of
  - Hybrid towers
  - Guyed towers
  - Chainette towers
- Development of minimum weight/cost design of towers
- Development of design for UHV and EHV transmission towers
- Analysis of tower behaviour and buckling strength of members
- Development of design guidelines
  - for use of hollow sections for towers
  - for joints and connections of hollow steel sections
- Investigation of effects of tolerances in fabrication and erection on tower behaviour
- Development of rational design criteria to ensure safety
- Risk Assessment of Power Transmission Line Towers under severe Climatic Conditions and Ageing

HEARTBEATS

"It was an excellent presentation. You are on a good way. Thanks!"

Lothar Stempniewski, Universitat Karlsreche, Germany

"Thank you for your invitiation. We are deeply impressed by the excellent work you have done in scientific research especially for the software you have developed by yourself."

Han Qiu Shi, Beijing Institute of Machinery , People's Republic of China

Tower Testing

The TTRS conducts full-scale testing of prototype towers for tower manufacturers and user organisations. The main loads acting on transmission line towers are due to wind, weight of conductors, snow load (where applicable) and self-weight. Towers should also be safe against snapping of conductors, and for dead-end conditions. In general, all the three components of loading (transverse, longitudinal and vertical) may be present at any loading point. The maximum height of tower that has been tested so far is 80m (microwave tower) and the heaviest tower tested was with a self-weight of 65t.

HEARTBEATS

"Structural Engineering Research Centre is doing an excellent job in the field of Structural engineering. Like other fields, the field of construction is also undergoing transformation. There is thus a need to update the practices that are presently incorporated in this field. Search never ends and one can learn from other areas including the foreign countries, whatever good is there. I hope SERC will not lag behind in continuing to update its area of work by incorporating what is good elsewhere and in the interest of users."

C. Ramachandriah, MP and Chairman, Standing Committee on Science and Technology, Environment and Forests

TYPES OF Towers / Structures Tested

GFRP - Steel Hybrid Towers for Power Transmission and Communication

- Electrically insulated and sustainable materials like Glass Fiber Reinforced Plastic materials (GFRP) are being studied for its suitability in latticed masts like power transmission and communication towers
- Detailed studies on the mechanical properties of Pultruded GFRP structural sections are carried out
- Compression and tensile behaviour of GFRP structural sections under wind and other loads are evaluated

24m Communication tower

X-braced panel

400/220kV DC line from NPCL Station at Nandikur near Mangalore and 400/220kV Station at Shantigram near Hassan, Tension Type"dd (30°-60°)/0°-15°" Dead End + 6m Body Extn.

- Development of guyed tower systems Portal type, V-type
- Emergency restoration system Transmission line tower rehabilitation
- Monopole towers Large cross arm deformations

PERFORMANCE EVALUATION OF **Transmission Line Towers for Overseas Clients**

CSIR-SERC Chennai's Tower Testing and Research Station facility has carried out such tests for Locwel, Inc. Canada; Oman Electricity Transmission Company, Oman; Ethiopian Electric Power Corporation, Ethiopia; Tehran Regional Electric Company, Iran - during 2009-10

HEARTBEATS

"I would like to express my deepest appreciation for the wonderful hospitality I received. My most sincere congratulations for the outstanding activities that are carried out in this facility. It was a special inspiration for me and it represents a model to be looked at. I wish we may find a common ground to share our experiences on research subjects of mutual interest."

Carlo Lai, EUCENTRE, University of Pavia, Italy

"I thank Dr Nagesh Iyer the Director of SERC for accepting to be host of my C.V.Raman Fellowship for Africa in India. I also appreciate the excellent arrangements made by my host scientists, Dr. G.S.Palani who made tireless efforts to make sure the objectives of the visit are well full filled. The same is with other staff of SERC. SERC has excellent facilities and achievements in Structural Engineering by any standards in the area of testing and research. Let this be the beginning of research collaboration between Tanzanian Institutions with CSIR-SERC."

Dr. Ing Joseph Msambichaka, Mbeya Institute of Science and Technology, Tanzania

WIND ENGINEERING & Wind Tunnel Studies

Aerodynamic design of cyclone shelter by CSIR-SERC deployed along the east coast of India

Wind Tunnel Studies on large and complex structures including Interference Effects

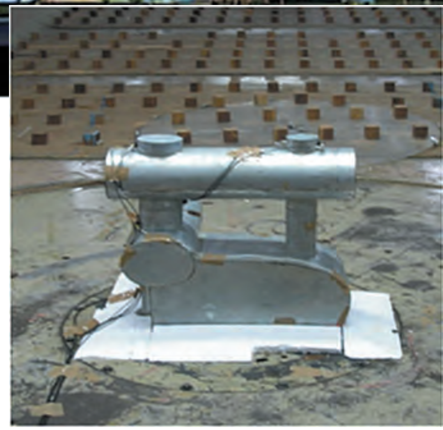
- Cluster of cooling towers, surrounded by Power House Block, ESP building, Bunker building and Chimney
- Magnitudes of wind-induced Pressures and Drag Force dependent on Wind Direction
- Recommendations given to account for enhanced effects due to surrounding structures which vary with angle of incidence, azimuth angle and elevation level

"It was a pleasure indeed to visit SERC. Breaking into new horizons is normal in a research institution. But what impressed me more was that the sight to higher objective was never lost while achievements came rolling in. It is this spirit that makes for inspiring leadership."

B.P.Singhal I.P.S. (Retd.), MP

HEARTBEATS

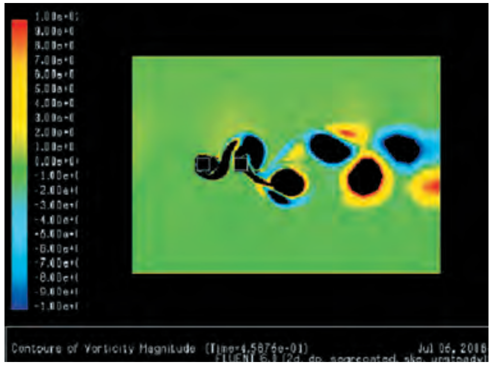
ONGC Office Building, Kolkata



Aero Elastic and Aero dynamics Studies on a Complex Tubular Building Model in Boundary Layer Wind Tunnel (BLWT)

- One of the four green buildings by ONGC (Kolkatta)
- Tubular Complex 3-D Building of height 100 m with a horizontal length of 113m
- 5 Elliptical + 1 Paraboloid building components having 3 frequencies <1.0Hz indicating significant dynamic response due to wind
- No standard procedures available; no Codal provisions for DESIGN PARAMETERS

- Unique design solutions are provided based on BLWT experimental investigations
- Design procedures are made simpler by giving CRITICAL WIND ANGLES
- Human comfort is verified by analysing Tip acceleration at the top of the structure



Recent investigations

- **Interference effects**

  Cooling towers, chimneys, prisms

- **Pressure measurements**

  Tall buildings, bridge pylons and the like

- **Sectional models (static / dynamic)**

  Bridge cross-sections

- **Dynamic response of wind turbine blades**
- **Computational fluid dynamics**

HEARTBEATS

"Excellent structural and wind engineering research facilities. Research staff are very friendly and committed to doing some excellent research in many useful areas... My best wishes!"

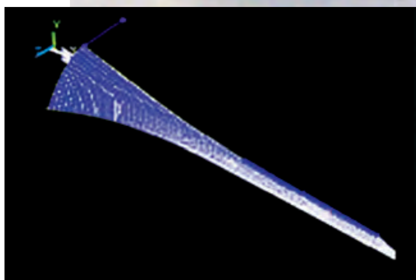
M. Mahendran, Assoc. Prof., Queensland University of Technology, Brisbane, Australia

DEVELOPMENT OF 500kW low-cost horizontal axis wind turbine (NMITLI)

Under the prestigious CSIR New Millennium Indian Technology Leadership Initiative (NMITLI) project scheme, development of 500kW low-cost horizontal axis wind turbines has been undertaken with NAL, Bangalore, and Sangeeth Industries, Coimbatore, as collaborating institutions.

- Evolution of a comprehensive indigenous methodology and creation of design data base for the development of low- cost technologically-advanced wind turbine specially suited for the Indian wind environment and a 500kW wind turbine installed and commissioned at the Sangeeth Wind Farm, Coimbatore District, to gain operational experience






EARTHQUAKE-RESISTANT
Structural Design

Cost-effective Earthquake-Resistant Construction System using Reinforced Hollow Concrete Block Masonry (RHCBM)

IN THIS CONSTRUCTION SYSTEM:

- Building is constructed using structural grade (M20) hollow concrete blocks
- It is reinforced with steel bars that are taken from foundation through the hollow spaces of the block at regular intervals, and in addition horizontal reinforcement is also provided at critical locations as per the design. The vertical reinforcement is taken into roof/floor slabs to achieve integrity
- In-situ concrete grout is placed in the hollow spaces to form concealed columns
- This reinforcing technique enables the building to behave as a three dimensional structure, to effectively resist the earthquake/cyclonic loading

APPLICATION AND USE:

- This construction system can mitigate the ill effects of natural disasters, such as earthquakes and cyclones

RAW MATERIALS:

- Building materials including cement, sand, aggregate, steel reinforcement bars and the like.

Machinery / Equipment:

- Hollow block making machine, concrete mixer m/c, and other construction tools.

Minimum economic unit: 500sq.m

Total investment: 500 sq.m. x ₹ 2,186 = ₹ 10,93,000/- (Estimated rate per sq.m. to be Rs1,286/- at the rates prevailing in 1977, has been increased accounting for escalation in prices and 5% interest increase per year)

Technology Transfer methodology:

By training and demonstration to the Trainers of the trainees at CSIR-SERC campus, Chennai, or by suitable arrangement

Product acceptability:

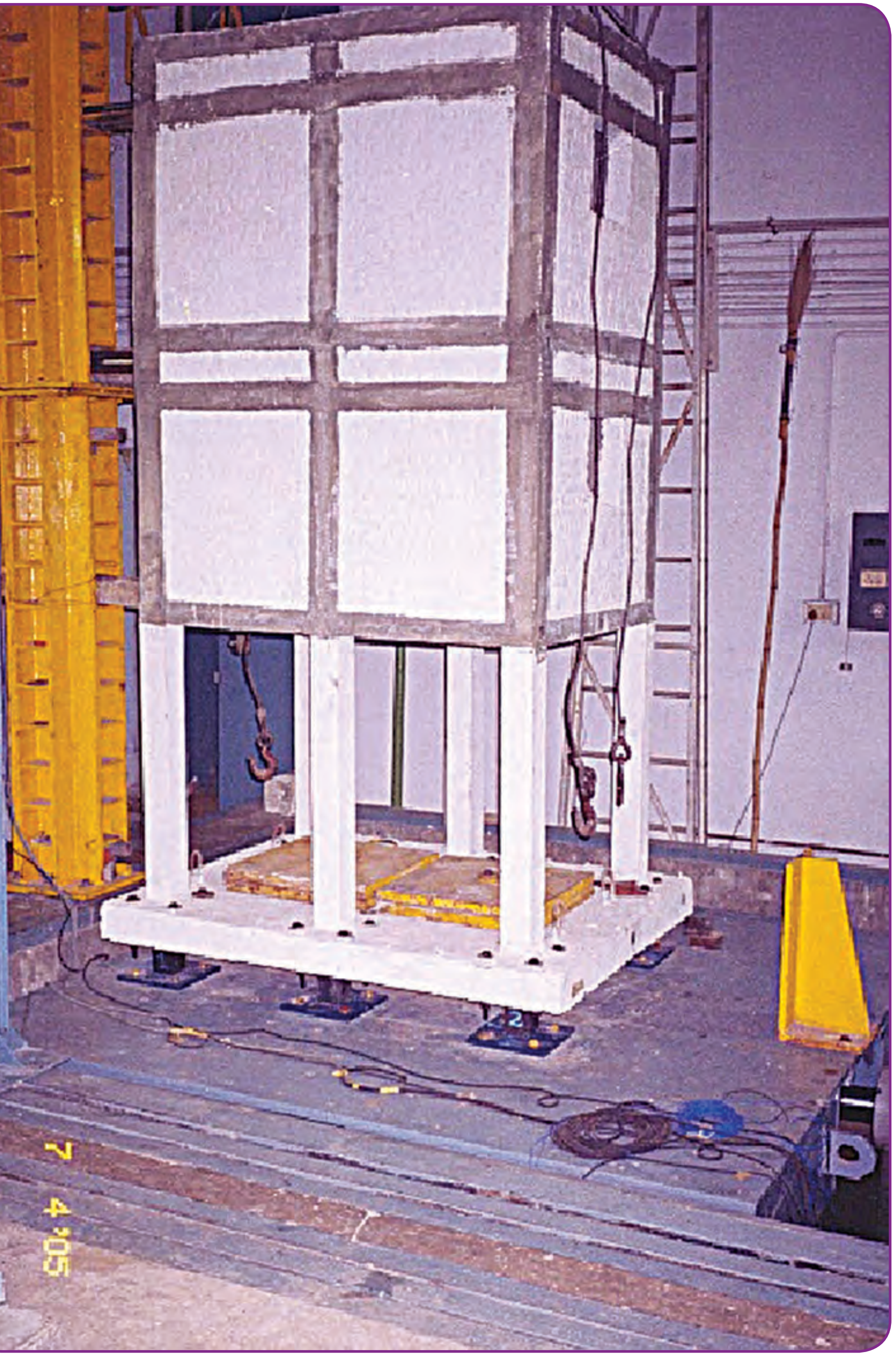
- This technology has shown tremendous product acceptability due to increasing occurrence of earthquakes in our country

Marketability:

- As our Indian government has proposed 1.4 million dwelling units to be built per year in the rural areas, its marketability can be estimated as 1.4 lakh units per year.

- Seismic performance evaluation of buildings
- Push over analysis, testing
- Base isolation
- Development of rubber-based isolators; Shake table tests

- Passive energy dissipation devices; X-Plate, visco-elastic; shape memory alloy
- Seismic retrofitting Techniques, feasibility; Beam column joints, improvements to detailing
- Dynamic testing of full-scale structures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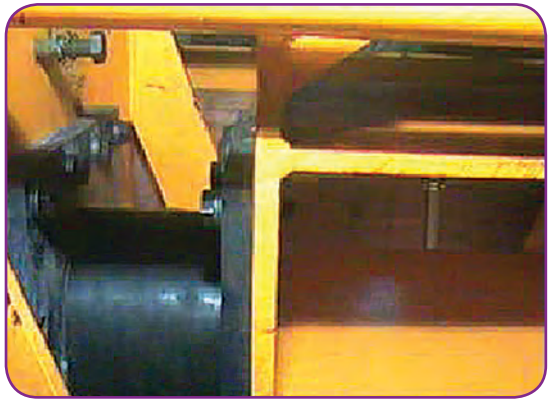
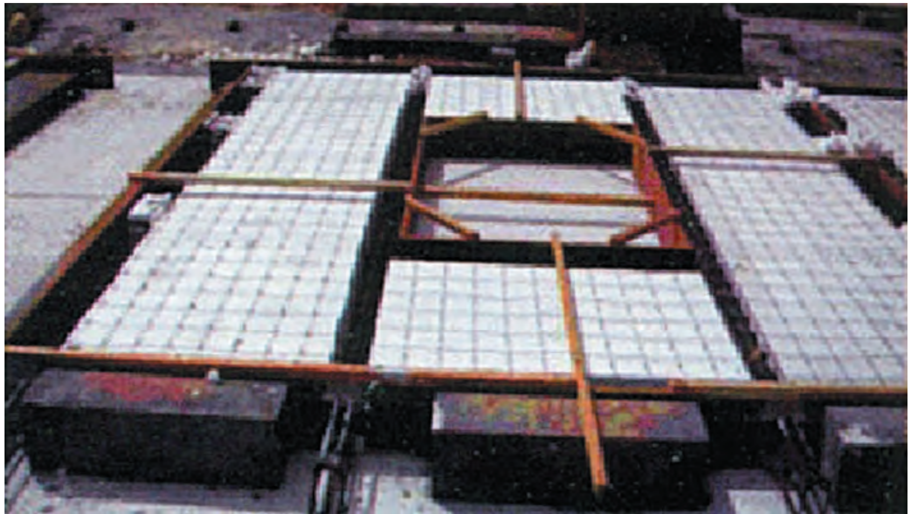


DEVELOPMENT OF SEISMIC-RESISTANT & Energy-Efficient Prefabricated Building System

- Developed high performance innovative prefabricated building system for low and medium rise concrete buildings.
- A (G+1) prototype building was assembled and investigated under earthquake motion of 0.08g 0.16g 0.24g 0.36g corresponding to maximum considered earthquake of the expected PGA of structures situated in Zone-II, III, IV and V respectively and 0.50g (IS 1893-2002) and 0.50g with high frequency seismic input.

The structure has withstood the maximum earthquake loads successfully. This study clearly indicates that this prefabricated lightweight wall panel building can be effectively used as seismic- resistant building

Wall Panel with window opening being shifted



Wall panel with window opening ready for casting of outer concrete wythe

HEARTBEATS

"The R & D work going on in SERC Chennai is very much inspiring. All scientists are working hard, and thereby contributing for the national economy. I am sure that by joint efforts the vision 2020 will be achieved. I wish all success."

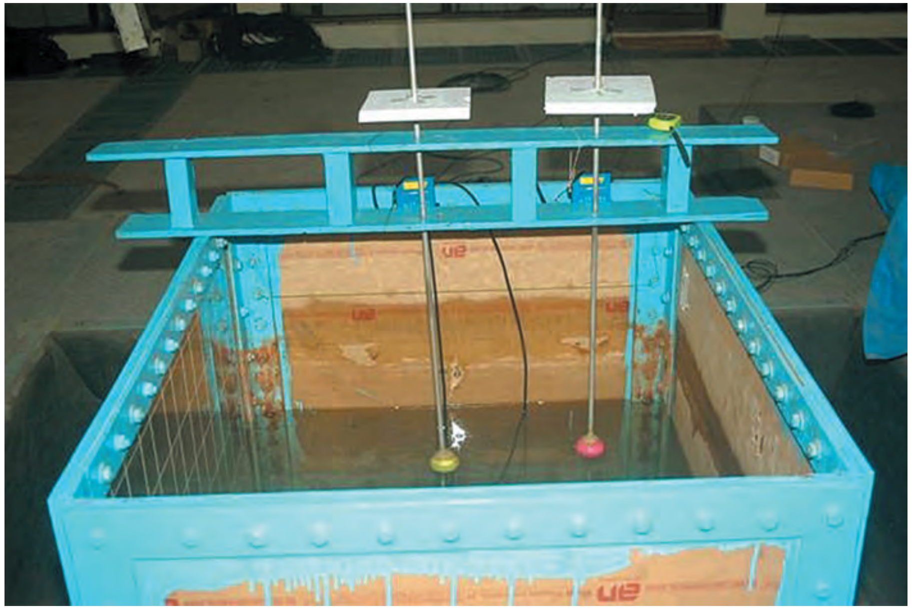
Bachi Singh Rawat, Minister of State (S & T), Govt of India

"I am impressed by the excellent work in SERC and am particularly happy to see the synergistic interaction with DAE originated a long time back that strengthening rapidly now. I wish SERC the very best in the future."

R. Chidambaram, DAE-Homi Bhabha Professor, BARC, Mumbai, India

SEISMIC PERFORMANCE
Evaluation of liquid storage tanks

- Seismic safety of liquid-filled containers is of great concern
- Seismic design of liquid storage tanks requires knowledge of sloshing frequency of liquid, the wave amplitude and hydro dynamic pressure distribution on tank walls
- CSIR-SERC has undertaken these studies with 6-Degrees of Freedom seismic Shake Table
- Sloshing probe has been developed indigenously
- For external input acceleration of 0.1g, the maximum observed acceleration inside liquid was 0.95g



"It was wonderful to be here once again and witness inauguration of the Seismic Shake Table Facility. I am sure, with the strong expertise in structural analysis that exists here, this facility will take contributions of SERC to national development to significantly higher level with the availability of such a facility. My compliments to everyone associated with this facility.."

Anil Kakodkar, Chairman, AEC, Mumbai, India

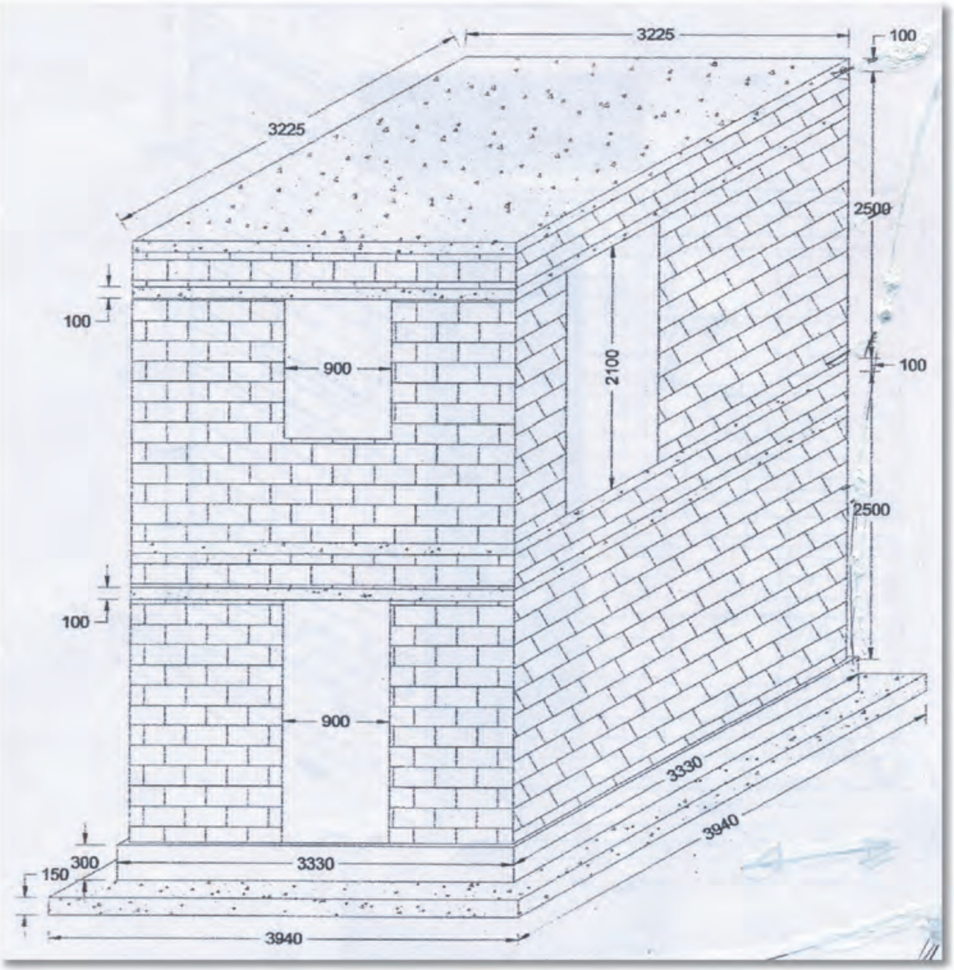
"Small things make perfection, But perfection is no small thing." Every time I visit SERC, I am reminded about the continuous pursuit for perfection and excellence and more importantly, the kindness, the concern, and hospitality. Thanks!"

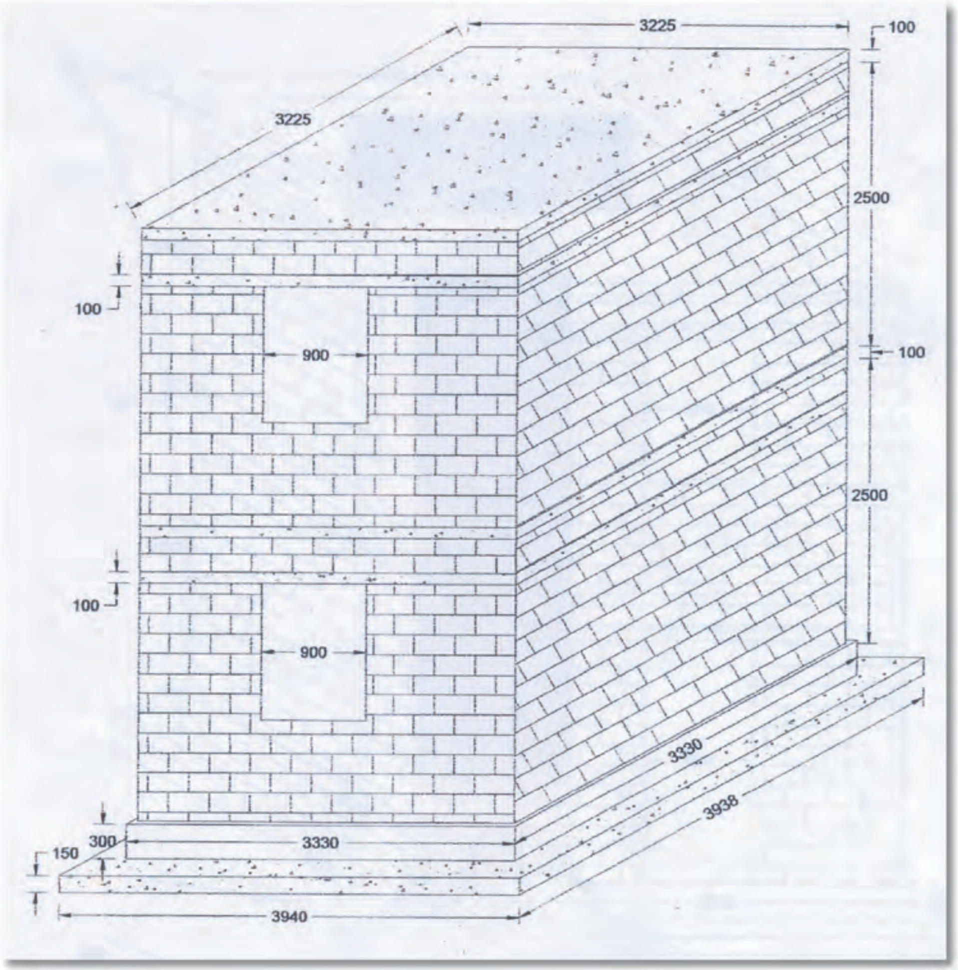
D.V.Reddy, Civil Engineering, Florida Atlantic University, Boca Raton, USA

"SERC has a very talented team and world class facilities. I wonder why we did not visit earlier but better late than never. We can look at a very long term relationship in the interest of the country."

M.S. Rana, Director, Konkan Railway Corporation Ltd., Navi Mumbai

SHAKE TABLE STUDIES ON **Brick Masonry Buildings Retrofitted with Polyfunctional Textile**



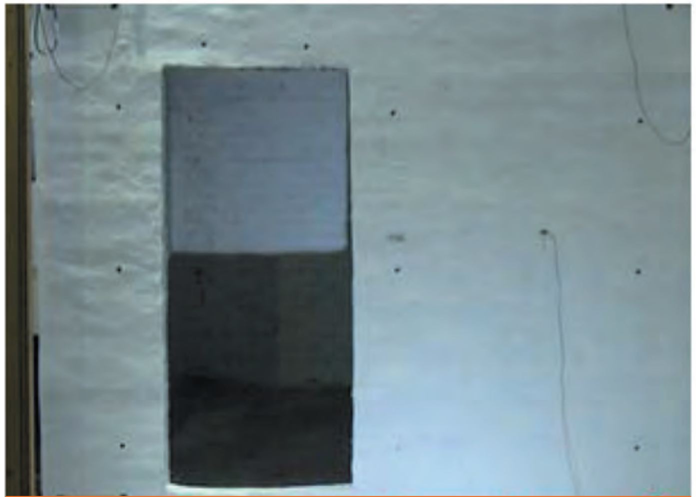


Elevation of Brick Masonry Building

Instrumentation

Acceleration pickups and non-contact laser-based displacement sensors

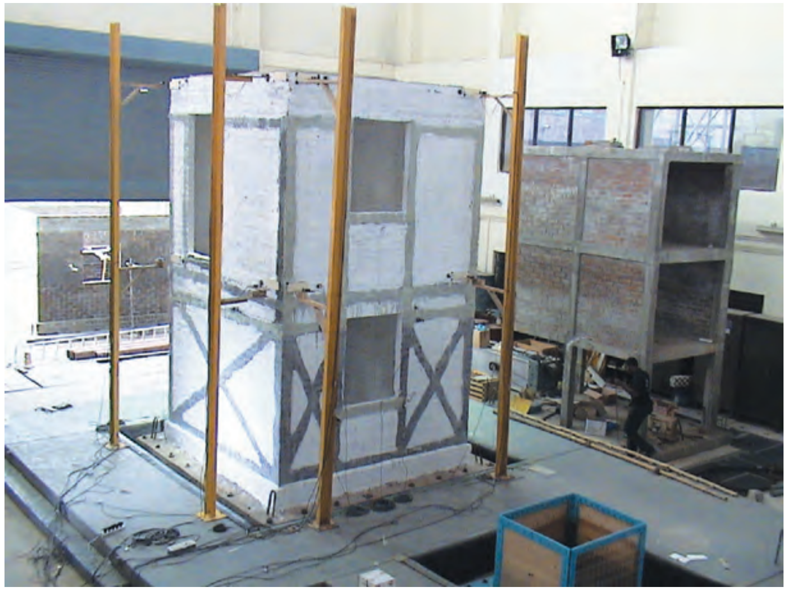
Strain gauge-based sensor system for measuring the crack opening



Markers on the test structure, for displacement measurement from image processing

High-speed video camera

BUILDING MODEL
ready for experimentation

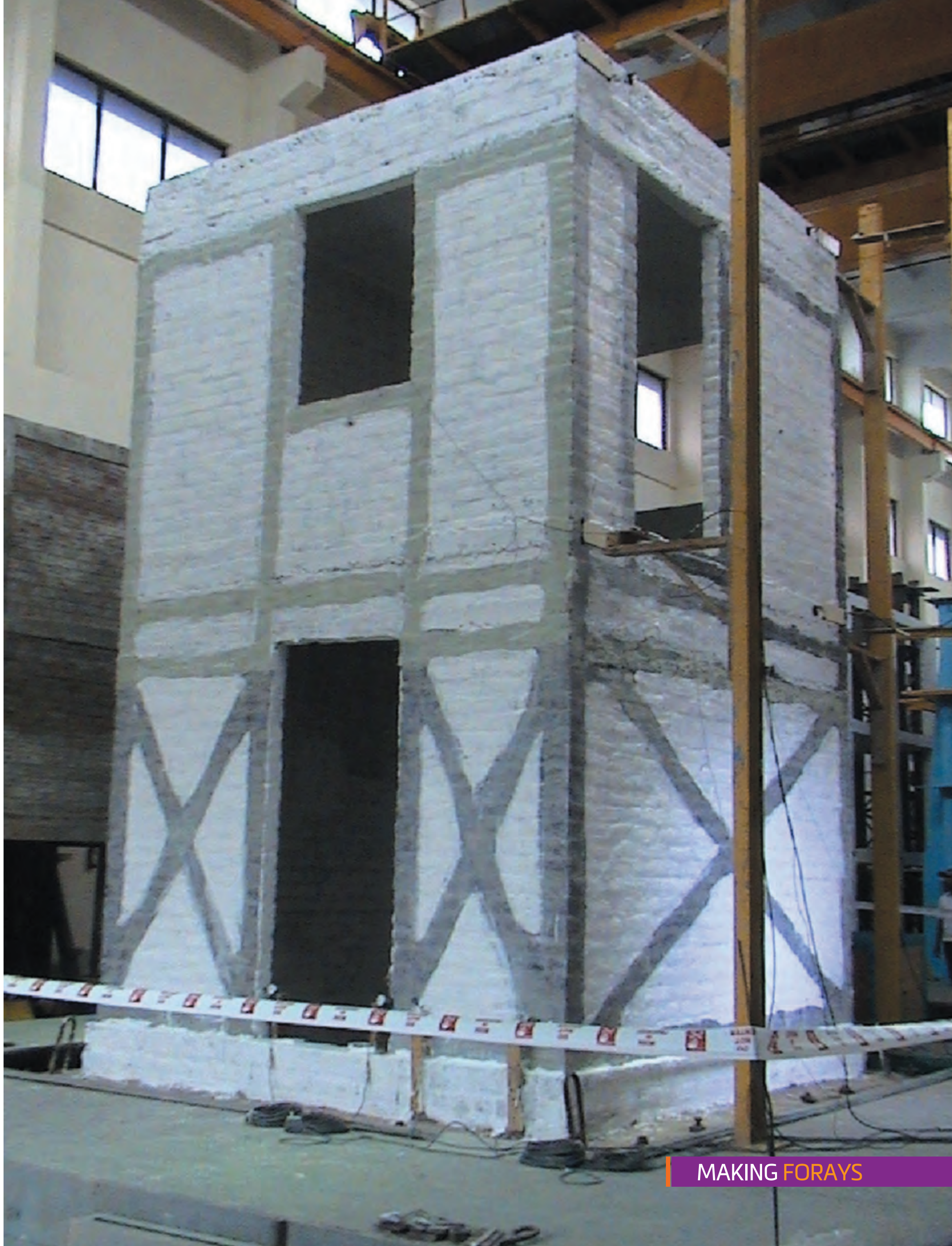


"It was a pleasure to visit SERC. I find the variety of projects the care in their execution and the quality of the personnel extremely impressive. It is evident that the institution enjoys the leadership of a very progressive and knowledgeable director. I wish the best to SERC!"

Armen Der Kiureghian, Taisei Prof. of Civil Engineering, University of California, Berkeley, USA

"A very educative and purposeful visit to the institute. The work underway is both relevant and impressive. Greatly impressed with the commitment and enthusiasm of the scientists and the wonderful facilities they have managed to create. My very best wishes!"

U.L.Chopra, Planning Commission, New Delhi, India



EXPERIMENTAL Observations (exterior walls)

Sliding type of failure through the horizontal bed joint, at plinth level - View 1

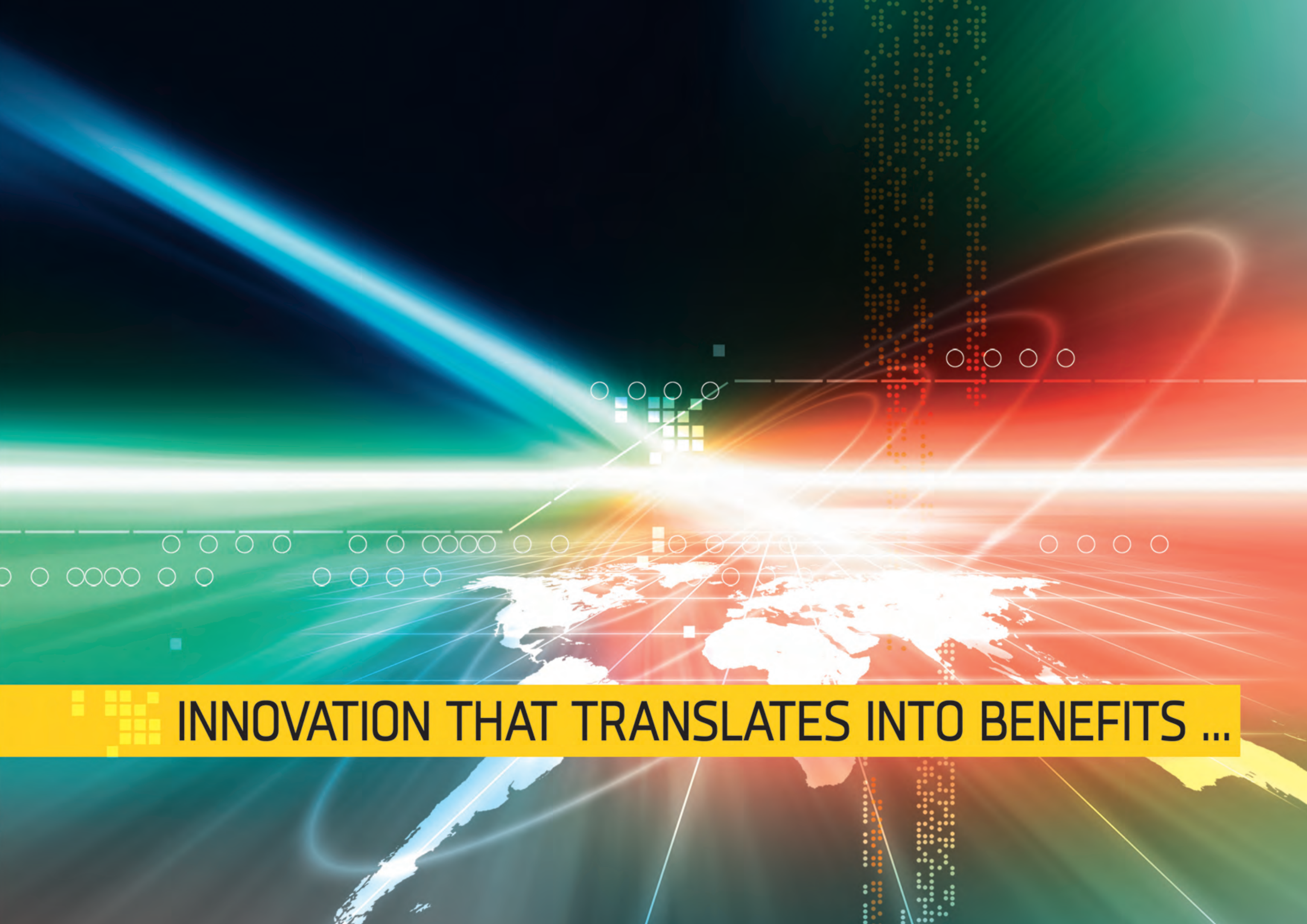
Corner separation due to out-of-plane bending

Sliding type of failure through the horizontal bed joint, at plinth level - View 2

Sliding type of failure through the horizontal bed joint, at lintel level

Effectiveness of retrofit

breaking free from the mainstream



INNOVATION THAT TRANSLATES INTO BENEFITS ...

Novel and innovative solutions for STRUCTURAL ENGINEERING CHALLENGES

PREAMBLE

CSIR-SERC has been in the forefront in providing innovative/novel and cost-effective solutions/services to the challenging problems faced by industry or society in related fields. It has also contributed immensely in the strategic sector through highly creative/innovative and just-in-time solutions.

As a service centered R&D institution, CSIR-SERC provides solutions that are usually specific and unique to an industrial problem. The impact value and the benefits accrued to the society are huge. Thus, these solutions have not only entailed large direct benefits and savings but also invaluable and huge indirect savings to the industry - public and private sectors, society and strategic sectors that cannot be directly measured.

These challenges are selected to highlight the impact - direct and indirect. CSIR-SERC has provided out of the box solutions to the problems posed. Some of the grand engineering challenges are:

- High-Strength Deformed Bars
- Re-Engineering of The Navigational Span of Pamban Railway Bridge for Broad Gauge Conversion
- Remote Structural Health Monitoring & Evaluation - THE CSIR-SERC SOLUTION
- Boundary Layer Wind Tunnel Studies on Industrial Power Plant Structures and High Rise Buildings of Complex Shapes
- Creation of Heavy-Duty Structures for Astar Laboratory
- Performance Evaluation and Innovative Methodology for Evaluation of Railway Bridges
- Use and Design Of SIFCON/Alternative Material for Use in Underground Reinforced Hardened Shelters
- Blast-Resistant Design of Explosive Storage Structures
- Engineered Green and Sustainable Materials of Construction
- Development of Seismic-Resistant and Energy-Efficient Refabricated Building System
- Shake Table Experiments
- Deomonstration Building
- Appropriate Solutions to Strategic Sector
- Probabilistic Seismic Hazard Atlas
- Laced-Steel Concrete Composite System

High strength deformed bars for
CONCRETE REINFORCEMENT (1966-70)

CSIR-SERC carried out a number of studies for the development of High-strength deformed bars for concrete reinforcement at the instance of the Committee on "Savings in Structural Steel through Standardization" set up by the Ministry of Steel and the Planning Commission Panel on "Economies in Construction Costs".

Economic advantages are :

- Saving in steel can be as much as about 40%
- Slender sections will become possible
- Less congestion of steel and,
- Improved bond leading to a more even distribution of cracks in the structure.

Tests confirmed that cold-worked Grip bars produced by TISCO in collaboration with the CSIR-Structural Engineering Research Centre are as good as bars produced abroad. The most distinctive feature of the Grip bar is its excellent performance in bond when tested in accordance with IS 2770-Part I-1966 "Method of Testing Bond in Reinforced Concrete Pull-out Tests". The results show that Grip bars have a bond strength which is a little over 200% of that of mild steel bars of the same diameter at a free end slip of 0.25mm.

For this pioneering contribution, CSIR-SERC received the Import Substitution Award of the Board on Awards of FICCI with the citation **"For Developing Indigenous Knowhow For The Manufacture Of Grip Bars For Concrete Reinforcement."** The patent on Grip Bars made over to the Tata Iron & Steel Company for commercial exploitation fetched a royalty of ₹ 1,00,000 during the year 1970. [At 2014 rates, the cumulative royalties earned from this single license for CSIR during the period 1970-1984 would roughly amount to a whopping ₹ 3 crore!]

Ultra High-Performance Fibre-Reinforced Concrete for REPAIR AND RETROFITTING APPLICATIONS

The main advantages of this system are:

- Increase in flexural strength
- Higher ductility
- Significant energy absorption
- Simple and easy to adopt
- Speedier construction

Wide application in bridges, power plant structures, heritage structures and such others

The flexural behavior of RC beam retrofitted with Ultra High-Strength Cementitious Composite (UHSCC) overlay has been investigated for possible application in the domain of repair and retrofitting of RC structures. A set of RC beams have been tested up to failure under four point bending. Some RC beams have been preloaded up to 60% and 70% of the ultimate load of RC beam. The strengthening of preloaded RC beams has been carried out using UHSCC overlay, attached beneath the tension face of the damaged beam. The thickness of the overlay is kept as 10mm. The bonding between the damaged beam and the UHSCC layer is made using epoxy resin and their thickness is maintained as 3mm. For 70% preloaded RC beams, the overlay is provided throughout the span of the beam and in the constant bending moment zone whereas for 60% preloaded RC beam, the overlay is provided only in the constant bending moment zone. Strengthened beams have been

RC BEAM WITH UHSCC OVERLAY

tested under four point bending load. During testing, the parameters such as load, deflection, cracks, failure pattern have been monitored. From the investigations, it is noted that (i) the ultimate load carrying capacity of all the preloaded strengthened beams is higher compared to control beam (ii) the ultimate load carrying capacity of 60% preloaded strengthened beam where strengthening is only in the constant bending moment zone is approximately 10% larger compared to control beam (iii) the deflection corresponding to ultimate load for all the beams is more or less same as that of control beam. Higher energy absorption and ductility has been observed in all the strengthened beams.

Ultra high-performance fibre-reinforced concrete is a potential candidate for repair.

Fibre-reinforced concrete products are environmental-friendly and cost-effective in many applications. Thin layers of ultra high-performance fibre-reinforced concrete for repair and retrofitting of structures will bring in economy.

CONTROL RC BEAM

FAILURE BEHAVIOUR RC BEAM WITH UHSCC OVERLAY

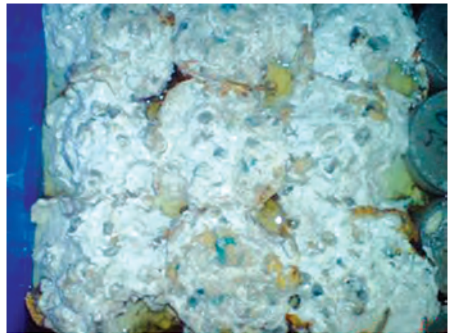
Self Compacting Concrete (SCC)

- Concrete that readily flows into every corner of a formwork and gets compacted by gravity without the need for vibration
- Applications: structures with innovative geometries and congested reinforcements

Laced Reinforced Concrete (LRC)

LRC provides reinforcement in both strut and tie directions leading to large ductility

- Very high flexural rotation capacity (up to 80 without fibres)
- Suitable for blast-resistant structures and explosive storage buildings
- Fibre-Reinforced LRC provides excellent ductility and energy absorption under cyclic shear loading



RESEARCH ON NEW MATERIALS

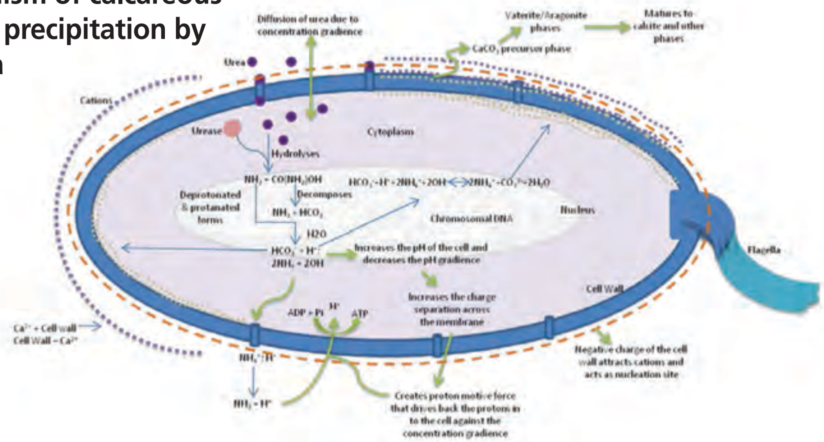
DEVELOPMENT OF NEW ENGINEERED AND SUSTAINABLE CONSTRUCTION MATERIALS

Research and development in concrete composites have led to several new formulations achieving superior strength and impermeability characteristics compared to conventional cement concretes. Development and application of these concrete composites for the construction of special as well as general structures, besides development of materials and techniques for repair and rehabilitation of structures, are the main objectives of the Advanced Materials Research laboratory. It is manned by highly qualified scientists and well-trained technicians with specialised knowledge in:

- Design, development, and testing/ evaluation of new as well as conventional concrete composites
- Development of concrete products with enhanced durability properties against corrosion of steel, sulphate attack, chloride ingress and other hostile environment
- Application of new materials such as stainless steel and non-metallic reinforcements for special structures
- Development of building blocks from different kinds of soils and industrial wastes
- Development of designs suitable for blast and shock resistant buildings and structures
- Evaluation/characterisation of building materials, concrete admixtures, repair materials
- Design of concretes for special requirements - such as high performance concrete (HPC), self-compacting concrete (SCC), ultra High performance fibre reinforced concrete (UHPFRC), reactive powder concrete (RPC), slurry infiltrated fibrous concrete (SIFCON), structural grade geopolymer concrete (GPC), latex modified cement concrete (LMCC) and laced reinforced concrete (LRC)
- Assessment of distress in RCC buildings and structures through in-situ testing, chemical analysis and strength evaluation, and providing expert advice and suggestions for repair / retrofitting.
- Geopolymer Concrete - Eco-friendly, fast setting and durable
- Ultra High Performance Concrete - High strength, light weight and ductile
- SIFCON - Thin structures, high energy absorption and improved ductility

Concrete Evaluation with BIO-MINERALS

Mechanism of calcareous crystals precipitation by bacteria



Curing medium	Designation
Control	C
Normal water	NC
Luria bertania broth	LBC
Waste water	WWC

Cell concentrations: 106 and 108 (cells/ml)

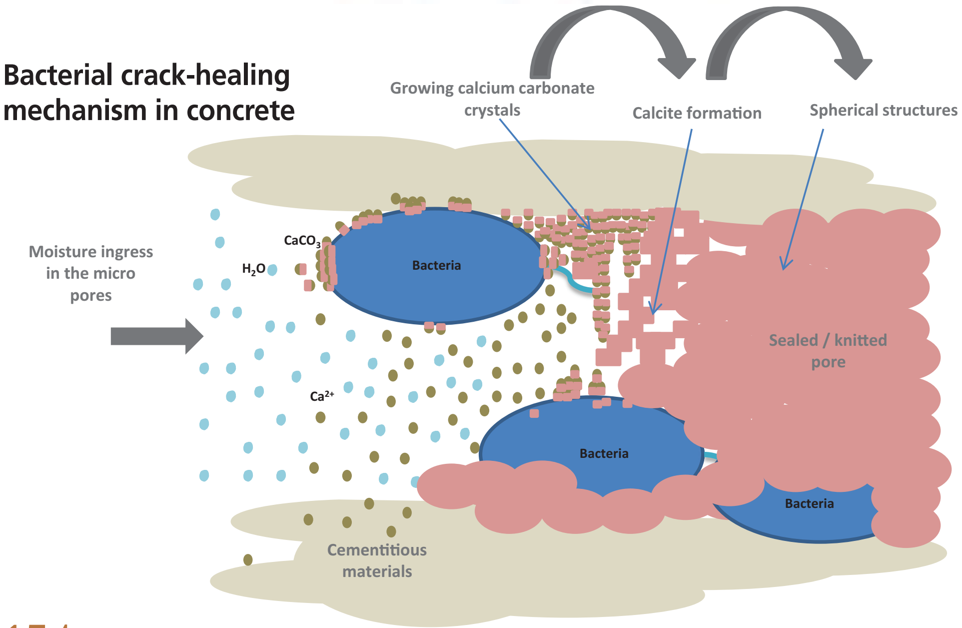
Cement mortar cubes 70.6mm

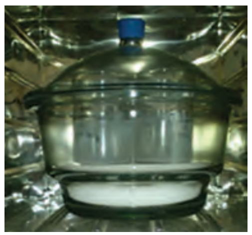
Cement: Sand 1:3

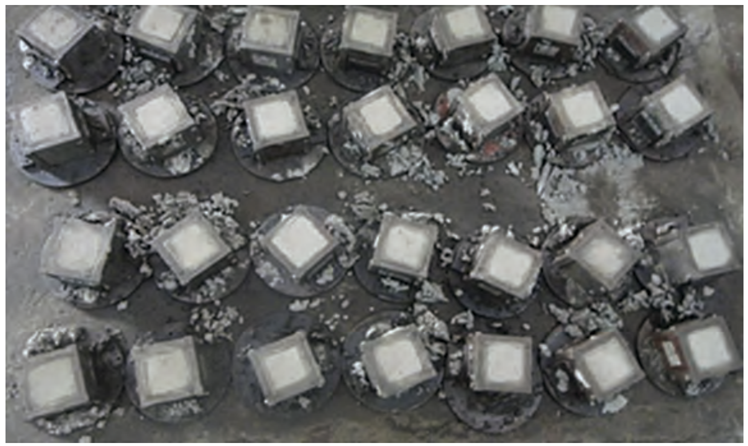
Water to cement ratio 0.39

Consistency and Setting time			
	Consistency %	IST(min)	FST (min)
Control	30.5	215	420
Bacterial cement	29.0	230	450

Bacterial crack-healing mechanism in concrete

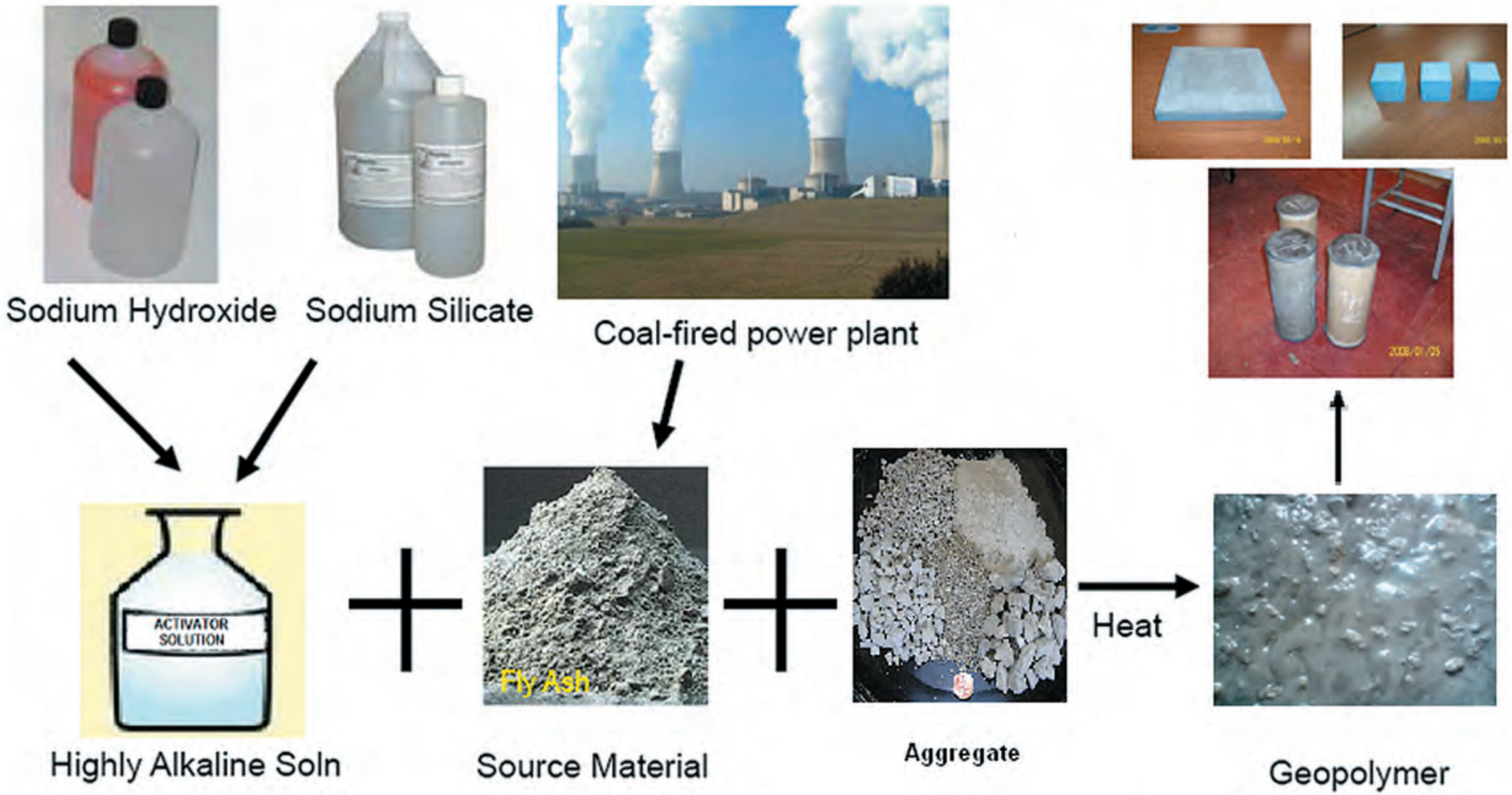


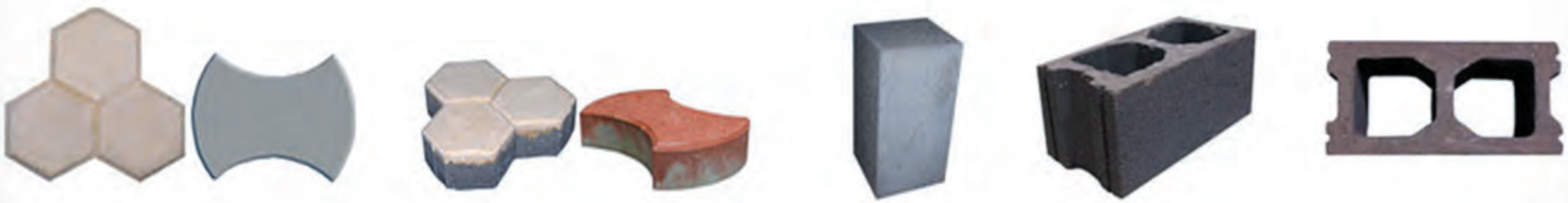




Technology for geopolymer

CONCRETE BUILDING / PAVER BLOCKS

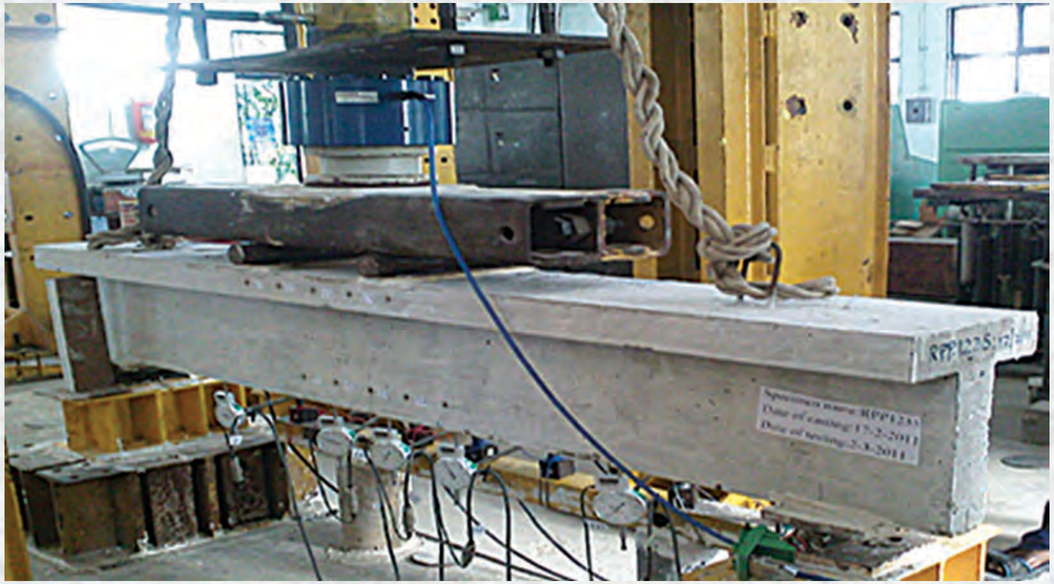




A wonder material without cement!

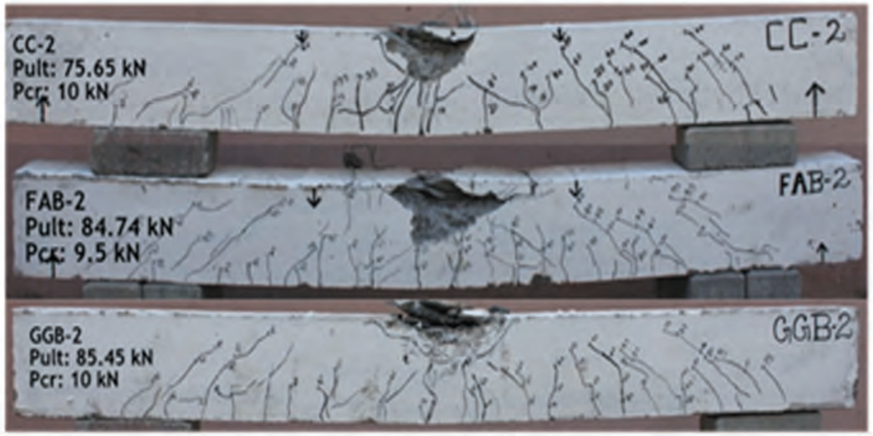
STRUCTURAL-GRADE
Geopolymer Concrete (M20 to M150)
Products

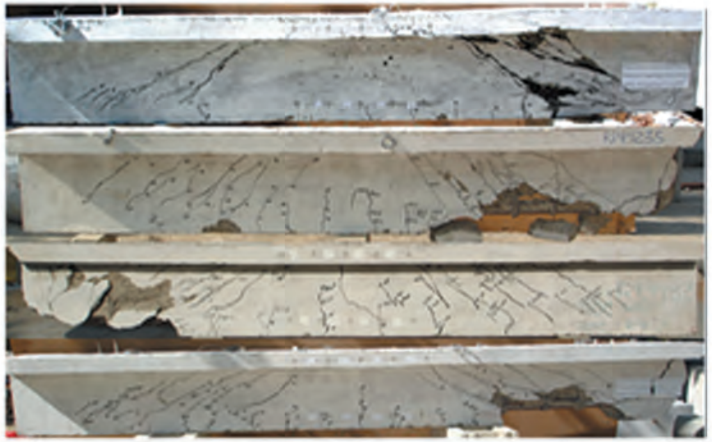
- Concrete Structures - buildings, bridges, dams and such others
- Complete replacement of cement in concrete with cementitious materials such as fly ash and slag
- Laboratory-level / Long-term behavior and durability are being studied.
- Geopolymer concrete products are environmental-friendly
- Technology is presently available for commercialization, however keeping in mind the importance of civil infrastructures, long term behaviour and durability is being studied.
- Cost at par with cement based concrete
- Mix design as per specific client requirements can be provided

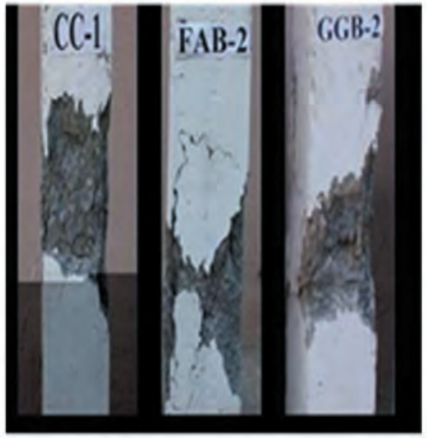


REINFORCED
GPC Beams and Columns

- Reinforced GeoPolymer Concrete (RGPC) beams were subjected to flexural and shear loading. The behavior of RGPC speciments were satisfactory and matched or exceeded the performance of corresponding OPC beams in terms of ultimate moment capacities.
- The cracking and service load momets were lower (10-30%) compared to OPC beams while the post yield ductility was somewhat lower.
- Crack patterns and failure modes of GPC columns are similar to those of OPCC columns but they show lower buckling strength and greater lateral deflection.







SELF-COMPACTING CONCRETE
UNDER-REAMED PILES

Self-compacting concrete under-reamed piles are ideal as foundations for buildings in black cotton soil or other similar types of expansive soils, filled up ground, soft strata and the like. It is generally difficult to assure the structural integrity and achieve uniformity of cross sectional area of under-reamed piles using conventional concrete. Necking, pockets of honey-combing and variability in the dimensions of shaft and bulbs are some of the problems that have been encountered in practice during construction of under-reamed piles. Generally, under-reamed piles are cast by dropping concrete down the borehole and hence there is a risk of concrete segregating and getting blocked against the sides of the reinforcement cage. In a pile that is badly made there may be a reduction of the shaft diameter or there may be voids and cavities in the concrete of the shaft and in many instances the bulb which increases the bearing capacity of the pile is not formed. Further, improper or insufficient compaction not only results in inhomogeneous, non-uniform concrete but drastically lowers the performance of concrete.

Ensuring proper compaction through appropriate vibrators has been difficult and has led to these problems. Presence of voids and honeycombs not only reduce the load carrying capacity of piles but also lead to corrosion of reinforcement in chloride and sulphate soils. Under-reamed piles obtain support mainly from the adhesion or frictional forces on the surface of the pile shaft and due to bearing forces on the bulb. Hence, the formation of shaft and bulbs plays a very significant role in the load carrying capacity of

View of SCC piles

piles both in tension and compression. In the case of self-compacting concrete under-reamed piles, the load-carrying capacity is higher due to the complete formation of the pile. Self-Compacting Concrete is able to flow freely under its own weight both horizontally and vertically and completely fill the formwork of any dimension and shape without leaving voids. During placement and while flowing, the concrete retains its homogeneity without separation of aggregate from paste or water from solids and without tendency for coarse aggregate to sink downwards through the fresh concrete mass and the pile shaft and the bulbs are well formed.

Conventional piles

Some of the advantages include enhanced productivity due to increased speed of construction, reduced labour cost, improved work environment and increased life of structure due to enhanced durability.

The Self-Compacting Concrete Products are environmental-friendly and cost-effective in many applications.

HEARTBEATS

"1. Excellent structural testing / analysis facilities

2. (DRDO + CSIR) - The core strength of INDIA's scientific - technology should be able to meet the Defence requirements in structures for military applications.

3. Our co-operation should flourish in the days to come."

B. Rajagopalan, Director, R & DE (Engrs), DISHI, Pune, India

"CSIR-SERC Chennai has played a dominant role in setting the pace for pioneering research in Structural Engineering and production of new technology in the country. The organization needs to continuously innovate and create new thrust areas in this sphere. New designs and innovative approaches needs to continually address the concerns of the organization. My best wishes!"

Francis Fanthome, MP (Lok Sabha)

RESEARCH ON NEW MATERIALS

Design and development of alternative construction material (Laced Reinforced Concrete) LRC having high rotational capacity and confinement for explosive storage structures. Developed technologies for construction of green buildings and demonstrated using use of fly ash and slag up to 50-70% for structural applications. Developed synthetic aggregates to replace of natural aggregate using fly ash. Also, developed low-energy inorganic binder system for a Portland cement substitute.

RPC - development of ultra high strength concrete (compressive strength more than 200MPa) with excellent durability characteristics suitable for thin walled structures, long-span bridges and roof structures, nuclear waste containers. SCC - development and demonstration of free-flowing/ pumpable concrete in a highly reinforced structure with high volume of industrial byproduct eliminating vibration, reducing noise and shortening the construction time.

Fly Ash Pelletization

Fly Ash Aggregate of Different Sizes

A view of construction of High Volume Flyash Concrete White topping at CSIR-SERC

ULTRA HIGH-PERFORMANCE FIBRE-REINFORCED CONCRETE (UHPFRC) & REACTIVE POWDER CONCRETE (RPC)

- Use optimized mix of ultra fine siliceous powders, selected fibres, special processing including pressure moulding and curing regime with heat treatment

High compressive strength (150-200MPa), flexural strength of 30-40MPa and fracture resistance - Gf -15-40N/mm

- Application: Long-span bridges, precast sewers / culverts, pressure pipes (upto 20 MPa), cooling towers, facades / kerbs in aggressive environs, anchorage blocks, repair and retrofit, vibration control, machine components

FLY ASH
AGGREGATES

- Conversion of fly ash into aggregates results in large scale utilization of fly ash, a waste product from the thermal power plants.
- Can be used to produce concretes for structures.
- Structural-grade lightweight concrete with a 28-day compressive strength of 30 MPa can be produced using these aggregates.
- Building blocks can be produced using fly ash aggregates

Fly ash is a major industrial waste from thermal power plants. This waste can be converted into aggregates by processing and structural-grade concrete can be produced from these aggregates. The aggregates are almost spherical in shape and contribute towards enhancement of workability of workability of concrete. The aggregates are lighter and more porous in nature having bulk density of about 970kg/m^3 which is about half that of conventional granite aggregates. The apparent specific gravity is 1.52 indicating that they are lightweight aggregates. Due to lower thermal conductivity of these concretes, there is a possibility of reduced energy requirements for air-conditioning of buildings. Fly ash aggregate concretes protect steel from corrosion leading to durable concrete structures. The aggregates being porous in nature contribute to self-curing of these concretes eliminating conventional water curing. Permeability indicating tests such as rapid chloride permeability indicate the satisfactory durability characteristics of this concrete.

The fly ash aggregates are environmental friendly and cost-effective in many applications

Advanced Composite Construction Materials - Process Technologies developed

High performance concrete (HPC) - An innovative cement concrete which increases lifespan of buildings and other structures
Applications - Construction of buildings, bridges, dams etc.,

- High-volume replacement of cement with supplementary cementitious materials like fly ash and blast furnace slag.
- Leads to reduction in green gas emission
- Reduction in the hydration temperatures during initial hydration
- Enhance long-term durability

Full knowledge regarding HPC is available with CSIR-SERC, based on specific client requirement... mix design can be provided.

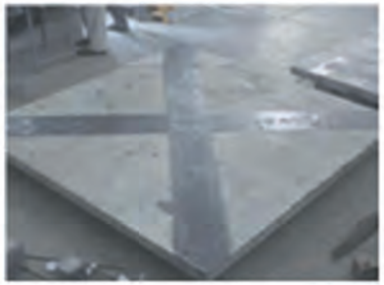
High-performance concrete products are environment-friendly

Synthesis of alternative binder and aggregate / filler / fibre from waste materials

Developed cement free concrete mix of strength 40-150MPa (Geopolymer Concrete)

Techniques for Repair and Retrofitting of Concrete Structures using Non-metallic reinforcement

- Based on Glass Fibre Reinforced Polymer (GFRP) or Carbon Fibre Reinforced Polymer (CFRP)
- High Strength (500-1000MPa), excellent durability in corrosive, alkaline and mild acidic environs
- Stiffness comparable or slightly less than that of steel



- Exhibit linear stress strain behaviour up to failure unlike the bilinear elastoplastic behaviour of HSD rebars
- Ribbed GFRP/CFRP rebars exhibit excellent bond strength comparable to HSD and TMT rebars while plain bars exhibit low bond strength

Geopolymer Concrete Pavement (Green & Eco-friendly)

Laying of GPCC

Wet Gunny Curing

TEXTILE-REINFORCED CONCRETE PROTOTYPING TECHNOLOGY (TRCPT)

An apparatus and process to produce textile-reinforced concrete structural and non-structural components submitted to CSIR for patenting process.

Depending on the resource availability, the textile can be chosen appropriately for various applications to produce textile reinforced concrete.

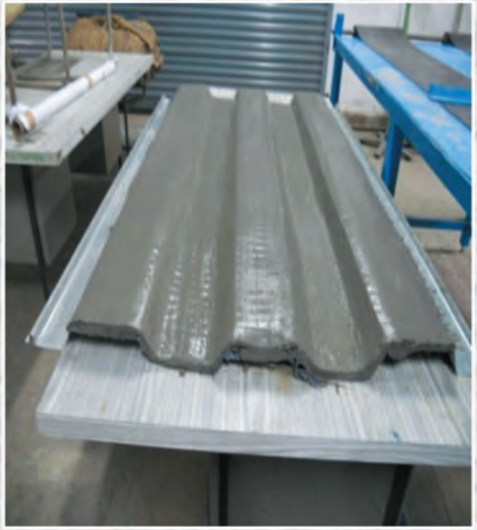
- Technology development: TRCPT consists of an apparatus and a process/technology to produce textile reinforced concrete structural and non-structural components.
- Material development: FABcrete is one type of textile-reinforced concrete that adheres to any existing concrete/masonry structures without using additional anchoring methods/adhesives. FABcrete does not produce any shringage cracks, as commonly seen in many concrete construction. FABcrete is non-corrosive and leads to very filigree construction.

Production of structural and non-structural components of textile-reinforced concrete for rural and urban applications.

- A single technology for producing multiple structural and non-structural components of textile reinforced concrete.
- Both pre-fabricated and in-site applications are possible with TRCPT
- Concrete construction made possible without use of moulds.
- Non-corrosive and hence very filigree concrete construction is possible.
- Different products can be custom-made as per requirement without modification in the apparatus
- Apparatus and method for producing textile-reinforced concrete is developed at CSIR-SERC and the efficiency of the technology and product performance has been proven through research and also thorough in-site practical applications.
- TRCPT can be replicated at any construction site for producing textile reinforced concrete sheets/components
- The textile reinforced concrete products are environmental friendly and cost-effective in many applications.
- Many textile reinforced concrete indigenous products can also be manufactured by processing many natural fibers into textiles as per resource availability

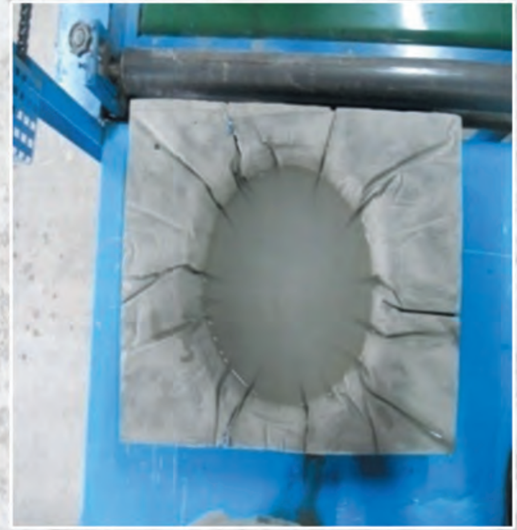
Huge economic benefit possible from technology TRCPT, if used in large scale construction sites to produce various custom made structural and non-structural components of textile reinforced concrete

Various Products using TRCPT



Roofing sheet

Slabs



Wash basin

Manhole cover

Strengthening of beams

Lining of existing damaged canal using FABcrete produced through TRCPT

USE & DESIGN OF SIFCON/ALTERNATIVE MATERIAL FOR USE IN UNDERGROUND REINFORCED HARDENED SHELTERS

Slurry Infiltrated Fibrous Concrete (SIFCON) structural elements possess better properties as compared to their counterparts built using conventional reinforced concrete. The main focus of the study is to throw more light on the design and construction aspects of underground reinforced hardened shelters, using SIFCON. Construction of underground hardened shelter requires prefabrication of various structural components at factory for better quality control.

Novelty / Innovativeness

Use of SIFCON material resulted in complete elimination of rebar and also in significant reduction in the thickness of the shell for construction of underground reinforced hardened shelters.

Achievements

- Both circular and hairpin SIFCON specimens show ductile behaviour.
- The load-carrying capacity of SIFCON specimens is higher when subjected to distributed load when compared to specimen subjected to line loads.
- The ratio of first crack load to maximum load observed was 1.5 to 2 for both circular and hairpin SIFCON specimens.
- All SIFCON specimens developed the requisite number of line plastic hinges to form a mechanism and retained significant loading even with large rotations at the plastic hinge regions.
- Circular SIFCON specimens have higher post peak response when compared to hairpin SIFCON specimens

Circular Specimen under 3-edge load

Typical views of Hairpin specimens under testing

SPECIAL FEATURES

Use of SIFCON material result in complete elimination of rebar and also in significant reduction in the thickness of the shell for construction of underground reinforced hardened shelters.

S&T CHALLENGES OVERCOME

The underground shelters which are subjected to heavy transient blast loading requires suitable material of construction which should possess higher tensile strains, higher energy absorption and better ductility characteristics. To achieve the above requirement, the conventional concrete requires large thickness and heavy reinforcement, which will lead to increased weight and other problems related to handling and erection. This has been overcome by use of SIFCON material and the study has been successfully demonstrated at laboratory level.

IMPACT OF THE DEVELOPMENT

Reduction in cross-section of structural element and non-use of rebars for underground shelters subjected to blast loading reduces overall cost of construction of such structures.

Due to reduction in weight, increased productivity of construction of underground shelters to house the control and command facilities near airports and strategic defense installation, which will effectively work even during war like situations.

HEARTBEATS

"Visitng SERC was an eye opening and exciting educative experience for me. Congratulations!"

N. Vittal, I.A.S., (Retd.)

"Today has been a great learning experience of a day of realization and pride to be FA to this fantastic laboratory of many first's. I wish you many monumental milestones. Best wishes for greater achievements!"

Sheila Sangwan, Financial Advisor, CSIR, New Delhi

Design of a New Profile for the HBJ
Gas Pipeline at the Narmada Canal Crossing

Objectives:

- Design of new profile for lowering the gas pipeline while in service

Challenges:

- To be lowered while in service
- By a depth of about 2.6 m from the existing profile.
- Ensure the gas pipeline to be located close to the proposed canal bed level of 74.254m. The proposed canal bed is 66.4m wide.
- The gas pipeline crosses the canal at an angle of 70^0.

The scope of the present investigation is limited to the following aspects.

- Design of new profile between 225m upstream and 600m downstream of the canal crossing and computation of stresses
- Determination of safe span for lowering operation and computation of stresses thereof
- Stagewise profile of the trench
- Guidelines/recommendations to be followed during execution from structural safety point of view

Pipe

Material	:	API 5L 60 Grade steel
Outer Diameter	:	0.9144m
Thickness	:	2.223cm
Weight	:	490kg/m
Design Pressure	:	92 kg/cm^2

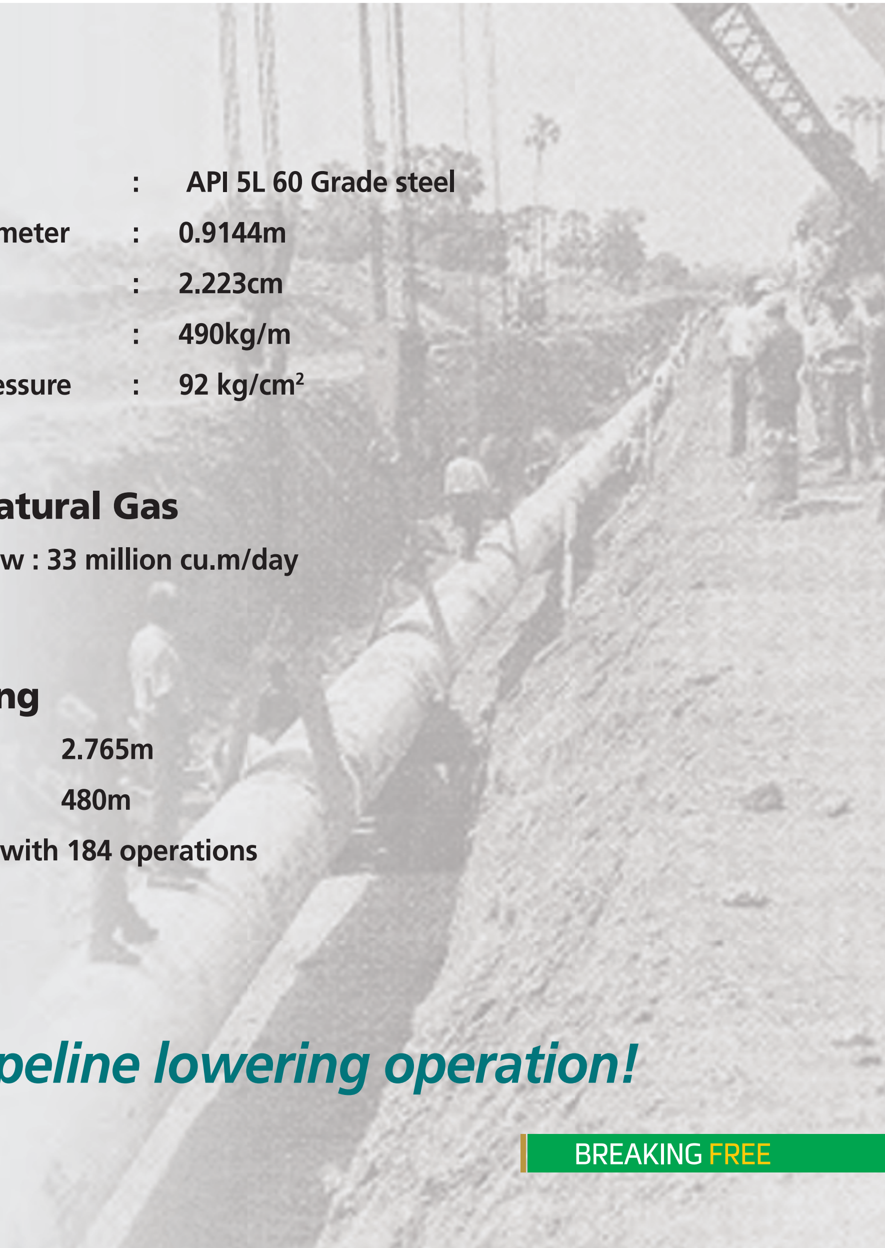
Gas : Natural Gas

Design flow : 33 million cu.m/day

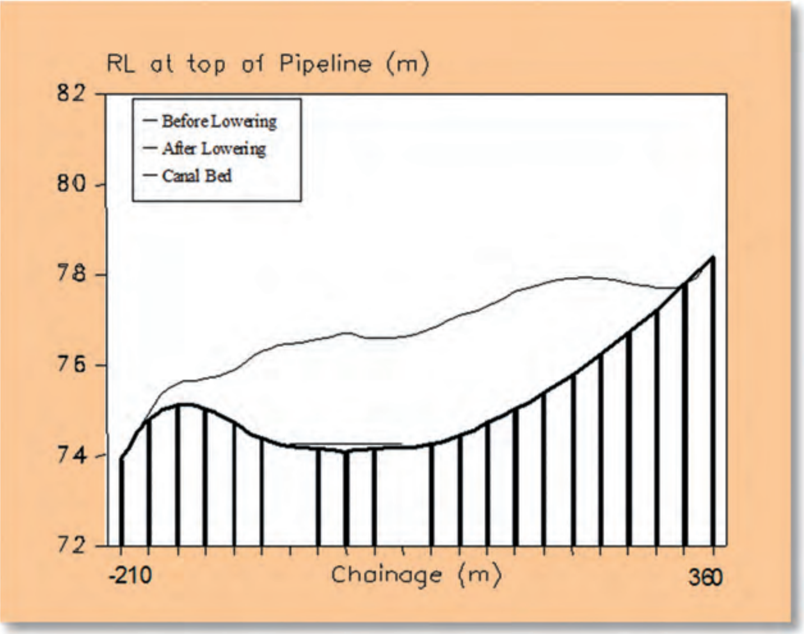
Lowering

Depth	:	2.765m
Span	:	480m

38 Stages with 184 operations

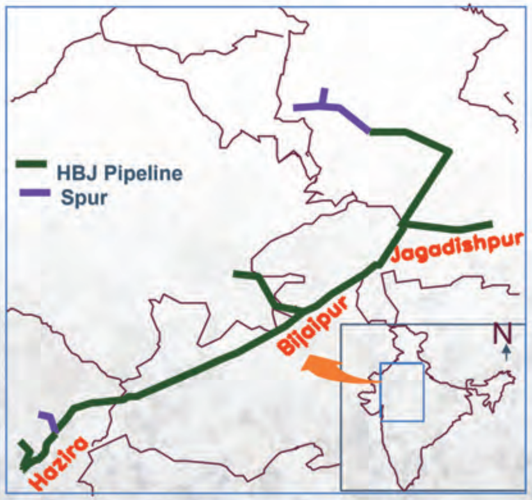


The world's first in-service large-size gas pipeline lowering operation!

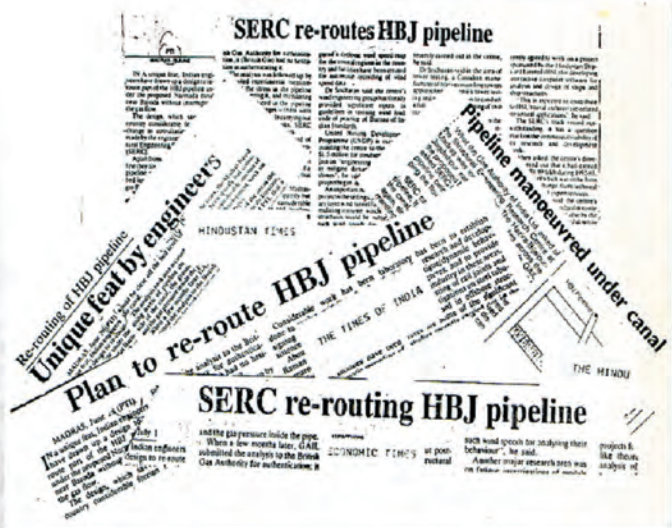


for
GAS AUTHORITY OF INDIA LTD.
NEW DELHI

Strain monitoring of the HBJ gas pipeline during lowering



NETWORK OF
OF HBJ GAS PIPELINE


SERC re-routes HBJ pipeline

Pipeline manoeuvred under canal

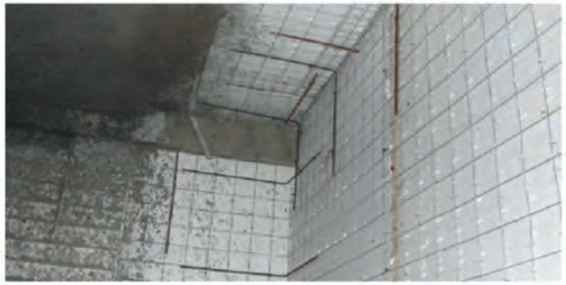
Unique feat by engineers

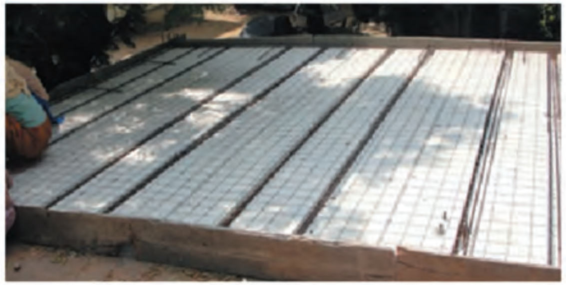
Re-routing of HBJ pipeline

Plan to re-route HBJ pipeline

SERC re-routing HBJ pipeline

Demonstration Building Using Light Weight Wall and Roof Panel with **Expanded Polystyrene (EPS) developed at CSIR-SERC, Chennai**

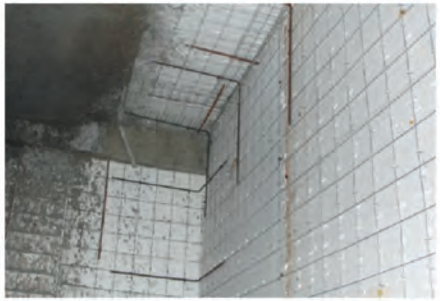




Structure	-	Framed
Roof & Wall	-	EPS Panel
Flooring	-	2ft. x 2ft. Vitrified Tiles
Windows	-	UPVC (grill)
Colour washing	-	Acrylic / Emulsion
Electrical	-	3 Tubelights, Two fan points, 3 plug points
Plumbing	-	Oval washbasin, WC, 3-taps
Sanitary/Drainage	-	One Inspection Chamber

Plinth Area	-	350 sq.ft. (32 sq.m.)
Cost per sq.ft.	-	₹ 1200/-

- Same cost as conventional buildings
- Faster and quality construction
- Ideal for affordable earthquake-resistant housing
- Thermal comfort



Intergration of
Sustainable Products / Technologies

A - Geo-Polymer Blocks/ Bricks

B - Self-Compacting Concrete (SCC)

C - Foam Concrete Blocks

D - High Volume Fly Ash Concrete

E - Light Weight Large Wall Panels using Expanded Polystyrene (EPS)

F - Fly Ash Bricks

Construction of four classrooms at KV-CLRI

Completion in a record time of 90 days!

Blast-Resistant Design of Structures for CENTRE FOR FIRE EXPLOSIVES & ENVIRONMENT SAFETY (DRDO), NEW DELHI

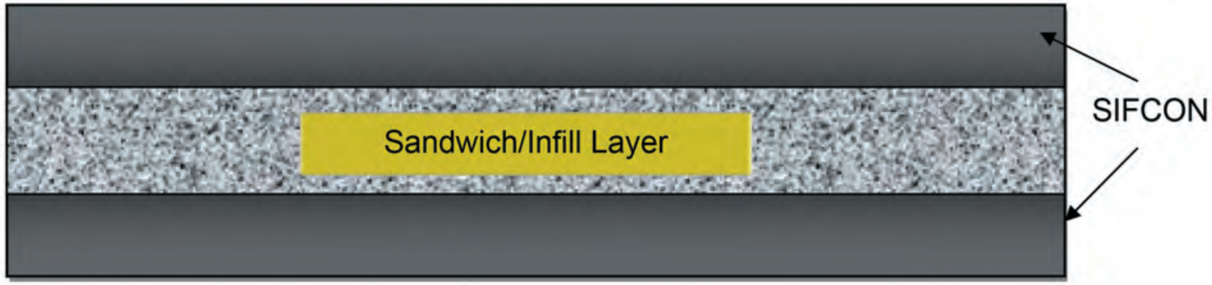
SPECIAL FEATURES OF THE DEVELOPMENT

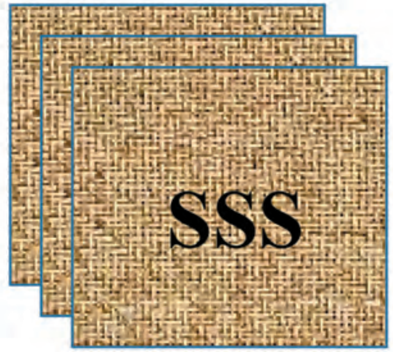
- Simplified material modelling to describe the complex material behaviour of LRC to dynamic loads
- Innovative design of Igloos using laced reinforced concrete for substantial performance improvement under blast loading
- Sustaining high strain rate due to blast loading keeping safety and reusability of acceptor igloos
- Minimization of safe separation distance between donor and acceptor igloos
- Field demonstration of reusability of explosive storage structure

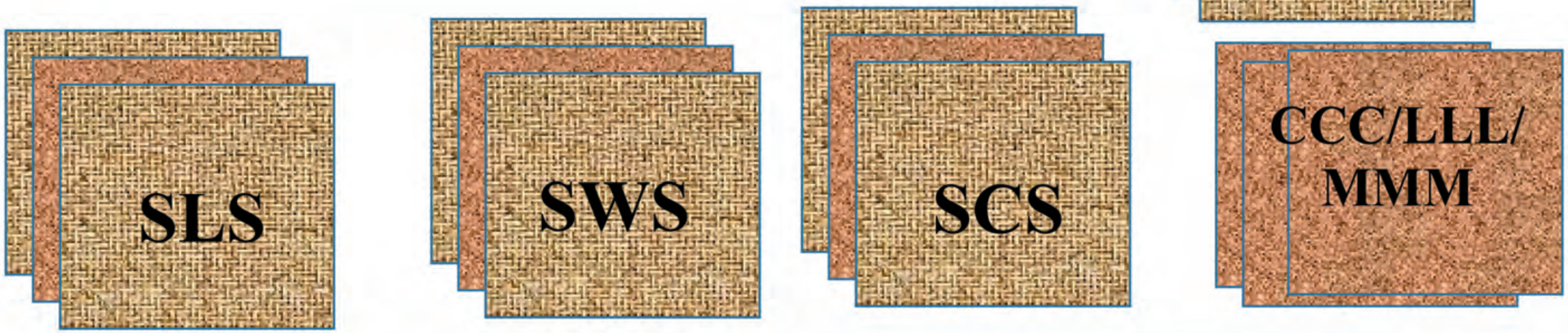
Considering the advantages, particularly, rotational capacity and confinement, that laced reinforced concrete structural elements possess as compared to their counterparts built using conventional reinforced concrete, CSIR-SERC has carried out analysis, design and evaluation of explosive storage structure using laced reinforced concrete. The knowledge gained and the design and construction methodology developed for igloos as part of this work are very unique and strategic in nature. Such knowledge is not available in the public domain.

The designs are successfully demonstrated and validated based on field measurements. Survival potential of an ammunition storage structure for 75T NEC has been verified for the first time in the country by blast tests.

Development of IMPACT-RESISTANT PANELS







Panel configurations

Letter	Meaning
S	SIFCON
L	Latex modified concrete
C	Plain cement concrete
W	Wire mesh
M	Mortar without coarse aggregates

Panel	Type
Material	SSS, SLS, SCS, SRS, SWS, CCC, LLL, MMM
Thickness (mm)	50, 60, 75, 90, 100
Bullet Calibre	5.56 mm, 7.62 mm
Obliquity	0,15,30,45,60 Deg

RE-ENGINEERING OF THE NAVIGATIONAL SPAN OF PAMBAN RAILWAY BRIDGE FOR BROAD GAUGE CONVERSION

The objectives of the development are:

- To verify the structural adequacy of the navigational span of the Pamban Railway Bridge for conversion of meter gauge to broad gauge rail traffic.
- To ascertain the condition of the structure through correlation between experimentally measured and numerically predicted responses.
- To suggest structural strengthening measures to improve the safety margin of the navigational span under increased axle loads.

The work involved determination of the condition of the structure in terms of its reserve capacity to carry additional loads. In addition, the navigational span of Pamban bridge had to be re-engineered to withstand the higher axle loads and satisfy the clearance requirements of broad gauge rail traffic. A validated mathematical model of the truss and floor systems of the navigational span is used to check the structural adequacy of several alternate solutions for strengthening. Based on the study, the most suitable strengthening option has been recommended.

Special features of the development

- A novel re-engineering cum structural strengthening strategy that consists of a new truss-floor configuration with lowered floor to satisfy clearance requirements of broad gauge traffic is proposed
- Counter-weight balancing mechanism to introduce convenience in operation and maintenance of the navigational span

S&T challenges overcome

- The structure is aged and qualified to be of heritage value.
- Fully "determinate" structure - even a member removal or joint weakening can bring down the structure - almost impossible to "reconfigure".
- Location of the structure in the hostile environment where the rate of the corrosion is the second highest in the world.
- Strict adherence / compliance to the clearance between the high tide level and the flooring of the bridge for navigational use.

Extremely difficult margins/clearances for accommodating broad gauge height and width clearances to propose modifications to the configuration -"near impossible" scenario to strengthen the structure for broad gauge conversion.

- Reduced and unreliable safety margin due to the age and adverse environmental operative conditions.

- Necessity to propose simple and effective strengthening measures that could be adopted, given the critical environmental conditions of the structure.
- Reliable fixing of the operating bounds for the structure so as to ensure safe movement of traffic across the bridge.

Outcomes/Benefits accrued

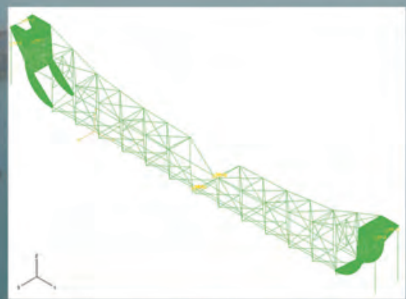
- Novel strategy to combine the design of a strong floor system at a lower elevation and selective modification to the truss structure
- Reliable structural performance of the bridge is ensured under heavier axle loads even after preserving its heritage value
- Extended the life of the existing structure through reliable and economic means. Direct savings of at least to ₹ 900 crore through the novel methodology of design and configuration suggested

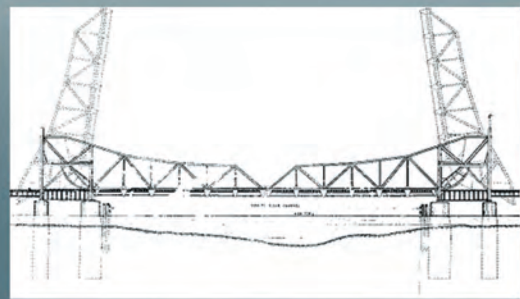
Societal Impact

The railway bridge acts as a vital link between the mainland and the Rameswaram island. The development carried out based on the proposed methodology has high societal impact in terms of safe movement of people and traffic to and from the island.

The successful strengthening option has eliminated the need to construct a new bridge. Apart from direct economic benefit due to cost savings, this has resulted in protecting the environment from the disturbances due to construction of new bridge at the site.

This is the critical link for vital export/import business operations and, the location of the bridge is important for strategic reasons. Hence, the method suggested to strengthen the navigational span of the Pamban bridge assumes great national importance.

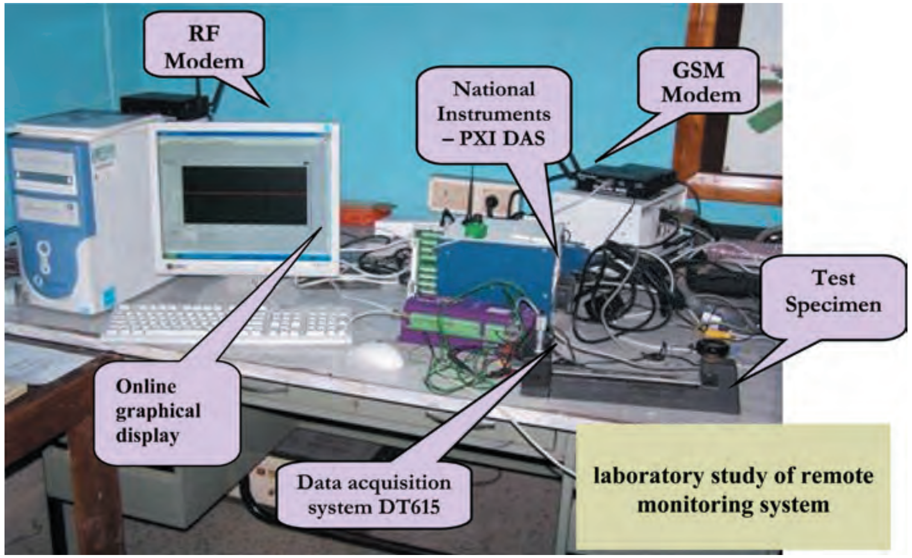




Remote Structural Health Monitoring & Evaluation - THE CSIR-SERC SOLUTION

Remote Structural Health Monitoring (RSHM) Technology has been developed for long-term monitoring of a number of nationally important and strategic structures and for ensuring safety and structural integrity. The developed technology has got the advantages like simultaneous monitoring of number of structures geographically located at different places, uninterrupted collection of data for normal operation as well as during natural calamities, advanced warning about the health of the in-service structures. This system provides the user a versatile platform to integrate different data acquisition units and hence acquire data from assorted sensors. The system can accept input to monitor load as well as structural responses (static and dynamic). Global System for Mobile Communications (GSM) network, Public Switched Telephone Network (PSTN) and Radio Frequency (RF) are used to remotely transfer data from the instrumented structure to the monitoring station. The SMS alarm messages which the RSHM system sends to a group of users will inform in advance any damage or abnormal behavior of the structure. Also, user defined features like emergency alarming and automatic high speed data acquisition, delivery of summary file, real time monitoring of selected channels are unique in the developed RSHM system.

Special features like integration of different data acquisition systems



laboratory study of remote monitoring system

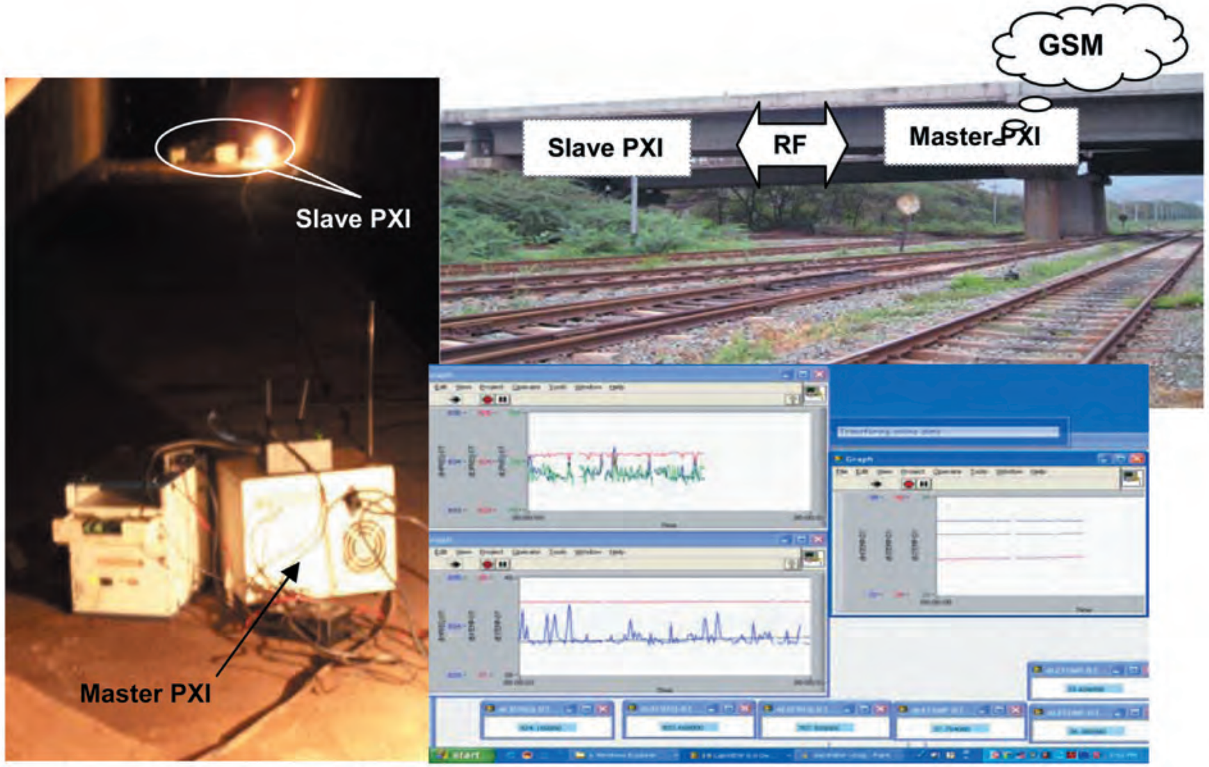
HEARTBEATS

"Highly impressed about your research activities and help to the local communities. Please keep it up."

Francis B. Ackah, Ghana National Petroleum Corporation, Ghana

"Very impressive facility and work, especially the transfer of technology to the locals. Keep it up."

Victor Kofi Sunu-Atta, Ghana National Petroleum Corporation, Ghana for acquiring data from assorted sensors, in a single platform, choices of different modes of communication depending upon the availability of connectivity, generation of SMS alarms are the unique features in the developed technology. This makes the developed technology a powerful and unique one for remote monitoring of structures.



This technology has been applied to monitoring of a prestressed concrete road bridge at Visakhapatnam and a prestressed concrete railway bridge near Chennai. The monitored responses of the bridges are successfully transmitted to the monitoring station at CSIR-SERC, Chennai in real-time.

Health monitoring of all special structures and infrastructure facilities is extremely important for maintenance scheduling and life extension. Maximising the useful service life of any structure is extremely beneficial to the society. A life extension by 25 to 50 years based on health monitoring has a huge economic impact. Considering thousands of crores of rupees are invested annually, the economic benefits are easily discernable, particularly for a developing country like India.

Estimated value of annual and cumulative output derived by the industry would be at least a few hundred crores annually.

Performance evaluation
OF RAILWAY BRIDGES

A large number of bridges on Indian Railways (IR) are requiring retrofitting / rebuilding on account of increased longitudinal force in the current loadings as compared to the old loadings. The loadings on IR have been revised a number of times over the years. This increase in longitudinal loads has led to large number of bridge sub-structures failing in the revised loadings, necessitating costly retrofitting/ rebuilding.

Performance evaluation under increased axle load of railway bridge has been carried out towards determination of

- longitudinal forces
- deflection
- bending moment
- shear force

The bridge superstructure is of steel-plate girder, prestressed box girder type, masonry arch bridge having ballasted/ballast-less track system. Longitudinal force has been evaluated at rail level, on the girder and on the trestle. Special fixture/ load-cells arrangement has been designed and fabricated for the measurement of longitudinal force.
Another important parameter is the evaluation of dynamic amplification factor (DAF) for the bridge.

Dynamic tests consist of tractive effort of the train formation; braking force cases by applying the brakes when the train formation approaches the span at different speeds have been evaluated.

- Procedures and methodologies for condition assessment of prototype railway bridges
- Reliable methodologies for instrumentation, testing, measurement for performance evaluation of railway bridges.
- Long-term performance assessment of bridges

These developed methodologies can be applied to any other type of bridges as well.

Performance evaluvation / condition assessment of some of the bridges in the Southern Railway section

Sensors for Structural Health Monitoring

The fiber optic sensor-based structural health monitoring system can be applied to major civil engineering structures like bridges, containment vessels, dams, port structures, etc

- Development of packaged Fiber Optic Sensors (FOS) for embedding in concrete and mounting on steel structures
- Formulation of procedures for mounting FOS on steel and concrete
- Development of temperature compensation procedures for FOS
- Developed methodology for corrosion monitoring in RCC structures using FBG sensors
- Performance assessment of FOS under static and cyclic loads
- Long-term stability assessment of FOS

Developed FOS technologies for structural health monitoring were successfully applied on a bridge structure and the health of the bridge was monitored for five years. Thus it can be applied for structural health monitoring of civil engineering structures.

Based on our studies on characterization, Indigenous FOS and Interrogators are being developed by CSIR-CGCRI and CSIR-CSIO

Application of Fibre Optic technology for the first time in CIVIL ENGINEERING

Distributed damage diagnostic techniques for sustainable Structural Health Monitoring(SHM) using Wireless Smart Sensor Network(WSSN)

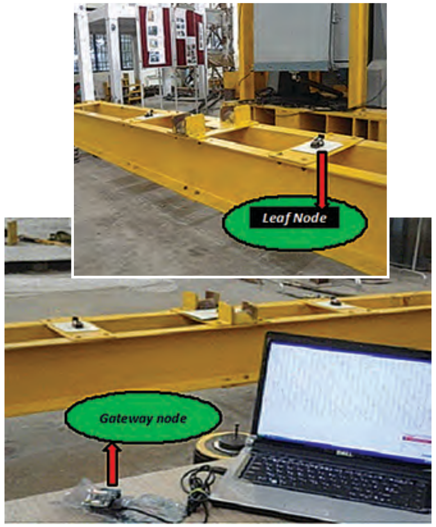
- Sustainable health monitoring of civil engineering structures like bridges.
- Provide a cost effective platform for SHM through wireless smart sensor networks
- Help in carrying out timely repair or retrofitting work to the distressed structures.
- Certainly has a high societal impact.
- Output only damage diagnostic techniques
- Robust under environmental variability
- Robust under measurement noises
- Reduced data communication across WSSN
- Reduced power consumption for communication in WSSN

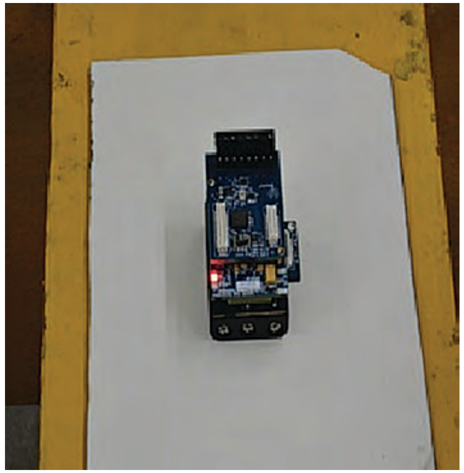
Laboratory level

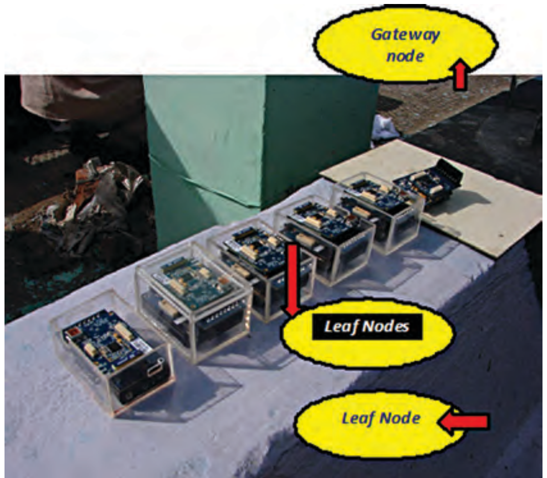
The product does not create pollution of any sort to the environment

- Motes at Leaf nodes and Gateway
- Laptop
- Data storage devices.

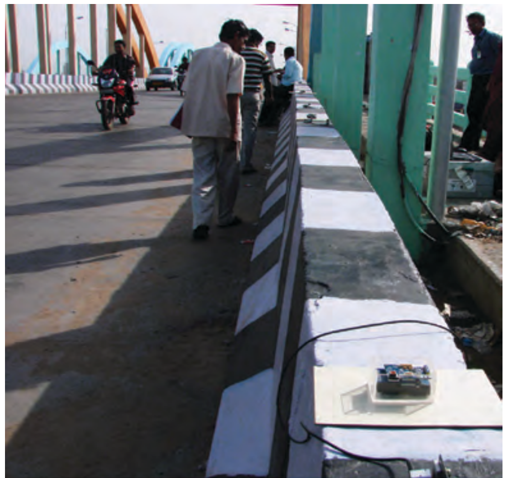
Cost of 12 Motes – USD 10,000







Data acquisition at the gateway connected to the laptop

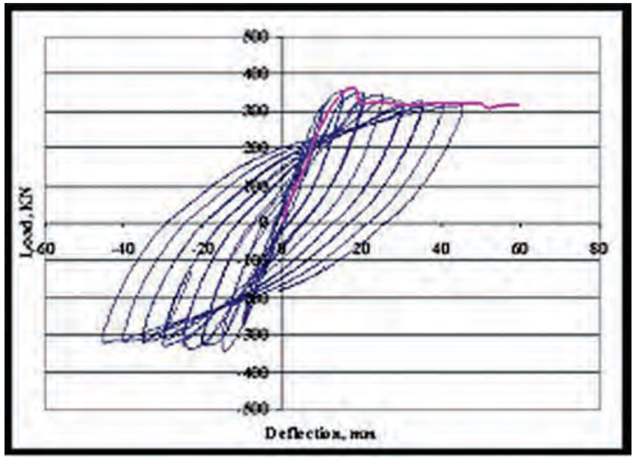


Field demonstration of SHM using WSSN at Velachery-Tambaram bridge, Chennai.

STEEL STRUCTURE
RESEARCH

Medium duty test floor measuring a plan area of 12m x 5m and a shake table bay of size 5m x 3.5m. Test floor supports loading frame up to 10t dynamic load. Test floor grid helps to simulate dynamic loads using the mechanical electro-hydraulic actuators.

- Computer controlled closed loop unidirectional shake table (2.5m x 2.5m) coupled with a servo actuator (100kN capacity)
- Ultrasonic Flaw Detector - EPOCH-4
- Ultrasonic Thickness Gauge - EDISON-1M
- Integrated Portable Hardness Tester - TH-130
- Coating Thickness Gauge - TT-210
- Digital Data Logger-48 Channels - MGC Plus
- Inclinometer - WYLER



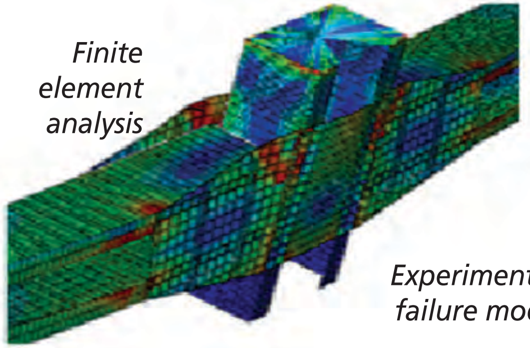
No prefabrication for joints
On-site installation
No need for skilled supervision

Cold-formed Steel Beam-column Connection for Affordable Housing

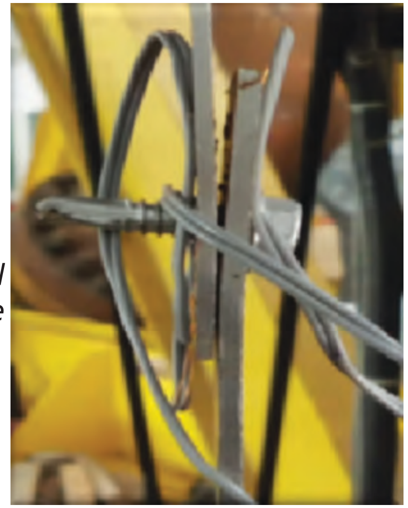
First ever attempt on beam-column connections with self-drilling screws in India

- Pre-engineered mass rural housing
- Light weight construction
- Savings on foundations
- Fast-track construction for habitation during natural disasters

Finite element analysis



Experimental failure mode

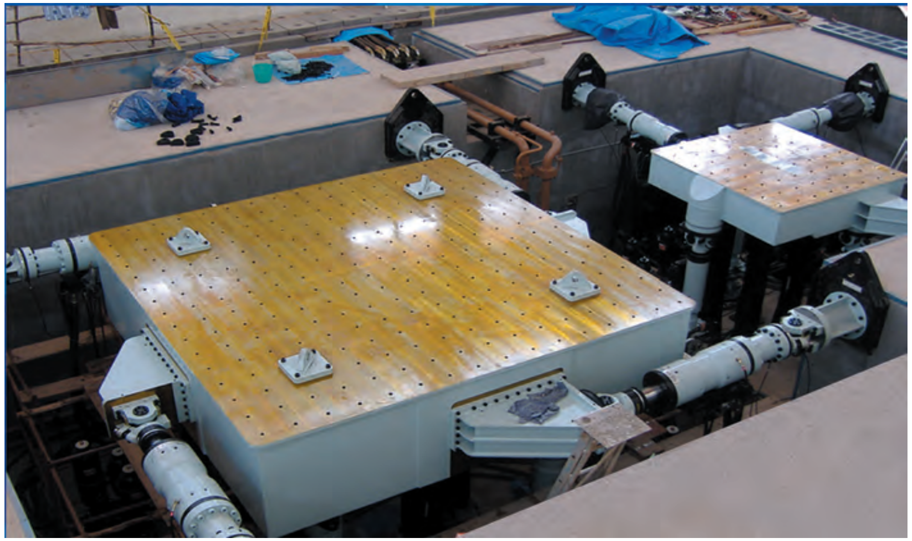


Experiments on Self-drilling screw lap joint

ADVANCED
SEISMIC TESTING & RESEARCH

Development of Seismic Resistant and Energy Efficient Prefabricated Building System

Construction industry is under pressure to increase productivity, reduce cost and enhance the quality levels of constructed facilities. Prefabricated method of construction is the only solution to encounter the growing demand for housing. In this background, CSIR-SERC has designed and developed a prefabricated concrete building system and joint assembly for efficiently and economically constructing walls, floors and roofs using expanded polystyrene sandwich (EPS) panels. This system also enables construction of buildings in earthquake prone areas which



demand light weight, high strength, large ductility or deformability for in-plane and out-of plane loading, avoidance of fragmentation of elements. The salient features of the building system are:

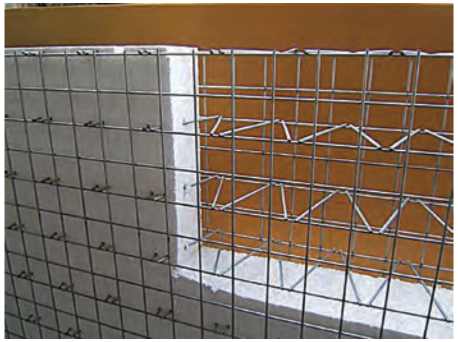
- The entire structure made of precast concrete sandwich large panels for walls and roof is light in weight and easy to handle, transport and erect.
- Room size wall and floor units are produced off-site and are assembled and jointed efficiently on-site to form robust disaster resistant structures.
- The dead load on foundation is reduced by approximately 40% and, therefore, light and simple foundation is sufficient.
- The perfect bond between the inner core and outer skin makes the system integrated for composite action which further enhances the performance.

- The reinforcement provided uni-directionally in the precast panels contribute to structural strength of the system to carry gravity and lateral loads.
- The precast wall and roof panels are efficiently connected together to form enclosures and contribute to the transfer of loads to the foundation.
- The jointing system is simple and structurally adequate.
- The well-detailed joints exhibit excellent seismic performance in the shake table experiment.
- The wall and floor panels are joined in-situ using a quick setting high strength material ensuring adequate strength at an early age leading to speed in assembling the panels.
- Use of flyash in large quantities in self-compacting concrete results in cost reduction and also enables eco-friendliness.
- Large size closed cavities in EPS panels render high thermal performance. Thus the structure provides satisfactory thermal and acoustic insulation for the constructed facility.
- The panels perform excellently well and are a unique combination of strength, lightweight, ductility and durability

Some applications

- In mass housing constructions where speed and quality is the priority.
- For construction in earthquake prone zones.
- Construction with desirable thermal and acoustic characteristics / insulation.
- For achieving reduced weight of construction.
- For single and multistoried buildings.

This technology has been transferred to M/s Synergy Thrishlington, Mohali.



Prefabricated building (G+1) assembled on shake table for seismic performance assessment

Shake table test on base isolated building

PASSIVE ENERGY DISSIPATION
DEVICES (DAMPERS) AND BASE ISOLATORS

Patent filed No.2441 DEL 2013

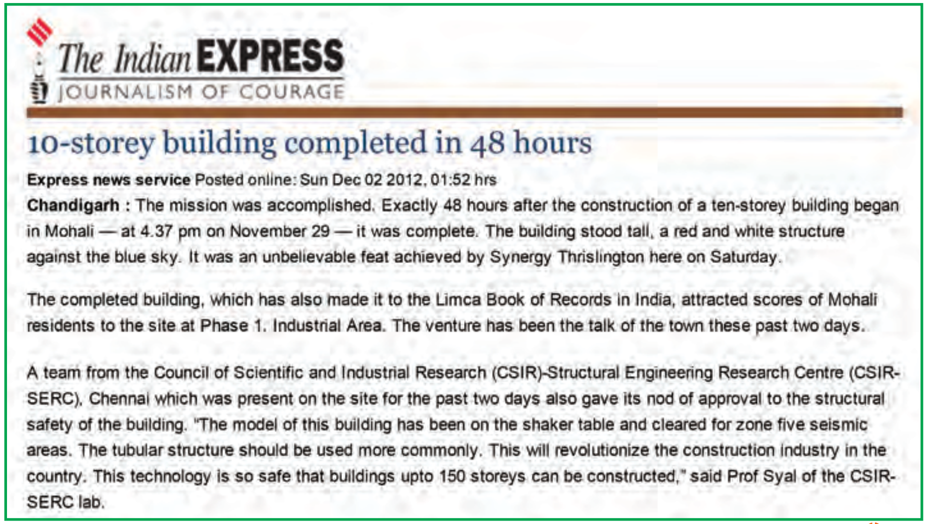
- For mass housing and affordable buildings
- For quality and speedy constructions
- Constructions in earthquake prone areas
- Lightweight buildings in poor soil conditions

For all types of single and multistoreyed buildings

The panels are sandwich type comprising of two high strength concrete wythes separated by an inner lightweight core. The panels are one of the most structurally efficient system in terms of low material consumption. The panels are extremely light in weight and are easy to handle, transport and erect. The panels are assembled on the site edge to edge to form an enclosure and the joints between the wall to wall and roof to wall is connected. The system provides satisfactory thermal and acoustic insulation for the constructed facility. Besides structural soundness the use of waste material in large quantities is also involved which adds to the reduction in cost and eco-friendliness of the system. The entire system is light in weight, durable, and resistant to forces caused by disaster such as earthquake. Thus, the panels are a unique combination of strength, lightweight, ductility and durability. A (G+1) building constructed using these panels when tested performed excellently in seismic zone -5 loadings.

Sustainable and green construction through savings in energy costs for cooling or heating.

View of precast wall and floor panels assemble for (G+1) building on shake table for seismic test



The Indian EXPRESS
JOURNALISM OF COURAGE

10-storey building completed in 48 hours

Express news service Posted online: Sun Dec 02 2012, 01:52 hrs

Chandigarh : The mission was accomplished. Exactly 48 hours after the construction of a ten-storey building began in Mohali — at 4.37 pm on November 29 — it was complete. The building stood tall, a red and white structure against the blue sky. It was an unbelievable feat achieved by Synergy Thrislington here on Saturday.

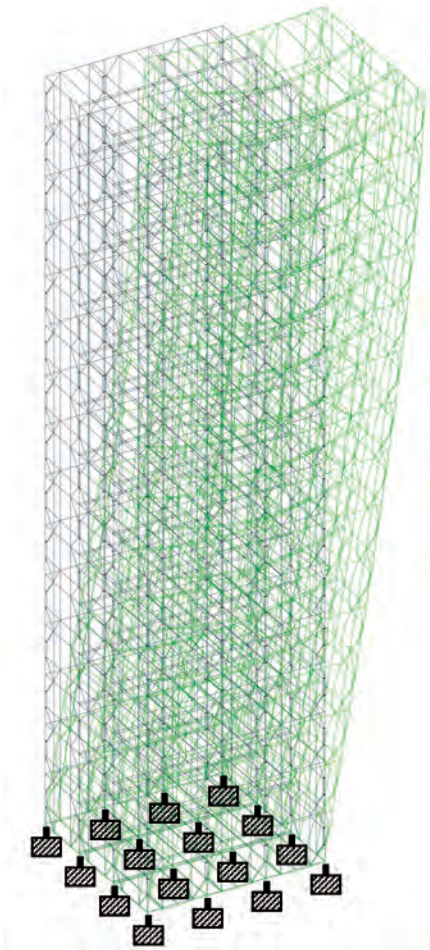
The completed building, which has also made it to the Limca Book of Records in India, attracted scores of Mohali residents to the site at Phase 1, Industrial Area. The venture has been the talk of the town these past two days.

A team from the Council of Scientific and Industrial Research (CSIR)-Structural Engineering Research Centre (CSIR-SERC), Chennai which was present on the site for the past two days also gave its nod of approval to the structural safety of the building. "The model of this building has been on the shaker table and cleared for zone five seismic areas. The tubular structure should be used more commonly. This will revolutionize the construction industry in the country. This technology is so safe that buildings upto 150 storeys can be constructed," said Prof Syal of the CSIR-SERC lab.

PERFORMANCE EVALUATION OF
G + 7 COLD ROLLED STEEL FRAMED STRUCTURE

Scaled model of the G+7 framed structure on the shake table

- This is the first ever test of this magnitude in India, carried out successfully on a shake table for a cold rolled steel framed structure.
- The framed structure on the shake table has been appropriately instrumented to measure the deflection, strain and acceleration.
- Seismic response spectrum analysis of G+7 and G+14 storey framed structures has been carried out corresponding to Zone V and the deflection and the stresses obtained are within the permissible limits.



Lateral displacement of G+7 and G+14 storey frames

PERFORMANCE EVALUATION OF CRITICAL STRUCTURAL COMPONENTS

Performance Evaluation of Composite Antenna Cabin under Shock Loads

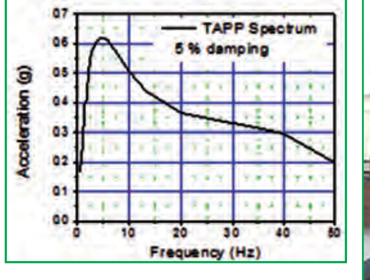
- Pulse type: Half sine wave
- Magnitude: 25g (160mm Drop)
  Pulse duration: 6 millisecond
- No of Pulses : 3
- Direction: Vertical
- Instrumentation: Strain gauges & Accelerometers
- Progressively increasing earthquake motions were quantified by peak ground accelerations corresponding to zones II, III, IV and V as per IS:1893-2002 (Part I) for soft soil conditions. Based on the tests, it is found that the overall performance of the scaled model of the G+7 cold rolled steel framed structure is satisfactory.

Drop height for Vertical Shock - 160 mm

FIRST EVER SUCH EXPERIMENT IN THE WORLD - 15 DEC 2010

Performance Evaluation of Spent Fuel Tank under different Load Conditions and Row & Tray Configurations

Storage and stacking of spent fuel trays are critical to the proper functioning of a nuclear plant. The stability of these trays and the methodology adopted for their stacking play a crucial role in their seismic performance. Accuracy of finite element modeling has to be validated by shake table tests. The analytical prediction of stability of spent-fuel trays becomes more involved due to fluid -structure interaction effects and issues relating to non-linearity arising out of contact mechanics and friction-induced un-certainty. Towards evaluating the seismic performance of spent fuel tray assemblies, a series of tests were conducted.



Typical Response Spectrum

Spent fuel tank

SEISMIC PERFORMANCE OF
PET BOTTLE NYLON+6 FISHNET HOUSE

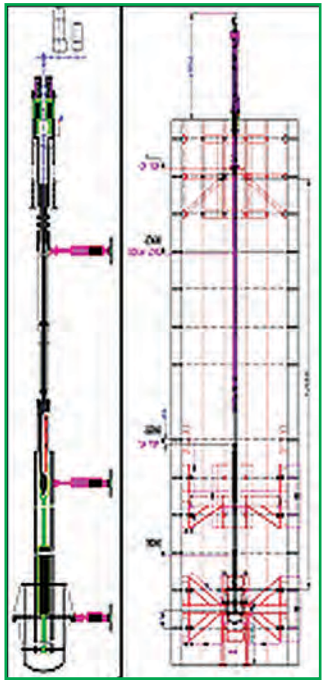
Seismic performance evaluation of the low cost PET bottle Nylon+6 fishnet house (3m x 3m in plan & 3m height) is carried out on the 4m x 4m shake table. The house constructed uses discarded PET bottles filled with mud as bricks and nylon+6 fishnet as reinforcement instead of conventional steel. Shake-table tests are conducted using the 4m x 4m tri-axial table for assessing the seismic resistance of the low cost house. Seismic excitation is applied in a progressively increasing manner and the response of the structure is studied. The seismic excitation input is derived from the mathematical process of 'spectrum compatible time history generation'. The design spectra composed of a band of frequencies and specified by the Indian code of practice for earthquake resistant design of structures founded on soft soil is made use of to derive the input acceleration time history.

Before application of the seismic motion, the basic dynamic characteristics of the structure, namely, natural frequencies and damping are evaluated by giving a small pulse loading at the base of the structure and the free vibration response of the structure is collected. The natural frequency for the test building is found to be 5.75Hz in the direction parallel to wall contains door and window openings and 8.5Hz in the direction parallel to solid walls, more stiff direction. The sequence of application of earthquake motion is in the following steps of PGAs, starting from 0.1g, 0.16g, 0.24g and 0.36g, simulating the seismic zones in India, further 0.5g, 0.6g, 0.7g, 0.8g, 0.9g and 1.0g are applied twice of each PGA excitation. The building is found to withstand all the applied PGAs without collapse with the present base condition.

CONTROL & SAFETY ROD DRIVE MECHANISM (CSRDM)

CSIR-SERC is in the forefront to develop technologies or to provide appropriate solutions to the strategic sector. Number of activities encompassing advanced studies using the experimental facilities at CSIR-SERC were executed during this period. Some of the salient achievements made are:

- Experimental evaluation of multi-support seismic excitation on Control and Safety Rod Drive Mechanism (CSRDM) of the Pressurised Fast Breeder Reactor (PFBR). This is conducted for the first time in South Asia.
- Vibration performance of the CSRDM under tri-axial excitation to simulate earthquake conditions
- Seismic performance of Diverse Safety Rod Drive Mechanism (DSRDM)
- Seismic qualification of Control and Safety Rod Drive Mechanism (CSRDM) of a Prototype Fast Breeder Reactor (PFBR) is successfully conducted for the first time in India using the pseudo-dynamic test facility at CSIR-SERC.
- Safe functionality of the dropping mechanism was successfully ensured during multi-support seismic excitation under OBE (Operational Basis Earthquake) and SSE (Safe Shutdown Earthquake) conditions.



THE HINDU

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TODAY'S PAPER » NATIONAL

CHENNAI, August 28, 2011

Reactor shutdown system can withstand severe quakes

SPECIAL CORRESPONDENT

SHARE · PRINT · T+

P. Chellapandi, Director, Nuclear and Safety Engineering Group, Indira Gandhi Centre for Atomic Research (IGCAR), at the Structural Engineering Research Centre (SERC), Taramani, on Saturday. (From left) Nagesh R. Iyer, Director, SERC, and S.C. Chetal, Director, IGCAR, are in the picture. — Photo: A. Muralitharan

The shutdown system of the 500-MWe Prototype Fast Breeder Reactor (PFBR) at Kalpakkam has been designed to withstand severe earthquakes, S.C.Chetal, Director of the Indira Gandhi Centre for Atomic Research (IGCAR), said on Saturday.

Its capacity was six times the recorded level of acceleration that occurred following an earthquake, he told reporters after the demonstration of seismic tests on the shut-down system at the Structural Engineering Research Centre (SERC) campus in Taramani here.

P. Chellapandi, Director, Nuclear and Safety Engineering Group, IGCAR, added that compared to the potential of the magnitude of earthquake [as measured on the Richter scale] in the coastal stretch of Kalpakkam, the system's capacity would be about three times.

Scientists of the IGCAR and SERC demonstrated the reliable operation of the shutdown system at a Rs.40-crore testing facility, which was funded by the two Central organisations. The system had been developed, meeting all the stringent specification of international design and construction codes. After completing all the simulated tests at the IGCAR, another round of tests was performed at the SERC.

Dr Chetal explained that two independent

PROBABILISTIC SEISMIC HAZARD MAP OF INDIA

Capabilities and Features:

- All the knowledge of past earthquakes and mapped faults captured
- About 760 faults and 38, 860 recorded seismic events of magnitude 4 in the country compiled
- State-of-the-art probabilistic seismic hazard analysis (PSHA) conducted covering the entire country on a grid size of 0.2° x 0.2° (finest grid ever done)
- Results presented in the form of PSH maps at type A rock level
- Ready-reckoner for evaluating the earthquake response spectrum at any given site

Challenges:

- Collating large amount of data (seismological/seismo-tectonic/ geological/ historical) from various reliable sources
- Data integration and converting into useful design input for engineering applications

Outcome:

- Peak Ground Acceleration contours (in terms of 'g') corresponding to mean return period of about 2500 years, for the entire country, in line with the current International Codes of Practice.
- Spectral acceleration contours corresponding to 0.2s and 1s periods also developed

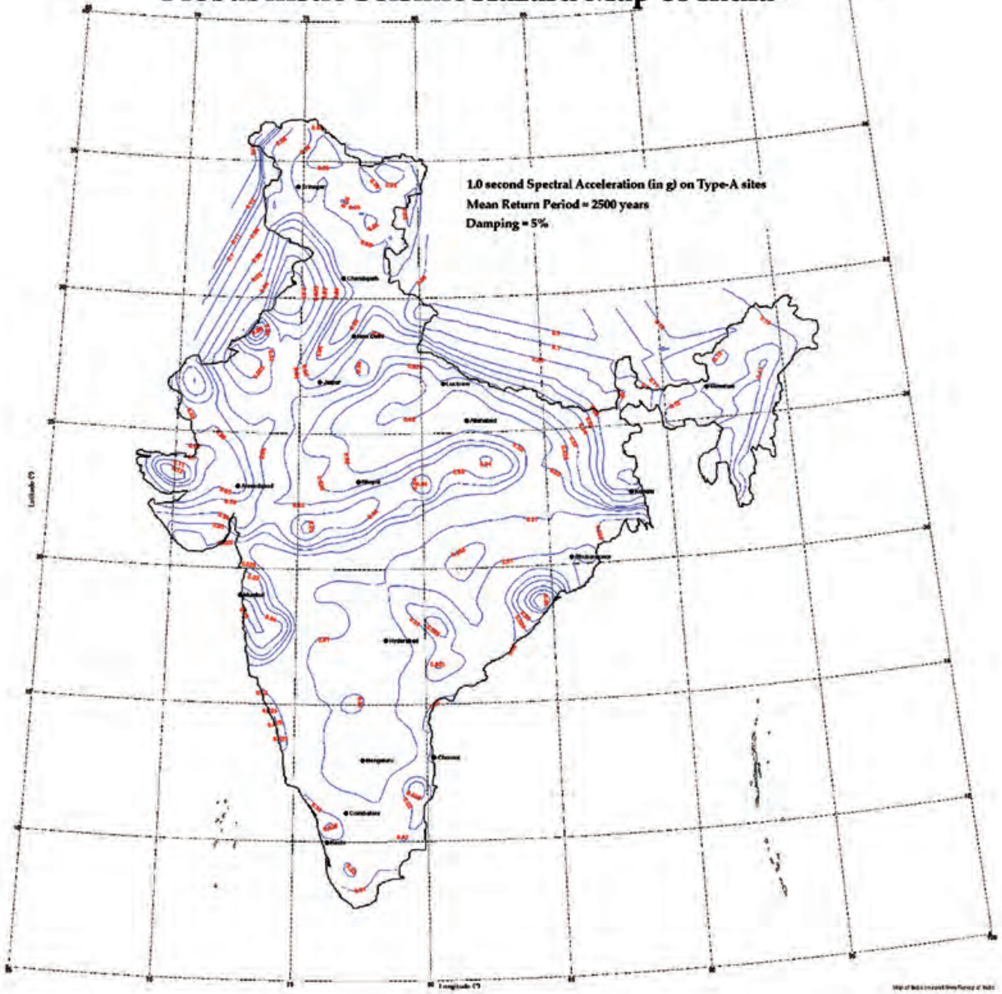
Leading to:

- Rational, Economical and Safe design of buildings and structures against the earthquake hazard

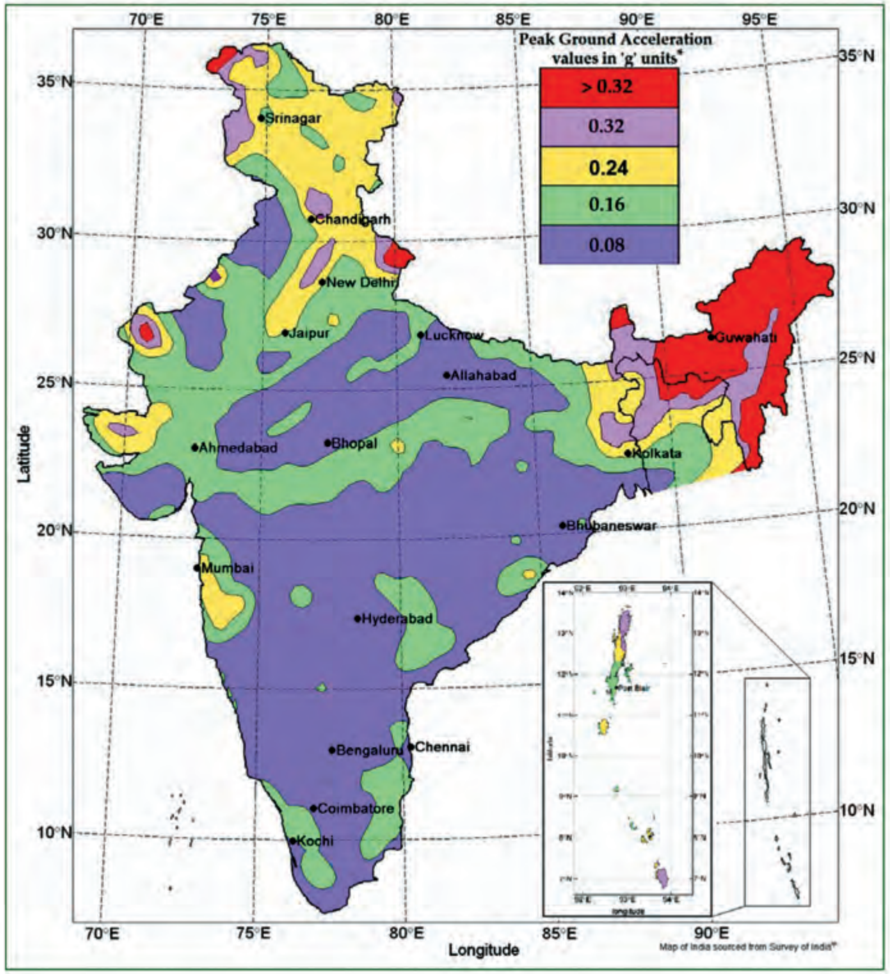
Users:

- Government agencies including strategic sectors
- Disaster mitigation planners and management authorities
- Risk planners and insurance agencies
- Practicing Engineers including Architects
- Society at large

Probabilistic Seismic Hazard Map of India



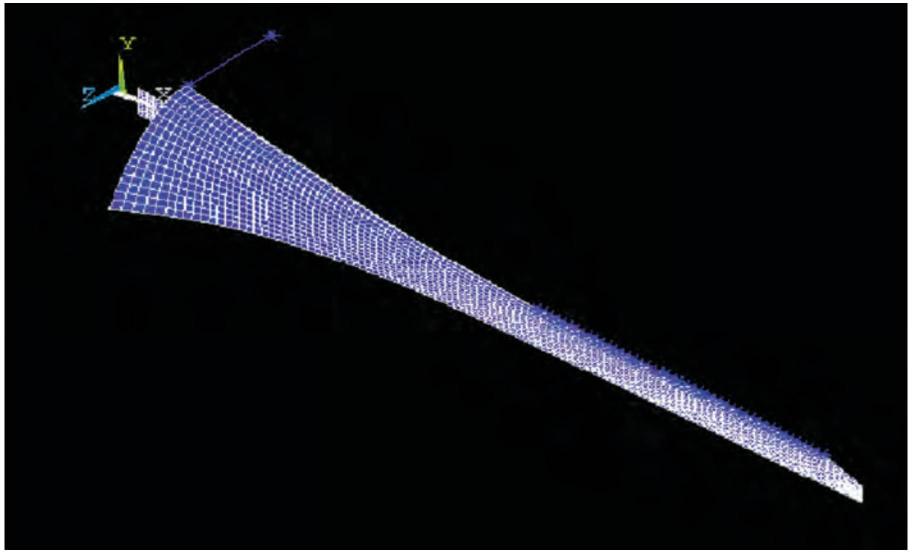
REGIONAL SEISMIC HAZARD BASED ON PGA AT TYPE-A ROCK LEVEL (MEAN RETURN PERIOD ~ 2500 YEARS)



DEVELOPMENT OF
500 KW WIND TURBINE

Development of 500kW Low-Cost Horizontal Axis Wind Turbine (June 2004 - March 2008). Collaborating Agencies with CSIR-SERC: CSIR-NAL, Bangalore & M/s Sangeeth Group of Industries. (Project under NMITLI Scheme of CSIR)

Based on the input provided by CSIR-NAL with high component mass of 25 tonnes and thrust of 12.2 tonnes as lateral loading at the top of the proposed 60m tower, the tower has been designed for 50m/s basic wind speed. The design of the tower also includes tuning of the fundamental frequency of the tower in order to avoid severe resonance with turbine operating frequency of 34 rpm (0.57Hz). The structural design of the guyed tower takes into consideration of various tilt-up or tilt-down positions with the turbine weight. Evolution of a comprehensive indigenous methodology and creation of design data base for the development of low cost technologically advanced wind turbine specially suited for the Indian wind environment and a 500kW wind turbine installed and commissioned at the Sangeeth Wind Farm, Coimbatore District to gain the operational experience. The foundations for the tower, winch and guys have been designed, assuming a bearing capacity of 20 tonnes / sq.m. for the sandy gravel soil at the site. The designs involved special detailing of guy anchorages, and a base hinge for the tower. A shear key mechanism has been used in the guy foundations.



STEEL-CONCRETE COMPOSITE
LIGHT WEIGHT LOAD BEARING WALL PANELS

- Outer steel skin made of cold formed steel sheet with light-weight foamed concrete (LFC) core interconnected by through-through studs
- Experimental and analytical studies on effect of confinement action of LFC on axial load-deformation behaviour & ultimate capacity
- Failure modes - vertical splitting and diagonal shear failure of concrete followed by sheet crippling
- Increase in axial strength is about 200% compared to plain LFC panels
- Axial deformation at failure is about 3 to 5 times that of plain LFC panels
- Suitable for load bearing construction in low-/medium- rise buildings due to significant axial load carrying capacity and ductility
- Potential for enhancing seismic performance, retrofitting, impact and shock resistance applications

LACED STEEL-CONCRETE COMPOSITE SYSTEM

Contribution

Evolution and evaluation of new user-friendly laced steel-concrete composite (LSCC) system

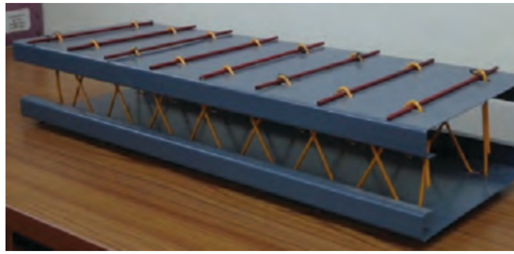
Uniqueness

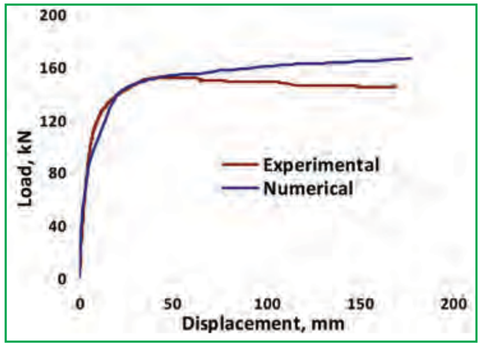
- New configuration by integration of simple structural elements
- Optimised material usage to result in enhanced strength, deformation and rotational capabilities
- Welding replaced with novel way of connecting the cover plates
- Efficient to resist suddenly-applied dynamic loads such as blasts and earthquakes
- LSCC beams exhibit large support rotation, nearly twice compared to steel-concrete composite beams with conventional connectors
- Post-peak response indicate load drop of maximum 15% only for either monotonic or cyclic reversal load
- LSCC beams possess 3X cyclic ductility factor as compared to Laced Reinforced Concrete beams

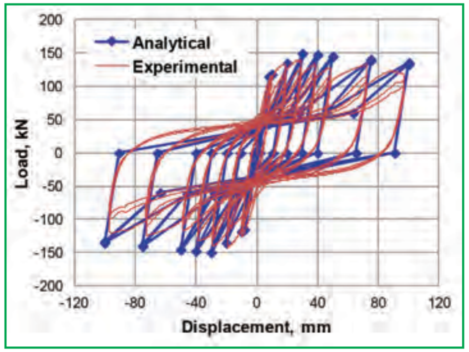
A product with enormous potential, direct use for structures to resist suddenly applied dynamic loads, spin-off for other similar structures

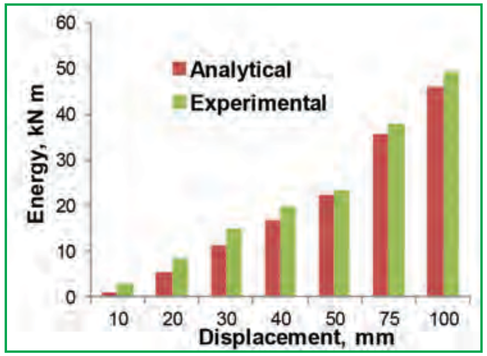
Indian Patent filed - 1886DEL2011 dated 05.07.2011

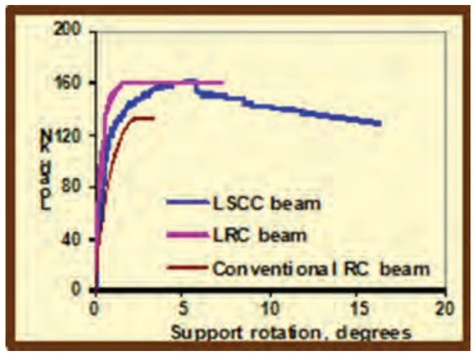
International Patent No. WO 2013/005232 A1 dated 10.01.2013











PASSIVE ENERGY
DISSIPATION DEVICE & BASE ISOLATORS

Passive energy dissipation devices (Dampers)

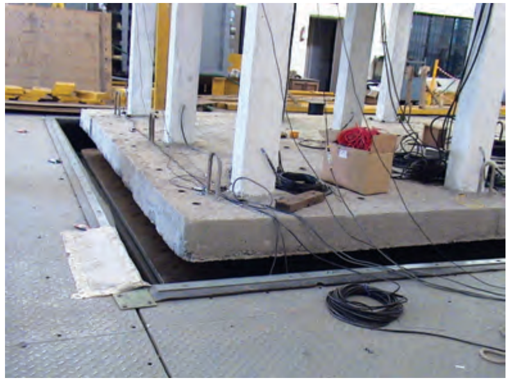
CSIR-SERC has patented a process for the manufacture of a passive energy device (PED) from a hysteretic shear polymer. The hysteretic shear polymer is based on Indian standard natural rubber (ISNR). The hysteretic shear polymer is prepared by processing the ISNR at a temperature in the range of 50°C to 100°C with suitable additives, such as china clay, semi-reinforcing furnace (SRF) carbon black, zinc oxide, steric acid, vulcaniser sulphur, tetra methyl thiuram (TMT), 2-mercapto benzo thiazole (MBT) and spikel oil. The hysteretic shear polymer so obtained is fabricated to make a passive energy device (PED). The passive energy device thus obtained provides shear strain as high as 200% linearity and shear strength >25kg per sq.cm., which is useful for dissipating shear load due to seismic forces in buildings

Imported dampers and isolators are at least three times more expensive than the developed products

Base Isolators

The product developed is a laminated natural rubber isolator with alternating layers of small thickness of rubber and steel shims, bonded to each other through a suitable heating and pressure treatment. The steel shims prevent the rubber from bulging out and thus increase its vertical stiffness, which is a necessary property of these isolators. Lateral stiffness is however kept at a minimum level so that the over-all structural time period is elongated and thus a reduction in seismic acceleration could be achieved. Lead core is introduced at the center, which yield at vary small levels of lateral displacement and hence increases the damping of these products. CSIR-SERC has developed these products along with Rubber Board, Kerala and these have also been tested for seismic loads using the shake table facility. Element level characterization have also been carried out to estimate the shear load deformation characteristics of these elements.

The process of commercialization for base isolators have been initiated with M/s Taylor Devices, India



Model building on base isolator

river bank

SOLIDITY THAT SUSTAINS LIVELIHOOD ...

Specialized Facilities/ Equipment that rank among the best in India

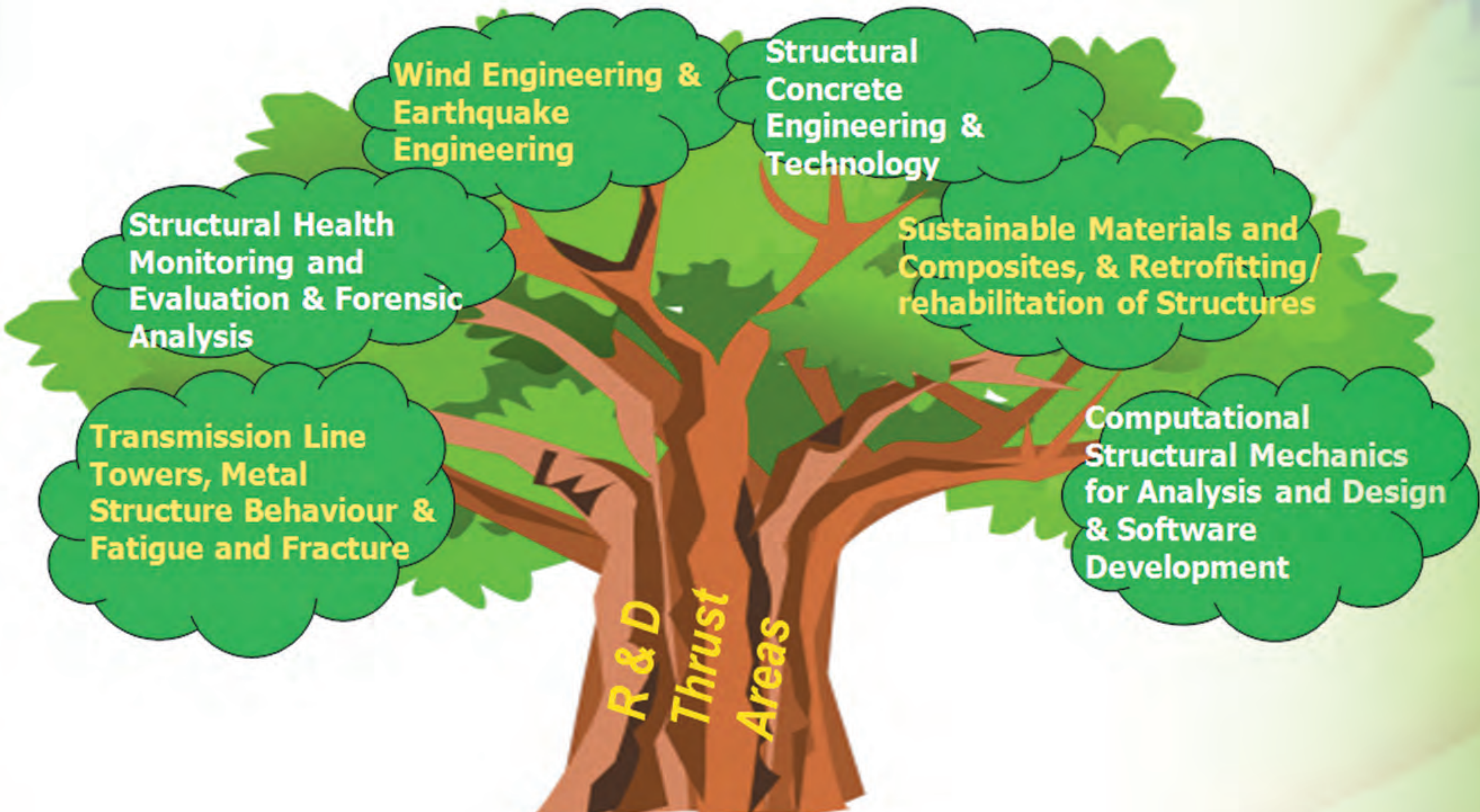
When compared with CSIR - SERC it would be rather rare to find another institution anywhere in the world which has experimental and test facilities to cater to various aspects of structural engineering under one roof. All the infrastructure required, to install and commission the state-of-the-art equipment and hardware, has been planned and designed by the scientists of CSIR - SERC. Further, the core competencies and the facilities would rank individually as the best.

CSIR-SERC VISION

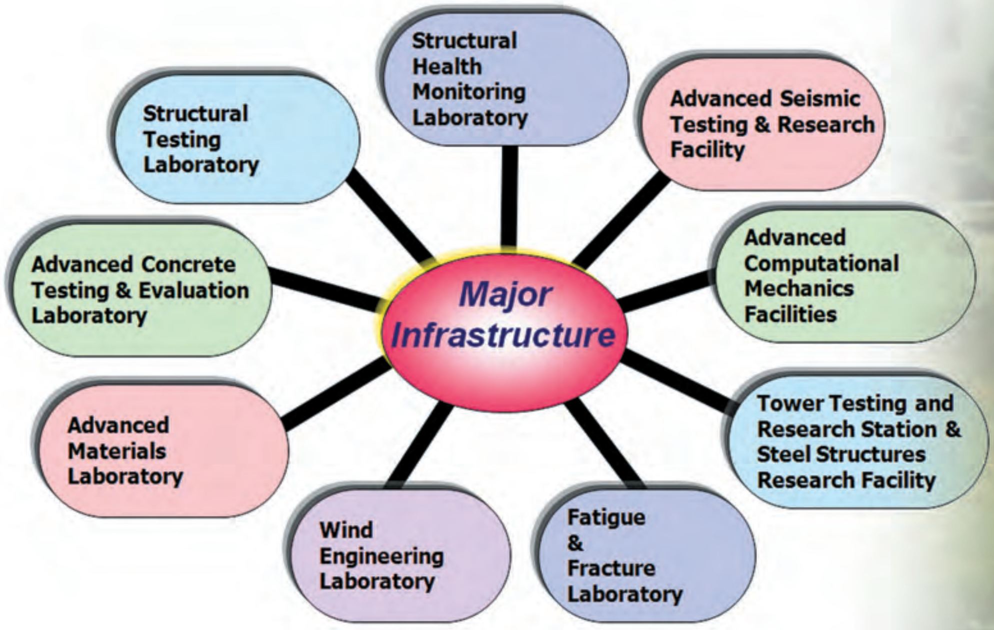
The vision of CSIR-SERC envisages that it shall continuously strive to excel on its expertise, facilities and performance in order to be a globally competitive R&D organization in Structural Engineering.

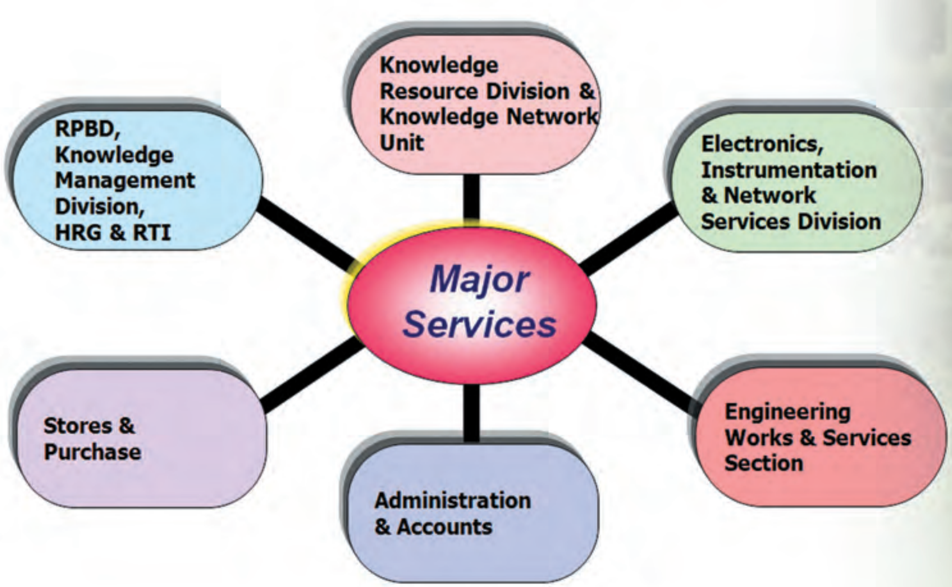
Towards this, CSIR-SERC will

- initiate innovative programs of R&D for technology / expertise development leading to reliable and safe designs and construction practices
- initiate action to establish advanced / state-of-the-art facilities for experimentation and advanced analysis / software development
- work to publish high quality technical papers in international journals, to enhance IPR content in R&D activities and to attract external financial support to R&D programs
- put its best efforts for transfer of technology and expertise for industrial / societal benefits



What we stand for...


Major Infrastructure
Structural Health Monitoring Laboratory
Advanced Seismic Testing & Research Facility
Advanced Computational Mechanics Facilities
Tower Testing and Research Station & Steel Structures Research Facility
Fatigue & Fracture Laboratory
Wind Engineering Laboratory
Advanced Materials Laboratory
Advanced Concrete Testing & Evaluation Laboratory
Structural Testing Laboratory


Major Services
Knowledge Resource Division & Knowledge Network Unit
Electronics, Instrumentation & Network Services Division
Engineering Works & Services Section
Administration & Accounts
Stores & Purchase
RPBD, Knowledge Management Division, HRG & RTI

Structural Testing LABORATORY [STL]

- Heavy duty floor for testing prototypes as well as model structural components
- The heavy-duty floor size is 30m x 8.8m and each anchor point is capable of carrying a vertical load of 40 tonnes. The floor is designed as a twin box with wall and slabs 50cm thick. The loading plant installed on the floor can apply a static load of 480 tonnes and a dynamic load of 240 tonnes.
- Hydraulic loading plant up to 100-tonne capacity for static and dynamic loading
- Servo-controlled electro-hydraulic system with 250kN and 500kN actuators
- Instrumentation for measurement of deflection, strains, rotation, etc. during testing
- Reaction frames
- EOT crane of 10-tonne capacity

Reaction mass type

Electro-Dynamic Shakers

APS Dynamics Model 400 ELECTRO-SEIS (Reaction mass type Electro-Dynamic Shaker) APS 144 **DUAL-MODE** with Power Amplifiers

- Can be used in a vertical or horizontal free armature mode with rated force down to less than 3Hz. Can be used in Free Body Mode; Fixed Body Mode; Free Armature Mode; Shaker Table Mode
- Maximum Force, Vector 100lb, 445N
- Maximum Stroke, p-p 6.25in, 158mm

Shaker model 400 with 4001 0.5Hz Horizontal Operation reaction mass system

APS Dynamics Model 400 ELECTRO-SEIS shaker with additional reaction masses for testing in horizontal excitation

M/s Spectral Dynamics make Jaguar Model excitation signal controller, measuring and signal analysis system

Advanced Concrete Testing & EVALUATION LABORATORY [ACTEL]

A view of test specimens exposed to accelerated carbonation in walk-in type carbonation chamber

Laboratory Facilities for evaluating physical and chemical parameters of concrete including:

- Pre-tensioning bed of 60m long and casting yard
- Concrete specimens casting facilities and mixers
- Concrete cutting machines for dressing concrete specimens
- Compressive (200T) and Flexural testing machines (50T)
- Table vibrator for compacting concrete specimens
- Large capacity carbonation chamber of size 3.6m x 3.6m x 2.4m (perhaps, the largest internationally) with regulation for temperature, humidity & CO_2 for accelerated carbonation test on concrete specimens
- Diffusion cells with accessories for determining diffusion co-efficient of concretes
- Data logging systems for recording current
- Potentiostat / Galvanostat for basic polarization studies

HEARTBEATS

"Impressive facility - well organized and effective. Cordial and knowledgeable staff provided great hospitality and good information about the research and testing done here"

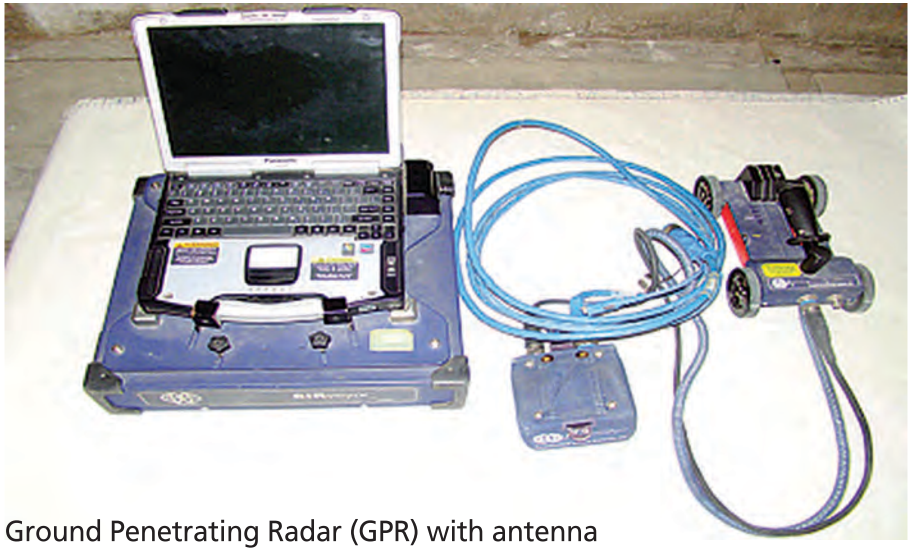
David Young, Shenen Chen, Brett Tempest, UNC Charlotte Dept. of Civil Engineering, USA

Facilities for field investigation for ASSESSMENT OF CONCRETE QUALITY

- Rebound Hammers for determining surface hardness of concrete structures
- Ultrasonic pulse velocity tester for determining concrete quality with respect to integrity and homogeneity
- Impact Echo systems for flaw detections and thickness measurement
- Ground Penetrating Radar (GPR) for determining concrete quality by image processing
- Endoscope for internal damage assessment in concrete structures
- Microscope for crack width measurement
- Core drilling and sampling equipment (50 - 300mm dia; 1200mm depth) for concrete structures
- Cover meter for cover depth determination
- High pressure grouting equipment

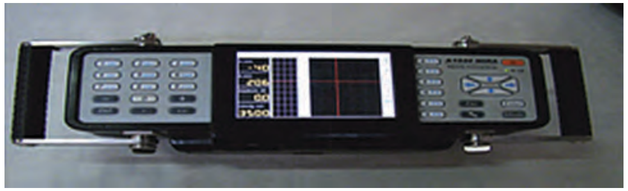
Impact Echo System

Ground Penetrating Radar (GPR)



Ground Penetrating Radar (GPR) with antenna

Impact Echo (IE) with scanner



Low frequency ultrasonic tomograph (pulse array)

Facilities for field investigation for assessment of corrosion damage:

- Half Cells for potential survey
- Resistivity meter for resistivity survey
- Corrosion rate measurement using GECOR-6 / 8
- Corrosion rate measurement using Galva Pulse

Scanner for Non-destructive testing of concrete structures NDT-CE Scanner

For the non-destructive evaluation of concrete structures, advanced techniques such as ground penetrating radar, impact echo and ultrasonic pulse echo are used. The data can be collected manually with each of the techniques and post processed separately. For larger areas and better accuracy, automatic data collection is required. For this, an automated scanner under the collaborative project is procured from BAM, Berlin and installed at ACTEL, CSIR-SERC. Using this scanner, different heads such as radar,

impact echo and ultrasonic pulse echo can be mounted. The scanner can be fixed in horizontal and vertical position and also under the bottom side of a slab. The scanner will be helpful in the data collection for large reinforced concrete structures.

Rapid Chloride Test (RCT) kit

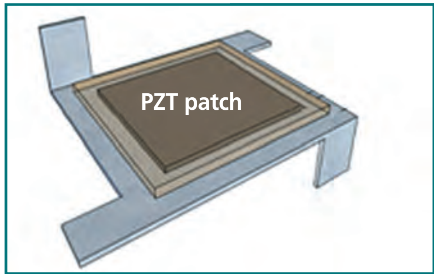
AC impedance based corrosion measurement system

Structural Health MONITORING LABORATORY [SHML]

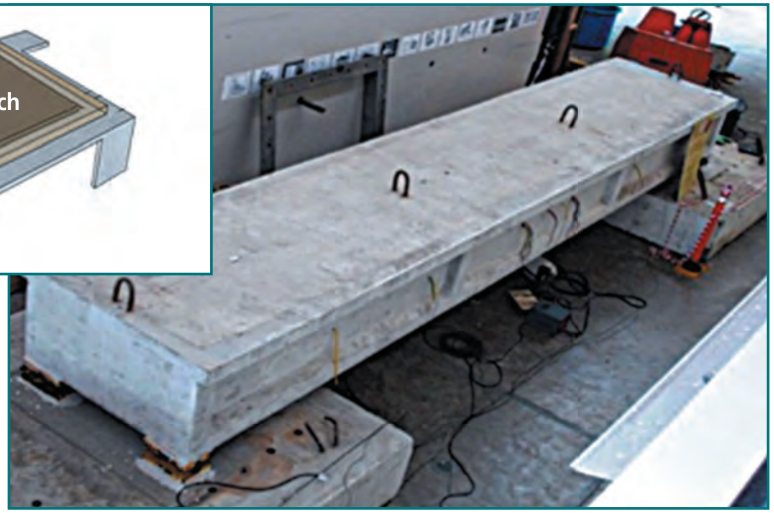
- Data Loggers for Static Strain Measurement - up to 300-channel capacity
- Dynamic Data Acquisition System - up to 88-channel capacity
  - *64 Channels for Strain Measurement*
  - *8 Channels for Displacement Measurement*
  - *8 Channels for Voltage Measurement*
  - *8 Channels for Acceleration Measurement*
- Data Loggers for Vibrating Wire Sensors - up to 60-channel capacity
- Data Loggers for Fiber Optic Sensors - EFPI and FBG types
- Non-Destructive Residual Stress Evaluation by Magnetoelasticity
- Blind-Hole Drilling Equipment for Residual Stress Measurement
- Displacement Transducers and Total Station for Deflection Measurement
- Tilt and Inclinometer System for Structural Monitoring
- Modems, Antennas, Hardware and Software for Remote Structural Health Monitoring
- Equipments for In-Situ Stress Measurements in Concrete / Masonry Structures (Core Drilling / Flat Jack technique)
- Wireless Structural Testing System of 64-channel capacity with various wireless sensors for measurement of strain, displacement, tilt, acceleration.

Development of impedance based structural health monitoring

- SPIESE - Smart Piezo Impedance measuring Embedded Sensor developed for better Sensitivity to localized structural changes & long term health monitoring of massive concrete structures
- Using small PZTs as co-located actuators and sensors impedance curves gives a qualitative picture of damage. Sensors are small, unobtrusive and inexpensive & Detection can be controlled
- Detect incipient structural fault, such as cracks in concrete and loosening of bolts in steel and can be remotely controlled



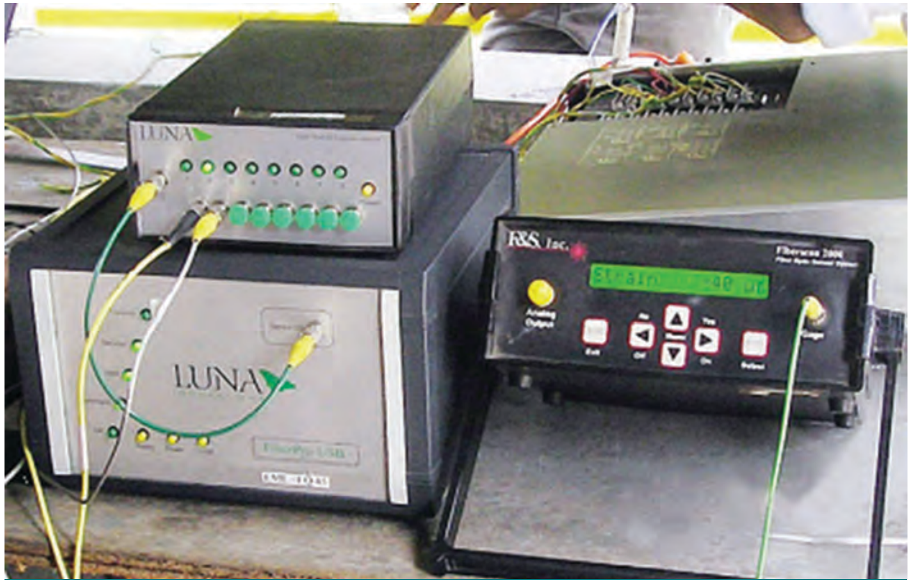
SPIESE – Smart Embedded Sensor



Scaled down Bridge Model

FBG (Fiber Bragg Grating) INTERROGATOR

It is a four-channel FBG interrogator for taking measurements from Fiber Bragg Grating strain sensors, temperature sensors, pressure sensors, acceleration and ruggedness for field measurements. The scanning frequency of this interrogator per channel is 1000Hz. It is compatible with existing HBM strain gage data logger. It is also compatible with existing 64 channel BG interrogator. This FBG interrogator enables the simultaneous acquisition of data from both electrical resistance strain gages and FBG strain sensors. This equipment will be used for research and development in the area of structural engineering.



Data Loggers for Fiber Optic Sensors

Engineering Instrumentation

96-channel MGC plus Data Acquisition System (M/s HBM make) consisting of

- ***48 strain gage channels***
- ***16 LVDY channels***
- ***16 Accelerometer channels***
- ***16 Voltage channels***

Multi-shaker excitation system for forced vibration testing of bridges consists of

1. Six Inch Throw APS - 400 make Electrodynamic (ED) shakers - 4 nos.
2. Model 4001 Horizontal Operation Reaction Mass system for low frequency excitation
3. Reaction mass assemblies - 4 Nos.
4. Dual Mode Amplifier (144) - 4 Nos.
5. Jaguar High Performance Desktop Acquisition/Control Peripheral with 6 input channels, 2 output channels (upto 36 input channels) by M/s Spectral Dynamics
6. Force Transducers (PCB208 A12) with cables
7. Accelerometers (PCB393B04) with cables
8. SUN Ultra system loaded with MIMO analysis
9. Laptop with MISO analysis and Star analyser software
10. JAGUAR Signal Analysis Software for MIMO analysis

Sensors

- Inductive Displacement Transducers, Probe version Measuring Ranges of ±10mm, ±25mm and ±50mm
- ±100mm, Laser based Displacement Sensor
- Deltatron Miniature Accelerometers
- Catman Professional Data Acquisition Software
- ME'scopeVES Visual Modal Analysis Software
- Instrumented sledge hammer kit for forced vibration testing of bridges.
- M/s Crystal make 31-channel ambient vibration testing system for operational model analysis of structures.
- Force balanced triaxial accelerometers, Model: Episensor ES-T, Kinemetrics, Inc,USA.
- Agilent 4294A Precision Impedance Analyzer with 3499 Switch/Control System with 20/40 channel multiplexer module.

Salient features of the developed remote health monitoring scheme are :

- The scheme/system can operate in any mode of communication, i.e. RF/PSTN/GSM depending upon the availability of network at site
- In a single platform, data can be acquired remotely from different type of sensors which are normally used for structural health monitoring
- A portion of the sensors can be activated/deactivated from the monitoring station itself, depending upon the conditions and requirements
- The system can acquire both high speed dynamic data and also slow speed static data
- The RHM system can send alarm messages to the user in case of any abnormal event and acquires data at a higher sampling rate automatically
- Sensors with higher sampling rate and lower sampling rate can be seen in a single window
- The developed scheme/system can be integrated with other data acquisition devices which are already in use at CSIR-SERC. Additional data acquisition systems can also be integrated in the future
- The scheme has capabilities for data synthesis/reduction using user defined algorithms to reduce the data transmission load
- Apart from transferring data files at specified intervals, the scheme can also provide summarized data file for each channel on daily / weekly / monthly basis

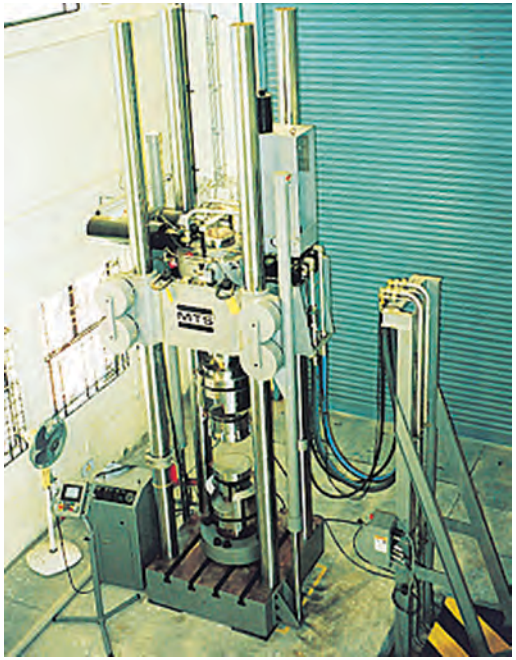
Advanced MATERIALS LABORATORY [AML]

Facilities for testing physical properties of cements and cementitious materials

- Moulding machine for development of building blocks
- Testing equipment for the assessment of resistance of cement concrete composites to abrasion, impact, carbonation and chloride permeability/diffusion
- Concrete core drilling equipment
- Special mixing equipment
- Concrete cutting machine for preparation of test specimen from samples taken from structures
- Polymer impregnation unit & Mini self-contained chemical laboratory
- Non-destructive testing equipment for concrete (PUNDIT, Schmidt / Rebound hammer)
- Testing frames for flexural and bond studies on concrete

Salt-spray chamber for accelerated corrosion studies

- Impressed current set-up for accelerated corrosion test
- GECOR corrosion testing equipment
- 1000kN-capacity Universal Testing Machine (UTM)
- 3000kN-capacity electronically controlled Compression Testing Machine
- Rapid Chloride Test kit
- Mercury Intrusion Porosimeter
- Computer operated, walk-in type, temperature-cum-relative humidity control chamber
- Initial Surface Absorption Test apparatus
- Plummet balance (for particle size distribution measurements)
- German gas and water permeability apparatus
- 2500kN servo-hydraulic controlled Universal Testing Machine
- Heat of Hydration
- Spectrophotometer



2500 kN servo-hydraulic controlled UTM facility

Advanced Materials Laboratory

Eirich mixer machine

Carbonation chamber

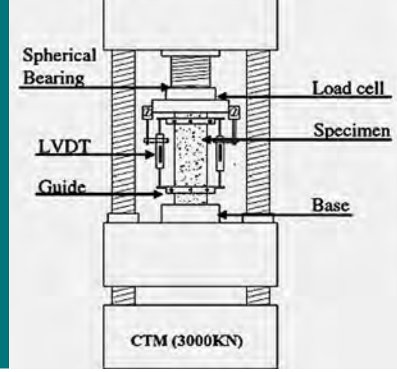
Temperature cum relative-humidity chamber

3000 kN capacity servo control Compression Testing Machine

Thermal cyclic chamber

Concrete Creep Testing
LABORATORY [CCTL]

As a part of developing concrete creep testing laboratory at CSIR-SERC, ten MICROTEST F-ECH-4c/1200kN hydraulic systems for compression creep testing were procured and installed in the basement of AsTAR Laboratory. Each machine has a rigid 4-legged frame with height adjustable upper crosshead and hinged upper plates, and has an axial compression capacity of 1200kN. It has an integrated hydro-pneumatic loading device housed at the bottom with a single-ended single-acting hydraulic actuator. The special feature of the machine is the integrated automatic closed loop servo-controlled system which will enable the machine to maintain the load to within ±1%, without human interference, even when temperature varies within 14°C to 45°C. Each machine is capable of testing 4 nos. of 150mm × 300mm high concrete cylinders in series. Training on the operation of these machines was also given by engineers from M/s Microtest, S.A., Spain, to the identified staff members.



Compression
TESTING MACHINE [CTM]

Compression Testing Machine (CTM) is used to test the compressive strength of the materials or structural elements. It helps to determine the behaviour of material under compressive load. The compressive strength for cubical and cylindrical specimen, split tensile strength for cylindrical specimen and flexural test for prismatic specimen can also be determined. The CTM installed at CSIR-SERC is the product of Microtest. Its compressive load capacity is 3000KN and flexural load capacity is 250kN. Since the machine is directly connected to the computer with software named SCM3000, it can be monitored and regulated using the same and both in load and displacement control mode, thus reducing the risk of using regulating and loading buttons in the machine. The deformation of the specimen at each point is recorded and its stress - strain behaviour of specimens can be obtained. This helps in determining the elastic limit, proportionality limit, yield point, yield strength and ultimate load. The load-deflection curve can also be retrieved directly from the CTM application in the computer to which the machine is connected. The fiber closing around the machine has also reduced the risk of causing accidents due to sudden failure of the materials / specimen.

Steel Structures RESEARCH FACILITY [SSRF]

Major Equipment at Steel Structures Research Facility (SSRF)

Uniaxial Shake Table

This uniaxial shake table has dimensions of 2.5 x 2.5m. The capacity of the actuator is 100kN and the stroke length is ±75mm. It can produce any excitation like Sweep sine, sine, triangular, square waves. This shake table can be used to study the dynamic characteristics of scaled down models of the structures.

50 kN Fatigue Rated Actuator

The fatigue-rated 50kN actuator has a stroke of ±125mm. The system working pressure of the actuator is 210 bar. The actuator can be operated with either load or displacement control method. The actuator can be used for static and fatigue testing of structural components having capacity less than 50kN.

Automatic foam concrete machine

The automatic foam concrete machine can be used for foam concrete production. The machine consists of a foam generator and a mixer, assembled on one frame connected with hoses. Protein-based foaming agents are generally used for generation of foam. Mixing mechanism consists of two multidirectional blades. The capacity of the machine is up to 3 cubic meters per hour. The machine automatically produces foam concrete of definite density. Mixer can be used for foam concrete production, as a plaster station or for production of high quality mixture.

Non-Destructive TESTING (NDT) EQUIPMENT

SSRF has the following NDT equipment for health assessment of steel buildings and structures:

1) Coating thickness gauge: To measure the applied paint or protective coating thickness on the ferrous and non-ferrous metal surfaces.
2) Hardness tester: To evaluate the hardness of the metals in terms of various units so as to assess the material soundness and yield strength of the metal. The hardness tester can work on 0^0, 45^0 and $+90^0$ angle surfaces.
3) Thickness gauge: To measure the thickness (range 2mm to 200mm) of the metallic components. Generally used to find the residual thickness of components, which are affected by corrosion.
4) Dye penetrant test: To identify the surface cracks developed on the weld or parent metal.
5) Ultrasonic flaw detector: To detect and evaluate the cracks, flaws and any delamination developed on the metallic components and structural elements.
6) Magnetic Particle testing: To detect surface and shallow depth cracks in the metal components.
7) 3D Disto: Laser-based 3D coordinates, distance and profile measuring instrument

Impact Test FACILITY [ITF]

Impact testing machines are used to characterize the impact performance of various materials and components. These impact testing systems utilize various technologies to deliver impact forces - including pendulum styles, drop weight styles, and machines to simulate high-rate loading.

CEAST 9350 is a floor standing impact system designed to deliver 0.59-757J or up to 1800J with optional high energy system. As the premier model in the CEAST 9300 line, this model includes many time-saving features and supports a large variety of options–from chambers to extra energy. CEAST 9350 works with the impact software and data acquisition system to make analysis simple. This versatile instrument can be used to test anything from composites to finished products, and is suitable for a range of impact applications including tensile impact, puncture, Izod, and Charpy.

Features of the Instrumented Impact Test Facility:

- Modular crossheads with interchangeable drop weights - change weights safely in seconds
- Visual IMPACT Software - for collecting, analyzing, and reporting detailed impact performance data
- High-speed data acquisition rates: up to 2MHz simultaneous sampling - more data where you need it
- Features such as high-energy configuration, weighing system, automatic lubrication, anti-rebound, environmental chamber, pivoting specimen loader, and automatic specimen feeding system

A view of CEAST 9350 model of machine

Advanced Seismic Testing and RESEARCH LABORATORY [ASTAR]

CREATION OF HEAVY-DUTY STRUCTURES FOR ASTaR LABORATORY

The objectives of the development are:

Advanced seismic testing facility at SERC is established with the goal of stimulating the research activity in earthquake engineering in this country and all the three major seismic testing methodologies, namely, cyclic testing, pseudo-dynamic testing and shake table testing are available in south Asia for the first time.

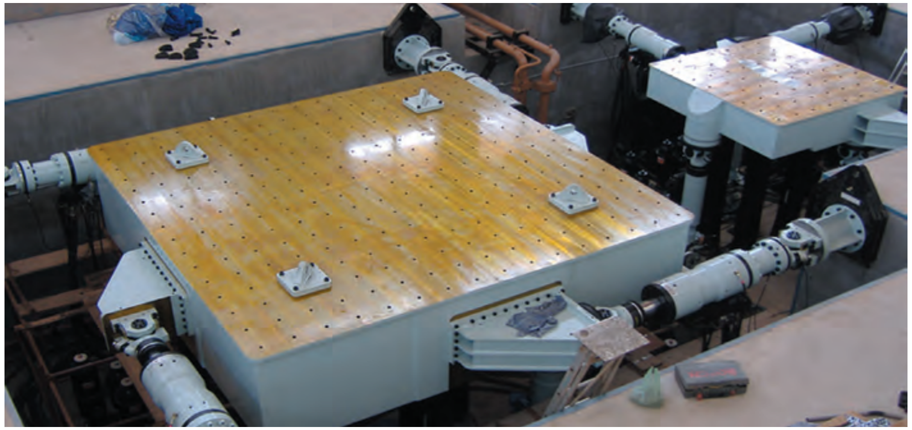
Special features of the development

A unique shake table facility, consisting of two shake tables for synchronous and asynchronous motion of structural payloads with weights up to 50t and subjected to simulated ground motions of 0.6g acceleration and monitoring and recording of their seismic performance in a real time has been established. Simulation of multi-support excitations and tri-axial ground motion inclusive of rotational ground motions are the novelty, hitherto unavailable in the earthquake-prone south Asian countries.

S&T challenges overcome

While it has been conceived to establish an advanced seismic testing and research laboratory for investigating the effects of earthquake on buildings and structures, it was found more challenging and important, considering the available soil condition, to design a structural scheme, where high source vibration will not be propagated to sensitive control rooms and adjacent laboratories. Accordingly, a seismic mass is designed to absorb the dynamic reach from the 4 x 4m and 2 x 2m table system, which consumed a total of about 112 metric tonnes of TMT bars and around 1480m^3 of RMC of grade M30.

To achieve better durability characteristics and to promote use of industrial wastes, High Performance Concrete with ground granulated blast furnace slag (GGBS) (replacing cement by 50%) has been used in the construction of the building. Design and commissioning of a heavy-duty box reaction wall for multi-level and multidirectional pseudo dynamic facility, capable of testing a specimen of 14m height; such a facility is unique and first of its kind in India.



Features

- 30t capacity, 4m x 4m, tri-axial shake table facility
- 5t capacity, 2m x 2m, tri-axial shake table facility
- Pseudo-dynamic test facility consisting of four numbers of ± 5t, ±50mm actuator
- Response measurement and data acquisition capabilities for 128 channels
- Hydraulic power supply system
- Servo controlled unidirectional slip table (0.9m x 0.9m) coupled with an electro-dynamic shaker (5kN capacity)
- Heavy-duty test floor of plan dimension 10.5m x 14m with an anchor grid of 1m x 1m
- Heavy-duty box shaped reaction well for multi-level and multi-directional dynamic / pseudo-dynamic testing of structural components up to a height of 14m with an anchor grid of 1m x 1m
- Two numbers of heavy duty EOT crane each with a load handling capacity of 20 t with synchronous operation
- Captive power supply by two diesel generator sets each of 750kVA with facility for synchronous operation
- Digital ambient vibration measurement system (micro-tremor recorder)
- Pile Integrity Testing Equipment
- Assorted range of vibration measuring system (accelerometers, velocity sensors and LVDTs) with matching amplifiers
- Portable recording devices (e.g. multi-channel digital recorder)
- Vibration exciters / shakers of mechanical and electrodynamic types
- Building shaker for 0.1Hz to 20Hz with 10t force
- Ultrasonic test equipment for assessment of concrete quality / dynamic modulus
- Computational facilities for dynamic analysis of structures & Modal analysis software
- High-speed Camera with 1000 frames/second for digital image processing response data

4m x 4m and 2m x 2m tri-axial shake table facilities

Pseudo-dynamic testing facility

Fatigue & Fracture LABORATORY [FFL]

- Heavy duty test floor of size 36m x 10.5m and two vertical reaction walls of 10.5m width and 7m height
- Computer-controlled closed loop servo-hydraulic fatigue testing systems with actuators of capacities ± 100kN, ± 500kN (2 nos.), ±1000kN (2 nos.) and ± 2000kN
- Fatigue rated, computer-controlled Universal Testing Machines (UTMs) of capacities ± 250kN and ±500kN; ± 250kN capacity machine has top-mounted actuator and load cell and hence can be used for corrosion fatigue studies.
- Static loading system of 5000kN maximum capacity ; 3 Nos.
- Loading frames for static and fatigue testing, of capacity up to 4000kN static and ± 2000kN fatigue
- Portable data acquisition systems for measuringstrain, pressure and temperature, including high speed data acquisition unit

- Crack depth gauges for detection and sizing of surface cracks by ACPD/ACFM techniques
- Ultrasonic flaw detector
- Environmental chambers for carrying out tests on materials and components at sub-zero and elevated temperatures
- Digital image processing system for surface crack growth studies and on-line image acquisition during tests
- Portable thickness meter with measuring range 0.6 - 399.9mm
- Hydraulic power packs of total capacity 390 lpm
- 320kVA diesel generator for uninterrupted test programmes
- Software for carrying out constant amplitude and random load tests using the actuators under load and displacement controls
- Software for carrying out static, fatigue and fracture toughness studies using the UTMs under load and displacement controls
- Software for random signal analysis and crack growth studies
- FEACrack software for fatigue crack growth analysis

A general view of the Laboratory facilities

A general view of the Laboratory facilities
Computer control room cum data acquisition facility

Tower Testing & RESEARCH STATION [TTRS]

- Test bed with prestressed rock anchors of each 500kN uplift capacity
- Sophisticated servo-controlled hydraulic loading system
- Simultaneous application of loads at all loading points of the tower being tested
- Continuous monitoring of resultant loads and angles of their application
- Strain gauge instrumentation and on-line data acquisition and processing
- Video cassette recording and closed loop TV systems for observation, recording and documentation
- Value added tower crane and other handling equipment for erection and dismantling of test towers
- Calibration arrangement for load cell and angle transducers
- Fabrication facilities

Control room of TTRS

Loading capacities and measurement accuracies	
Transverse	12000kN
Langitudinal	5500kN
Vertical	5000kN
Accuracy of loading	±1%
Accuracy of angle of application of load	± 20min

- Deflection measurements made digital records using total station theodolite - polygonal
- Test pad developed for testing circular / mono-pole towers
- Uninterrupted power supply during testing ensured with high power generators with auto-main-failure (AMF) system

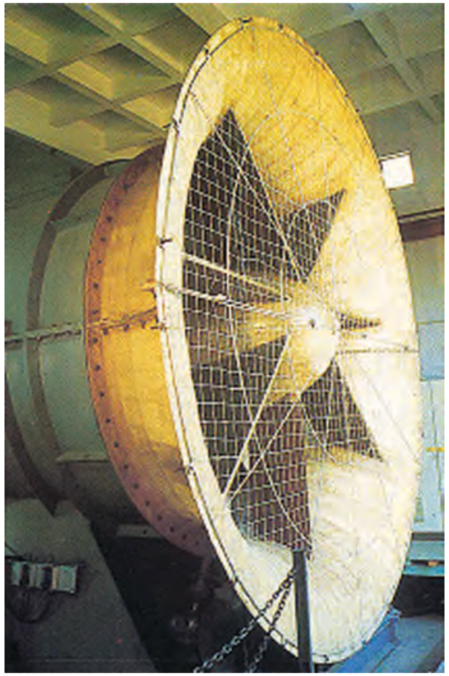
Value addition to the testing facility

Demands on energy and difficulty in getting land for transmission line corridors have necessitated to consider completely innovative methods of configuration and design of towers. One of the ways to address multi-circuit capacity 800 kV and beyond is to have compact vertical tower lines. However, this would demand more number of points of observation for testing and evaluation A state-of-the-art Real Time Digital Control System (RTDCS) has been installed and integrated with the existing system to address such issues and also provide highly interactive and reliable solutions. This system entails precise application / release of load at any given point of time during the testing. The Control System has efficient hardware and software to measure upto 40 channels which can also identify any associated defects during the testing and evaluation. The software is web enabled and the entire test process can be web cast and also recorded for future analysis in case of any failure.

Wind Engineering LABORATORY [WEL]

Atmospheric boundary layer wind tunnel having a speed range of 0.5m/sec to 55m/sec and, comprising

- Dantec transversing system accommodating two hot wire probes
- Hot wire anemometer system with lineariser, signal conditioner and welding units



Howden-Sirocco 600HP fan which generates wind

- Six components force balances
- Data translation cards capable of recording 64 analog single-ended signals
- Multi-channel PC based digital remote A/D high-speed Scanivalve pressure scanning system
- Upgraded Windows-based high-speed PSI electronic pressure measurement system
- Setra Model 370 digital pressure gauge with internal battery operation
- Pressure calibrator(0-100mb)
- Particle Image Velocimetry (PIV) system
- Features of the boundary layer wind tunnel are as follows:

Tunnel	:	**Open circuit blower type**
Variable speed	:	**0.5 m/sec - 55m/sec**
Fan	:	**Axial flow**
Fan motor & power rating	:	**Howden-Sirocco make; 600HP, 740rpm**
Test section	:	**18m x 2.5m x 1.8m (adjustable ceiling)**
Contraction ratio	:	**1:5**
Exit velocity	:	**11m/s (max)**

Full-scale field measurement facility comprising:

- Wind monitoring system
- Strain and DC voltage multi-channel Data

Acquisition systems

- Gill UVW, sonic and 3-cup propeller anemometers
- Piezoelectric type accelerometers: tri-axial accelerometers
- Ten-channel signal conditioners, amplifiers with associated accessories
- Four-Channel portable digital oscilloscope with built in printer and RS 232 interface
- TEAC PCM data recorder with related accessories
- Card module of 16-channel dynamic strain gauge signal conditioner
- Mobile field instrumentation laboratory

Parallel Computational facility for Computational Fluid Dynamics (CFD) studies comprising

- 8-processor computational servers
- FLUENT software

A view of the 52 m long Boundary Layer Wind Tunnel

Particle Image Velocimetry (PIV) facility

BIO ENGINEERING FACILITY

A laboratory that deals with the study and utilization of the biological materials as a source of components that can enhance the mechanical properties of the concrete. The main motive of the laboratory is to isolate the potential microorganisms (bacteria, algae, fungi and the like) that either act as a cementitious material by itself or secrete cementitious material with its metabolic activity. Studies related to the metabolism, rDNA technology for strain improvement and bio-nanomaterials/composites are the advanced studies that are of great economical importance are also carried out in the laboratory for the development of sustainable concrete technology.

Goals in detail

- Isolation and identification of the potential organisms
- Culturing techniques with preservation and sterilization facilities
- Recombinant DNA technology facilities
- Enzymes and proteomics
- Morphological characterization with phenotypic, genotypic and bio-enumeration facilities
- Metabolisms and molecular phylogeny
- Bio-nanocomposites / materials
- Reactor and fermentor technology
- Bio-informatics
- Advanced facilities for application on concrete

Laboratory Facility

The laboratory is quite spacious to accommodate the work space required for every student for their individual research work with well organized infrastructure. Ample work space with all necessary equipment to meet the microbiological, biotechnological and genetics requirements. Separate sections based on the space and environment required for the work. Ample facility for incubation, sterilization, decanting and washing with preservation is also available.

Functional Materials and CHARACTERIZATION [FMC]

FMC laboratory was initiated mainly to characterize the cementitious materials and their functional behaviour. Studies related to the development of new nanomaterials and their functional behaviour with the cementitious moieties are the current area of study which is of great economical importance to the society to overcome the major issues related to the failure of concrete structures.

Goals in detail

- Studies on the application of various nanomaterials and their compatibility with cementitious materials
- Characterization of the cementitious materials using XRD, TGA facilities
- Studies related to the particle size of the cementitious materials and the nano composites
- Advanced studies on the application of the nanocomposites to the concrete to obtain a sustainable concrete technology

Laboratory Facility

The laboratory is built with all the safety zones that is required for the handling of nano materials, chemicals, acids and cementitious materials. Ample work space with all necessary equipment to meet the chemical technology and nano-technology requirements. Separate sections based on the space and environment required for the work.

Knowledge NETWORK UNIT [KNU]

CSIR–SERC has a state-of-the-art 3-tier data centre which caters to the ICT requirements of CSIR-SERC. This data centre is equipped with sophisticated infrastructure including High-end Servers, huge SAN storages and efficient Network components. A very sophisticated Unified Threat Management (UTM) system has been installed to efficiently and securely manage the campus wide Network. Encryption is maintained at system level / data level, depending on the requirement.

Being among the approved institutions of higher learning for NKN connectivity CSIR-SERC has been provided with a 100Mbps link. Through this connectivity access to High Performance Computers such as GARUDA, GLORAID USA, other Research and Educational Institutions: Pan India and across the globe are proposed.

The enterprise applications developed as part of the CSIR ICT project initiative have been deployed at the CSIR-SERC data centre. These applications are being accessed by all the laboratories of CSIR.

The CSIR-SERC web site and the Intranet are being managed and maintained by the KNU by continuous updating of the authorized content received from staff. KNU also looks at design and content management of the web design periodically. The AcSIR site is also being presently managed and maintained by the KNU.

The License servers of LSDyna, Matlab and many such scientific software are being maintained at the KNU data centre

Knowledge RESOURCE DIVISION [KRD]

As one of the leading research libraries in the field of Structural and Civil Engineering in India, the Knowledge Resource Division serves the research, educational, information and general needs of its scientists, researchers, students and other staff as well as scholars from all over India.

Its collection of over 14 thousand volumes and 4 terabytes of unique digital content includes a portfolio of distinguished special collections, notably the journal articles database, proceedings database and institutional repository. It connects users to the leading publishers' scholarly databases with the most comprehensive, specialized, and up-to-date information in their fields, and pursues an active role in educating scientists and students in how to make the best use of these resources. Increasingly, it is prioritizing the digitization of unique materials and collections in order to make them available to any user at all times.

Circulation, reference, photocopying, online project research profile service, auto alert service, Research Alert (an in-house publication) and other digitized facilities on the campus intranet help researchers identify appropriate materials in the Library's holdings and other online sources connected through the KRD portal.

The RFID system has been adopted for issue and return of books and publications. RFID is a combination of radio-frequency-based technology and microchip technology and is being used as tracking and theft detecting system. RFID facilitates easier and faster counter service, inventorying, and materials handling.

KRD brings out a monthly current awareness service titled Research Alert that covers articles of journals received in KRD. This is a monthly service being offered since 1993 and has subscribers nation wide at present. A copy is also hosted in the CSIR-SERC intranet.

Inauguration of the VIGYAN auditorium

The VIGYAN AUDITORIUM

The VIGYAN Auditorium building houses an auditorium with a seating capacity of 400 and two seminar halls in the first floor which can accommodate 80 (10.87 x 9.77m) and 40 (9.77 x 5.32m) persons for conducting smaller meetings, parallel seminars and parallel sessions. The building also has a spacious front lobby, a guest lounge for dignitaries, a green room, an office and a pantry. Two circular columns of 45cm diameter and 7.5m height with ornamental finish provide an aesthetic elevation of the building. All the required service facilities for conducting conferences and seminars have been planned in the building. The total floor area is 1055sq.m. in the ground floor and 400sq.m. in the first floor. The auditorium is octagonal in plan with a side of 10m, clear width of 24.04m and a diagonal length of 26.13m. The total floor area is 482.8sq.m. which includes the stage area of 90sq.m. The stage has a maximum width of 6m. The main structure is of reinforced concrete with eight circular columns of 600mm diameter, connecting beams at foundation, lintel and roof levels and shell roof The shell roof is of umbrella type consisting of eight tapering cylindrical shells connected by rib beams, and ring beams at top and bottom. The entire shell roof was cast monolithically by continuous concreting to avoid construction joints. Thickness of the shell is 10cm with local thickening to 11cm at the rib beams. Concrete of grade M25 was used for the shell roof while M20 was used for other structural members. The shell roof has been treated with polyurethane based waterproofing coating.

The structure of the auditorium building consists of reinforced concrete frames with beams and slabs, and is founded on piles. The foundation is with reinforced concrete riven cast-in-situ piles resting on rock at a depth of 7.0 to 8.0m. The soil has been stabilized with sand-lime piles and lime grouting to minimize settlement and upheaving of the floor. The diameter of the piles is 600mm for the main columns of the auditorium and 450mm for other columns. The (main) auditorium is provided with reinforced concrete umbrella type tapering cylindrical shell roof is now a landmark for the campus.

Material-handling FACILITY [MHF]

CSIR-SERC has procured several material handling equipment to take care of day-to-day material / store handling within the campus. These include an articulated Hydraulic mobile crane of 11-tonne capacity with maximum operational height of 9 metres, a Forklift truck of 3-tonne capacity and a battery operated four wheel industrial platform material-handling unit used for transportation of loads upto 2 tonnes on asphalt or smooth concrete, dry and trampled down road for short haul services. In addition to these, equipment to be used on the shop floor have been added. These are, battery operated stackers of 2-tonne capacity each, an electric pallet truck of 2.5-tonne capacity and a manually operated hydraulic pallet truck.

Aimed at promoting eco-friendly and smoke-free mode of transport in the CSIR Campus, CSIR-SERC purchased electric-run rickshaws designed by Central Mechanical Engineering Research Institute, known as 'Soleksha'. Director, CSIR-SERC inaugurated the Soleksha on 16th April 2012 for use in the CSIR Campus as an experimental measure. Its specialty is that it runs on solar electricity.

Director, CSIR-SERC & Co-ordinating Director, CMC inaugurating the Soleksha at the CSIR Campus

DINING HALL

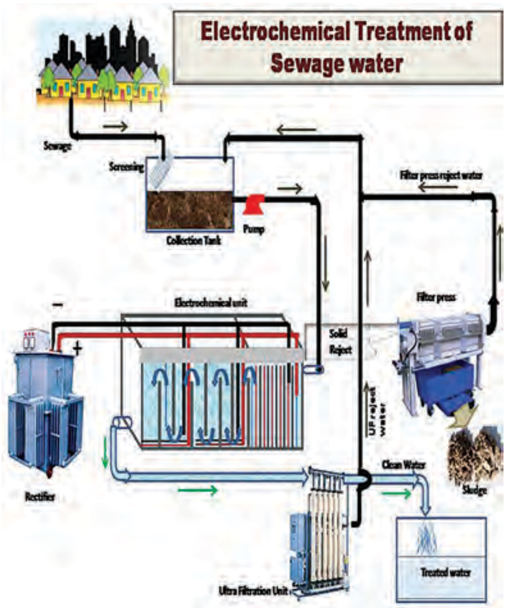
In order to facilitate the dining requirements for the participants/ delegates attending the various national seminars / symposia conducted by CSIR-SERC at the Vigyan Auditorium and, by other participating units in CSIR Campus, besides for the guests accommodated in Trainees' Hostel, a fully air-conditioned, 400 capacity, New Dining Hall has been constructed with ground floor and first floor facilities spanning a total build up plinth area of 1014m^2. It comprises of Modern Cooking facilities, and is equipped with VRF System, LED lighting, a helical staircase enhances the beauty and elegance of the new dining hall. The hall is expected to be ready for use in a few weeks.

RECORD & ARCHIVAL UNIT

For the Administrative Offices of CSIR-SERC and CMC

TREATMENT OF SEWAGE WATER GENERATED AT TTRS BY ELECTROCHEMICAL PROCESS-PILOT SCALE TESTING

Pilot scale electrochemical treatment system comprising electro-coagulation, flotation and oxidation was installed at SERC-TTRS in November 2014 to study its amenability for the treatment of sewage water generated in the campus. The COD, TSS, BOD, pathogenic bacteria etc can be removed from the wastewater and the treated water can be used for gardening and agricultural purpose. Based on the tests, two types of flow-sheets are suggested.




TRAINING & DEVELOPMENT COMPLEX
PROF. SAMIR K. BRAHMACHARI
LEADERS OF CSIR
CSIR LEADERSHIP SUMMIT
AcSIR
Training & Development Complex
CSIR - SERC, CHENNAI

Training and DEVELOPMENT COMPLEX [TDC]

DG, CSIR inaugurated the Training and Development Complex building at CSIR-SERC during his visit. The unique features of the building are the facilities consisting of academic segment and halls of residence. The building has energy-saving electrical fittings, structural glazing with high UV radiation protection, high-volume fly ash used in bricks for masonry walls and in concrete for pavement and road works. It is to be noted that this is the first building constructed using green and eco-friendly technologies and also the first GRIHA proposed rated building among the CSIR laboratories.

HEARTBEATS

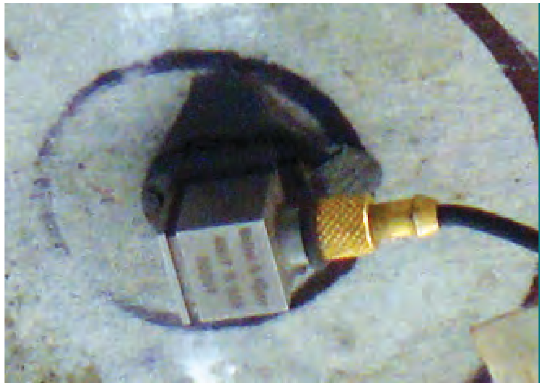
"Congratulations to SERC KNU team for high quality maintenance and operationalization of the ONE CSIR initiative! My best wishes for your extremely important work that is helping transformation of CSIR into world's largest chain of laboratories"

Vijay Bhatkar, Chairman, IIT Delhi

Experimental LINK BUILDING

The Director General inaugurated the Experimental Link Building built entirely using the in-house technology developed by CSIR-SERC. The working mechanism of the electro-dynamic shaker and force transfer from shaker to the building along with scanning process of the Laser Vibrometer during excitation to simulate earthquake excitation of the building was explained and demonstrated to the Director General, CSIR.

Measurement of vibration excitation of Experimental Link Building of CSIR-SERC with APS 400 electro dynamic shaker in vertical mode



Uniaxial and Triaxial Accelerometers used for vibration measurements

Accelerometer instrumentation of ELB of CSIR-SERC during construction stage for vibration measurement

Vibration testing of experimental link building after completion while Director, CSIR-SERC and Prof. S.K. Brahmachari, DG, CSIR observing the test

PGRPE / AcSIR

An area which has been engaging regular attention of CSIR, is the shortage of skilled human resource in the entire area of science and engineering. Though out celebrated academic institutions are doing an excellent service by producing the quality person power, the numbers are nowhere near the needs.

Realizing its responsibility in helping fulfil this national need, CSIR-SERC through the efforts of CSIR started a unique Post Graduate Research Program in Engineering (PGRPE), (later amalgamated to Academy of Scientific and Innovative Research (AcSIR)) in August 2010. The uniqueness stems from a rigorous quality check in multi-stage filtering for admission on an India wide selection basis, specially searched and developed course material, special considerations on faculty skills and a range of 'soft skills' imparted to the students, and, above all, the course syllabus is designed by the developers of the technologies themselves with a heavy orientation on practical aspects. The courses offered are one of its kind. It is noteworthy to mention that the Academy was established by a Resolution of the Parliament in 2010 and received recognition

as an "Institution of National Importance" by the Academy of Scientific and Innovative Research (AcSIR) Act 2011. The Academy aims to maximize the number of qualified researchers and professionals of impeccable quality in the domain of 'science and engineering' and to equip them with the skills to innovate the conduct seamless interdisciplinary research. The objective of AcSIR is pursuit of excellence as well as doing something relevant. We promote the culture of being singularly dynamic and innovative.

Towards getting the best and bright minds into SERC/CSIR system, SERC has been identified for conducting PG programs in the area of Engineering of Structures. This is a two year full time residential program introduced from August 2010. The candidates selected are from among

who have identified fellowship/sponsorship/scholarship, etc. Another program on Renewable Energy was started from August 2012. In addition, CSIR-SERC has started taking candidates for doctoral programs as well, since January 2012. The faculty is mainly drawn from the scientists of CSIR-SERC and CSIR zonal units in the Campus and thus has provided an excellent opportunity to have intense academic interaction. The response from scientists for assuming the role of faculty at AcSIR has also been very encouraging.


like minds
COME TOGETHER

CSIR-KFA/DLR COOPERATIVE SCIENCE *programme*

Title: Efficient and Reliable Finite Element Analysis of Structures and Components

COLLABORATOR:

Sicherheitsforschung und Reaktortechnik (ISR), Jűlich, Germany under the CSIR-ISR (KFA)

Duration : April 1996 - March 2000

Objectives:

- Adaptive refinements for finite element analysis of structures
- Implementation of parallel FE analysis on cluster of workstations using MPI as software development environment
- Implementation of adaptive procedures in the parallel FE analysis with suitable load balancing techniques
- Development of a graphic user interface on Unix based workstations for interactive FE analysis

Title: Finite Element Analysis of Structures

Development of Error Estimator, Adaptive Mesh Refinement, Iterative Solver Techniques, and Parallelization on Coupled SMP Systems

COLLABORATOR :

Central Institute of Mathematics (ZAM), Forschungszentrum, Jűlich, Germany

Duration : Jan 2001 - Dec 2003

INDUSTRIAL PARTNERS:

India	**Germany**
National Institute of Information Technology Ltd. (NIIT) New Delhi	INTES GmbH (INTES) Stuttgart

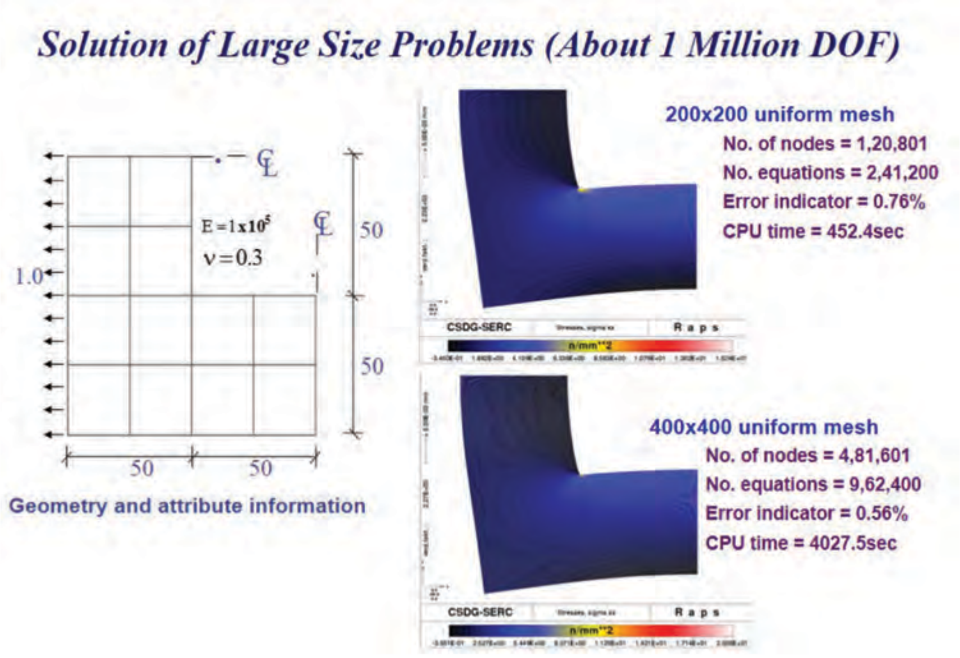
Scope:

- Development of error estimators for 2D and 3D finite elements for linear static and linear dynamic problems
- Development of h-adaptive mesh refinement strategies
- Implementation of efficient error estimation and adaptive refinement procedures in FINEART/PERMAS
- Development of efficient iterative solvers
- Development of a GUI for interactive FE analysis

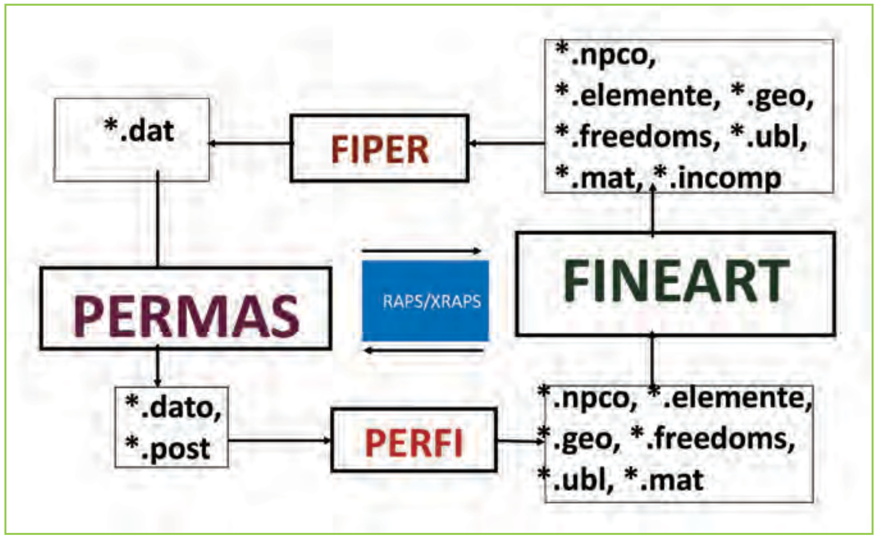
The first 2+2 programme in CSIR!

CONTRIBUTIONS

- A powerful pre- and post-processor for finite element modelling and display of results/responses with a host of features and implementation of efficient algorithms
- New *a posteriori* error estimator for
- Static Analysis (Modified global smoothing)
- Mode-dependent error estimator for vibration analysis
- Frequency domain using mode superposition principles
- Time domain - both spatial and time error estimators
- Implementation of adaptive time stepping technique
- Computationally efficient and reliable h-adaptive procedures for static and dynamic analysis
- Efficient procedures of multigrid technique and its implementation for static and dynamic analysis
- Validation and application to real-life problems

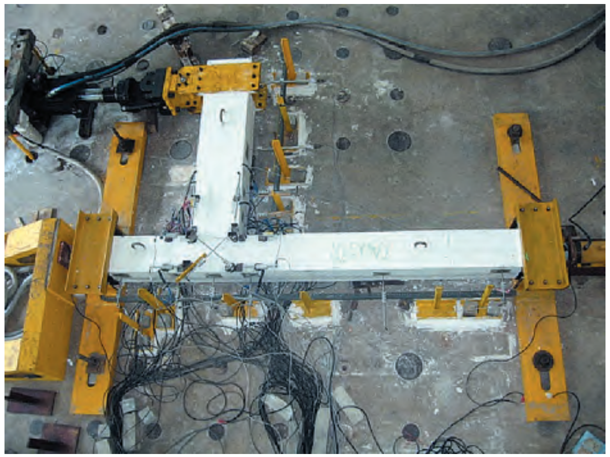


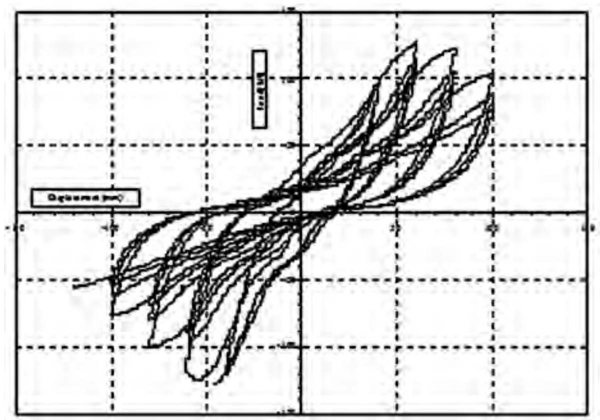
INTERFACE DEFINITIONS



International COLLABORATIVE *programmes*

1. Behaviour of beam-column joints under reverse cyclic loading to evaluate the seismic performance of existing and new reinforced concrete buildings
2. Retrofitting and upgradation of gravity load designed structures for resisting seismic forces
3. Development of new design concepts for seismic resistant design of building





CNR-CSIR BILATERAL PROGRAMME (PROJECT CLP- 00541)

September 2012 to December 2014

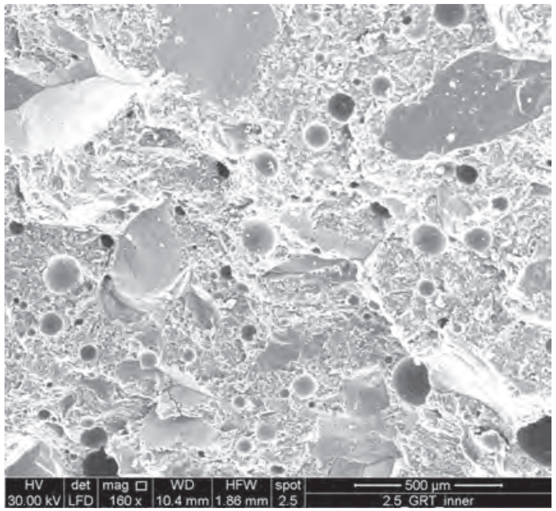
Development of Textile Reinforced Polymer Modified Cementitious Mortar for Retrofitting Applications

CSIR-Structural Engineering Research Centre, Chennai, India

CNR - Institute of Polymers Composites and Biomaterials, Naples, Italy

SCOPE

- Development of a polymer compatible in cementitious binder and also capable of wetting the textiles
- Development of a high performance polymer modified cementitious mortar and its optimization for embedding textile reinforcement
- Micro structural analysis of polymer modified cementitious mortar
- Setting up of Pultrusion machine for producing textile embedded cementitous sheets
- Experiments to find out the uniaxial behaviour of pultruded textile embedded polymer modified cementitious mortar
- Application of pultruded sheets on strengthening of typical structural members



UKIERI PROJECT (F. NO. 184-21/2014 (IC)

(Sept. 2014 to Aug. 2016)

Retrofitting and rehabilitation of reinforced concrete beams using ultra high performance concrete and basalt reinforced concrete overlay

Participating Institutions: CSIR-SERC and Cardiff University

Aim - Development of Methodologies for Retrofitting and Rehabilitation of Reinforced Concrete (RC) beams using Ultra High Performance Concrete (UHPC) and basalt reinforced concrete (BRC) overlay

Objectives

- Development and prefabrication of UHPC and BRC overlay
- Development of methodologies to integrate UHPC and BRC overlay with RC beams
- Characterization of the interfacial bond between old concrete substrate and overlay
- Experimental investigations on behavior of RC beams with overlays
- Analytical methodologies to predict the response of RC beams retrofitted with UHPC and BRC overlay
- Performance-based design guidelines for repair and rehabilitation of RC beams retrofitted with overlay

HEARTBEATS

"A great job done! Kudos to the Director CSIR-SERC and team. Best wishes."

Samir K. Brahmachari, Former Director General, CSIR, New Delhi

VISUALIZATION OF AUTOMATED MULTI-SENSOR NDT ASSESSMENT OF CONCRETE STRUCTURES

Period: April 2012- March 2015

Consortium Partners of the collaborative project

CSIR Structural Engineering Research Centre (SERC),Chennai, INDIA

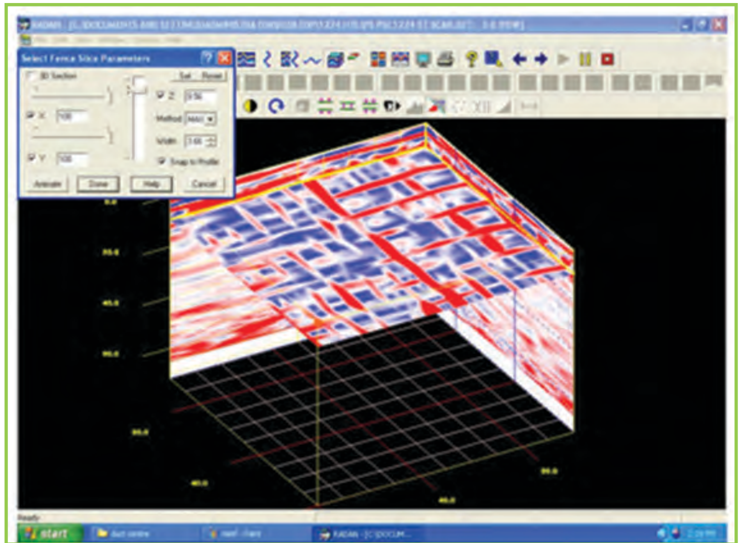
Bundesanstalt für Materialforschung-und–prüfung (BAM) Berlin, GERMANY

Lucid Software Limited (Lucid) ,Chennai, INDIA

Specht, Kalleja + Partner GmbH (SKP), Berlin, GERMANY

- Developing a platform for effective multi-sensor NDT data fusion & combine the data from different sources.
- Development of a scanner system which can collect overlapping measurements with sufficient accuracy required for effective data fusion.
- Development of various low level (i.e., raw or pre-processed data) as well as high level (i.e., pixel-based) data fusion algorithms to combine the collected datasets on the test specimens.
- Development of advanced visualization software tools
- The efficacy of the developed methodology and software tools to be tested under real-world conditions.

Scanner under operation in vertical mode



Reinforcements in the wall

joining hands

WITH COURAGE AND FAITH

BAM
Federal Institute for Materials Research and Testing

बी एच ई एल
BHEL

CONSULTANCY DEVELOPMENT CENTRE
25 years in Consultancy

CHAITANYA BHARATHI INSTITUTE of TECHNOLOGY
1979

केंद्रीय लोक निर्माण विभाग
CPWD

HITECH

CSIR-Tech

JINDAL STEEL & POWER

RAMBOLL

MANGALAYATAN UNIVERSITY

एनटीपीसी
NTPC
NATIONAL THERMAL POWER CORPN. LTD.

ओएनजीसी
ONGC

sesa sterlite
a vedanta company

INDIAN RAILWAYS
SOUTHERN RAILWAY

SRI RAMAKRISHNA INSTITUTE OF TECHNOLOGY
WISDOM · DISCIPLINE · PROSPERITY
COIMBATORE-10

Sri SAI RAM ENGINEERING COLLEGE

Easwari Engineering College
Educate & Excel

SRM UNIVERSITY
LEARN. LEAP. LEAD

St. PETER'S UNIVERSITY

Synergy Thrislington
Thrislington

VIGNAN'S
Foundation for Science, Technology & Research
UNIVERSITY

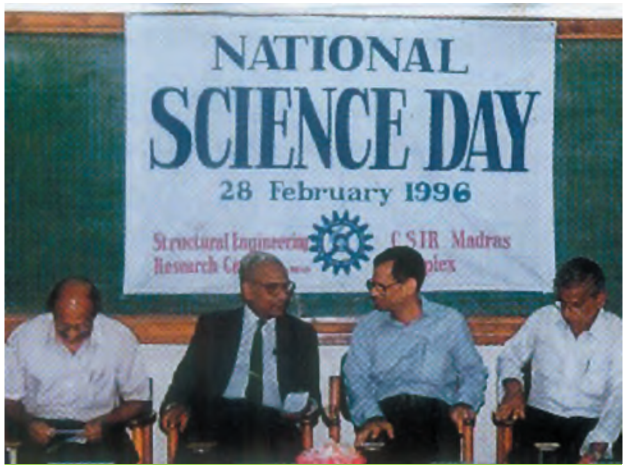
MEMORIES


STRESS ANALYSIS TECHNIQUES
25.February-1 March,1985
SCIENTIFIC & INDUSTRIAL
FOUNDATION STONE
C. S. I. R. CAMPUS,
WAS LAID BY
C.
AND SCIENCE & TECHNO
MONDAY, 21ST JUNE
FUNCTION PRESIDED OVER
K. K. SHAH.
OF TAMIL NADU


fondly cherished

NATIONAL SCIENCE DAY
28th February

1989: Chief Guest Shri C.Subramanian, Former Union Miniter of S & T



1996: Chief Guest Prof. M. Anandakrishnan, Vice-Chancellor, Anna University, graces National Science Day function

1998: Chief Guest
Prof. U.R. Rao, member, Space Commission

2000: Chief Gest Prof. R. Natarajan, Director, IIT, Madras

2002: Chief Guest
Prof. M. Ravindran, Director, NIOT, Chennai

2004: Dr. G. Thyagarajan, Ex. Director, CSIR-CLRI & Former Secretary, COSTED, delivering the National Science Day lecture

NATIONAL SCIENCE DAY
28th February

2006: Dr. T.N. Gupta (at the podium) and Dr. T.V.S.R. Appa Rao in the dais (second from left), are the special guests at National Sciences Day function at CSIR-SERC

2007: Dr. P.K. Biswas, former Advisor (S&T), Planning Commission, delivers National Science Day Lecture

2008: Dr. Placid Rodriguez, Chief Guest, is all keen to know about the structural model for wind tunnel testing

2008: Chief Guest
Dr.Placid Rodriguez, Director,
IGCAR, Kalpakkam

2009: Chief Guest
Dr.V.S.Ramamurthy,
Director NIAS

2010: Chief Guest: Dr. B. Gopalan, Chief Scientific Officer and Executive Director, Drug Discovery Research, Orchid Research Laboratories

NATIONAL SCIENCE DAY

28th February

2011: Chief Guest
Mr. Zakir Thomas, Project Director, OSDD, CSIR, New Delhi

2012: Chief Guest
Dr. Mitali Mukerji, Principal Scientist, CSIR-IGIB

2013: Chief Guest
Dr. R. Balasubramanian, Director, The Institute of Mathematical Sciences, Chennai

2014: Chief Guest: Prof. M.S. Swaminathan, Founder Chairman and Chief Mentor, UNESCO Chair in Ecotechnology, M.S. Swaminathan Research Foundation, Chennai

HEARTBEATS

"Excellent facilities and activity. I hope that we will be able to collaborate with you in the field of conservation of heritage structures."

Toshikazu Hanazato, Mie University, Japan

"I am going to make SERC my second home in Chennai. You have an excellent group of people and administration."

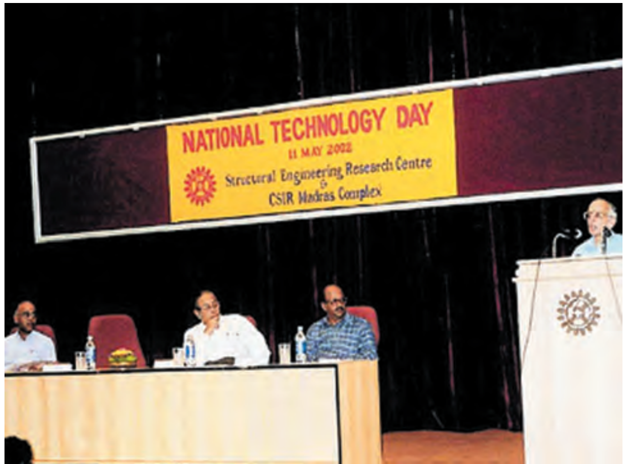
Prof. S.P. Shah, Northwestern University, USA

NATIONAL TECHNOLOGY DAY

11th May

1999: Shri A. Ramakrishna and Prof. Ananthakrishnan sharing dias

2001: National Technology Day lecture being delivered by Dr. S.B. Bhoje, Director, IGCAR, Kalpakkam



2002: National Technology Day lecture by Prof. M.S. Ananth, Director, IITM

2003: Prof. E. Balagurusamy, V-C, Anna University and Chief Guest on National Technology Day, delivering his address

2004: Shri V. Suresh, Chief Guest on National Technology Day being welcomed with traditional flowers

2006: Dr. Amit Chatterjee, Advisor to the Managing Director, TISCO, Jamshedpur, is the chief guest for National Technology Day

NATIONAL TECHNOLOGY DAY

11th May

2007: Chief Guest Dr. P.K. Biswas, former Advisor (S&T), Planning Commission

2008: Chief Guest S.Viswanath Former Chief Scientist, NAL and Member MC and RC , CSIR-SERC

2009: Chief Guest Dr.G.Bhaskar Raju, SIC NML Unit, Chennai and Dr. S.Pitchumani, SIC, CECRI Unit, Chennai

2010: Chief Guest Dr.K.Ramanjaneyulu being felicitated for delivering the G.S. Ramaswamy Lecture

2011: Chief Guest by Dr A.K. Sahu, Scientist, CECRI Unit, Chennai

2012: Chief Guest Dr. J. Rajasankar, Senior Principal Scientist

NATIONAL TECHNOLOGY DAY

11th May

2013: Chief Guests
Dr. Carmalin Sophia, Scientist, CSIR- NEERI and
Dr. Bala Pesala, Senior Scientist, CSIR-CEERI

2014: Chief Guests
Dr.N.Gopalakrishnan, Chief Scietist &
Dr. G.S.Palani, Sr. Principal Scientist, CSIR-SERC

HEARTBEATS

"Excellent institute. Very impressed with the good work being done by the scientists here. It is indeed encouraging to see the single-minded dedication of each and every person involved in the work here, with the Director leading his team. I wish SERC many many more successes. Keep up the good work and make India proud!"

Anu J. Singh, Joint Secretary & Financial Advisor, DSIR, New Delhi, India

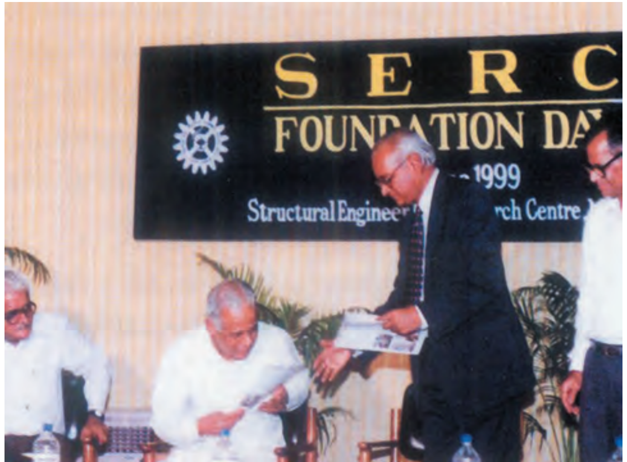
CSIR-SERC FOUNDATION DAY

10th June

1996: Prof. G.S. Ramaswamy, Founder Director, SERC receiving memento from Dr. RA. Mashelkar, DG CSIR

1997: Dr. P. Rama Rao, Chairman, Atomic Energy Regulatory Board, Mumbai delivering SERC Foundation Day Lecture

1998: Chief Guest Dr. S. Varadarajan, President, INSA, gracing the SERC Foundation Day celebration



1999: Prof. V.N. Gupchup, Chairman, Research Council presents the first copy of the new brochure an Experimental Mechanics Laboratory to Dr. H.C. Visvesvaraya, Chief Guest on the occasion of the SERC Foundation Day

2001: Dr. R. Chidambaram, DAE Homi Bhabha Chair Professor, BARC and formerly Chairman, AEC, graces the SERC Foundation Day function

2003: Director, SERC, presenting a memento to Dr. R.B. Grover, Director, Strategic Planning Group, Dept. of Atomic Energy & Chief Guest on the occasion of SERC Foundation Day

CSIR-SERC FOUNDATION DAY
10th JunE

2004: Director, CSIR-SERC presenting a memento to Prof. Prem Krishna on the occasion of SERC Foundation Day

2005: The Third Professor G.S. Ramaswamy Memorial lecture being delivered by Dr. C.S. Viswanatha, Chief Consulting Engineer, Torsteel Research Foundation, Bangalore, at SERC, Chennai

2006: The Fourth Professor G.S. Ramaswamy Memorial Lecture being delivered at SERC by Dr. R.K. Bhandari, Chairman, CDMM, VIT, Vellore

2007: Dr. Anil Kakodkar, Secretary, DAE, unveils the plaque commemorating the Inauguration of ASTAR-Lab in the august presence of other dignitaries

2007: Dias shared by Dr. Anil Kakodkar, Sceretary, DAE; Dr. T. Ramaswamy, DG, CSIR (Addl. Charge)& Prof. R.A. Mashelkar, Former, DG, CSIR

2008: Chief Guest Prof.V. Kalyanaraman Civil Engg. Dept, IIT Madras

CSIR-SERC FOUNDATION DAY

10th June

2009: Chief Guest
Shri A.Ramakrishna
Vice President, L&T, Chennai

2010: Chief Guest: Dr. H.C. Visvesvaraya, former Chairman, RC, SERC, Ghaziabad, former Chairman, RC, CBRI, Roorkee and Ex-Vice-Chancellor, University of Roorkee

2011: Chief Guest Prof. P.C. Varghese, Hon. Professor, Anna University; Formerly Professor & Head, Dept. of Civil Engg., IIT-M and UNESCO Chief Technical Adviser, University of Moratuwa, Srilanka

2012: Chief Guest Shri Zacharia George, former Scientist, CSIR-SERC and Principal Structural Consultant, M/s. Pithavadian and Partners

2013: Chief Guest
Shri S.A. Reddi, former Deputy Managing Director, Gammon India Ltd., Bangalore.

2014: Chief Guest Dr. G. Thyagarajan, former Director, CSIR - NEIST Jorhat, CSIR - IICT Hyderabad, CSIR - CLRI Chennai, former Commonwealth Science Diplomat, London

CSIR FOUNDATION DAY
26th September

1994: Shri N.V.Raman, Director, distributed the prizes to the winners

2000: Chief Guest
Prof. R. Natarajan, Director, IITM

2002: Prize winning children are *'all smiles'*, posing with Director, SERC

2003: Prof. P. Dayarathnam, formerly V-C, JNT Univ., Hyderabad addresses the gathering on the occasion of CSIR Foundation Day

2004: Shri K.V. Rangaswami, Senior Executive Vice President, L&T-ECC Division, Chennai

2005: Young visitors to SERC, Chennai, on the occasion of Open Day on CSIR Foundation Day

CSIR FOUNDATION DAY
26thSeptembeR

2006: Shri R.K. Celly, Executive Director, BMTPC, New Delhi delivering CSIR Foundation Day Lecture

2007: Dr. S. Kathiroli, Chief Guest, giving away the Dr. M. Ramaiah Prize for best technical paper

2007: Chief Guest
Dr. S.Kathiroli, Director, NIOT

Dr. K. Audi Sesha Reddy, SHAR, delivering the CSIR Foundation Day Lecture

2008: Chief Guest
Shri K. Audi Sesha Reddy
Dy. General Manager, SHAR

2009: Chief Guest
G. Narayanan, General Manager,
Southern railway

CSIR FOUNDATION DAY
26th SeptembeR

2010: Chief Guest Dr. Atmanand, Director, National Institute of Ocean Technology

2011: Chief Guest: Prof. C.V. Vaidyanathan, Vice-Chancellor, Sri Chandrasekharendra Saraswathi Viswa Mahavidyalaya


2012: Chief Guest
Prof. B.S. Murty, Professor, Department of Metallurgical & Materials Engineering, IIT-M


2013: Chief Guest
Dr. Manamohan R. Kalgal, Sr. Vice President, Ultra Tech Cement Ltd

2014: Chief Guest
Prof. Antony Jeyasehar, Dept.of Civil Engg.
Annamalai University

CPYLS PROGRAMME

2007

2012

2008

2009

2010

EUREKA QUIZ PROGRAMME

2008

2009

2010

2011

2012

2013

2014

EXHIBITIONS & EVENTS

SERC, Madras - Exhibition Stall in PETROTECH - 97 at New Delhi

Visitors at the SERC stall in the Technology Pavilion, IITF '98, Pragati Maidan, New Delhi, November 1998.

Shri G. V. Ramakrishna, Chairman, Construction Industry Development Council, chairs SERC-Construction Industry Meet on 18th August 1998.
Others seen from L to R are: Dr. R. K. Bhandari, ISTAD, CSIR; Dr. T. V.S.R. Appa Rao, SERC Madras; Shri A. Ramakrishna, L&T, ECC

Dr. T.V.S.R. Appa Rao, Director, SERC, Madras receives the CSIR Technology Prize 1999 from Dr. Murli Manohar Joshi, Hon'ble Minister for Science and Technology in the distinguished presence of Dr. R.A. Mashelkar, FRS, DG-CSIR and Prof. Ashoke Sen, Allahabad

EXHIBITIONS & EVENTS

Dr. T.V.S.R. Appa Rao, Director, SERC, Madras receives the shield for Engineering Technology in "Wind Engineering" from Dr. Murli Manohar Joshi, Hon'ble Minister for Science and Technology

Performance Appraisal Board Meeting (2002)

EXHIBITIONS & EVENTS

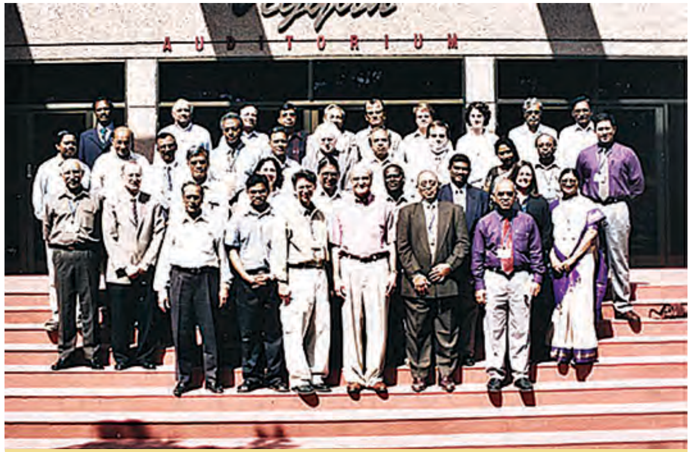
A section of the invited participants (CEOs and academic experts) of the One-Day Industry Get-together 'DEFINE 02', 11 March, 2002

SERC puts up its own show alongside CSIR showcase (28 Feb. - 4 Mar. '03)

Dr. Anil Kakodkar, Chairman, AEC, flanked by other dignitaries, during inauguration of National Seminar on Seismic Design of Nuclear Power Plants (21-22 February 2003)

Dr. A. Ramakrishna chairs the INAE-SERC Round Table on seismic microzonation (24 February, 2003)

EXHIBITIONS & EVENTS



Delegates from USA and India who attended the Indo-US Workshop (4 January, 2005)

Inaugural Dais of the 5th Asian Symposium on Polymers in Concrete (ASPIC-06), SERC (11 September, 2006)

SERC'S scientist explaining to visitors at the Amethi exhibition, 18-22 February 2006.

Dr. R.A. Mashelkar, DG-CSIR, delivering the inaugural address at the CSIR - Automobile industry get-together on Advanced Manufacturing Technologies at SERC, Chennai (17 December, 2005).

94th Indian Science Congress Exhibition 3-7 January, 2007

EXHIBITIONS & EVENTS

Academia - Industry get-together on Release of FINEART, SERC (23 February, 2007)

Hon'ble Shri Shashidhar Reddy, member, NDMA delivering inaugural address at NCWE-2007 (30 Oct. 2007)

Dr. N. Lakshmanan, Director, SERC, releases the Proceedings Volumes of SEC-2008

Visit of Dr. Kasturirangan, Member-Science, Planning Commission to SERC and CMC on Friday, 29th January 2010

EXHIBITIONS & EVENTS

Ground breaking ceremony of Innovation Complex

Technofest 2010 at Pragati Maidan, New Delhi

ROUTE 2013

DG, CSIR inaugurating the new entrance & dining hall

EXHIBITIONS & EVENTS

DG Inaugurating the experimental link Building

DG at the New Administrative wing

DG at Data Centre

DG, CSIR with the former Directors of CSIR-SERC
Dr. M. Ramaiah, Dr. T.V.S.R. Appa Rao, Dr. N. Lakshmanan &
Prof. (Dr. -Ing.) N. Rajagopalan, Chairman, RC

EXHIBITIONS & EVENTS

Outstanding Achievement award to CSIR-SERC for having demonstrated in championing the transition to an electronic work culture from DG, CSIR

DG Inaugurating the Training and Development Complex

VIII Asia Pacific Conference on Wind Engineering

EXHIBITIONS & EVENTS

CSIR Leadership Summit at CSIR-SERC,
28th December 2013

HEARTBEATS

"As all the other exemplary systems, operations and practices at SERC, I am impressed with the demonstration of commitment, performance and rigor in the manner in which systems have been designed and implemented. Best wishes!"

Dr.K. Jaykumar, Joint Secretary (Admin), CSIR

र.अ. माशेलकर, एफ.आर.एस.
महानिदेशक, वै.औ.अ.प.,
एवं सचिव, भारत सरकार
वैज्ञानिक तथा औद्योगिक अनुसंधान विभाग

R.A. MASHELKAR, F.R.S.
Director General, CSIR
& Secretary, Government of India
Department of Scientific & Industrial Research

वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद्
अनुसंधान भवन, 2 रफी मार्ग, नई दिल्ली–110001

COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH
Anusandhan Bhawan, 2 Rafi Marg, New Delhi-110 001

PS/H/ISTAD/3/99
December 15, 1999

Dear Dr Appa Rao,

I'm glad to know from the letter of Indian Red Cross Society addressed to you that the Cyclone shelters designed by SERC not only stood the test of the Super Cyclone but were instrumental in saving thousands of lives. While taking legitimate pride for this achievement. I would like to congratulate you and your team for making this possible.

The mammoth reconstruction and rehabilitation programme in Orissa lies ahead of us. It is my sincere hope that the SERC will create more landmarks to earn bigger laurels for CSIR, in future.

With my good wishes,

Sincerely,

(RA MASHELKAR)

Dr TVSR Appa Rao
Director
Structural Engineering Research Centre
Post Bag No. 8287
Taramani
Chennai 600113 (Tamilnadu)

Telephone : Office ; 3710472, 3717053, Residence ; 4618851, 4649359; Fax : (91 11) 3710618; E-mail : dgcsir@csirhq.ren.nic.in;csirhq@simetd.ernet.in
Gram : CONSEARCH NEW DELHI

प्रो. समीर के. ब्रह्मचारी
महानिदेशक, वै.औ.अ.प.
एवं सचिव, भारत सरकार
वैज्ञानिक तथा औद्योगिक अनुसंधान विभाग

Prof. Samir K. Brahmachari
Director General, CSIR
& Secretary, Government of India
Department of Scientific & Industrial Research

वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद्
अनुसंधान भवन, 2, रफी मार्ग, नई दिल्ली-110001

COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH
Anusandhan Bhawan, 2, Rafi Marg, New Delhi-110001

No. DG/PS/2010-156
28/06/2010

Dear Dr. Iyer,

Thank you for your letter no: 313(8.1)/2010-NRI dated 11 June 2010, enclosing a copy each of the books entitled *"CSIR-SERC Saga (1965-2010)* and *Flora & Fauna of CSIR-SERC-CMC."*

It was a delight to go through the pages of *"CSIR-SERC Saga* and to trace the genesis and evolution of SERC. There is no doubt that the publication has great archival value. I am sure that any new recruit to CSIR-SERC reading it will feel proud to have inherited such a rich legacy and be inspired to take it forward.

I am also greatly impressed by the great diversity of flora and fauna that thrives in the CSIR campus comprising SERC and CMC. It speaks volumes for the un-spoilt natural environment on the campus. I hope that the biodiversity, that has been so painstakingly and beautifully documented, keeps flourishing in the years ahead. I am sure that the book will touch the hearts of the readers and open their eyes to the biodiversity that surrounds them.

I extend my heartfelt congratulations to you, all the photographers and the Editorial teams for bringing out such wonderful and worthy publications.

With warm personal regards,

Yours sincerely,

[Samir K Brahmachari]

Dr. Nagesh R Iyer
Director
Structural Engineering Research Centre
CSIR Campus, Taramani
Chennai 600113 (TN)

Dr KRS

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the legacy FLOWS ON

New INITIATIVES

- Development of sustainable materials and construction technologies including nano/engineered materials
- Light-weight and pre-engineered construction panels for fast construction and use in rural areas
- Construction materials replacing (partial/full) a) cement (by flyash, waste materials, composites, engineered/manufactured materials and bio-materials) and b) high energy intensive steel (by 'Green' steel, metals and composites)
- Work towards development of geopolymer concretes, Ultra high strength concretes, etc. for sustainable, durable and efficient structures
- Biomimetic/ Bio-inspired materials of construction
- National Facility for Materials, Mechanics and Sensors (NAFAMMS)
- Effective waste utilization including construction & demolition waste
- Energy efficient buildings & infrastructure
- Innovative Integrated building management system & health management of infrastructure
- Non-conventional energy (wind, solar and hybrid) structures
- Design of structure against natural and man-made disasters
- CSIR-800/MSME cluster programs
- Development of eco-friendly, durable, energy-efficient construction materials and characterization
- Development of eco-balancing structural systems including green buildings with reduced carbon foot print based on non-conventional methods
- Performance based life cycle design approach
- Develop computational tools for multi-scale modeling of materials
- Evolve new sensor technologies & methods for structural health monitoring and assessment
- Evolve technologies for real-time, continuous remote health monitoring employing motes, self-sensing & GPS, GSM satellites, RF, image processing, WSN and the like
- Condition assessment & forensic analysis of damage/defect identification and evaluation

HEARTBEATS

"A very educational and professionally oriented institute. This institute has a great future and has all the credentials for building the same from the past. Evolve MEGA PROJECTS on a scale to make an impact on the country. I am happy to see that CSIR-SERC is restructuring itself to enable getting into multi-lab, multi-agency mega projects. You have a reputation and history of successful delivery. Look for opportunities... you can make national impact. I wish the institute best of success in all its endeavors!"

Dr. K. Kasturirangan, Former Member, Planning Commission of India

Proposed National Facility for Materials, Mechanics and Sensors (NAFAMMS)

NAFAMMS is being established as combined output of the activities of number of programs. Salient features of NAFAMMS:

- A unique advanced national facility with green features
- Built-up area of about 2800sq.m. (G+2)

To house sophisticated research facilities on materials, mechanics and sensors

- Heavy duty test floor area of about 300sq.m. with a payload of 500kN/sq.m.
- L-shaped vertical reaction walls (equal arms of 6m length) to facilitate bidirectional loading
- About 1700sq.m. lab space with state-of-the-art infrastructure like UTM, CTM, etc. for health monitoring, Nanotechnology lab, Bio-lab and functional materials lab
- Office space of about 800sq.m. towards knowledge generation & dissemination

Classification of Soil Sites of Chennai City

The overburden above the rock modifies the strong ground motion

- Major influence on the damaging effects of an earthquake

Seismic microzonation of important cities

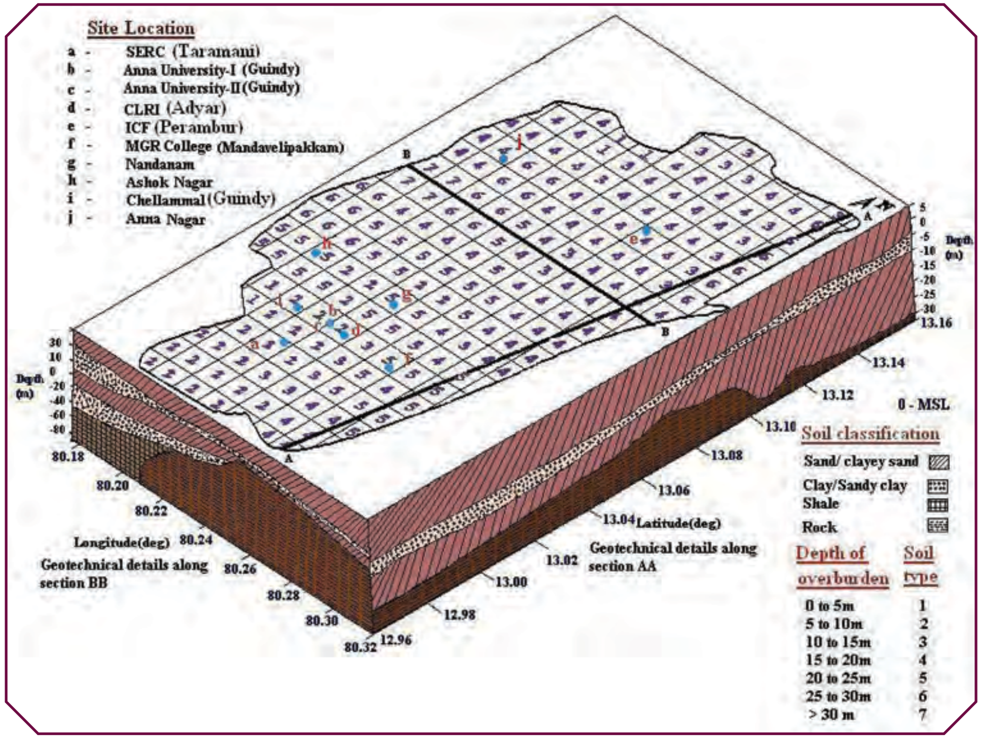
- Better understanding of the seismic hazard in the cities
- Useful in land use planning and disaster preparedness
- Helps in site-specific risk analysis and risk-consistent design of structures

Geophysical investigations are carried out for typical sites in and around Chennai city by a team from CSIR-NGRI in collaboration with CSIR-SERC

- Seismic refraction and Multi channel Analysis of Surface Wave (MASW) methods are used to arrive at the P-wave- and S-wave -velocities of the sites

TABLE 1
TYPICAL SOIL SITES OF CHENNAI CITY WITH CLASSIFICATION AS PER V_{s30}

Location	Latitude°	Longitude°	V_{s30} (m/s)	Site class
Taramani	13.0	80.2	380.7	C
Adyar	13.0	80.2	587.5	C
Mandavellipakkam	13.0	80.3	441.0	C
Nandanam	13.0	80.2	350.0	D
Uthandi	12.9	80.2	345.3	D
Ashok Nagar	13.0	80.2	330.8	D
Iland ground			323.7	D
Avadi	13.1	80.1	281.3	D
Pattabiram			346.0	D
Kalpakkam	12.6	80.2	203.1	D
Muthukadu	12.8	80.3	441.4	C
Tambaram	12.9	80.3	1110.8	B
Vandallur	12.9	80.1	1194.6	B
Kolavakkam			618.8	C
Padur			1575.0	A

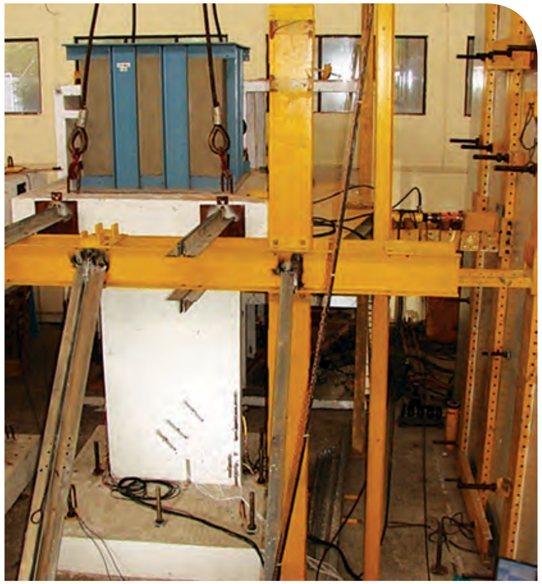


Chennai has three major depositions, viz., alluvium in the western part, coastal deposit in the central and eastern part and, shallow rock in the south west region

- The deposited soil consists of mainly clays, sands, sandy clays and occasional boulder/gravel zones
- The eastern coastal zone is predominantly sandy and the north western region is mostly clayey in nature
- Depth to rock (depth of overburden) varies from outcrop to more than 35m
- Depending upon the depth of overburden, the soil types are divided into seven categories

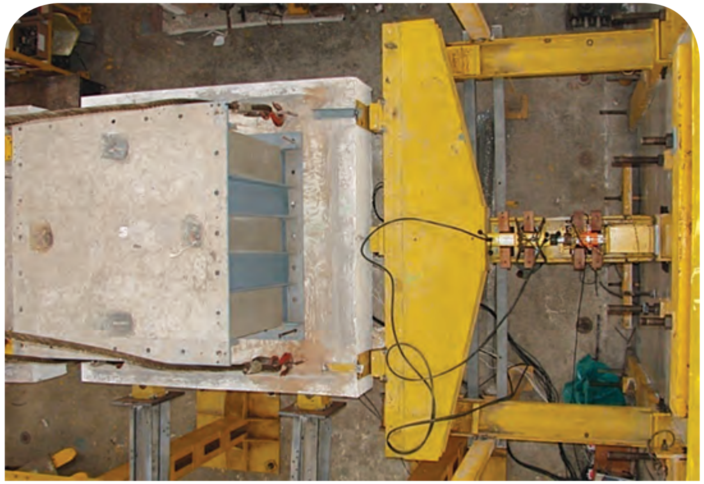
PUSHOVER TEST ON SHEAR WALL

- Monotonic loads are applied at top of the medium aspect ratio shear wall
- Top slab and additional mass kept on the top of the shear wall giving the constant axial stress in the shear wall
- Shear wall has shown a tri-linear behaviour, clearly indicating the concrete cracking, steel bar yielding and finally steel bar rupture
- Due to onset yielding of the bars at the extreme tension fibre, the stiffness of the wall continuously changes between lower yield load to upper yield load
- Over-strength ratio between ultimate force capacity of the shear wall and its on-set yield force is an important design parameter



CYCLIC LOAD TEST ON SHEAR WALL

- Cyclic load test is conducted on two shear wall specimens of similar dimension used in monotonic test
- A special type of lateral restraining arrangement is made to prevent/arrest lateral movement (Out-of-plane movement) in the shear wall
- Exhibited mild pinching type behaviour accompanied with large energy dissipation characteristics in both the tested shear walls and good amount of repeatability is observed
- A 20% reduction in both load and displacement is observed between the monotonic and cyclic loadings
- The performance of the test shear walls are compared against the limits given in ATC 40 and there is a good agreement under cyclic loading conditions



Bottom-Up Approach for the Synthesis of
Eco-friendly Multi-functional Admixture towards Green Construction

PROBLEM DEFINITION

Synthesis of multi-functional admixture (superplasticiser) from Bio-mass aiding the use of cementitious materials in construction (bottom-up → foundation for understanding complex reactions and micro-kinetics)

CHEMICAL ADMIXTURE-INTRODUCTION

Chemical Admixture - Additive to concrete mixture - to enhance concrete properties –fresh or hardened stage

ex: Superplasticisers, Corrosion Inhibitors, Set Retarders, Set Accelerators, Alkali-Silica Mitigating Inhibitors, Air-entraining agents, etc.,

Natural Resources towards Green Superplasticiser Extraction

Lignin

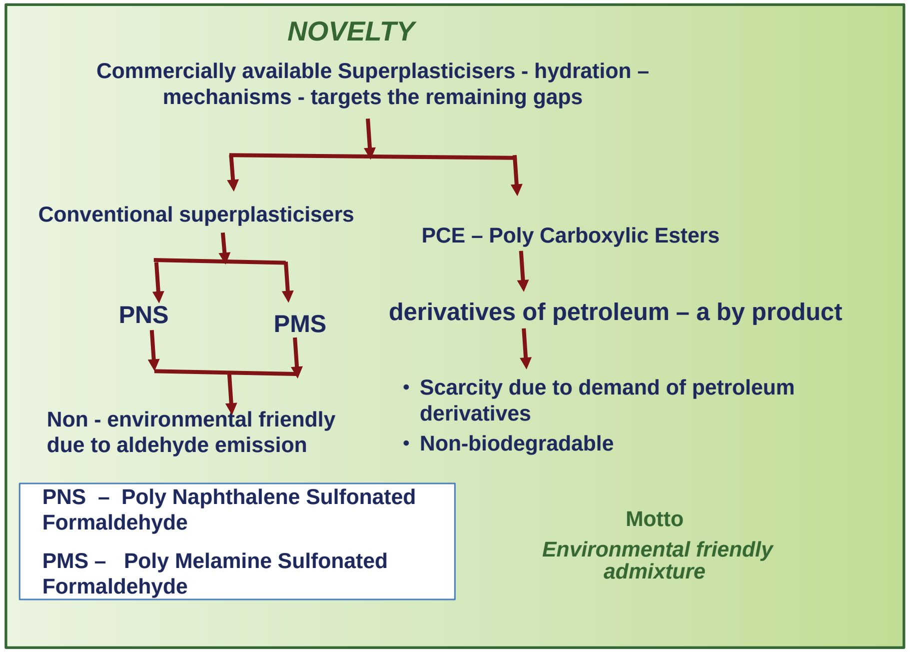
- Natural amorphous polymer – essential glue – plants structural integrity
- Extraction: difficult to extract from their parent moiety - complicated

Cellulose

- Most abundant bio-renewable and major biopolymer on earth
- Major constituent: cotton, wood, baggase and biomass
- Poly dispersed linear glucose polymer chains – form hydrogen bonded supramolecular structures
- Extraction: viscous process – non environmental-friendly (due to C2S emission)
- Only limited number of common solvents and not ecofriendly

Green Solvent

- Using ionic liquids (without any hazardous)



SUPERPLASTICISER (SP)

Organic Compounds of high molecular weight – Synthetic in nature

Technically - an admixture, which when added to concrete either

- imparts extreme workability without the addition of extra water, to produce ‘flowing concrete’, or
- allows a large reductionof the water content to be made without loss of workability; or
- permits a simultaneous increase in both workability and strength without incurring substantial extra cost

Separation of Cellulose from Biomass

- Resource : Sugarcane Bagasse
- Fiber nature of sugarcane bagasse - collected from field - dried at 40°C for 7 days
- Pith - fractioned - by hammering and screening - contains both cellulose and lignins

Schematic representation of Sugarcane Fiber

- Substrates coarsely ground before treatment and analyses
- Oxidative treatment - to remove lignin from the raw material
- Includes alkali and oxidizing agent -alkaline hydrogen peroxide

Experimental work

Natural Resource – Biomass sugarcane bagasse using green solvent – Hydrogen bonded supra-molecular structure - cellulose

↓

Hydration – Mechanism - Characterisation

↓

Structural Modifications – Changes in Chemical Functionalities – to adopt MULTI-FUNCTIONAL CHARACTERISTICS

Assembly of Carbon Nanotubes (CNT) in Bio-polymer Environment

Cellulose as Nanocontainer

- Multi-walled CNT and cellulose as polymer matrix
- Sonication– Covalent functionalisation of CNT and non-covalent attachment by physical л - л stacking interactions
- Loading high concentration of CNT – difficult

Functional Properties of Cellulose : Microfibrills - free lumens- active site for loading foreign particles – impart load carrying capacity – Nature's nano container

Electrochemical Studies on rebar

- Electrolyte – Pore solution +CNT loaded Cellulose SP
- Charge transfer resistance – increased
- Corrosion rate – decreased significantly at 0.5ml concentration

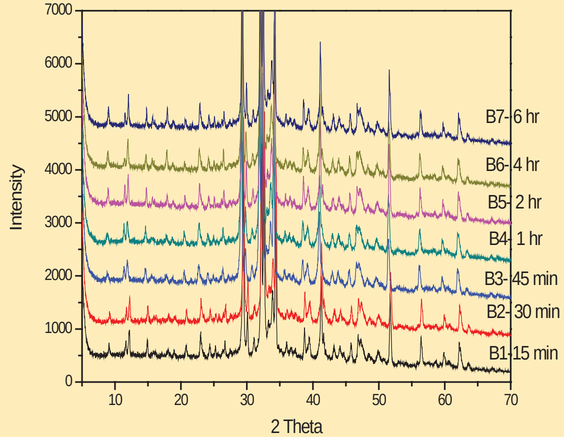
Electrochemical Study

Potentiodynamic Polaraisation and Impedance studies

- Control – pore solution, Spl1 – Polycarboxylic ester-based Sp, Spl2 – Cellulose Sp – electrolytes
- ASTM: G 180-04 – electrolyte, Rebar - Working electrode (1cm^2)
- Corrosion rate (mm/year) :
  - Control – 9.8x10-3
  - Spl 1 (0.25ml) – 10.0x 10-3
  - Spl 2 (0.25ml) – 8.6 x10-3 (about 12% reduction compared to control)
- Dosage optimization is essential to control corrosion

Hydration Study – X-ray Diffraction Analysis

Hydration of cement with (w/c - 0.28) and without (w/c - 0.40) Cellulose Superplasticiser (SP)



Hydration of cement in the presence of Cellulose Sp

- Early formation of ettringite in presence of Cellulose SP - hydration period at 15 min - ettringite peaks observed
- No alterations in the hydration products - indicates no pH change in pore solution
- Cellulose SP - Promotes the ettringite formation - Pores will be resolved at initial hydration stage due to the presence of needle like morphology - SEM - Highly compacted and dense formation of phases - due to platy crystal formation

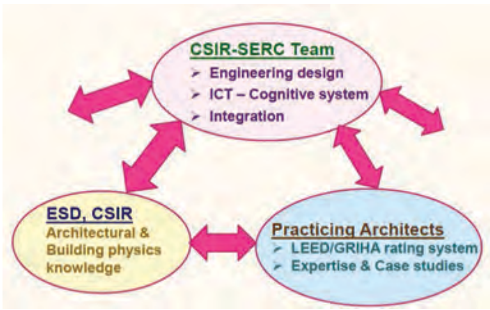
Objectives

- Define a framework for structural/architectural elements for smart sustainable buildings
- Develop interfaces based on cognitive science principles for training an intelligent system for structural performance and energy efficiency
- Performance evaluation of candidate solutions for selected sustainable buildings

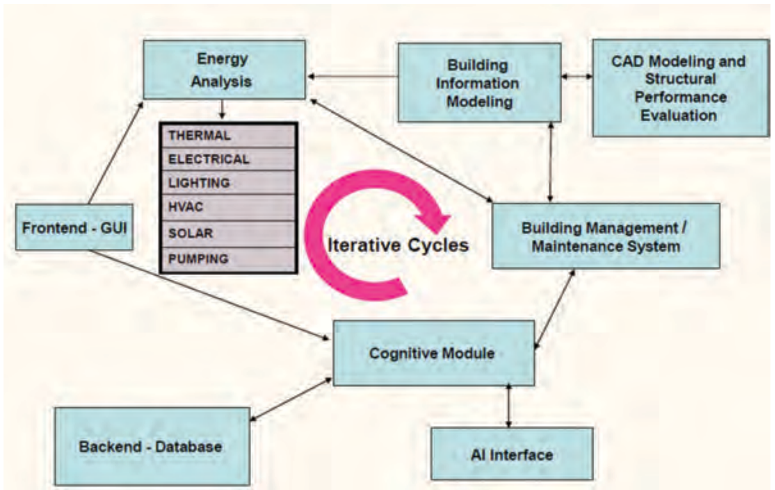
ECBC - Applicable Building Systems

- Building envelopes, except for unconditioned storage spaces or warehouses,
- Mechanical systems and equipment, including heating, ventilating, and air conditioning
- Service hot water heating
- Interior and exterior lighting
- Electrical power and motor

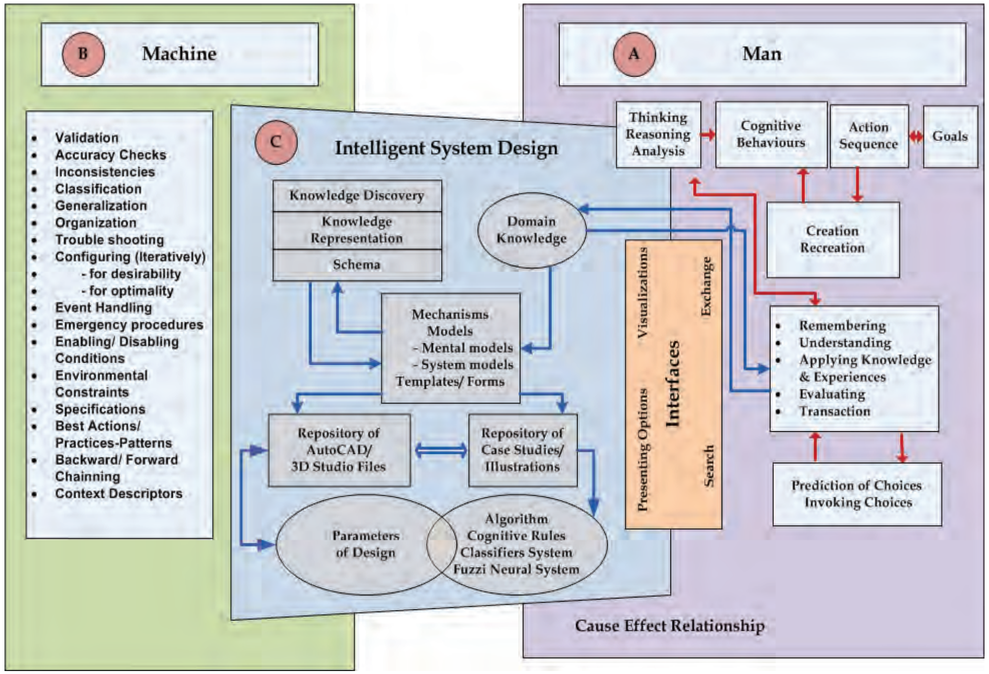
Consortium Approach



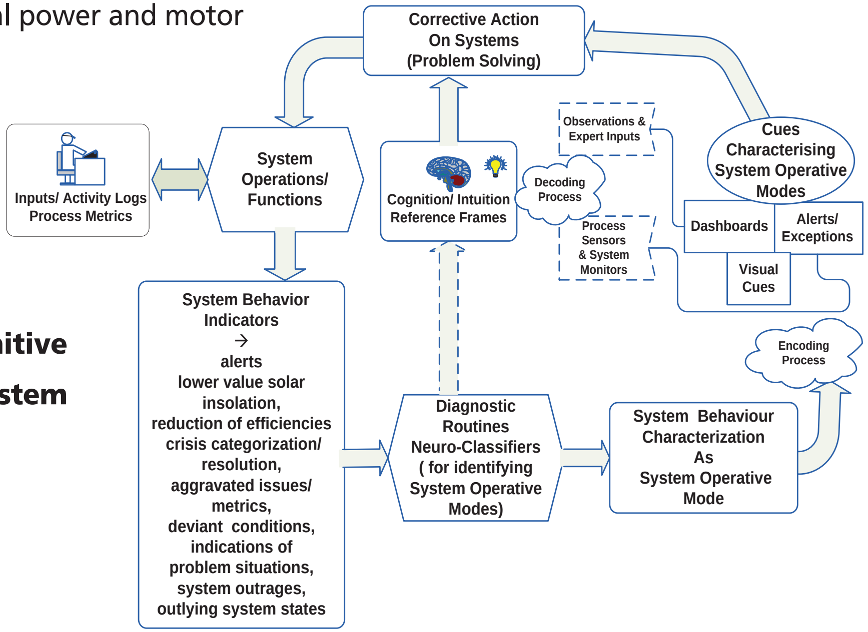
The Framework



System Design



Cognitive System



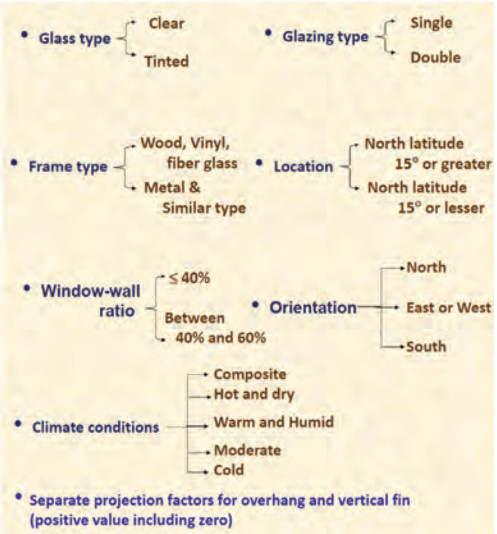
ECBC - Compliance Requirements

- Mandatory Requirements
- Prescriptive Requirements

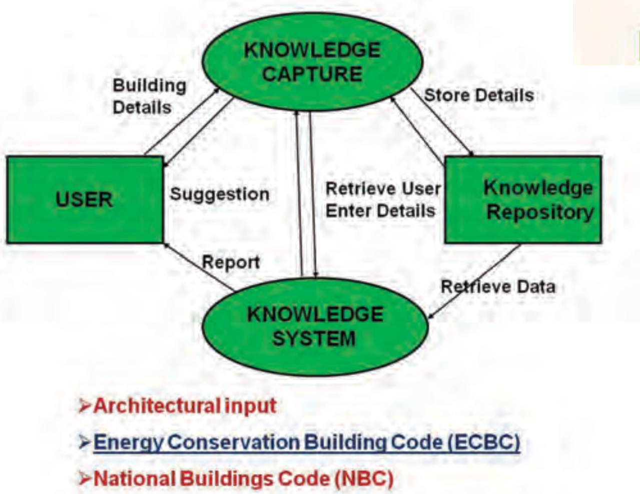
- New Buildings
- Additions to Existing Buildings
- Alterations to Existing Buildings

- Building envelope consisting of windows, walls, roofs/ceilings and floors
- Heating, ventilation & air conditioning
- Service hot water and pumping
- Lighting
- Electrical power

Characteristics about fenestration



Knowledge Capture & Repository



Building Sustainability Checks for Fenestration (Windows)

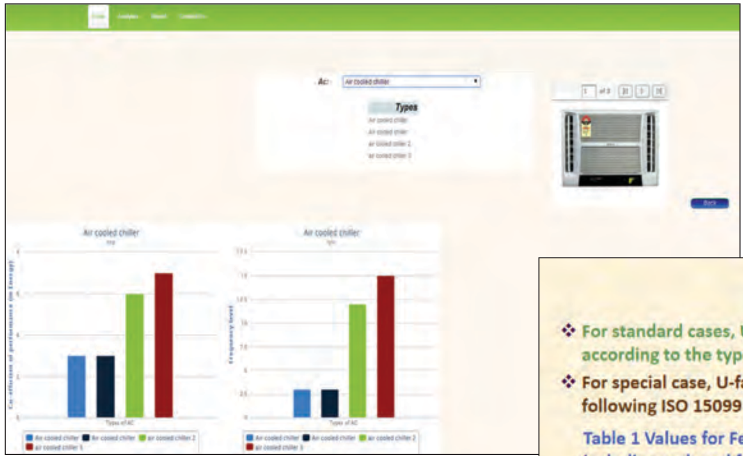
- U-factor • Solar Heat Gain Coefficient (SHGC)
- Visual Light Transmittance (VLT)

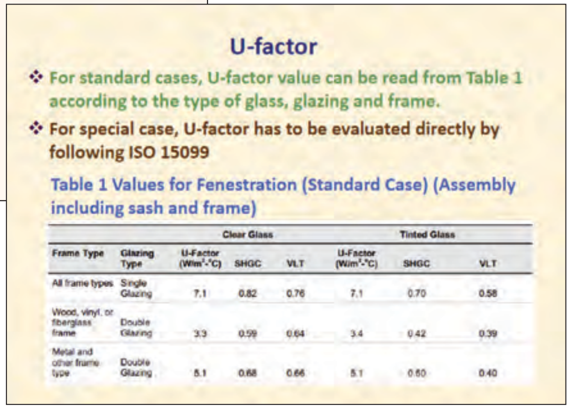
These parameters should satisfy the corresponding threshold (permissible) value.

Deliverables

The Intelligent system through its cognitive capabilities will be able to complement a human expert and also evaluate the design solutions/approaches in a very rational manner which can ensure

- Lifecycle cost benefits - reduction in energy consumption with the diligent design and execution of infrastructure
- Optimal design factoring in the required localization, availability of resources and evaluation of best possible scenarios
- Documentation required for certification / GRIHA LEED, MNRE clearance and alignment with evolving CPWD norms for compliance



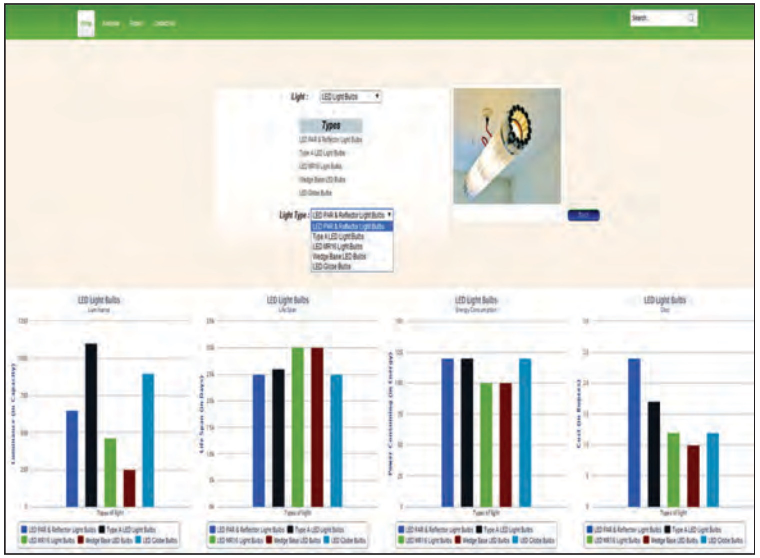


U-factor

- For standard cases, U-factor value can be read from Table 1 according to the type of glass, glazing and frame.
- For special case, U-factor has to be evaluated directly by following ISO 15099

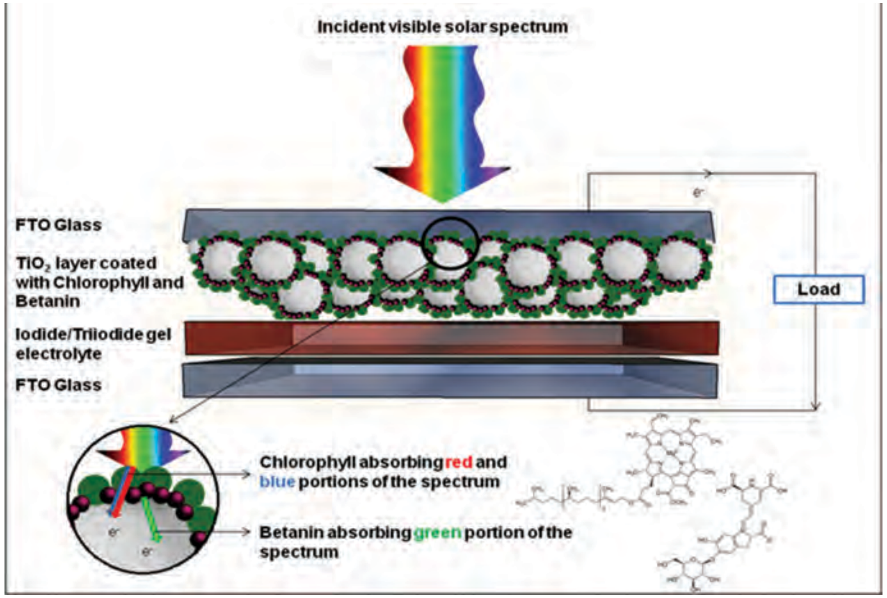
Table 1 Values for Fenestration (Standard Case) (Assembly including sash and frame)

		Clear Glass			Tinted Glass		
Frame Type	Glazing Type	U-Factor (W/m^2-°C)	SHGC	VLT	U-Factor (W/m^2-°C)	SHGC	VLT
All frame types	Single Glazing	7.1	0.82	0.76	7.1	0.70	0.58
Wood, vinyl, or fiberglass frame	Double Glazing	3.3	0.59	0.64	3.4	0.42	0.39
Metal and other frame type	Double Glazing	5.1	0.68	0.66	5.1	0.60	0.40

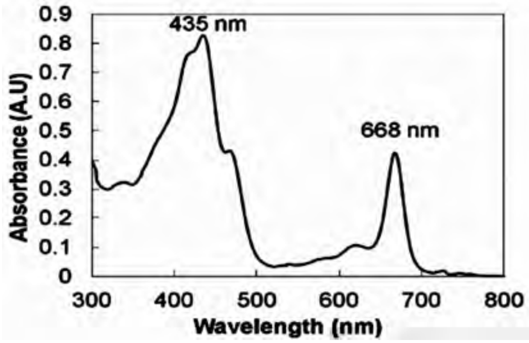


INTRODUCTION

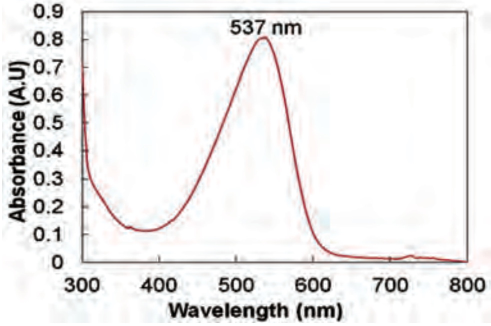
- Dye-Sensitized Solar Cells (DSSCs) are the third generation of solar cells whose advantages are low-cost production, low-energy payback time and flexibility.
- The sensitizer is the vital component of the DSSC, playing a major role of absorbing light and generating excitons. DSSCs typically use toxic dyes such as metal-based porphyrins or cyanin derivatives and also require complex synthesis.
- Compared to synthetic dyes, natural dyes which are found in plants can be easily extracted by simple procedures. Moreover, they are non-toxic, inexpensive and completely biodegradable; hence, they are being explored as alternative photosensitizers.

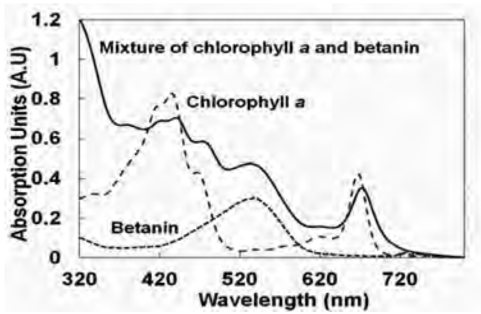


- However, natural pigments have narrow absorption spectra which result in low efficiencies of the solar cells. Achieving higher efficiencies and improving stability would make natural pigment sensitized solar cells an attractive alternative technology for portable, disposable electronics and BIPV (Building Integrated Photovoltaic) applications.
- In this study, we investigate co-sensitization of two complementary natural plant pigments: chlorophyll a, having absorption maxima at 435nm and 668nm (blue and red regions respectively) was used in combination with betanin, having absorption maxima at 537nm (green portion of the spectrum). Co-sensitization of complementary pigments is aimed at widening the absorption spectrum to effectively capture the visible spectrum so as to increase the efficiency of the device.



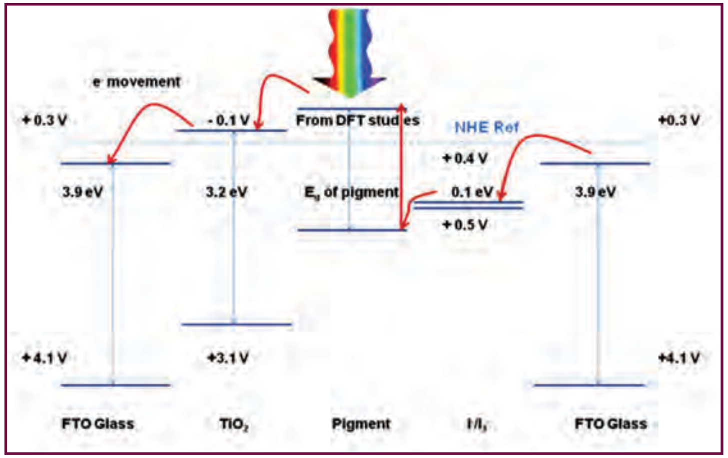
UV-Vis Absorption Studies of the Pigments

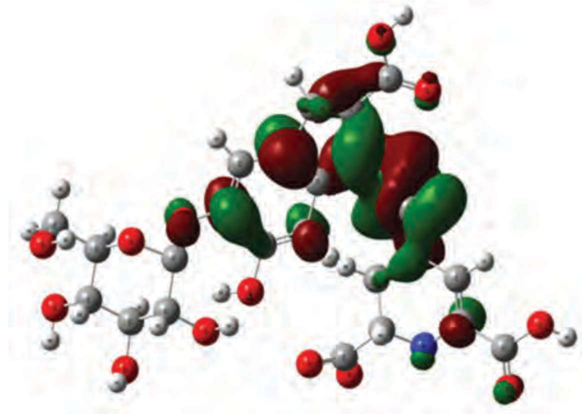


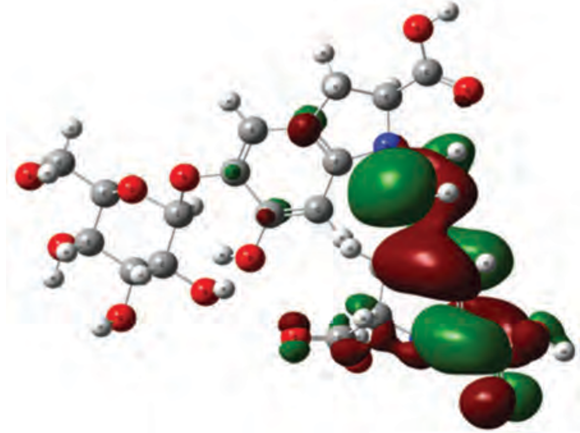


- Peak absorbance of chlorophyll-a extract from spinach at wavelengths 435nm and 668nm (blue and red regions respectively). Large spectral gap exists between 500nm and 600nm where a significant fraction of the incident solar radiation falls.
- To capture most of the incident solar radiation, a pigment absorbing in the green wavelength range is to be used with chlorophyll. Betanin, being more stable and having stronger anchoring groups to TiO_2, compared to other green light absorbing pigments, was chosen as the complementary pigment.
- Peak absorbance of betanin extract from beetroot at wavelength of 537nm (green region).
- Absorption spectrum of the pigments mixture (1:1 ratio) is broad and overlaps well with the incident solar spectrum.
- Hence the betanin-chlorophyll combination can effectively capture most the incident visible solar radiation. Absorption of light by the pigments generates excitons. DFT simulations were performed to ensure that the energy levels are aligned for effective charge transfer.

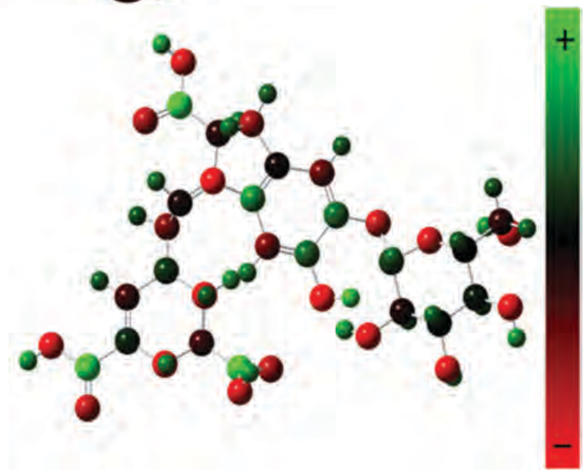
Band diagram showing the alignment of energy levels determined according to the oxidation and reduction potentials of each material vs. Normal Hydrogen Electrode (NHE).







Density Functional Theory (DFT) Studies of the Betanin using Gaussian 09



- From the DFT simulations, the energy levels of betanin were obtained with respect to vacuum, and the band gap was calculated from the predicted HOMO and LUMO levels to be 2.1eV. The band diagram was plotted according to relative positions of the energy levels.
- HOMO levels are located around the betaine moiety of betanin
- Excitation of an electron from one of the unshared pair of electrons of nitrogen present in the indole ring of betaine, to the π^* orbital.
- The $n \rightarrow \pi^*$ transitions occur by absorption of a photon in the visible wavelength range, which is responsible for the colour of betanin.
- On photo-excitation, electron density shifts from HOMO level to the LUMO level of betanin.
- LUMO energy levels of betanin are located around the betalamic acid group of betanin
- The charge distribution on the betanin molecule shows the highly electropositive carbonyl carbons of carboxylic acid groups.
- These carbonyl carbons draws electrons from the pyridine ring of betalamic acid (LUMO) which is subsequently injected into the conduction band of TiO_2.

I-V and P-V curves

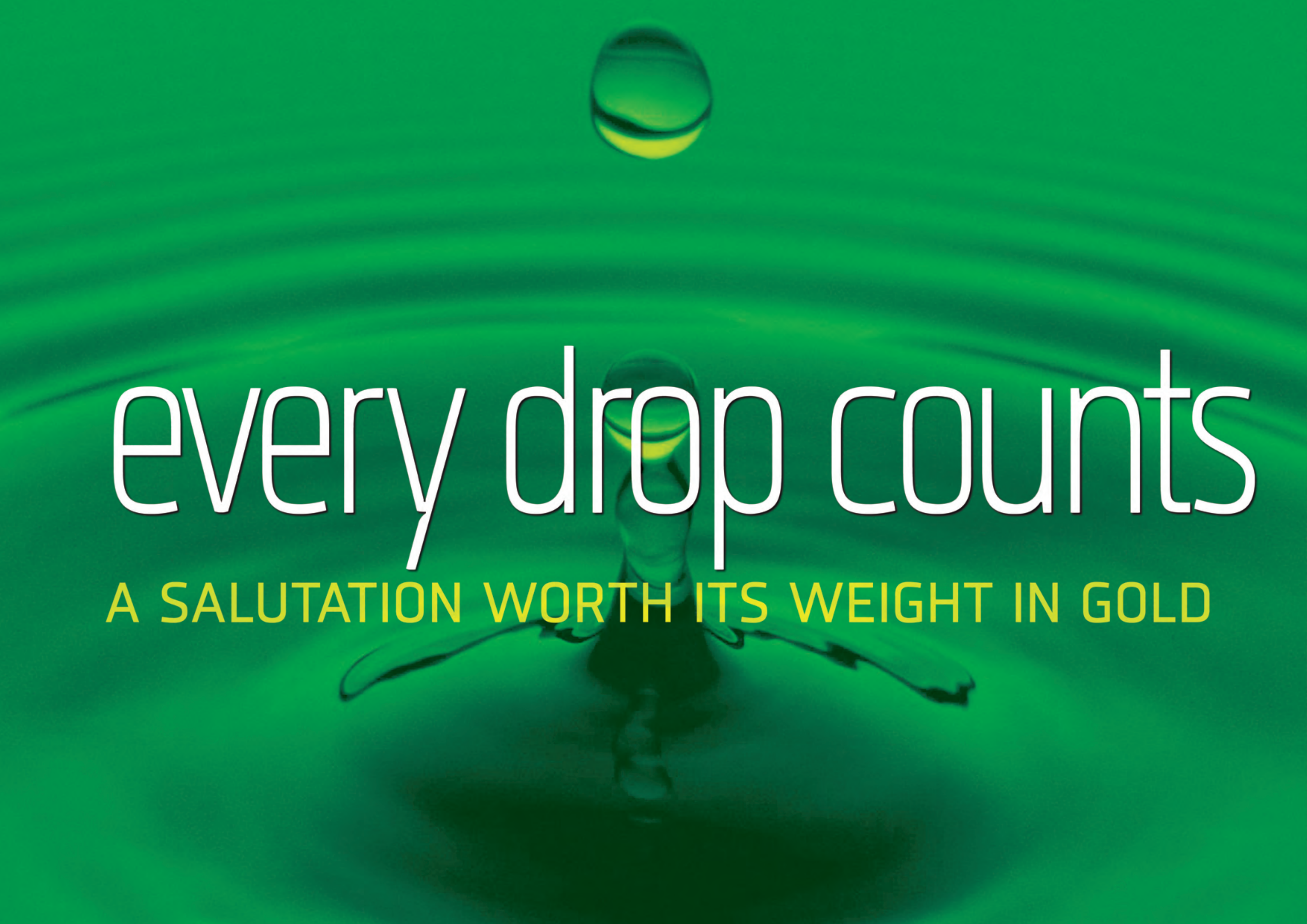
Configuration	V_{oc} (V)	I_{sc} (mA)	V_{max} (V)	I_{max} (mA)	P (mW)	F.F (%)	Efficiency (%)
Betanin solar cell	0.39	5.328	0.175	2.527	0.441	21.23	1.767
Chlorophyll-a solar cell	0.57	0. 356	0.330	0. 249	0.082	40.29	0.133
Betanin-chlorophyll-a co-sensitized solar cell (masked)	0.49	5.781	0.232	2.866	0.666	23.36	2.665
Betanin-chlorophyll-a co-sensitized solar cell (unmasked)	0.481	7.324	0.232	3.723	0.863	24.52	3.488

Efficiency vs. time

- The I-V characteristics of the solar cells were measured using the Oriel® AAA class solar simulator. The solar cells were tested under A.M 1.5G standard test conditions at, $100mW/cm^2$. with an active area of $0.25cm^2$ (results listed in the Table) .
- The betanin-chlorophyll solar cell co-sensitized solar cell gave the highest efficiency of 3.488% under unmasked conditions and 2.665% under masked conditions, due to its increased absorption spectrum by the complementary absorbing regions of the two pigments.
- This is by far the highest reported efficiency for DSSCs using raw natural dyes, not involving any chemical pre or post treatment procedures.
- Moreover, the co-sensitized solar cell, shows better lifetime and stability due to protecting hydrophobic nature of the phytol tails of chlorophyll-a.

Future Research Focus Areas

- Although the efficiencies obtained with these natural dyes are still below the current requirements for large scale practical application, the results are encouraging enough for future research.
- Stacked configurations of multiple natural pigments absorbing different wavelengths can be explored for high efficiencies.
- Optimization of solar cell components compatible with natural dyes, preventing degradation.
- Integration of green solar cells with green batteries for biodegradable solar powered electronics.
- Improved efficiencies would make natural photo-sensitizers a viable non-toxic, inexpensive and environment friendly option for Building Integrated Photovoltaic (BIPV) applications.


every drop counts
A SALUTATION WORTH ITS WEIGHT IN GOLD

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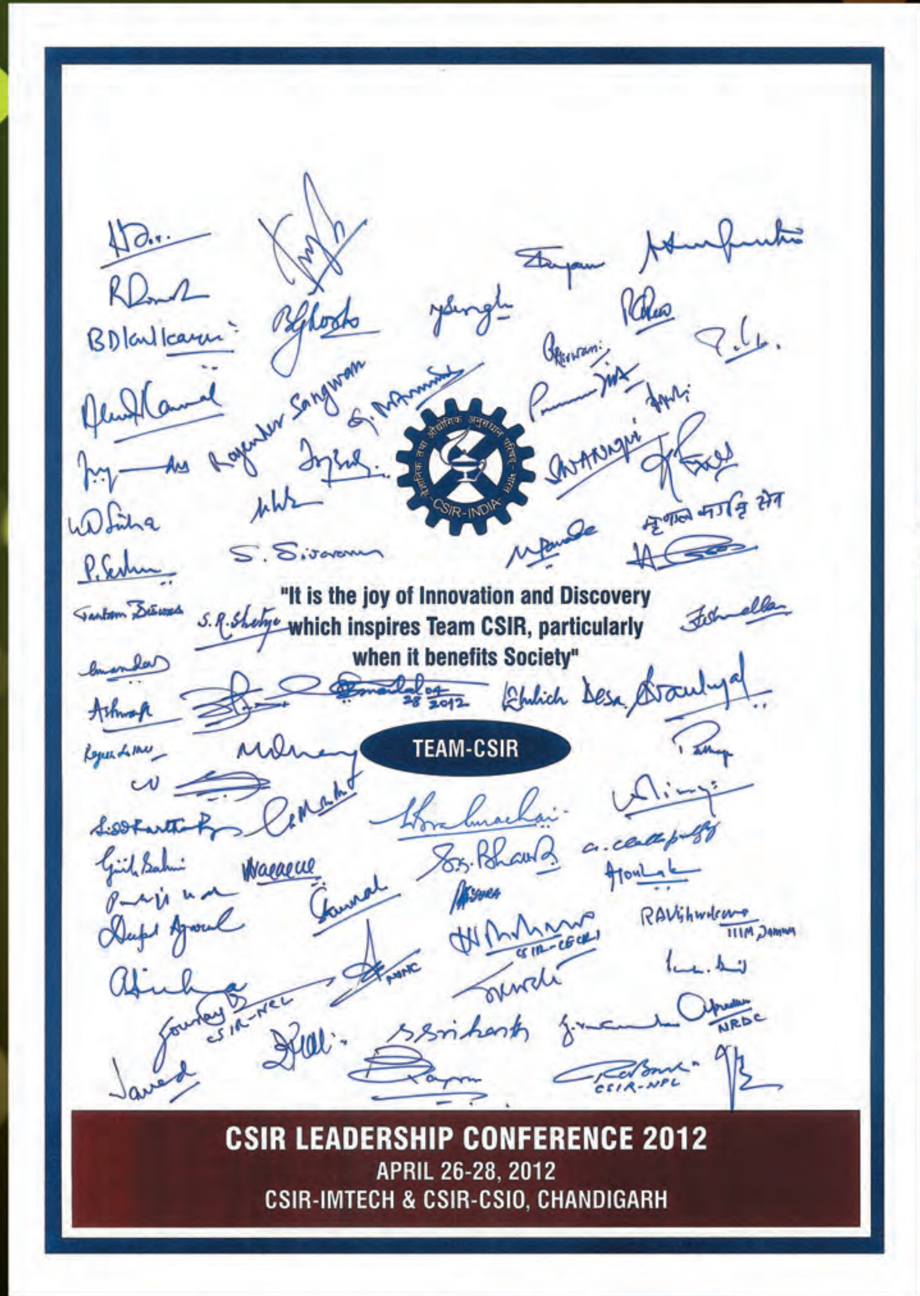

HISTORY BECKONS

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