International Conference on Technologies for the Sustainable Use of Natural Resources

Technical Session 1 A: Innovative and emerging technologies for sustainable development of natural resources in Asia and Pacific

India's Experience with Innovative Technologies for Sustainable Development & Resource-Efficient Infrastructure

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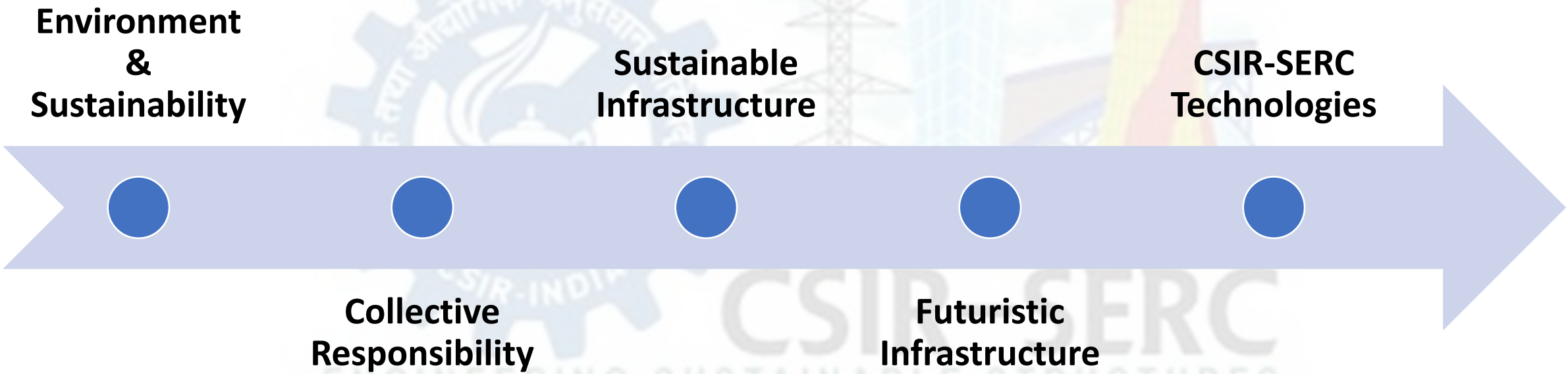
Outline


Environment & Sustainability
Collective Responsibility
Sustainable Infrastructure
Futuristic Infrastructure
CSIR-SERC Technologies

Environment and sustainability – a perspective

நிலம் தீ நீர் வளி விசும்போடு ஐந்தும் கலந்த மயக்கம் உலகம்

(Tholkappiyam, the oldest extant work of Tamil literature and the earliest Tamil grammar text)

The world is nothing but a delicate balance of the five elements

Earth, Fire, Water, Air and Sky (Space)

This balance has sustained life for millennia

Under increasing strain today and hence this message is more relevant today than ever before.

Environment and perception of life - inseparable

Earth:

- Our soils and land resources under pressure from urbanisation, mining, and deforestation
- Shrinking fertile lands
- Waste occupies more space than ever

Water:

Both extremes—no water and devastating floods.

வான்நின்று உலகம் வழங்கி வருதலால்
தான்அமிழ்தம் என்றுணரற் பாற்று

Rain is not just water but a life-sustaining nectar that allows for all forms of existence and sustenance

Fire: Fossil fuels – dependence to be reduced

Renewable energy - challenges of storage, recycling & sustainable adoption

True wisdom is foresight—protecting in advance, not repairing in ruin

Air: helps to sustain life on earth

declining air quality

Space: connects all others

In today's context - reminds us of the global atmosphere

the climate system that regulates our monsoon, rainfall, and temperature

Climate change has disrupted this equilibrium -cyclones, sea-level rise, heatwaves

environmental problems – interconnected

A disturbance in one element cascades into others.

Sustainability - a collective responsibility

For research: affordable, scalable and sustainable innovations

For industry: adopting **clean technologies, circular economy practices, and ESG principles**

For policymakers: Creating the enabling environment for adoption of sustainable technologies

For society, to rediscover our ancient wisdom : **harmony with nature** is the only true progress.

பகுத்துண்டு பல்லுயிர் ஓம்புதல் நூலோர்
தொகுத்தவற்றுள் எல்லாந் தலை.

Basic necessities of humans

Food, Clothing & Shelter

INFRASTRUCTURE

Energy to Environment
Materials to Infrastructure
Sensors to Robotics

Civil, Infrastructure and Engineering for

Connect with mobility infrastructure

Collaborate for automation, monitoring & mitigation

Converge to implementable technology

Convert Waste to Wealth

Shelter – Safe, Sustainable and Environmental friendly
Mobility – Planned and Durable – multi modal
Monitor – Prevention of any unwanted events
Mitigate – Natural and Man-made disaster
Automate – for quick implementation
Address – waste generation towards sustainability

Building Physics & Materials

Rural Infrastructure

Mobility Infrastructure & Planning

Automation & Robotics

Waste to Wealth

Structural Health Monitoring & Life Extension

Disaster Mitigation for Infrastructure

Sustainable infrastructure

Efficient design: Optimization to use less material and energy. (eg. Laced Steel-Concrete Composite System, bio inspired functionally graded composite panels)

Durability: Long life reduces resource use over time. (eg. Textile reinforced concrete)

Innovation: Use of advanced materials (e.g., geopolymer, recycled aggregates, ultra high performance concrete, engineered composites).

Monitoring and retrofitting: Extending lifespan of existing structures (e.g. SHM of bridges)

Disaster resilience: Designing for floods, quakes, and climate extremes (cyclone shelter, climate resilient buildings)

Foldable, modular structures developed by CSIR–SERC for quick deployment in disaster zones — combining efficiency, affordability, and reuse

Futuristic Infrastructure

Challenges

- growing populations and rapid urbanisation
- Resource Scarcity
- Environmental degradation
- technological advancements
- Climate change and disaster resilience

Futuristic infrastructure

Principles

- Sustainability
- Innovation
- Inclusive design
- Adaptability
- Integrate with environment

Future

- Traffic congestion
- Energy shortage
- Water pollution
- Water shortage
- Waste management
- Storm and flooding

Features

- Disaster resilience
- Infrastructure maintenance
- Renewable energy
- Urban metabolism
- Contribute towards SDGs

CSIR-Structural Engineering Research Centre

Advanced Seismic Testing & Research Laboratory

Advanced Protective Structures & Mechanics Laboratory

Advanced Concrete Testing & Evaluation Laboratory

Wind Engineering Laboratory

Steel Structures Laboratory

Tower Testing & Research Station

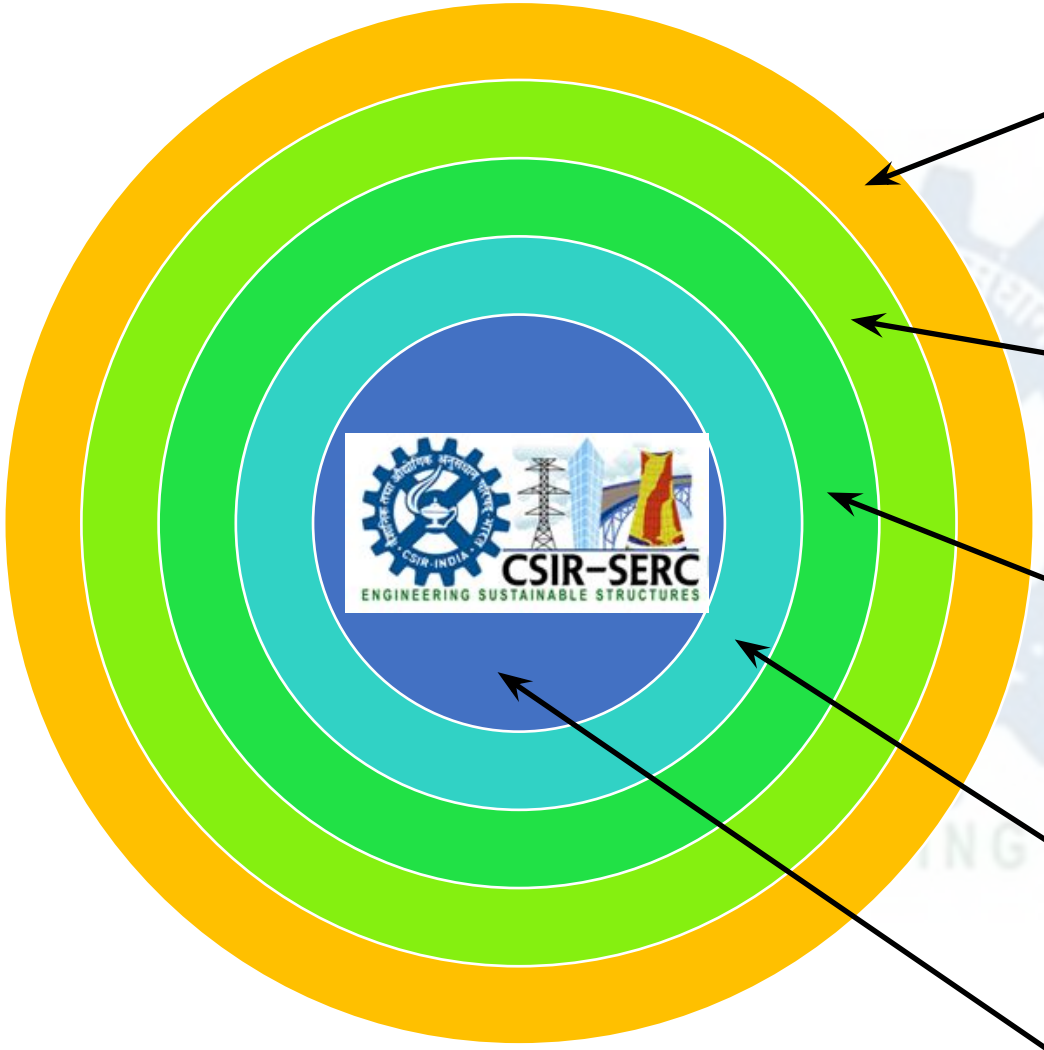
Advanced Materials Laboratory

Special & Multi-functional Structures Laboratory

Fatigue & Fracture Laboratory

Structural Health Monitoring Laboratory

Efficient Design for safe and sustainable structure



Good configuration – column, beam, shear wall location – Ensuring Strength

Load calculation & Analysis - Ensuring Stability

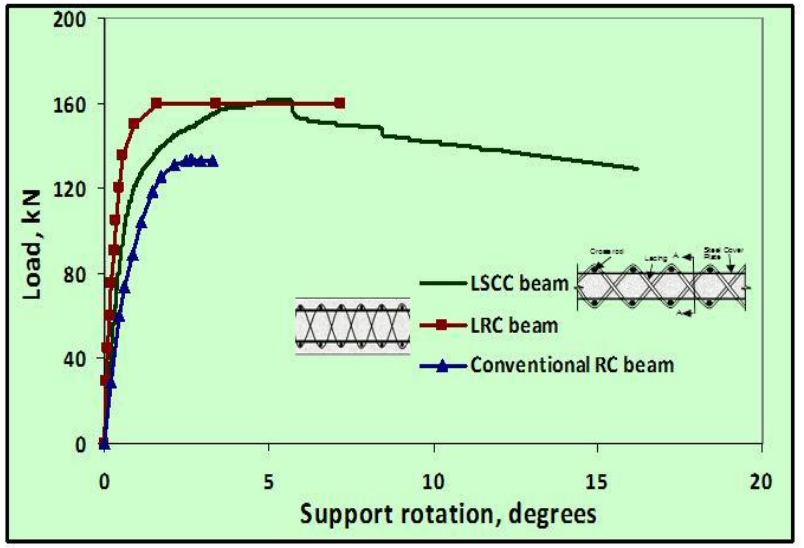
Materials, Design & Detailing including buildability - Ensuring Servicability

Construction, Monitoring & Maintenance – Ensuring Sustainability

Safe and Sustainable Structure – Ensuring Safety

Efficient Design

Laced Steel-Concrete Composite System



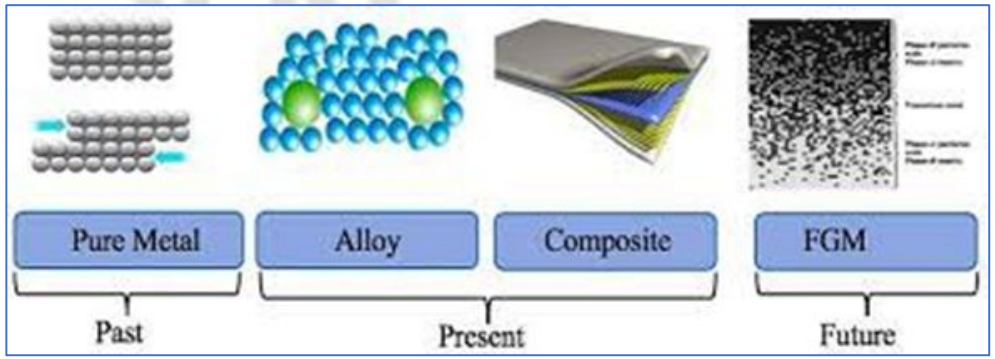
Innovative system with enhanced performance

Features:

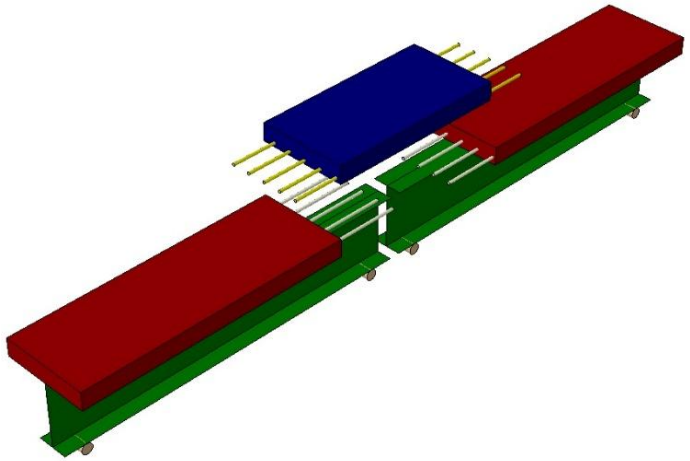
- New configuration by integration of simple structural elements and novel way of connecting the cover plates leading to replacement of welding
- Effective material usage to result in enhanced strength, deformation and rotational capabilities
- Efficient to resist suddenly applied dynamic loads such as blast, earthquake

Bio-Inspired Functionally Graded Cementitious panels for Impact Resistance

Fruit Peels/Nut Shells:
Survive fall from a height of 10-50 m



Advanced Materials

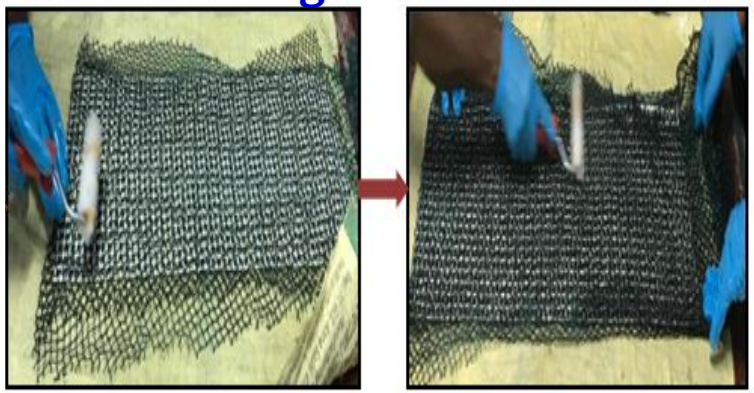


Expansion Joint-Free Bridge Deck System

Folded textile reinforced concrete fencing panels

3D printed building with Ultra High Performance Concrete

Hybridisation of waste fishing net with glass textiles



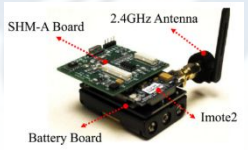
TRC U-drain using hybrid textile (layers of glass and waste fishing net)

Scalable Precast Modular Water Tank using thin precast panels
20000 liters Capacity

Structural Health Monitoring & Life Extension

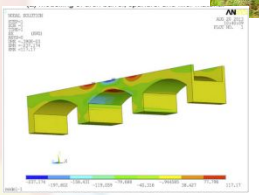
Instrumentation Techniques and Sensor Development

- Distributed Fiber sensing
- Indigenous Packaged FBG sensors for pipelines
- Smart wireless sensing



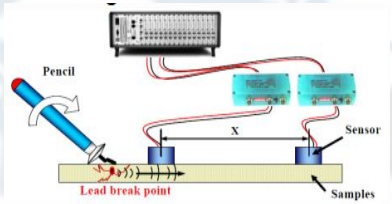
Bridges and Infrastructures

- Capacity enhancement of existing Bridges Innovative technique for evaluating / mitigation of longitudinal force on bridges
- Safety assessment of old bridges



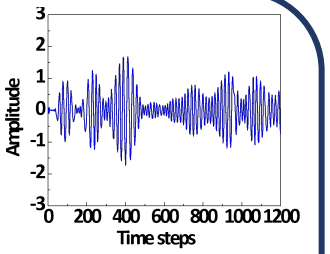
Pipeline structures

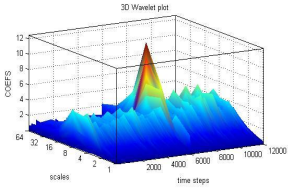
- Leakage detection using vibration, acoustic and guided wave propagation techniques
- Development of a baseline-free for localization of the defect/damage



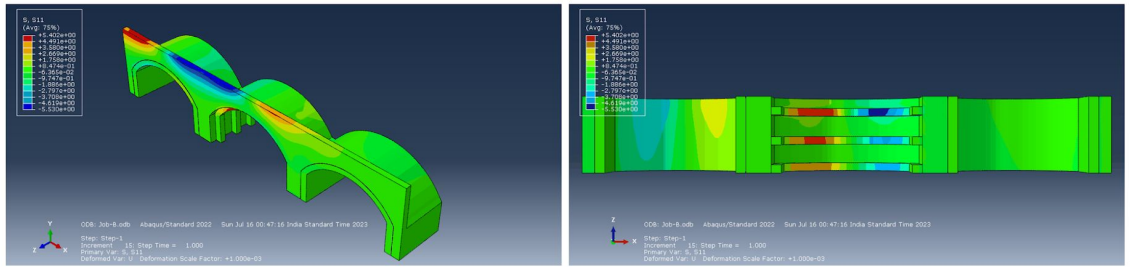
Damage Detection and Localization

- Subdomain based damage detection strategies
- Multivariate analysis techniques for damage detection considering environmental and operational effects
- Signal Decomposition & Reconstruction

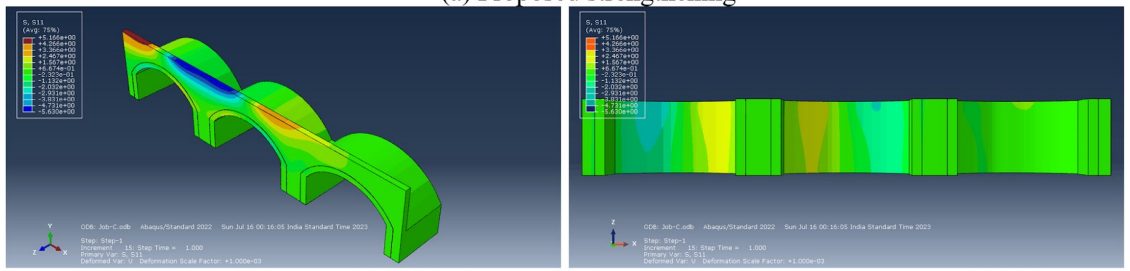




Development of Novel Retrofitting Strategy Masonry Arch Bridge



(a) Proposed strengthening



(b) Conventional strengthening

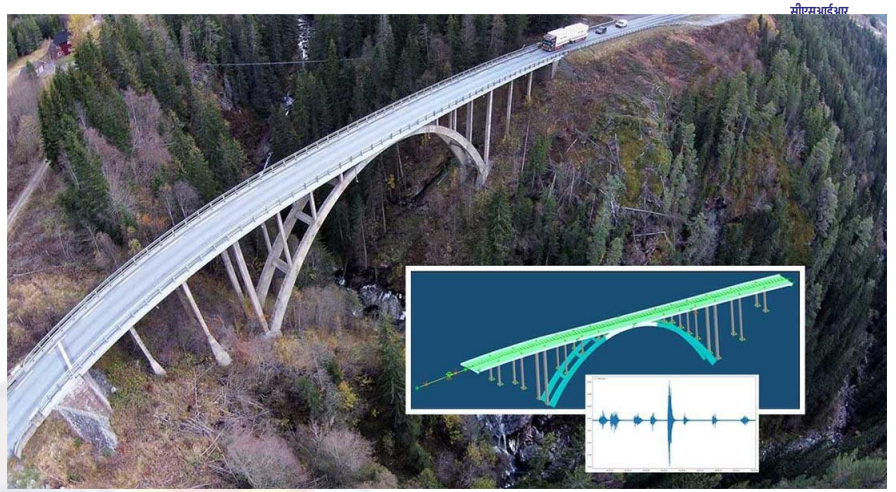
The innovative scheme conceptualized, designed and implemented on the failed arch span of a centuary old bridge brings the confidence in adopting such a system for many more existing age-old bridges for retrofitting/strengthening so as to increase the load carrying capacity and speeds on the railway and highway bridges.

Future Directions of SHM

- R&D towards developing low cost and robust sensors
- Development of robust models that are data driven but with a protocol of checking with physics based models
- Need for computationally efficient physics based models
- Striving for baseline-free methods or less dependence on baseline data
- Use of IIOT for monitoring a large number of structures/components
- Development of guidelines/methodologies is very important especially so in civil engineering

Tomorrow's SHM- Digital Twin for predictive assessment

- *Validate system model with real-world data*
- *Provide decision support and alerts to users*
- *Predict changes in physical system over time*
- *Discover new application opportunities for critical infrasctuture*



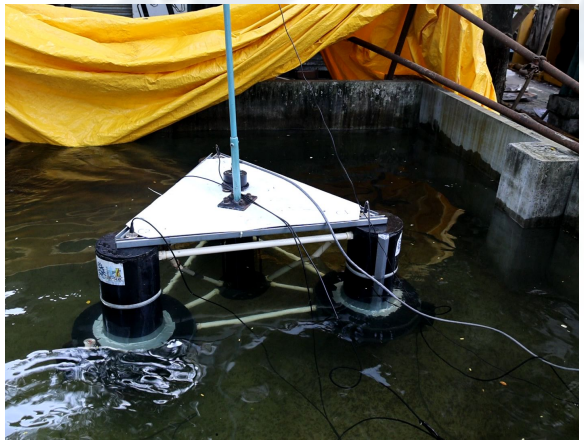
Digital Twin of a long-span bridge – Continuous interaction and updation of physical& simulated structure (Courtesy: Internet)

Poised to the game-changer technology for Monitoring, Assessment, Life Extension and Predictive performance of critical structures

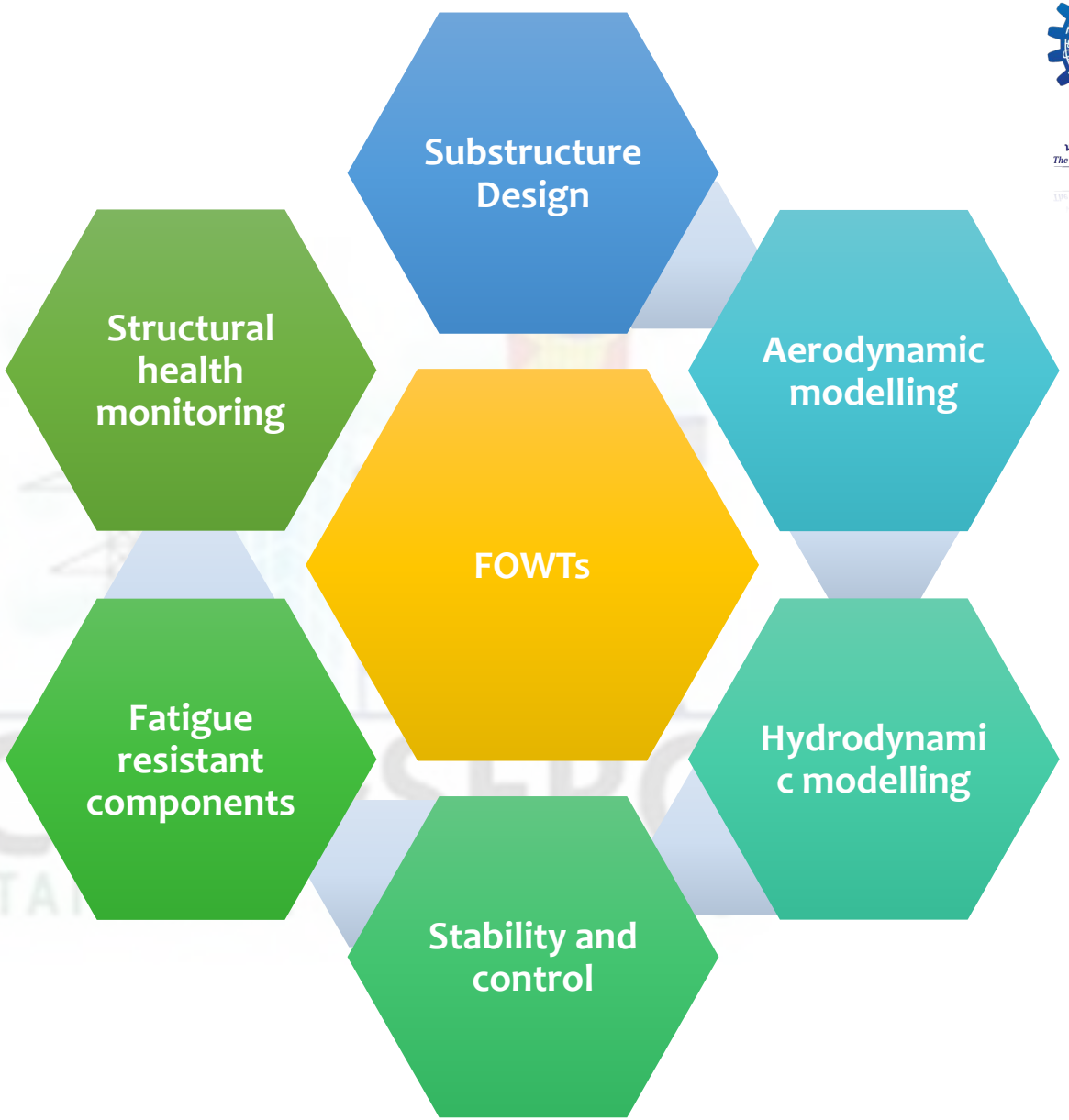
Picture Courtesy: Internet

Renewable Energy

Supporting structure for wind turbine

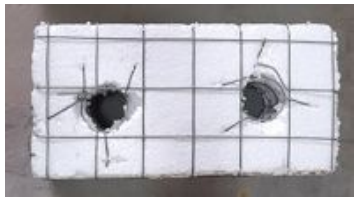


Floatability and free decay test in water tank



Technologies for Climate resilience

SECROBUILT TECHNOLOGY FOR HOUSING



Lightweight Block

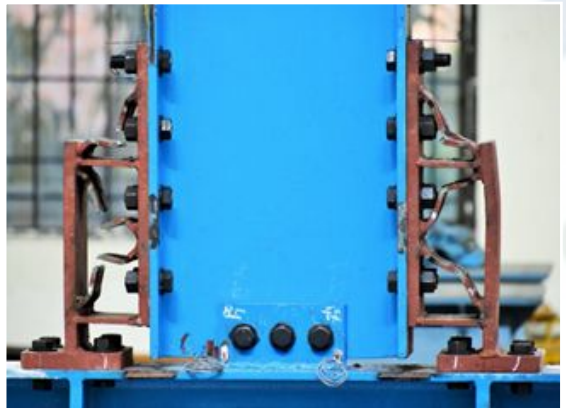
Rapid Assembly (1 storey per day)

Prefabricated Building Systems using EPS Panels

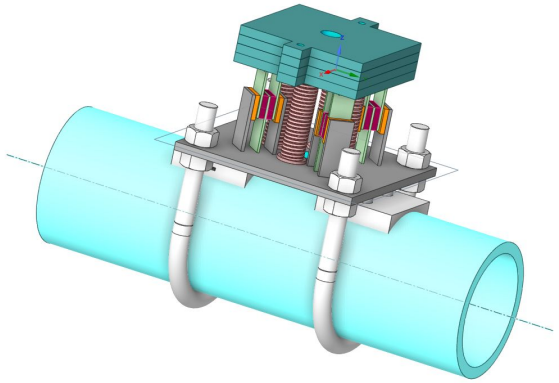
Technologies for Disaster resilience

Jut cavity bricks for enhanced seismic resilience

A cyclone-resistant shelter



Dissipative fuse link



Adaptive dampers

Role of policy makers

Policy & Regulation

- Set Standards for sustainable materials
- Mandate life-cycle cost analysis in infrastructure projects

Incentives

- Provide fiscal benefits for low-carbon materials and renewable integration.
- Promote public–private partnerships (PPP) in green infrastructure.

Governance & Oversight

- Establish sustainability indices for cities and infrastructure projects.

Education & Capacity Building

- Support inclusion of sustainability and green construction in engineering curricula.

"Policy creates the ecosystem — it sets the direction, priorities, and pace of sustainable development."

Role of Research / Academia

Material innovation: Green concretes, composites, 3D printed elements.
Design optimization: Using AI and computational modeling to minimize energy use.
Monitoring & analytics: IoT and sensor systems for structural health.
Demonstration projects: Pilot-scale structures that validate sustainable methods.
Knowledge dissemination: Training engineers, publishing standards, advising policy.

"Research provides the scientific backbone for sustainability — turning ideas into measurable, reliable technologies."

Role of Industry

translate research and policy into mass-scale implementation

Adoption of green materials:

– use of fly ash, slag, recycled concrete.

Technology commercialization:

– modular construction, BIM, 3D printing.

Lifecycle responsibility:

– from design to decommissioning.

Collaboration:

– partnering with R&D institutions for innovation.

Data and digital transformation:

– integrating AI, BIM, and IoT for performance tracking.

"Industry is the execution engine — the bridge between lab innovation and on-ground impact."

மணிநீரும் மண்ணும் மலையும் அணிநிழற் காடும் உடைய தரண்.

Which means clear water referring to potable essential for sustenance, open land which promotes agriculture, mountains where biodiversity exists, dense forest with cool shade provides concealment and a natural barrier.

Nature is the best protection not only in terms of strategy but also for a safer tomorrow.

If we respect nature, it will nurture us. If we neglect it, we pay the price.

Thank you