

Expansion joint-free bridge deck system using bendable cementitious composites

- *Indigenous technology for 'Atma Nirbhar Bharat'*

by

Dr. B.S.Sindu
(Senior Principal Scientist)

Dr. Ing.- Saptarshi Sasmal
(Chief Scientist)

E-mail: sindu.serc@csir.res.in; saptarshi.serc@csir.res.in

**Special and Multifunctional Structures Laboratory,
CSIR-Structural Engineering Research Centre,
Chennai, Tamil Nadu - 600 113, India**

Expansion joints are provided in bridges to accommodate the horizontal deformation of bridge decks due to thermal variations, shrinkage, external loads, etc., while allowing the continuous flow of traffic

Types of expansion joints

Small movement

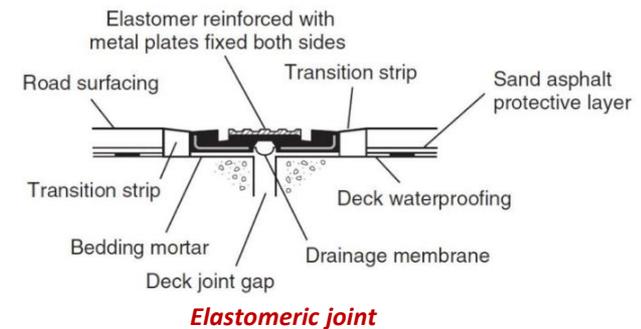
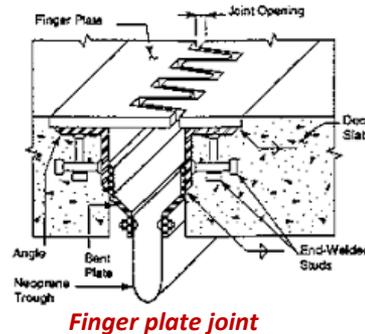
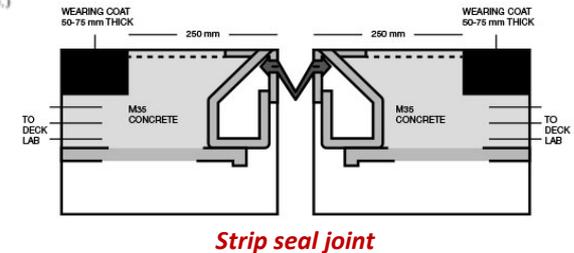
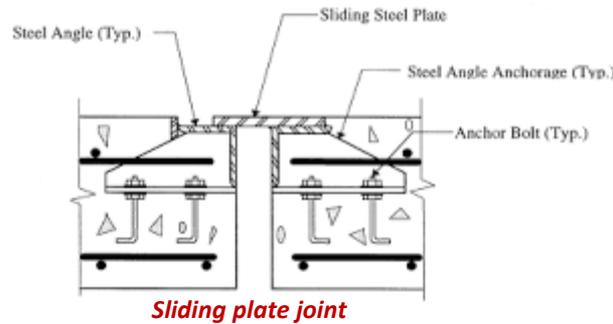
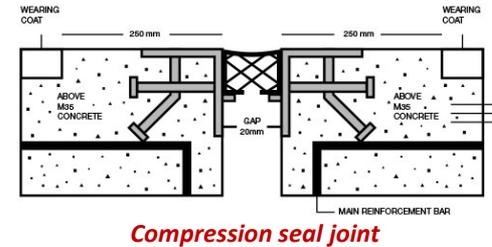
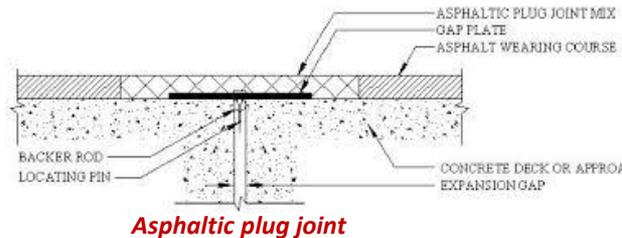
- Asphaltic plug joint
- Compression seal joint
- Sliding plate joint

Medium movement

- Strip seal joint
- Finger plate joint

Large movement

- Modular elastomeric joint
- Slab seal joint



- Durability and life of most of the bridges are affected by expansion joints
- Leakage of the drainage water accumulated in these joints - **sub-structural components get damaged**
- Debris accumulation in joints - **improper functioning** and causes stress on pavements
- Expansion joints also makes the **construction expensive** and requires huge maintenance



International Association for Bridge and Structural Engineering (IABSE)

- Life expectancy of expansion joints < Design life of bridges
- Cost of replacing expansion joints $\approx 3 \times$ Installation costs
- User costs - Primarily from disruption to traffic



Distress on road



Distress in pedestal

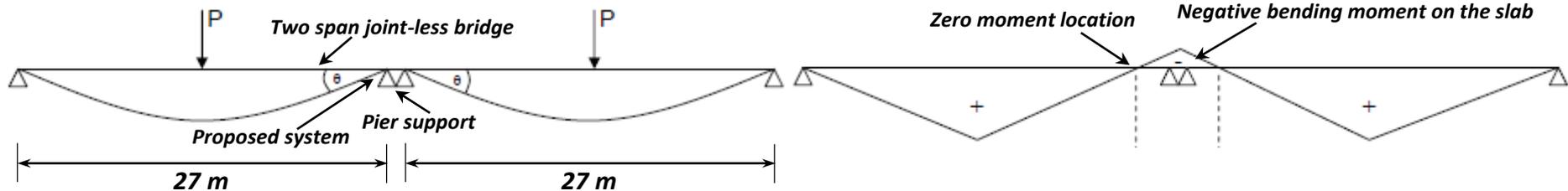
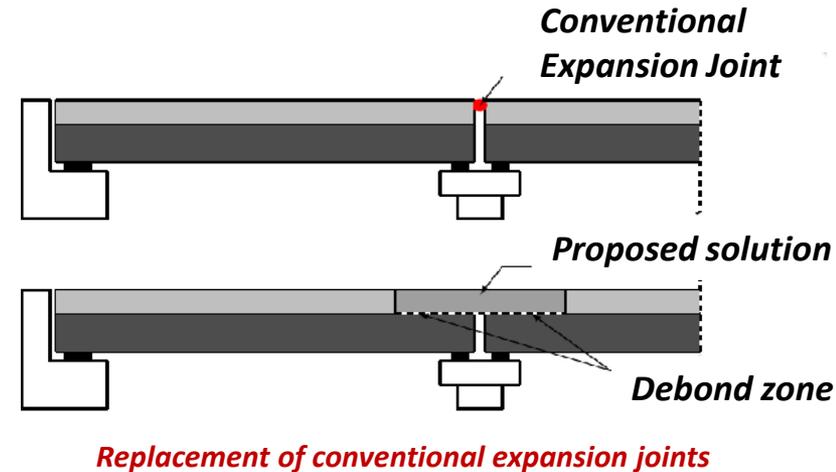


Distress in girder

Introduction

Proposed solution

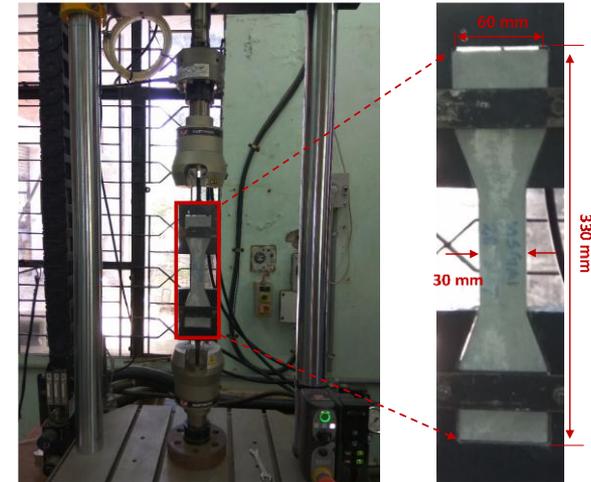
- ❖ Technology for development of expansion-joint free bridges using bendable cementitious composite without losing the functionality of simply supported spans
- ❖ Deck is continuous, Girders are separated



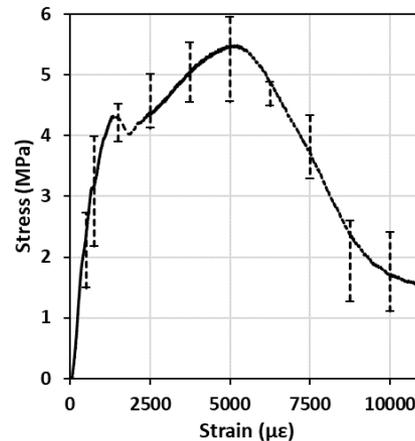
- Need for design and development of structural systems that can withstand high tensile stresses
- Need for development of engineered concrete with high tensile properties to reduce the reinforcement demand

Cementitious composite with high tensile performance

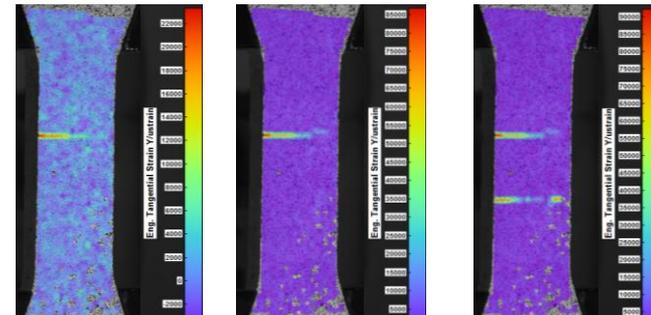
Micro-mechanically designed to impart superior tensile properties like strain hardening and high ductility



Direct tension test



Strain hardening phenomenon



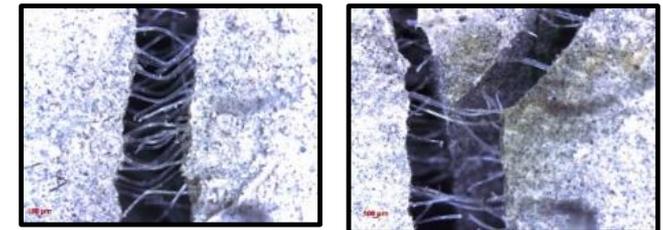
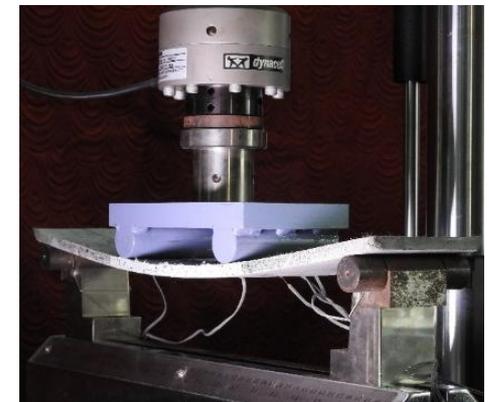
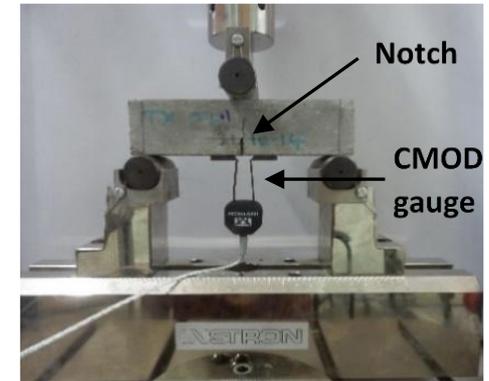
Multiple crack formation

Material Development

- Cementitious composite exhibited efficient crack-bridging, multiple micro-cracks (rather than a single macro-crack) and high strain capacity
- Increased Fracture Process Zone (FPZ) and energy dissipation capacity

Mechanical properties of Cementitious Composite

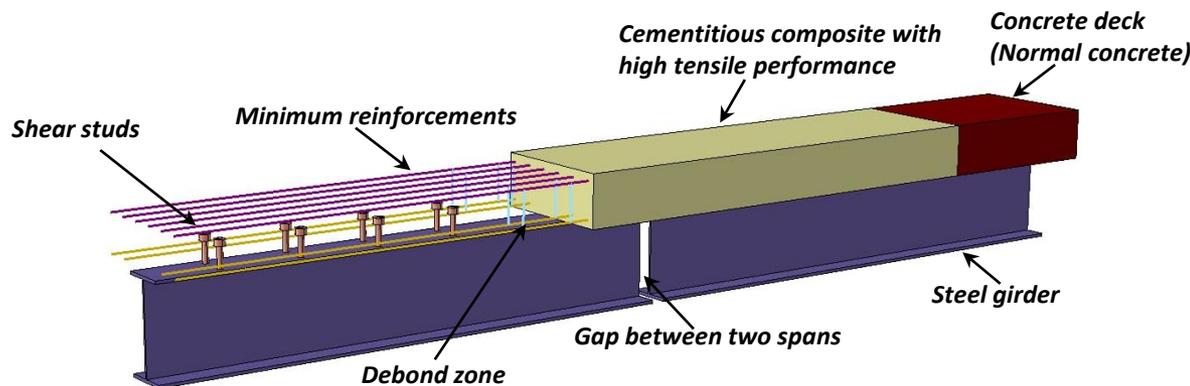
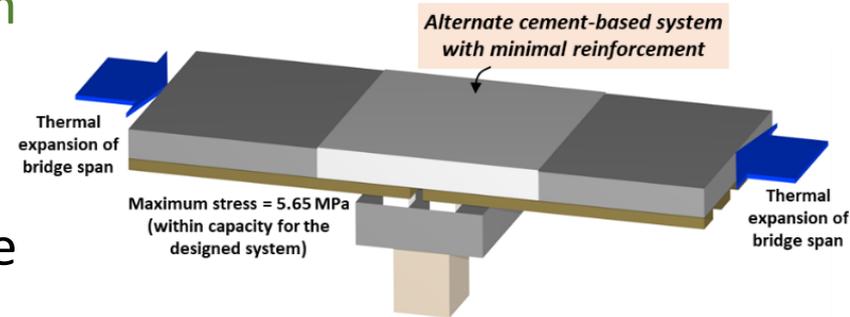
Compressive strength	43 MPa
Elastic Modulus	64 GPa
Tensile strength	5.49 MPa
Strain capacity	9000 $\mu\epsilon$
Flexural strength	17.58 MPa
Energy dissipation capacity	1.68×10^{-3} J
Fracture energy	1453.30 J/m ²



Crack bridging by fibers

System Development

- Design of system with minimum reinforcements
 - ✓ To make the implementation easier
 - ✓ To take full advantage of high tensile performance of developed material
- Designed to withstand moment arising due to end rotation arising from simply supported spans
- Configuration - Steel-concrete composite bridge system (steel I-girder and concrete deck)
- Center portion debonded to allow the simply supported functionality

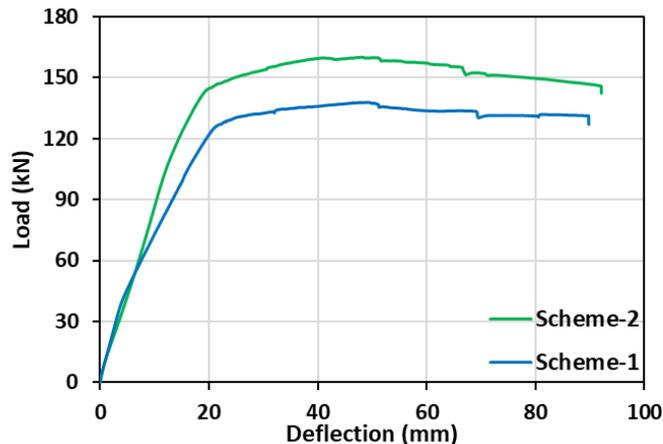


Specifications

- ✓ Length = 5% ($L_1 + L_2$)
- ✓ Width = W_s
- ✓ Depth = d_s
- ✓ Matrix = Cementitious composite with high tensile performance
- ✓ Minimum reinforcement
- ✓ Debonded from girder

Laboratory investigations

- Test carried out on full-scale joint portion of two simply supported spans (portion between inflection points) - 4 m
- To evaluate the load carrying capacity and bendability of the system
- Test carried out in servo-controlled actuator of capacity 50T
- Detailed instrumentation to capture strain, deflection, rotation and interfacial properties

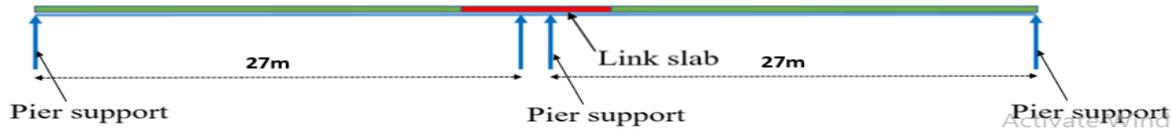


Major observations

- Higher load carrying capacity in comparison to Scheme-2
- Demonstrates good bendability
- Different components acting as a single unit
- Desired failure pattern

Numerical simulations of two span system

➤ Simulations on two full span composite girders with the proposed system

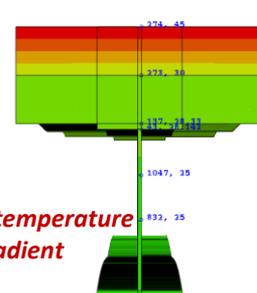
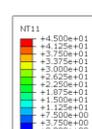
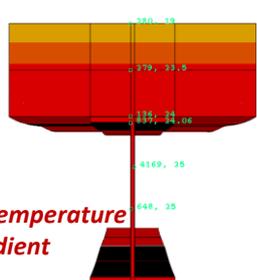
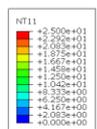
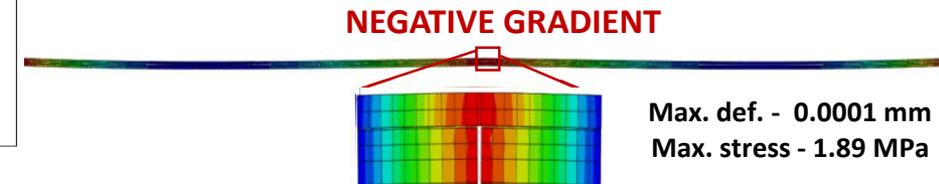
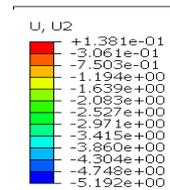
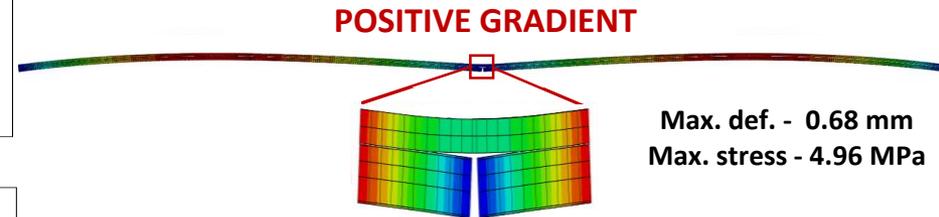
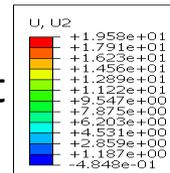


➤ Four different thermal loading scenarios

- ❖ Uniform temperature
 - Overall warming ($T_i - 25^\circ\text{C}$, $T_f - 45^\circ\text{C}$)
 - Overall cooling ($T_i - 25^\circ\text{C}$, $T_f - 5^\circ\text{C}$)
- ❖ Temperature gradient
 - Positive temperature gradient
 - Negative temperature gradient

Material	Thermal conductivity (W/m.°C)	Coefficient of thermal expansion ($1/^\circ\text{C}$)
Steel	53.3	1.2×10^{-5}
Concrete	1.36	1.0×10^{-5}
ECC	1.36	$1.1 \times 10^{-5*}$

**Wyrzykowski and Lura (2013), Cement and Concrete Composites, 35(1), 49-58*



Innovative Technology



Bridge deck with conventional expansion joint

Bridge deck with expansion joint - free technology

Innovative Solution

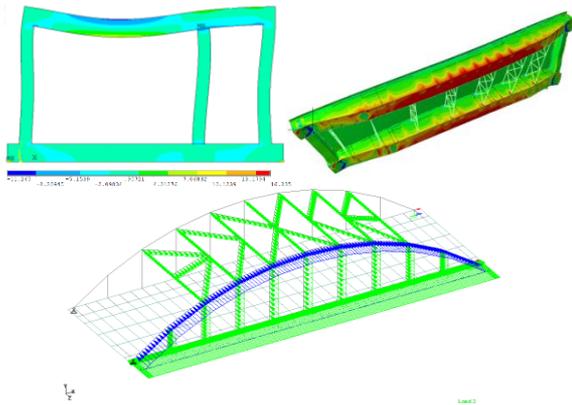


- Further details/queries about this technology can be directed to CSIR-SERC
- Stakeholder's meeting in March 2026

CSIR-SERC's expertise

New Material Development

- Development of high performance materials (ECC, UHSC, UHPC, TRC) with high mechanical and durability properties for construction of bridges
- Development of materials and systems for life enhancement of bridges



Analysis and Finite Element Simulations

- Moving load analysis of bridges under IRC load conditions and other load combinations
- Finite element simulations of structures with non-linear material properties

Structural Health Monitoring

- SHM of highway bridges through instrumentation and load testing
- SHM of vehicular underpasses (VUPs)
- Remedial measures for repair/deficient structures



Thank You

For further details, contact:

sindu.serc@csir.res.in

044-22549239