Ultra High Performance Concrete

Material, Design and Application

India's First Commercial Manufacturer: Since 2020

UHPC India Pvt. Ltd.

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ISKCON School – off Mumbai:

Feb 2021

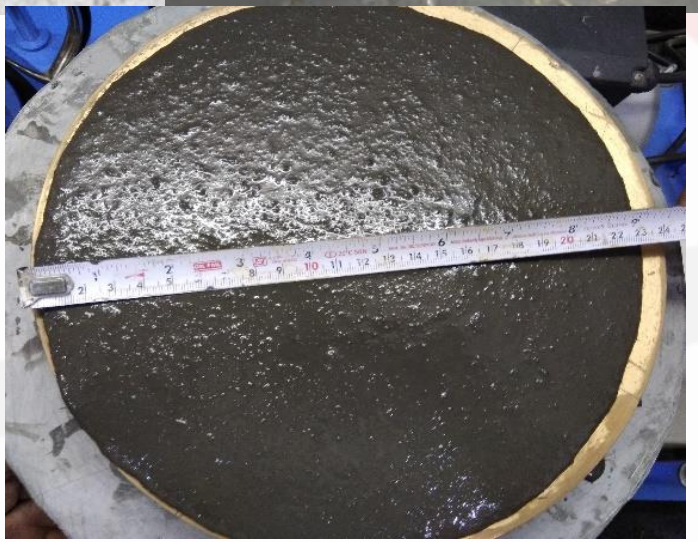
India's First Project

Concrete is the Wrong Choice of Word

Fibrous Composite

- Ultra High Performance Fiber Reinforced Composite (UHPFRC)
- Ultra High Performance Concrete (UHPC)
- Ultra High Performance Fiber Reinforced Concrete (UHPFRC)
- Reactive Powder Concrete (RPC)

UHPC – The Material



Ultra Green !!

Ultra Strong !!

Ultra Durable!!

Steel Fibers: 2% by Vol

0.2 mm (d) x 13 mm (L)

Tensile Strength ~ 2800 MPa

AR: 60 to 70

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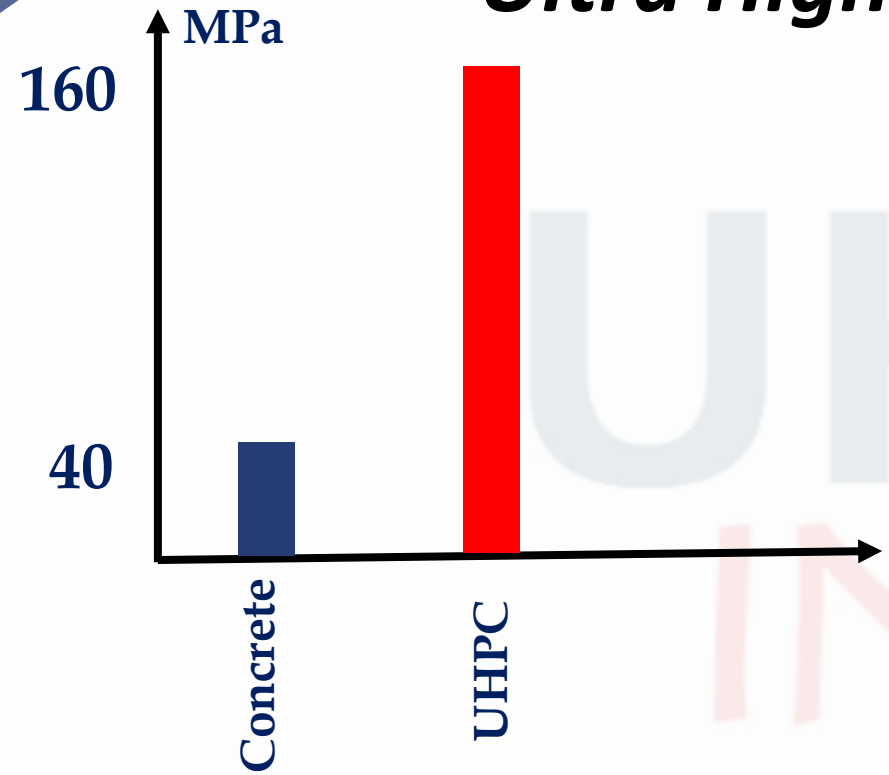
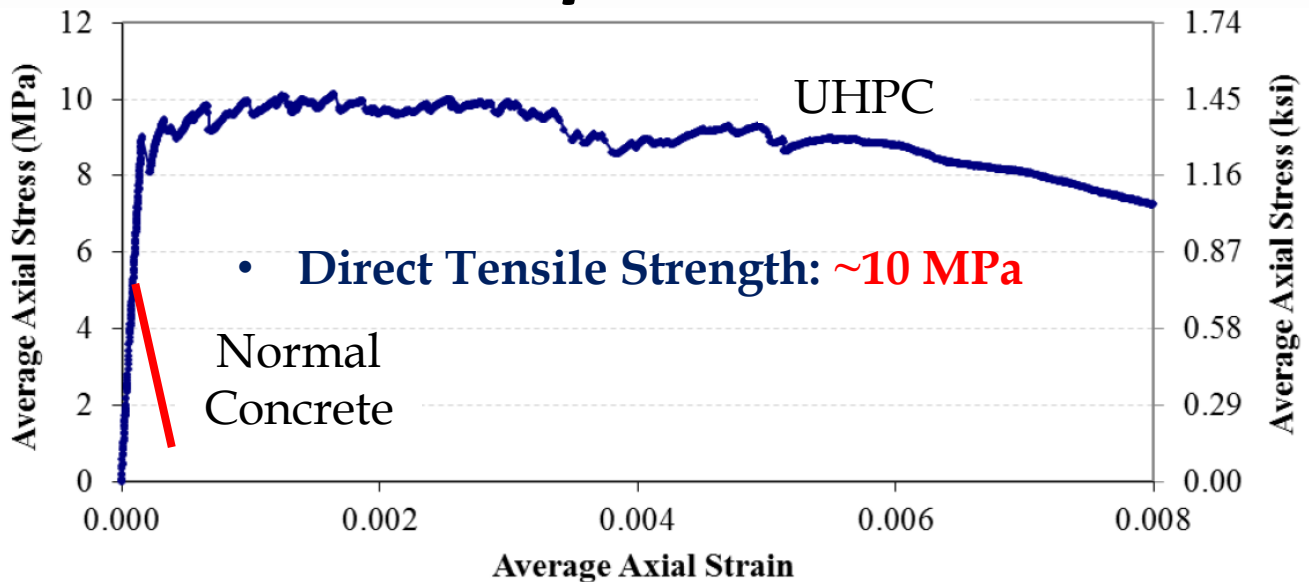
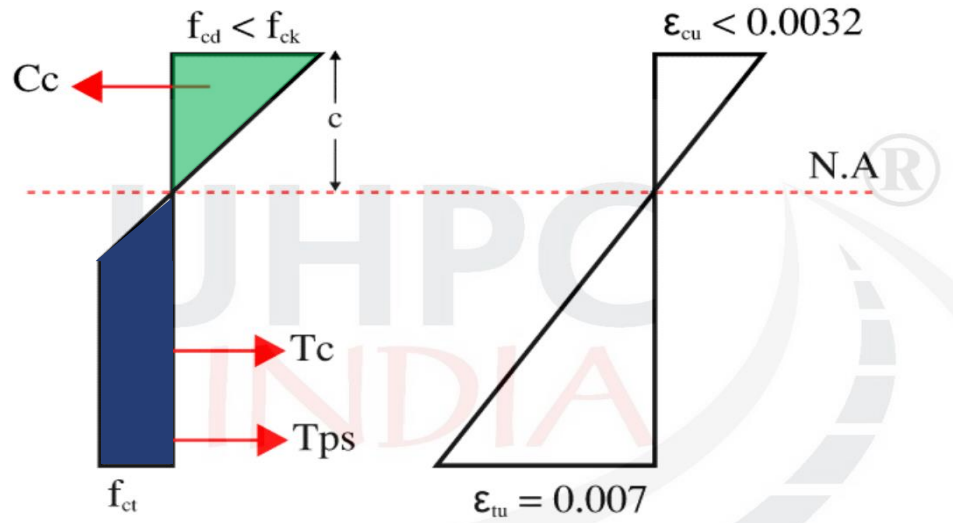
Ultra High Mechanical Properties





- **Compressive Strength: 140 MPa to 220 MPa**
- **Direct Tensile Strength: ~10 MPa**
- **Elastic Modulus: ~50,000 MPa**
- **Low Creep Coefficient:~ 1.0 (Normal Curing)**

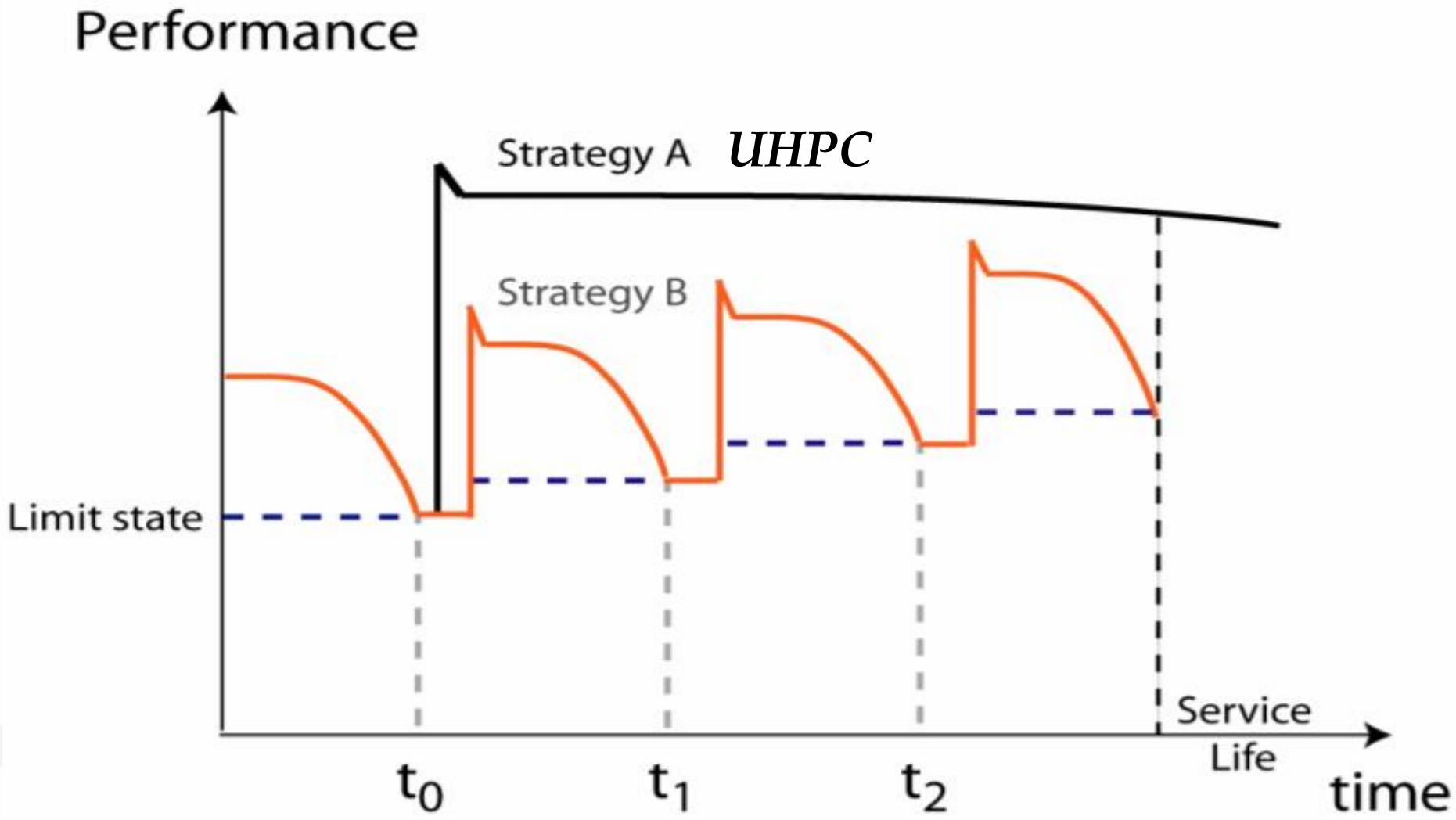


Flexural Design of Beams

Courtesy: Aaleti & Sritharan (2013)

Robust Durability Performance

Longevity: 100 Year Maintenance Free Life



Report: Samaris
WP14 D22

Concrete

UHPC

Structural Steel

- 50 % Weight reduction of structural elements
- Negligible/Low Reinforcing Steel
- 100 Year **maintenance free** service life
- Sleek and elegant Looks
- Ultra High wear and impact resistance
- Rapid development of strength:
  - > 60 MPa in 24 hours
  - > 100 MPa in 3 days

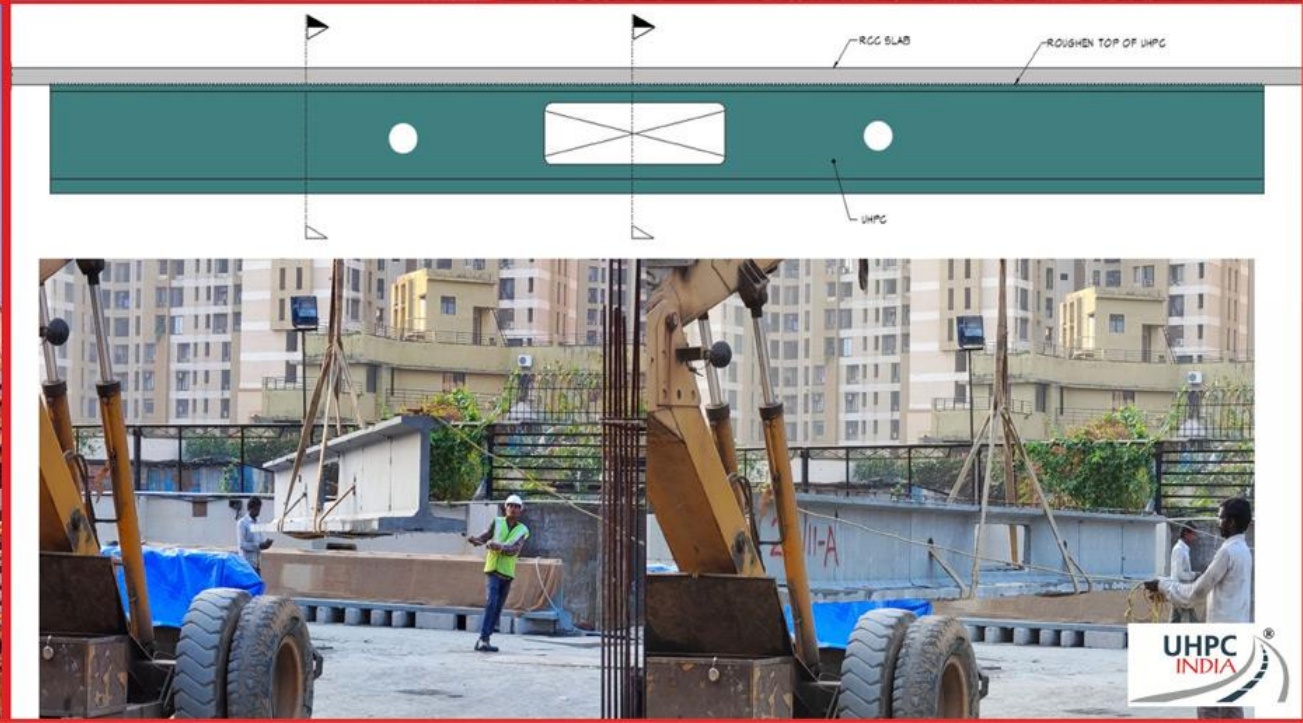
At a Fraction of Steel Cost, you get Steel Behavior

	Concrete	UHPC	Struc. Steel
Cu.m. Rate	Rs 7000	Rs 80,000 to 1,00,000	Rs 7,00,000
Ratio	**1**	**11 to 15**	**100**

Few of our Projects

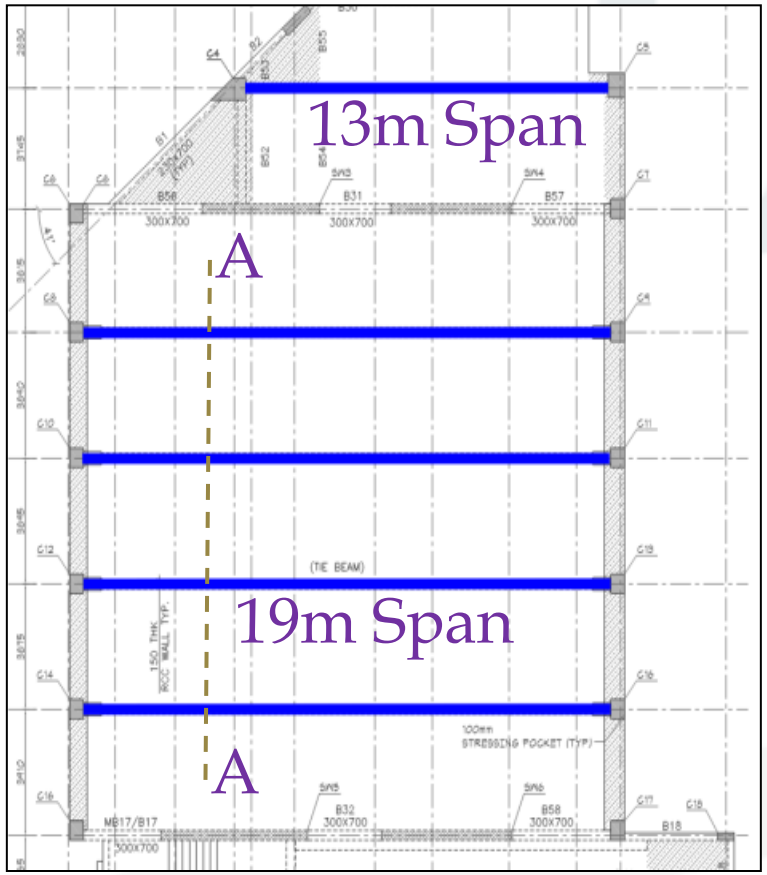
84 Hollow UHPC Beams

GCC Mumbai

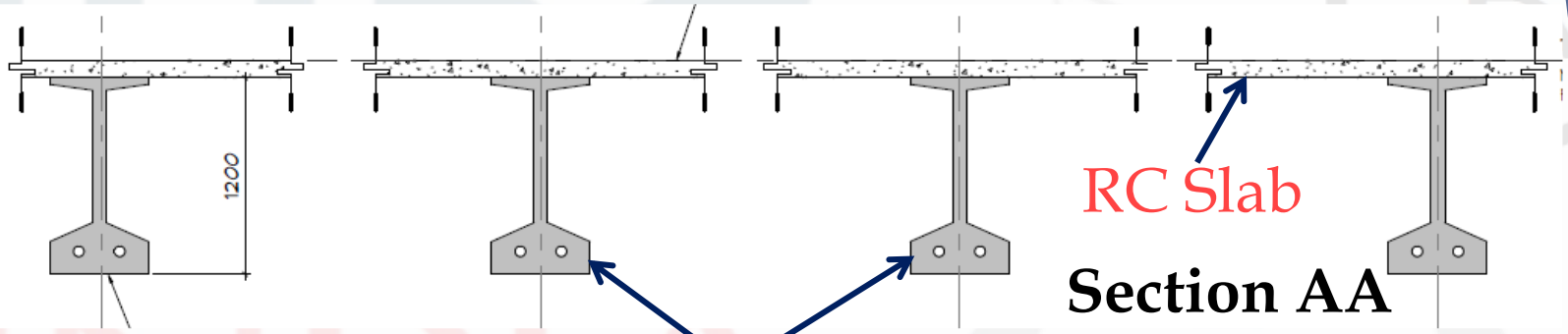


GCC Namaste, Mumbai

- Addition of a floor at the 13th Level in an existing hotel tower.
- The floor needed to be as light as possible.



Floor Plan



Section AA

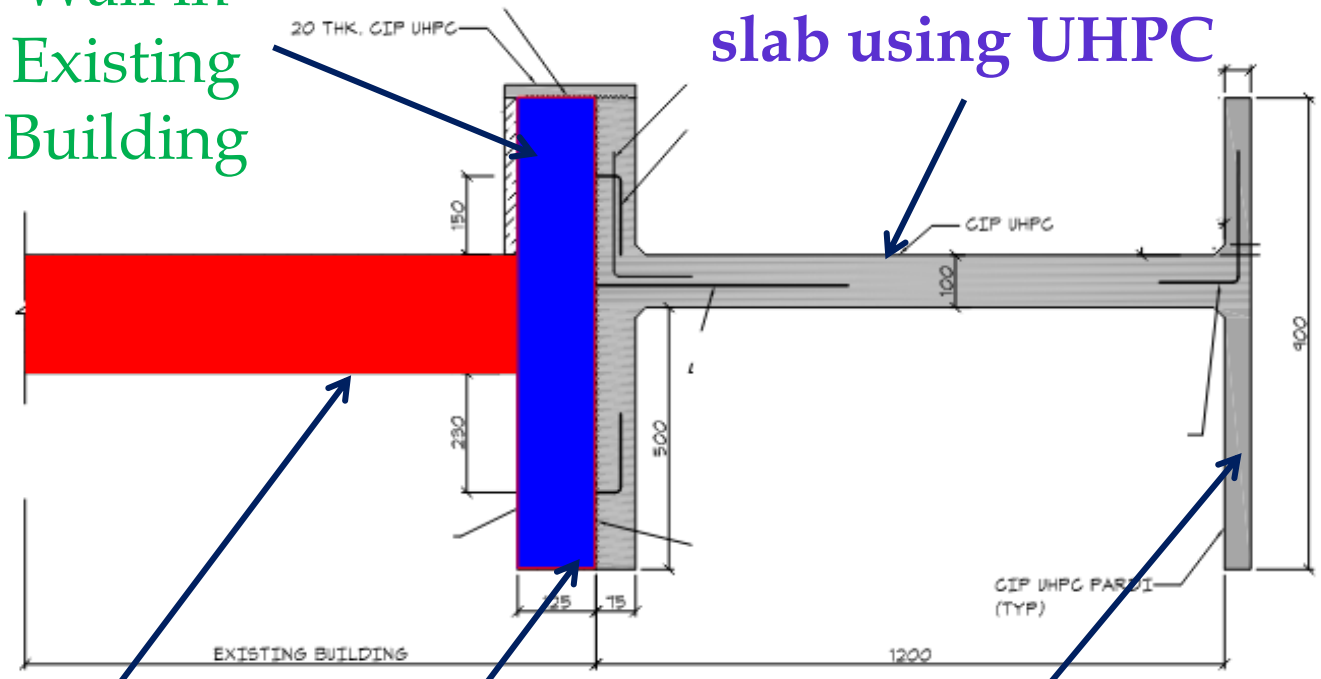
1200mm deep Light weight **cast-in-place** UHPC Girder

Bungalow Project– Tirupati

Extension of Existing Slab

RC Parapet Wall in Existing Building

1200 mm extension of slab using UHPC



- The cantilever extension must be lighter in weight

PT Slab in Existing Building

RC Curtain Wall in Existing Building

UHPC Curtain wall and Parapet to keep the building elevation uniform

Extended Slab

(SDC Dev Aangan, Mumbai).

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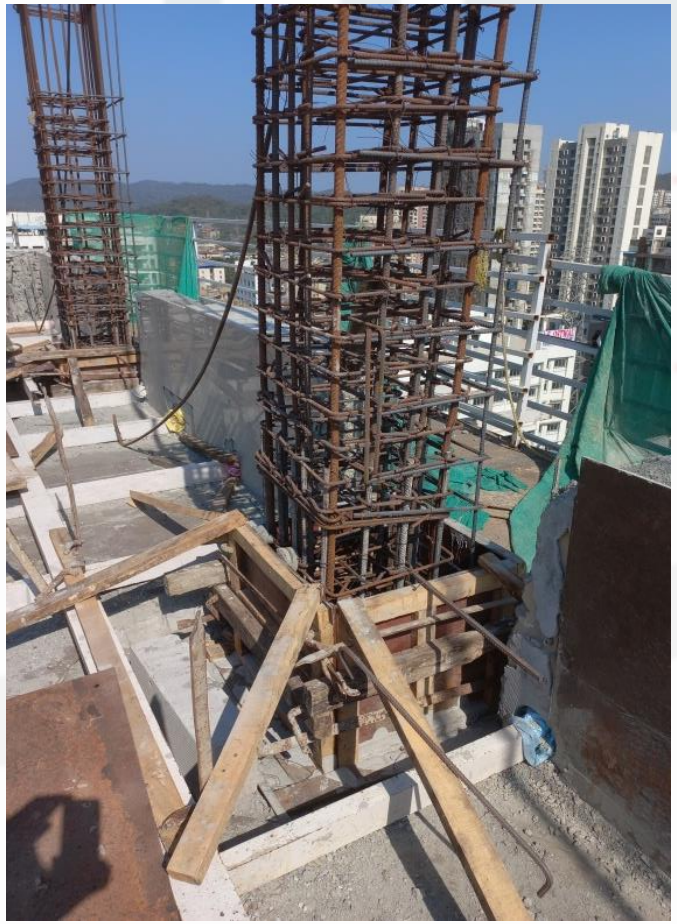
Column Splicing on existing building

- Required Development length in UHPC < 15 × bar dia.

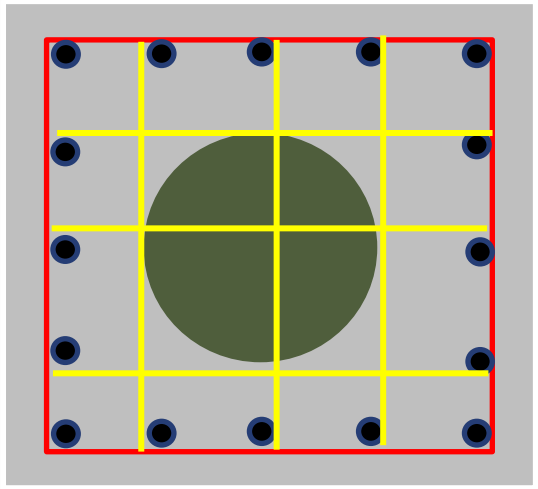


New Column Rebar

Existing Column Rebar

UHPC Column starter

RC-UHPC Composite Columns



- Currently tested for predominantly Gravity Loaded Columns.
- First Set of Tests Successful

Tested at IIT Hyderabad

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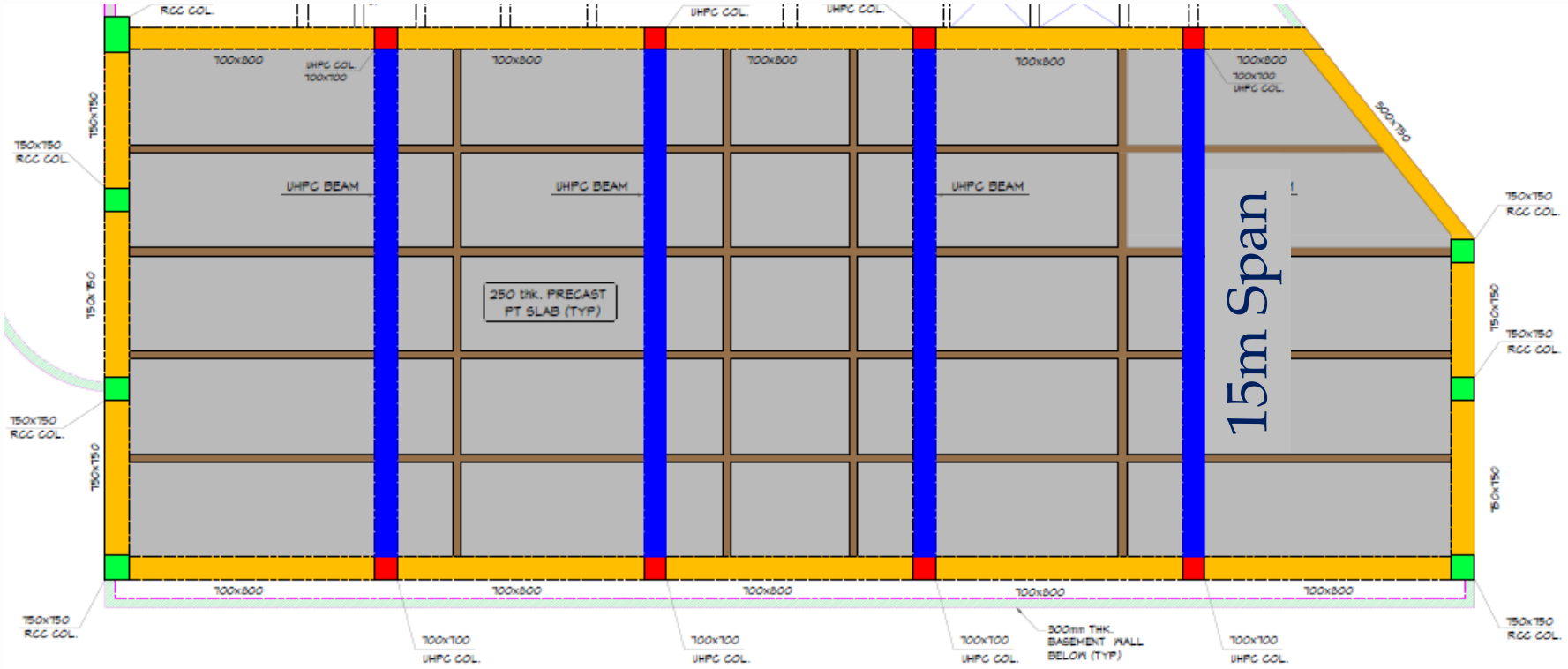
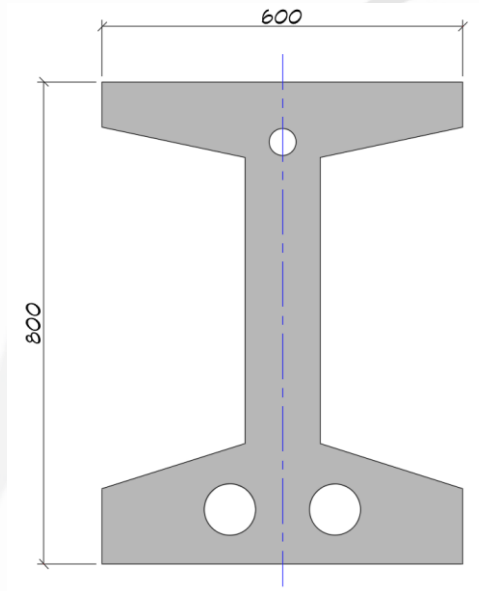
Retrofit for Additional Parking – Mumbai

- Existing Beams strengthened to support 3 Level Steel Parking Structure.

Motibaug C2, Mumbai



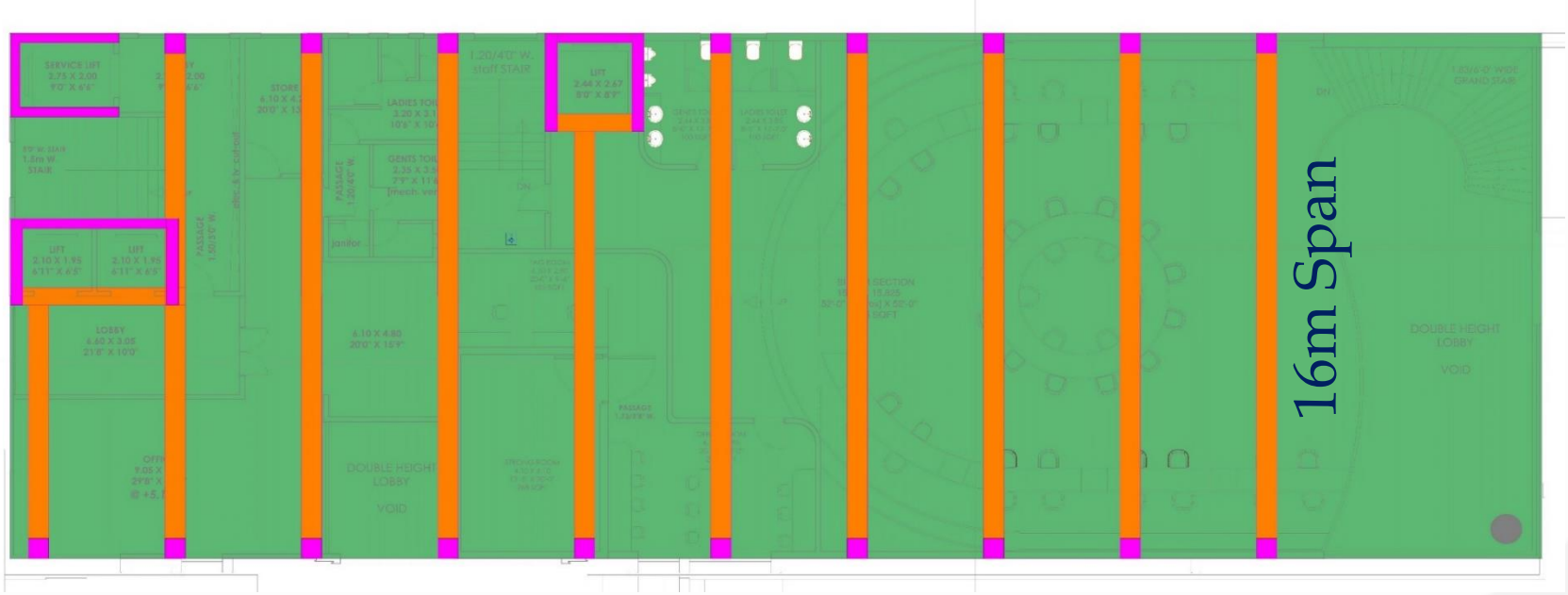
Floor Plan

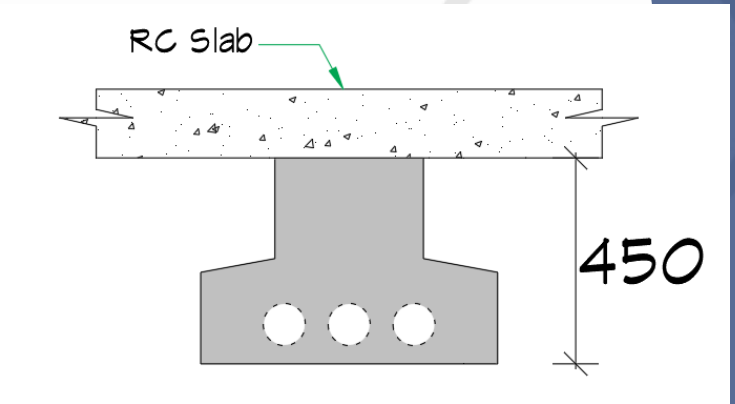


Proposed **precast** UHPC girder (800 mm deep)

- Longer Spans – Flexible space option at retail levels.

Upcoming Jewellery Store, Vellore





Proposed **precast** UHPC girder

- Longer Spans – Flexible space option.
- Super fast construction – Pre-casting.
- Floor-to-Floor height remains the same.

Dry Mix Jumbo Bags

UHPC Dry Premix in Jumbo bags

Ready-Mix UHPC

UHPC wet-mix in ready-mix concrete trucks

Precast Long Span UHPC Girders

Composite girders for bridges and buildings

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Busting Myths

Myth 1: UHPC Elements Needs to be Precast in a Facility

UHPC Premix manufactured in factory controlled condition

Batched Ice or Iced water

Weighed Steel Fibers

Mixing with High Energy mixer

Wet UHPC mixed at site

Myth 2: UHPC Cannot be Cast-in-Place

Shuttering for UHPC girders (19.0 m span) at 13th floor level supported over props

UHPC poured in place through bucket

Myth 3: UHPC Cannot be Pumped

UHPC Pumping

UHPC Pumping at 13th floor of an existing Hotel building in Mira road, Mumbai

Myth 4: UHPC has to be Steam Cured

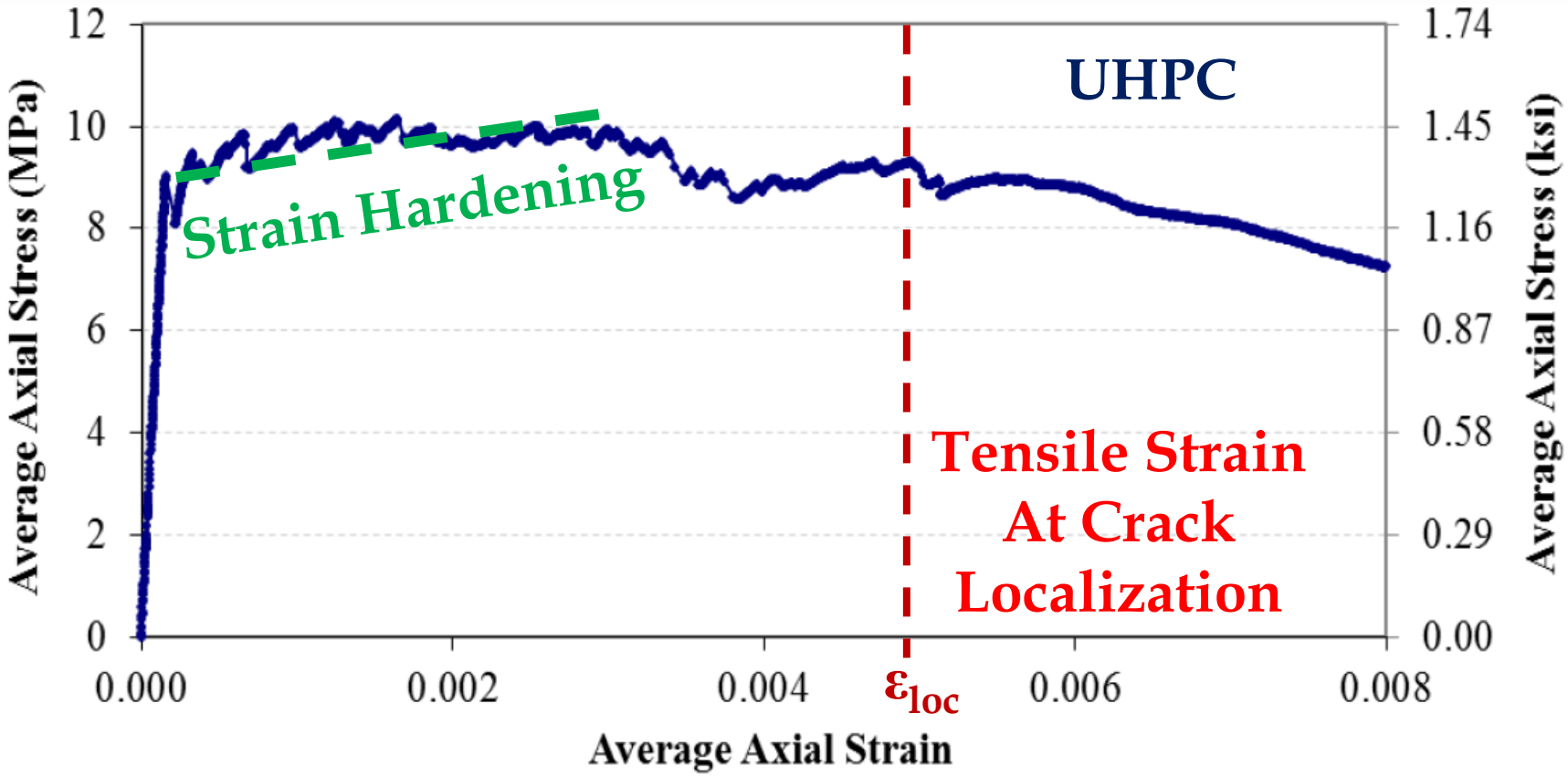
Normal water curing
Site mixing
Strength achieved (28 days)= 186 MPa
with a standard deviation of 8 MPa

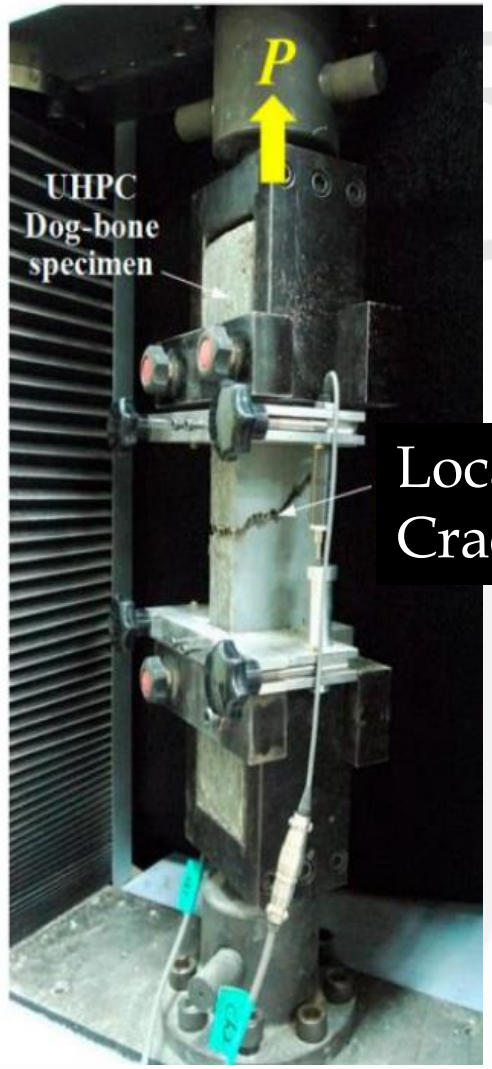
Curing using curing compound
Site mixing
Strength achieved (3 days) = 117 MPa

Myth 5: UHPC has to be poured within 30 minutes

A Good UHPC is workable for long hours

Myth 6: Flexural Strength is Sufficient to Define Tensile Property





Credits: FHWA

Two most important parameters to define tensile strength of UHPC.

Myth 7: Only French Code Can be Used for Design

MCS MAINTENANCE CONSTRUCTION SÉCURITÉ
INSTITUT D'INGÉNIERIE CIVILE

EPFL
ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Recommendation:

Ultra-High Performance Fibre Reinforced Cement-based composites (UHPFRC)

Construction material, dimensioning und application

English translation of the Technical Leaflet SIA 2052 with adaptations

For internal use

MCS-EPFL Lausanne, Switzerland, 17 April 2016

Adress:
EPFL-Swiss Federal Institute of Technology
MCS-Maintenance, construction and safety of structures
Station 18
CH-1015 Lausanne, Switzerland

SWISS STANDARD – SIA 2052 - 2016

ASTM C1856-17

ASTM INTERNATIONAL

Designation: C1856/C1856M – 17

Standard Practice for Fabricating and Testing Specimens of Ultra-High Performance Concrete[1]

This standard is issued under the fixed designation C1856/C1856M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ACI 239C - Upcoming

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Shear Strength of UHPC Beams/Girders

As per French Code of Practice, NF P-18 710 (2016)

Shear Strength = UHPC Concrete + Fibrous UHPC + Shear Rebar

As per Swiss recommendations (2016)

Shear Strength = ~~UHPC Concrete~~ + Fibrous UHPC + Shear Rebar

El-Helou and Graybeal (2022) experimental observations on pre-stressed UHPC girders

Shear Strength = ~~UHPC Concrete~~ + Fibrous UHPC + Shear Rebar

Shear crack at Peak Load

El-Helou, R. G., & Graybeal, B. A. (2022). Shear Behavior of Ultrahigh-Performance Concrete Pre-tensioned Bridge Girders. *Journal of Structural Engineering*, *148*(4), 04022017.

- **UHPC has a fine granular structure. Hence, no significant aggregate interlocking.**
- **Negligible advantage from Concrete/Prestressing**

Credits: FHWA

Shear Strength of UHPC

- UHPFRC depicts extraordinarily high Shear Strength
- For most common applications, Shear rebar is not Required

$$V_{Rd} = V_{Rd,U} + V_{Rd,s}$$

with :

$$V_{Rd,U} = \frac{b_w \cdot z \cdot 0{,}5(f_{Uted} + f_{Utud})}{\tan\alpha}$$

$$V_{Rd,s} = \frac{A_{sw}}{s} \cdot z \cdot f_{sd} \cdot (\cot\alpha + \cot\beta)\sin\beta$$

Approximate Shear Strength of UHPFRC:

For α = 30 degrees,

Design Elastic Strength = 5 MPa

Design Ultimate Strength = 6 MPa

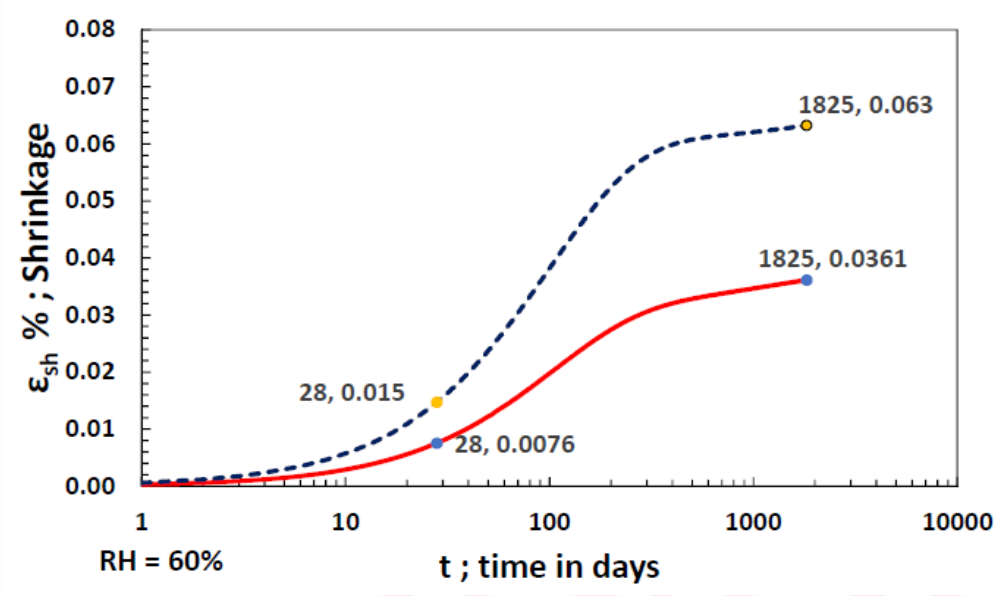
Shear Strength of UHPC = 9.5 MPa

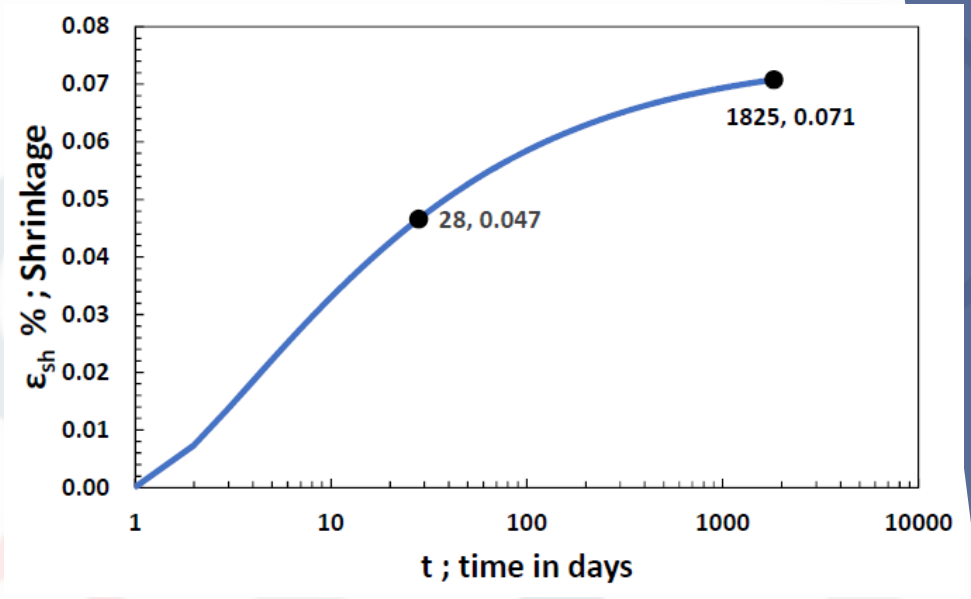
Courtesy: Swiss Code

French Code

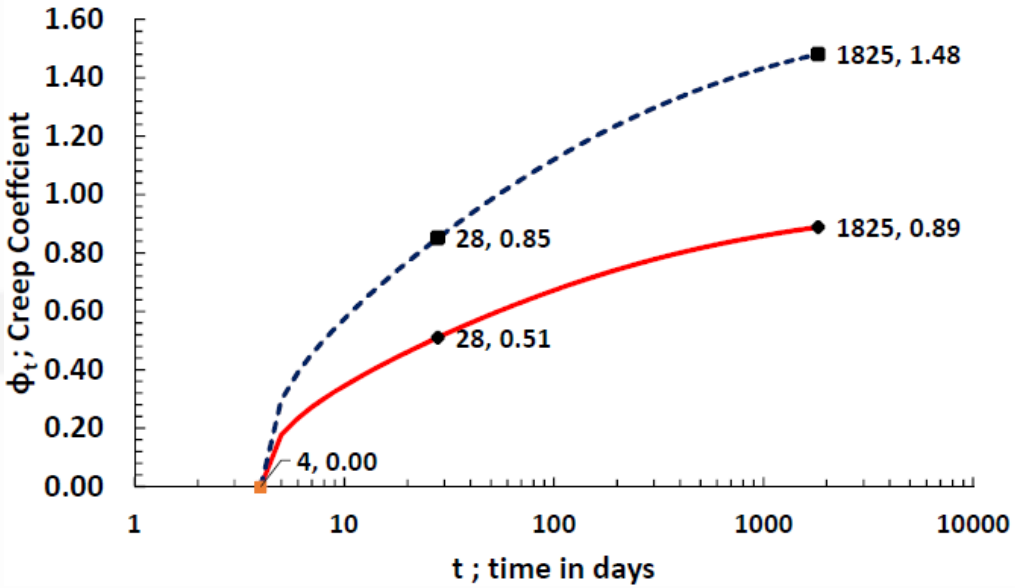
Swiss Code

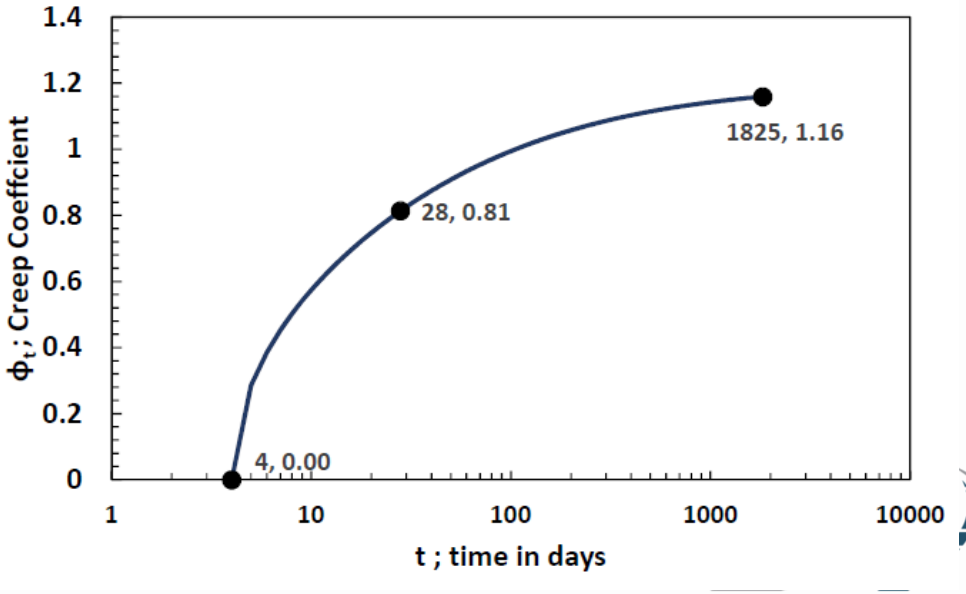
Shrinkage





Creep





Minimum Clear Cover to Post Tensioning Ducts

IRC 112-2020

75mm

Considering durability, bond and crack width requirements, irrespective of the exposure conditions and duct dia.

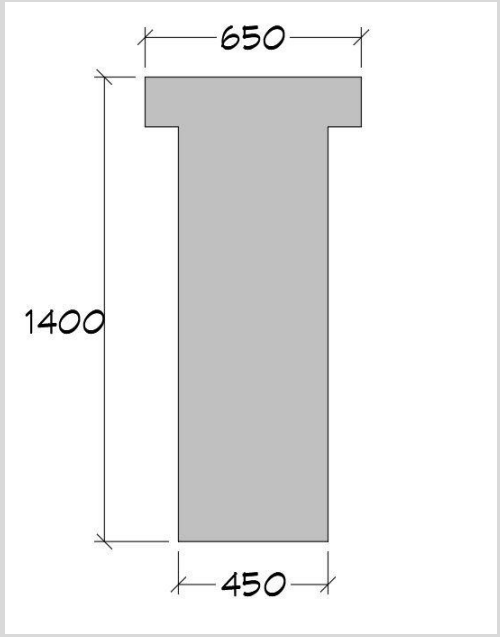
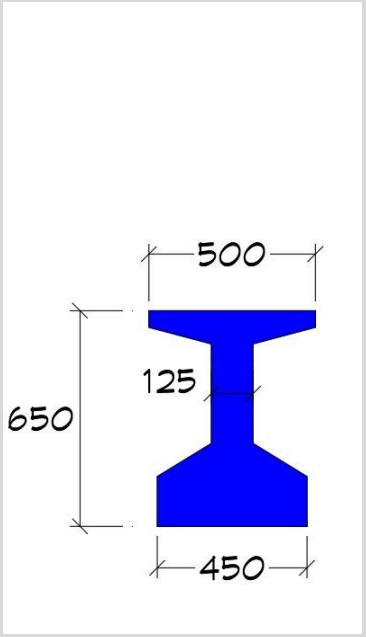
French Code

Duct Dia

Clear cover ~ Duct Dia

Upcoming Bridge Projects
Bridge Girder Size Comparison

Bridge Girder , 15m Span vs 15m Span

	RC Girder	PS UHPC I Girder	Difference
With SPV Loading			**750mm reduction in depth**
Span	15m	15m	**Similar**
Girder Self-Weight	**28.5 MT**	**7.9 MT**	**~72%** ⬇

~72% reduction in the Girder Self-weight.

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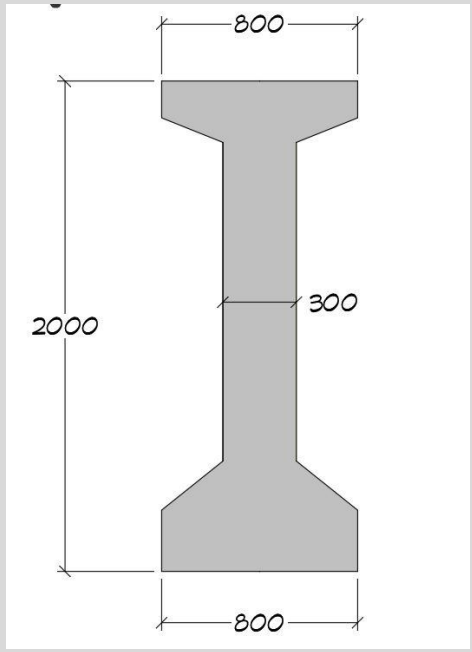
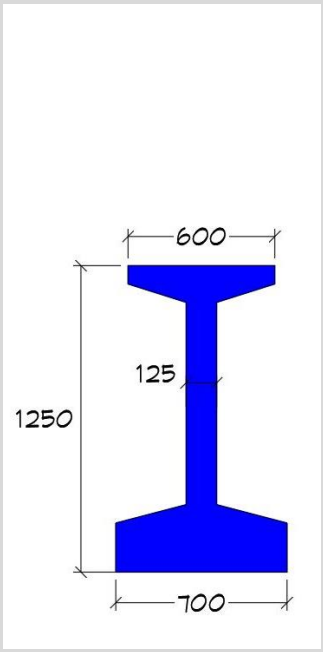
Bridge Girder , 30m Span vs 30m Span

	PSC Girder	PS UHPC I Girder	Difference
With SPV Loading			**750mm reduction in depth**
Span	30m	30m	**Similar**
Girder Self-Weight	**81 MT**	**32 MT**	**~60%** ⬇

~60% reduction in the Girder Self-weight.

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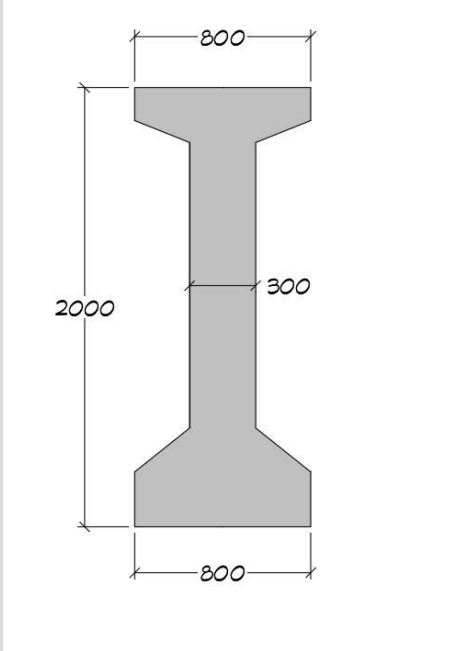
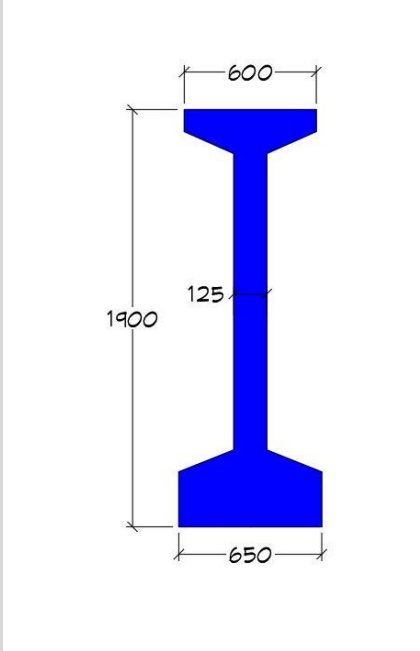
Bridge Girder , 30m Span vs 42m Span

	PSC Girder	PS UHPC I Girder	Difference
With SPV Loading			**100mm reduction in depth**
Span	30m	42m	~40% ↑
Girder Self-Weight	**81 MT**	**67 MT**	~17% ↓

~17% reduction in the Girder Self-weight even with 40% increased span.

~32% reduction in the number of piers in a major bridge (780m).

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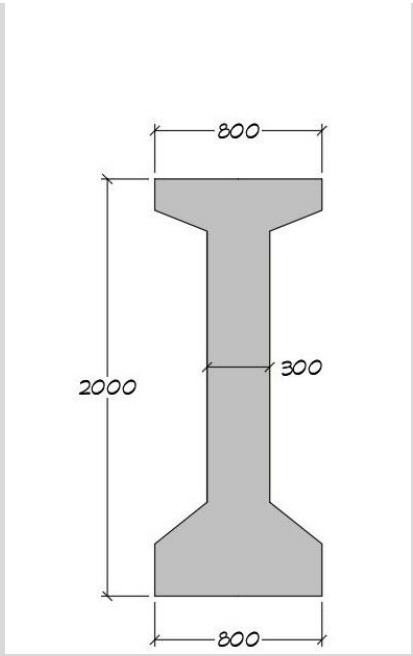
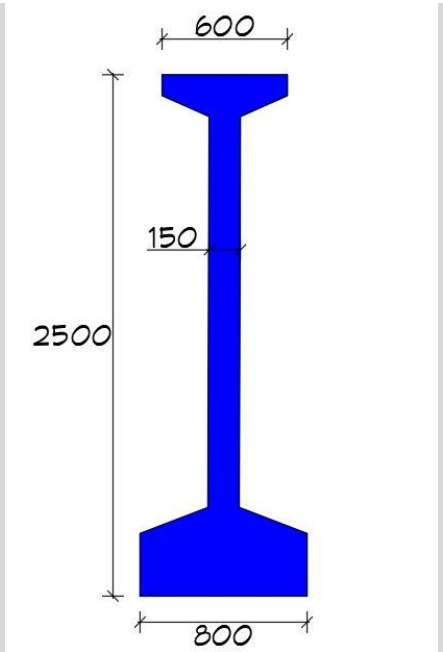
Bridge Girder , 30m Span vs 60m Span

	PSC Girder	PS UHPC I Girder	Difference
With SPV Loading			**500mm increase in depth**
Span	30m	60m	~100% ↑
Girder Self-Weight	**81 MT**	**122 MT**	~50% ↑

~50% increase in the Girder Self-weight even with double span.

~50% reduction in the number of piers in a major bridge (780m).

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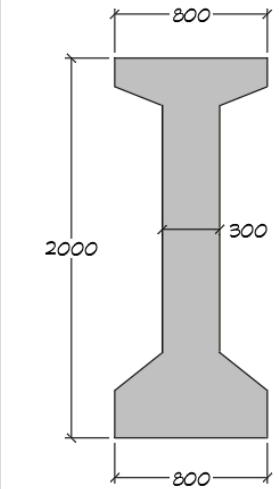
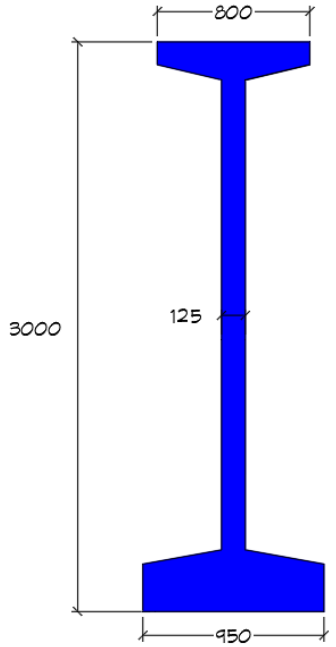
Bridge Girder , 30m Span vs 70m Span

	PSC Girder	PS UHPC I Girder	Difference
With SPV Loading			**1000mm increase in depth**
Span	30m	70m	~133% ↑
Girder Self-Weight	**81 MT**	**164 MT**	~102% ↑

~43% reduction in the number of piers in a major bridge (420m).

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Now Possible to Eliminate Concrete Box Girders for Longer Spans (60 to 70m)

If Structural Steel I-Girders are Possible

UHPC I-Girders are Possible as well

	Steel Plate Girder	UHPC I Girder	Difference
Span	60m	60m	
Girder Self-Weight	120 MT	120 MT	**Similar**
Girder Span-to-Depth Ratio	22.2	25	
Erected Cost	1.4 Cr.	0.8 Cr.	**43% Savings**

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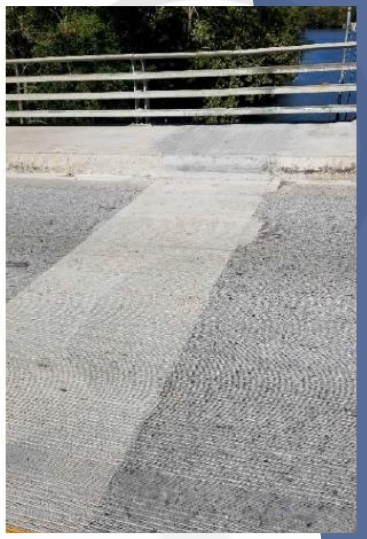
Misc. Infrastructure Application around the World

Other Applications in Bridge Engineering

Enhancing Strength and Durability of a Deteriorated Pier with UHPC Cover



Expansion Joints at Deck Replaced with UHPC Link Slab

Longitudinal Joints Repair / Filling with field cast UHPC

Credits: FHWA

UHPC wearing coat over Bridge deck

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Pedestrian Bridges around the World

Precast Circular - MORTH

UHPC India Pvt. Ltd. is expanding with

25 to 30 Micro UHPC Precast Facilities around India

2022-23

With Precasting and Infra Channel Partners

Build with your OWN UHPC!!

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आत्मनिर्भर भारत अभियान

THANK YOU !!

We Look Forward to create Value for You!!

MADE IN INDIA UHPC

UHPC® INDIA