THERMO-MECHANICAL BEHAVIOR OF PRELOADED LOW CEMENT CONCRETE UNDER HEATING AND COOLING PHASE OF FIRE EXPOSURE

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News / World / US News / How this Malibu mansion defeated wildfire. It's a concrete miracle

How this Malibu mansion defeated California wildfire. It's a concrete miracle

Amid the devastation in Malibu from the California wildfires, a USD 9-million mansion stands unscathed and defiant. Its owner, a retired waste-management executive, called it a "miracle". However, the three-storey house's survival is more of science than miracle.

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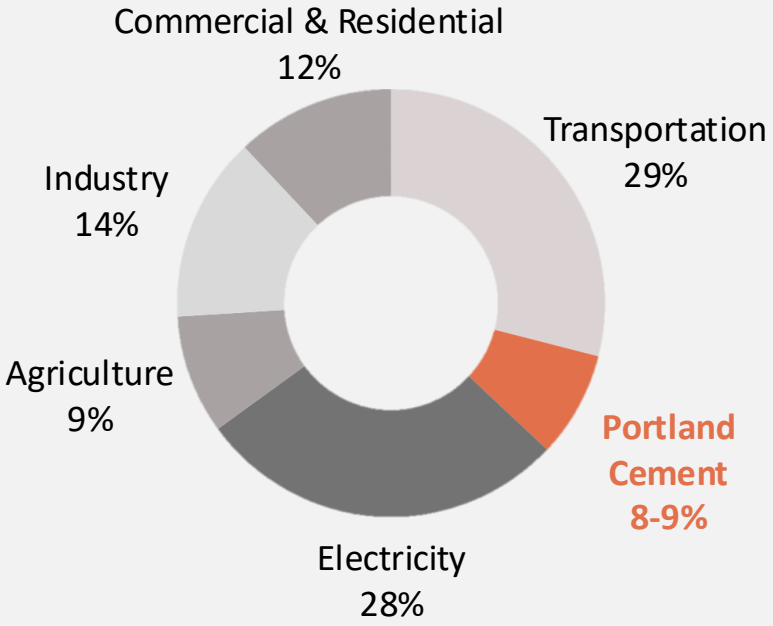
The Malibu mansion worth USD 9 million survived the California wildfires as other properties in the neighbourhood were burnt to ashes. (Image: AFP)

Miracle of Malibu: Lone house pictured still standing as LA fires leave $50bn trail of destruction

10 January 2025, 10:52 | Updated: 10 January 2025, 10:56

A single house was seen left standing amid the huge destruction caused by the fires. *Picture: Getty*

Research Significance



Sources of Global CO_2 Emissions [1]

	2020	2050
Concrete Volume (Billion m^3)	14	>20
World Population (Billions)	7.8	~9.8

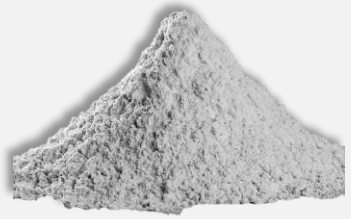
World Population vs. Concrete forecast [2]

Cement

- 68% reside in urban areas.
- 50% increase in annual cement production.

1. Monteiro, P., Miller, S., Horvath, A. (2017) Towards sustainable concrete. *Nature Mater* 16, 698–699. https://doi.org/10.1038/nmat4930
2. Envisaging the future of cities, World Cities Report (2022), (United Nations Human Settlement Programmer (UN-Habitat), wcr_2022.pdf (unhabitat.org)

Research Significance



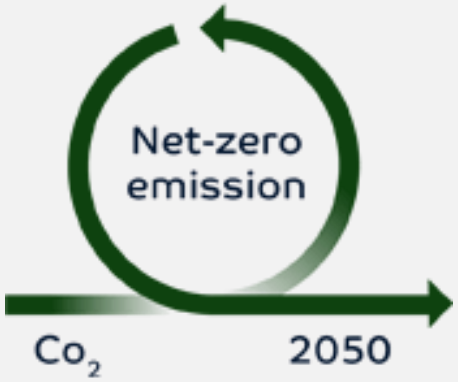
(**GGBS**)
(By product of blast furnace used to make iron)

Cement

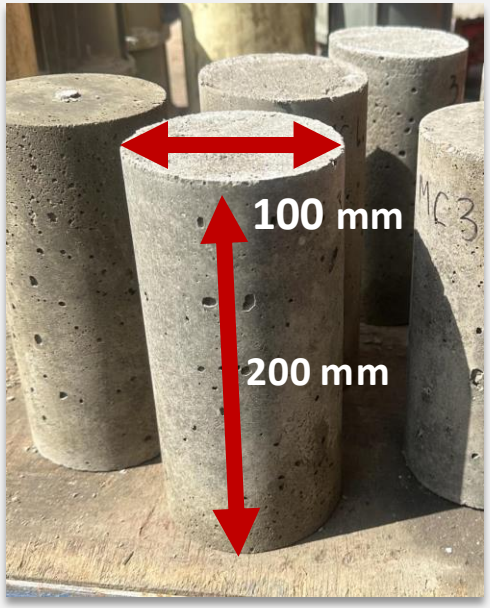
Replaced by

(**SF**)
(By product of elemental silicon or alloys)

(**FA**)
(By product of combustion of pulverized coal)



Specimens and Mix design



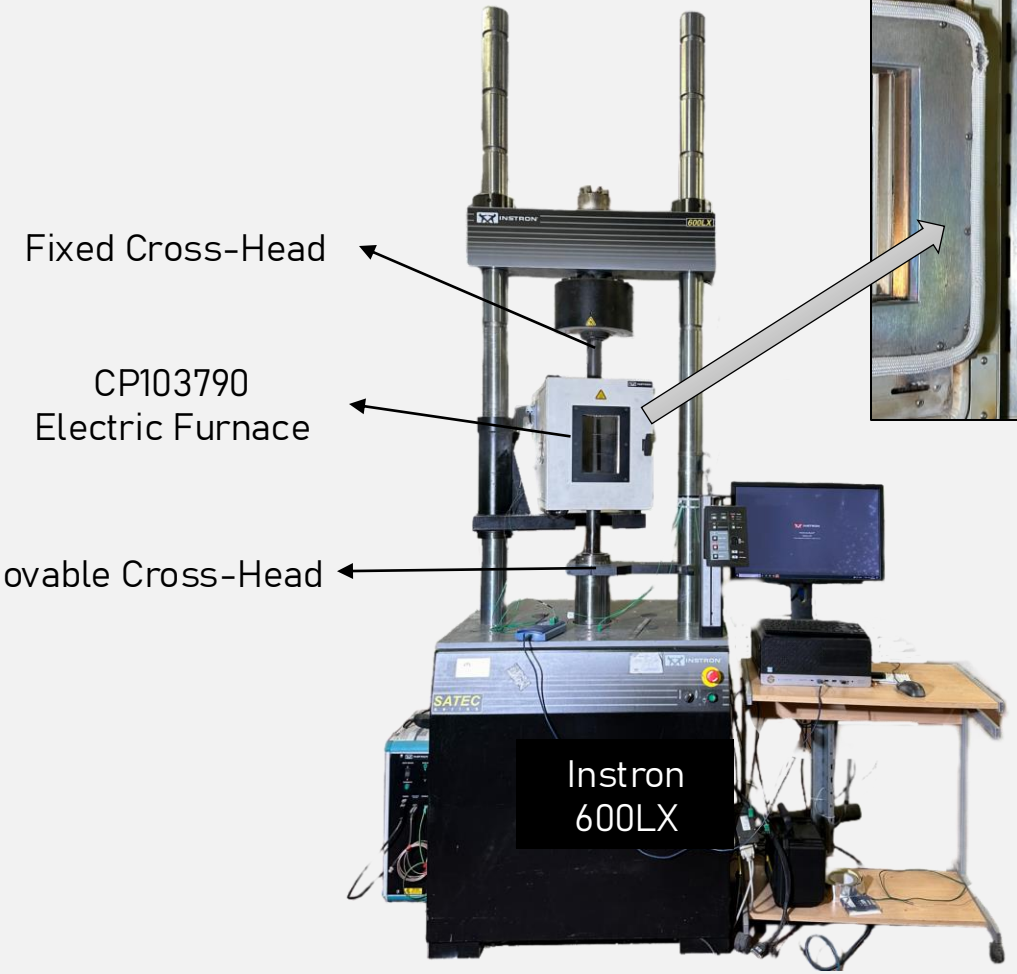
Specimen Dimensions

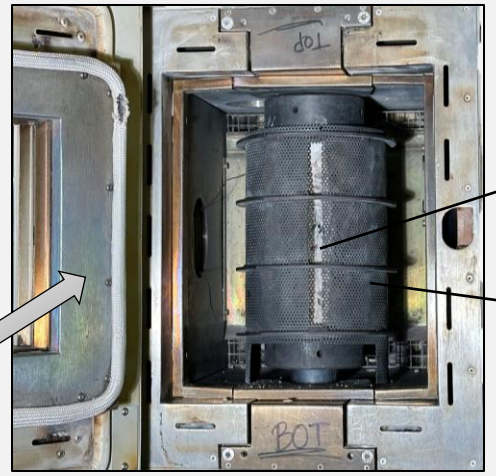
BS EN 12390-1:2021 – RC50/60

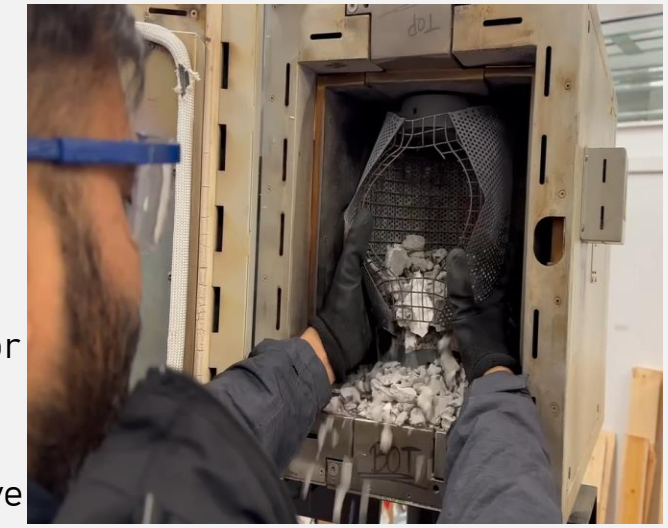
Materials	CS1	CS2
Cement (52.5 OPC) (kg/m³)	360	180
0/4 mm Concrete Sand (kg/m³)	724	705.09
4/10 mm Concrete Aggregates (kg/m³)	1181	1150
Ground Granulated Blast Furnace Slag (kg/m³)	-	180
Water (kg/m³)	180	180
Slump (mm)	50	52
Water/Binder ratio	0.5	0.5

BS EN 12390-1: (2021) Testing hardened concrete. Shape, dimensions and other requirements for specimens and moulds, https://doi.org/10.3403/30397529U

Experimental Setup







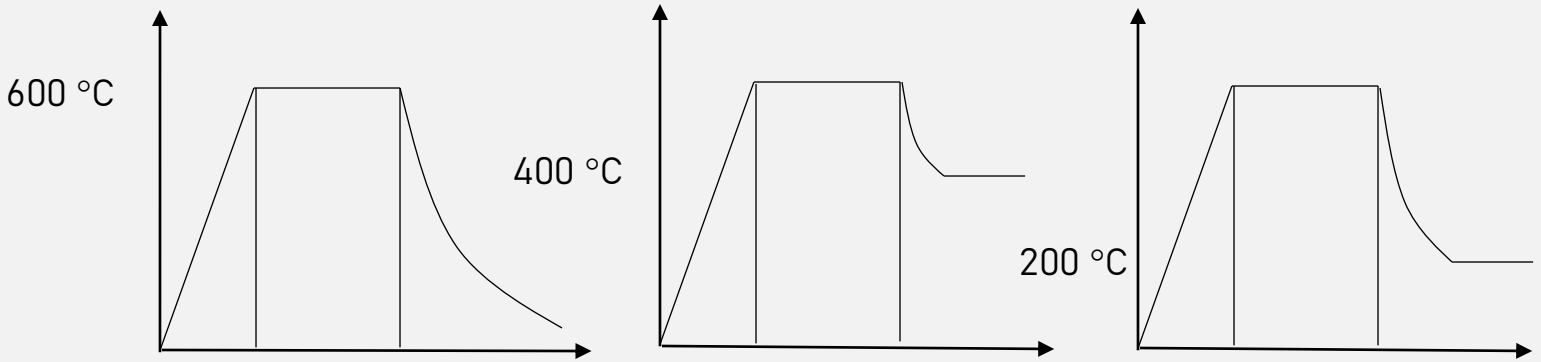
Testing Matrix

Part 1
Compressive Strength of concrete (MPa)

	Age	CS1 (OPC)	CS2 (GGBS)
Cubes	7 days	41.41	24.81
	28 days	57.99	42.12
	90 days	62.85	56.26
Cylinder	90 days	**51.82**	**51.43**

Part 2

30 % Sustained Preload



Heated to 600 °C-Held for 2 hrs.-Cooled too ambient

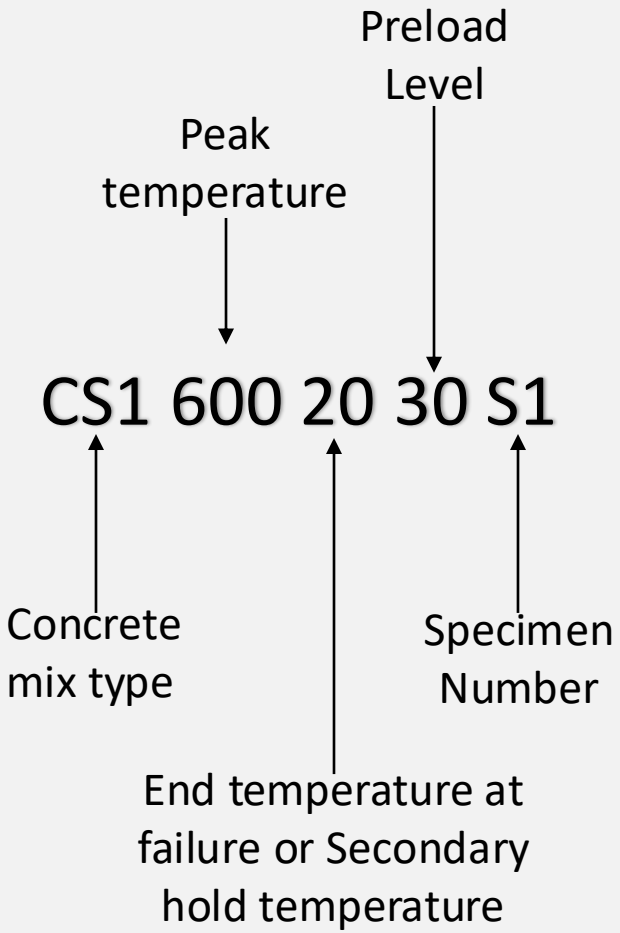
Heated to 600 °C-Held for 2 hrs.-Cooled too 400 °C- Held for 1 hrs.

Heated to 600 °C-Held for 2 hrs.-Cooled too 200 °C- Held for 1 hrs.

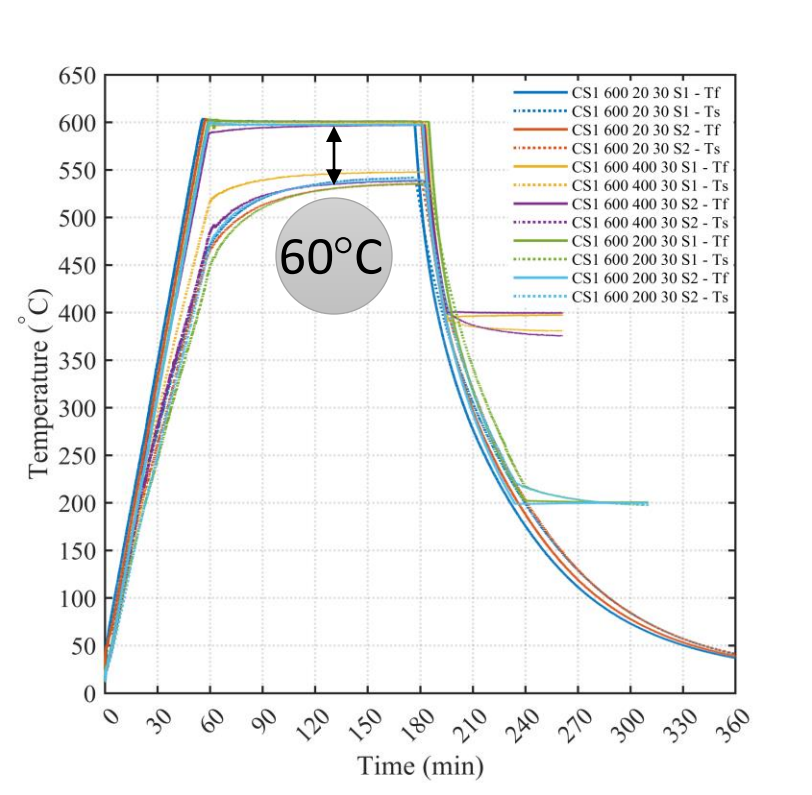
Part 3

Reloaded from sustained load to failure

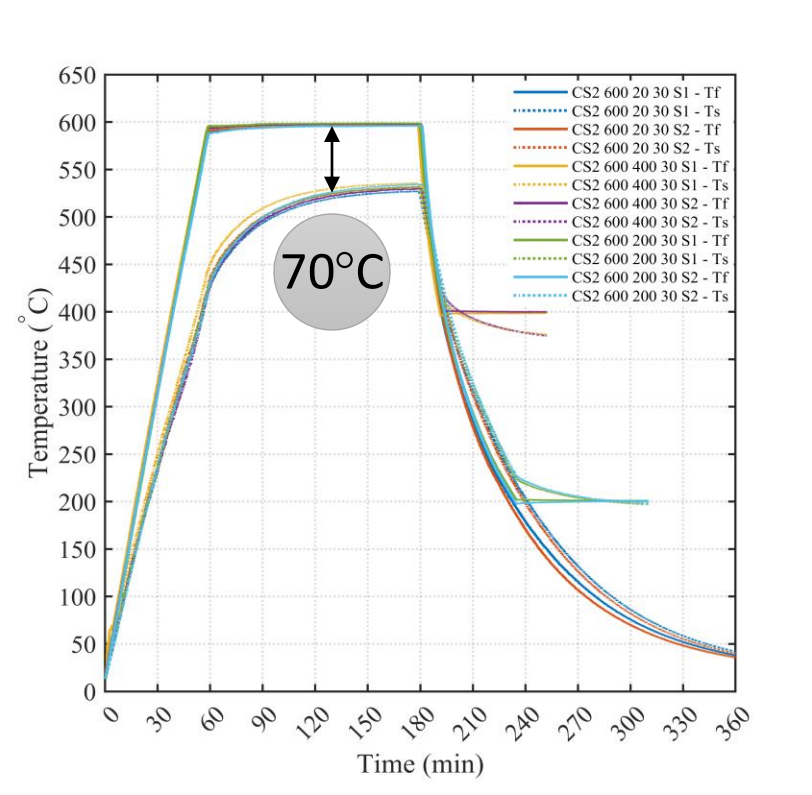
Results and Discussion



Temperature Measurement

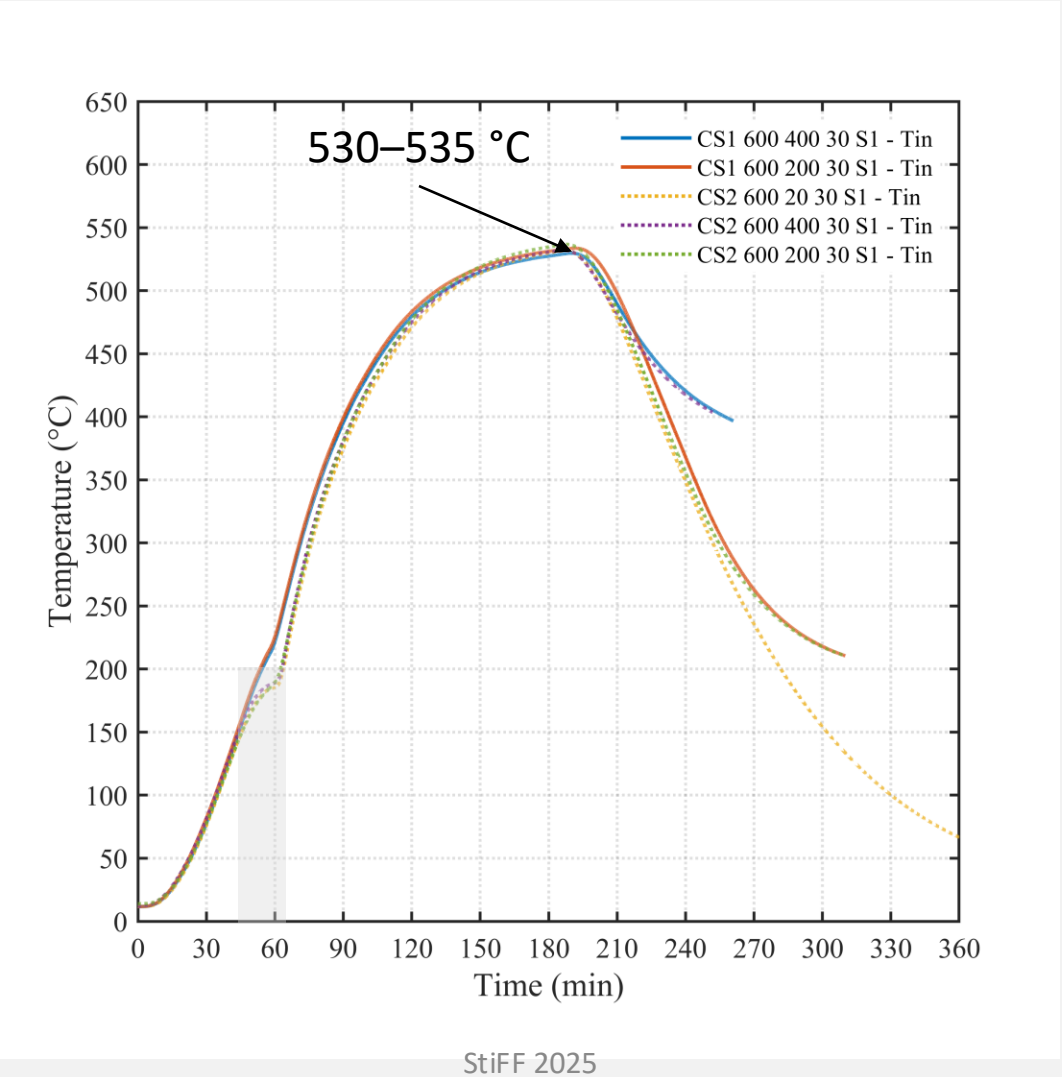


Measurement of *Tf* and *Ts* for CS1 Mix



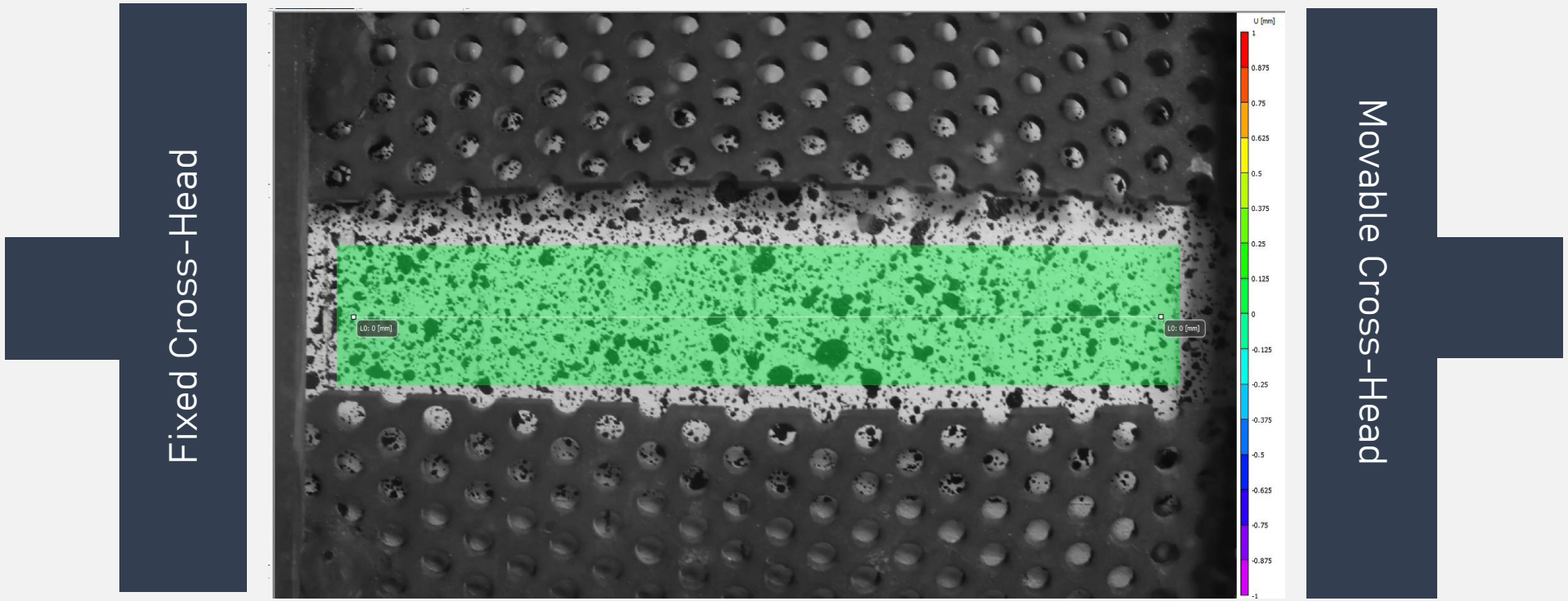
Measurement of *Tf* and *Ts* for CS2 Mix

Internal Temperature Measurement



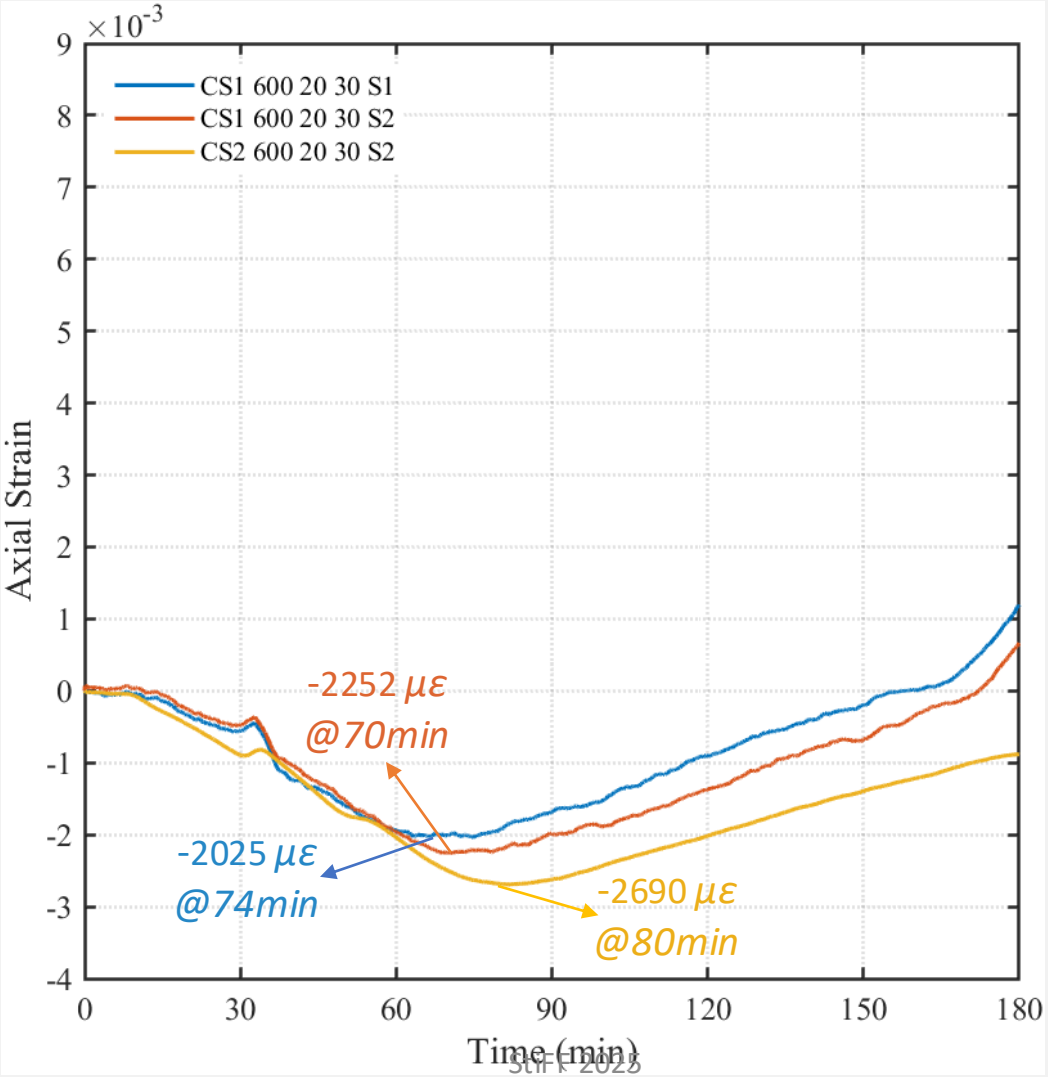
Measurements

- Cross-Head Displacement (Instron)
- DIC (Digital Image Correlation)

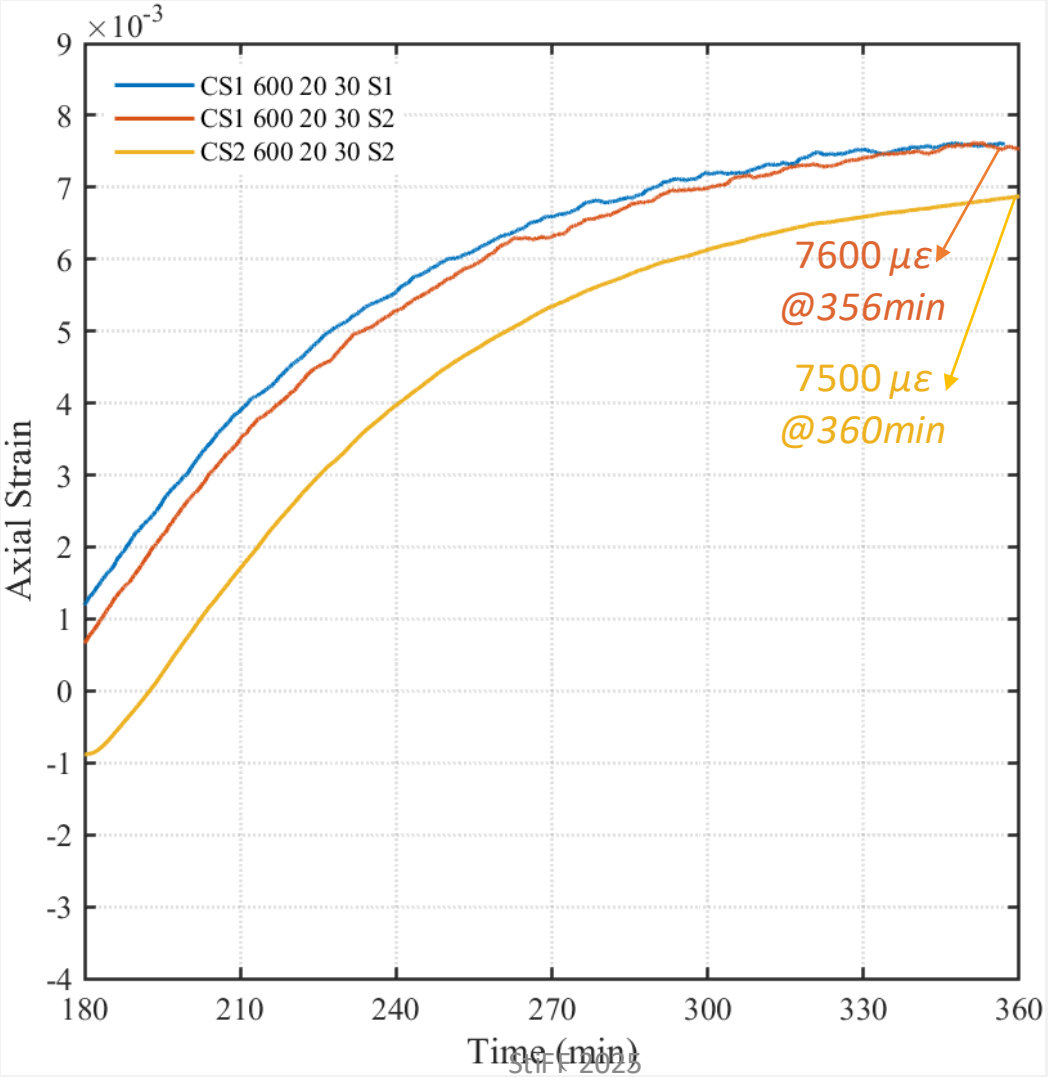


×300 Speed (1800 Images at 10 Sec Interval)

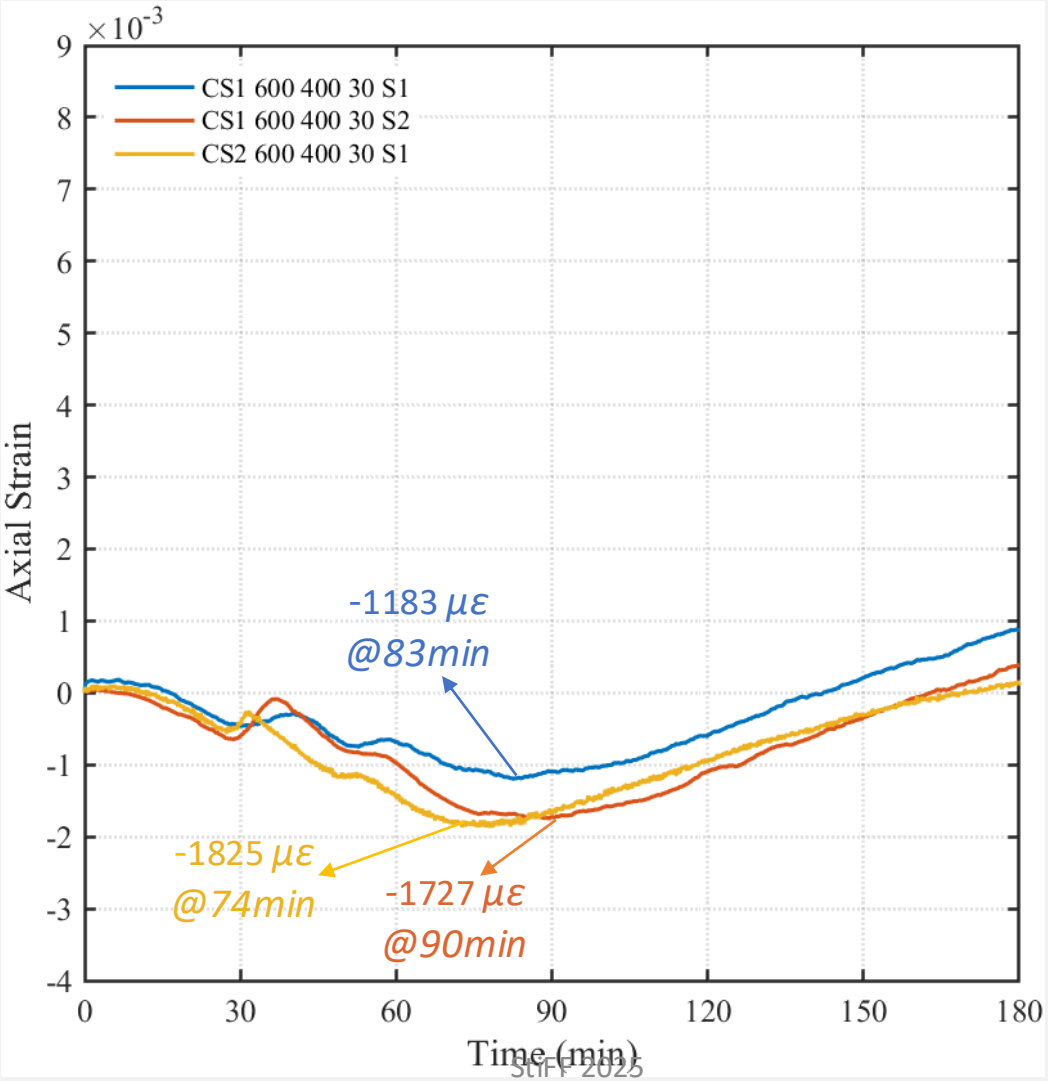
600 20 30 Combination- Heating Phase



600 20 30 Combination- Cooling Phase



600 400 30 Combination- Heating Phase



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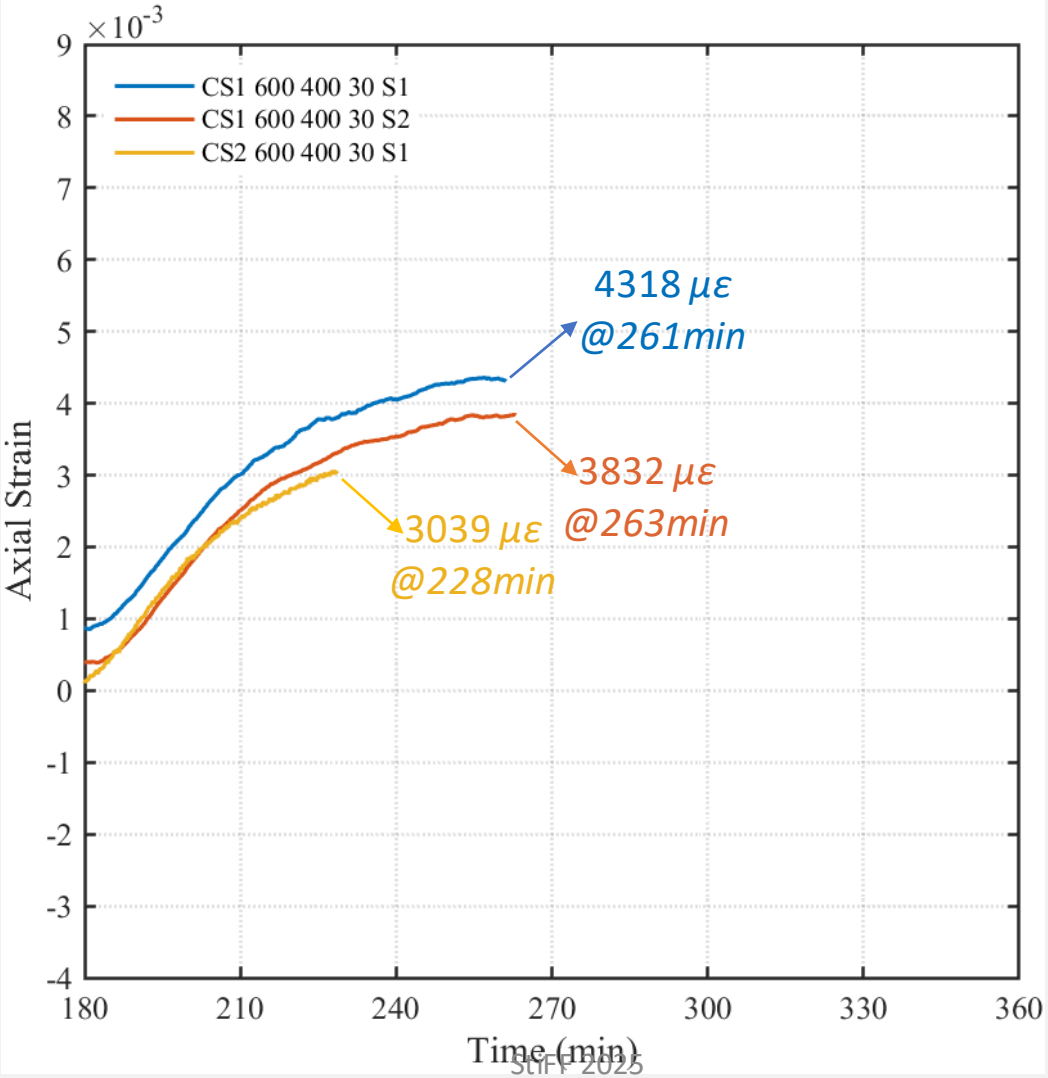
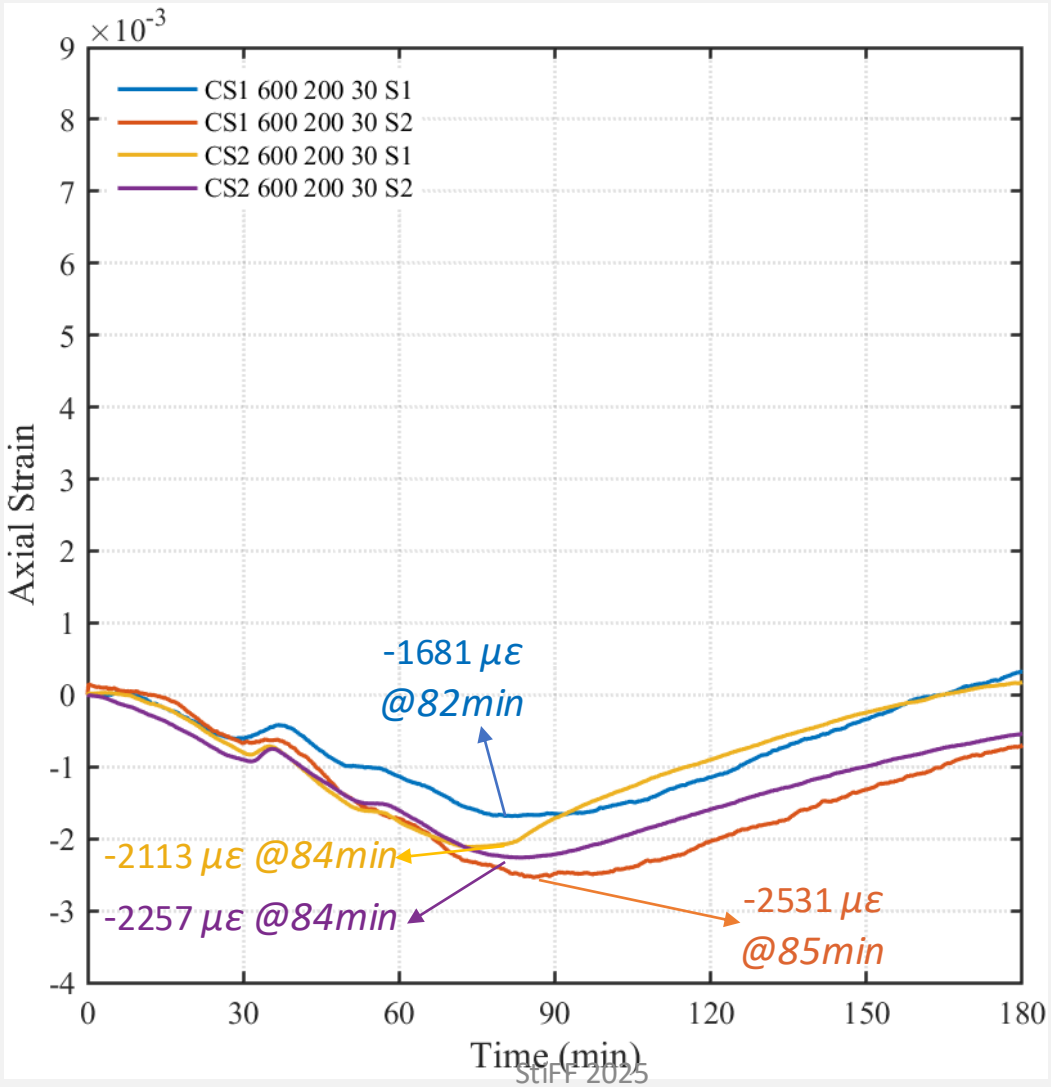
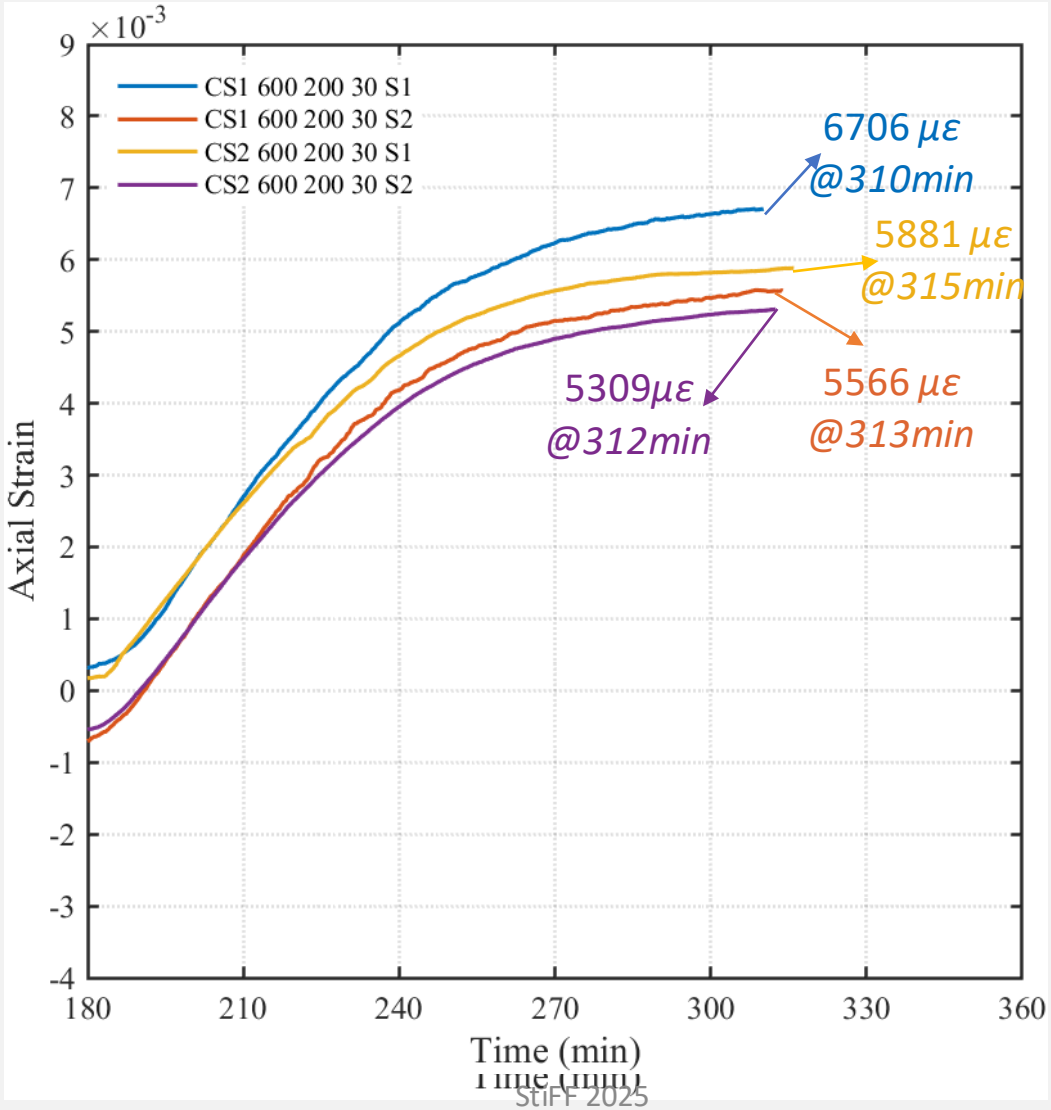


600 200 30 Combination- Heating Phase



600 200 30 Combination- Cooling Phase

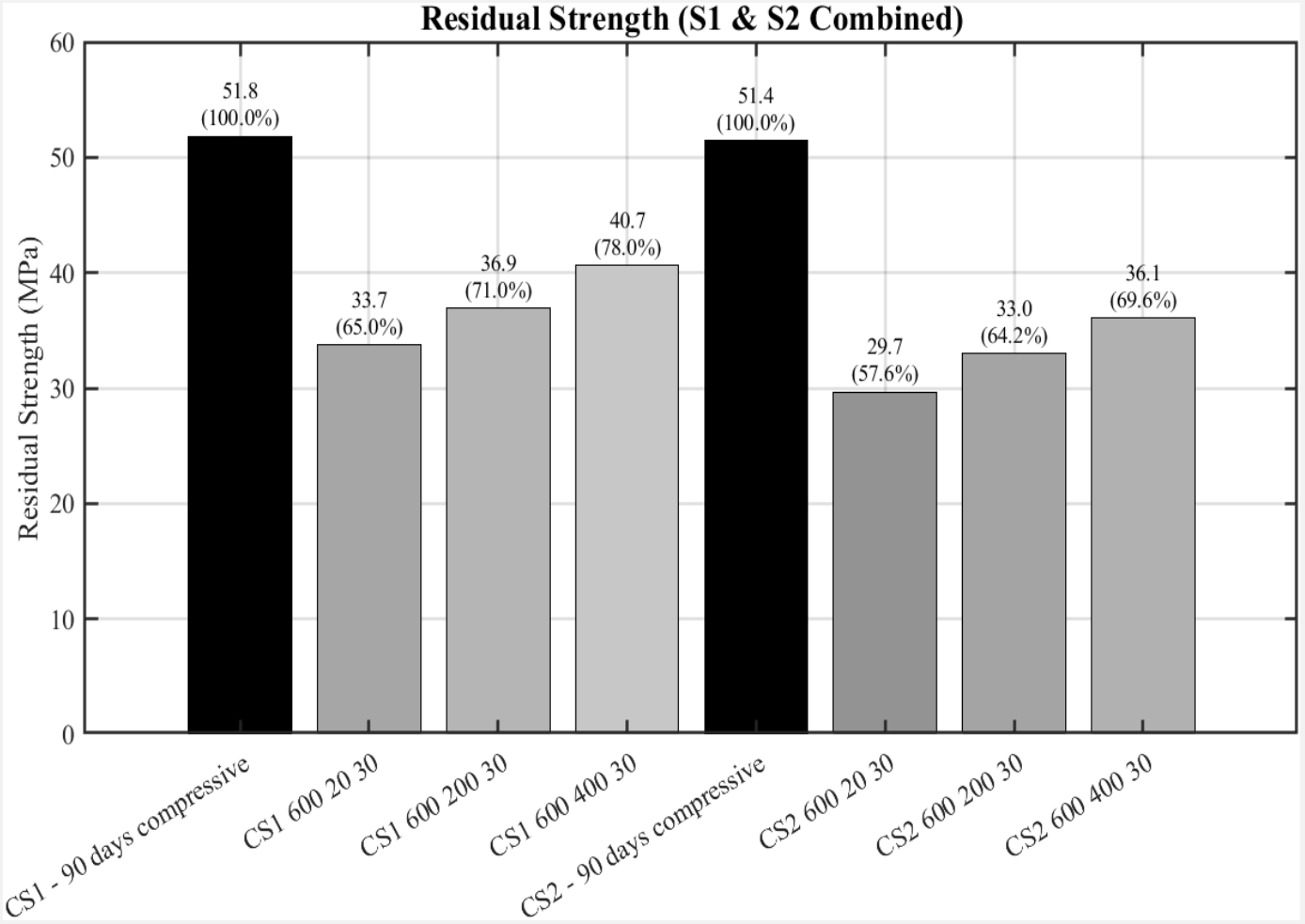


Residual Strength Assessment

Test Description	Failure load	Avg.	Residual Strength	Failure Mode
	kN	kN	MPa (%)	
CS1 - 90 days compressive		407.0	**51.82 (100%)**	C
CS1 600 20 30 S1	263.4	264.9	33.73 (65%)	Col
CS1 600 20 30 S2	266.4			Col
CS1 600 200 30 S1	281.3	289.8	36.90 (71%)	C
CS1 600 200 30 S2	298.3			C
CS1 600 400 30 S1	305.4	319.4	40.66 (78%	Col
CS1 600 400 30 S2	333.4			C
CS2 - 90 days compressive		404.0	**51.43 (100%)**	C
CS2 600 20 30 S1	233.5	233.0	29.67 (57.6%)	Col
CS2 600 20 30 S2	232.5			Col
CS2 600 200 30 S1	258.6	259.3	33.02 (64.20%)	C
CS2 600 200 30 S2	260.1			C
CS2 600 400 30 S1	284.6	283.4	36.08 (69.6%)	C
CS2 600 400 30 S2	282.1			C

Columnar

Cone



Conclusions

- **OPC (CS1)** retains more strength after fire, while **50% GGBS replacement (CS2)** retains less.
- Both mixes **regain some strength during the hold at high temperature**:
  - **OPC increased by 13%** from 20 °C to 400 °C.
  - **GGBS increased by 12%** over the same range.
- GGBS shows better thermal resistance, with lower surface temperatures than OPC.
- Internal temperatures are similar in all specimens, indicating comparable heat transfer.
- On average, GGBS expands more than OPC during heating.
- Strain recovery is faster in OPC, while **GGBS contracts more slowly**.

Thank you !
Any questions or suggestions ?

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