CrossFire
Advanced Structural Fire Engineering at Intersections Among Disciplines
Como, May 26-30, 2025

Toward fire-safe FRP strengthening systems

Reza M. Firouz – Researcher, CERIS, IST, Lisbon, Portual

Introduction

Fiber reinforced (FRP)-based strengthening approaches for strengthening reinforced concrete (RC) structures is usually challenged by lacking sufficient endurance in fire and high-temperature exposure. Amongst all, near surface mounted (NSM) technique shown to be efficient, but could be adjusted to fire-safe safe approach. Using cement-based adhesive (CBA) with sand-coated CFRP (SC-CFRP) is a possible candidate to this adjustment (Figure 1).

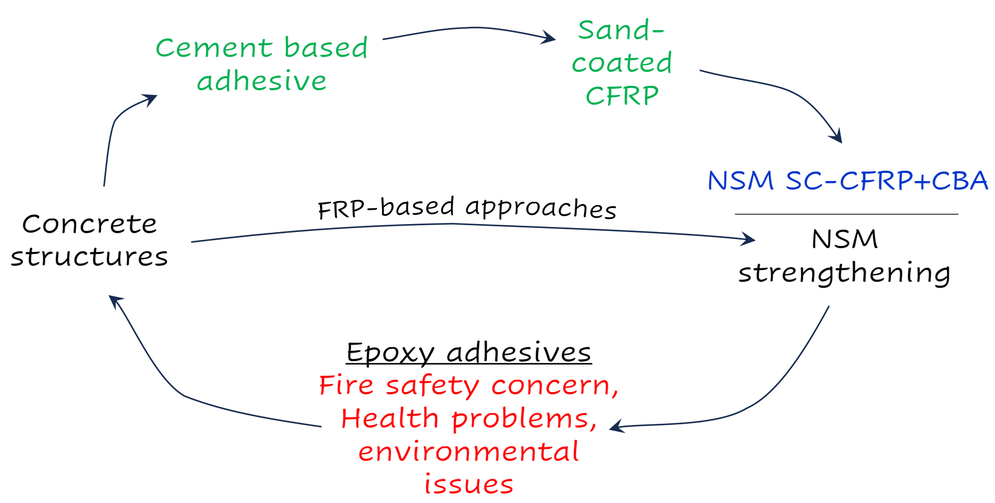

Figure 1. Graphical abstract

Sand-coated CFRP strips

Mechanical grip at the interface of matrix and FRPs increases the stress transfer performance in FRP techniques Sand-coating seems to be effective, and sand-coated GFRP, BFRP, and CFRP bars are used these days. However, high-temperature exposure is still a concern using them. Also, rectangular sections (CFRP strips) are preferred due to higher surface to cross-sectional area. SC-CFRP strips with CBA for NSM strengthening is discussed here (Figure 2).

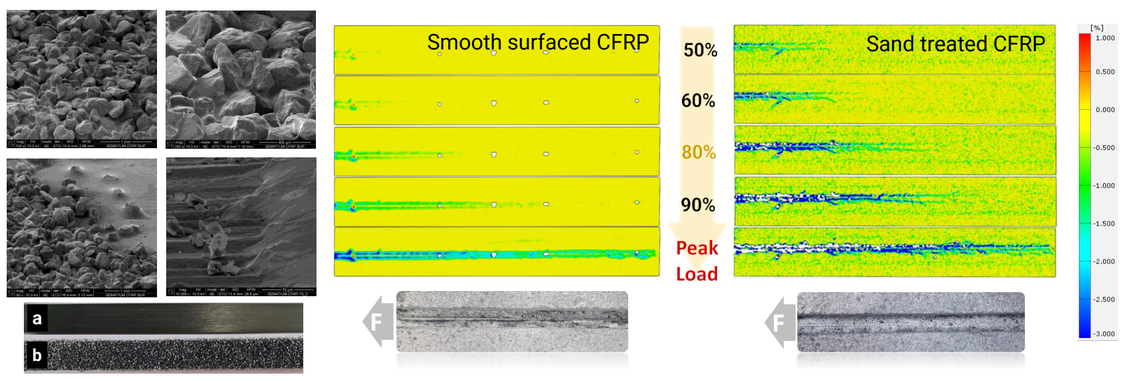

Figure 2. Sand-coating effect

A comparison: bond performance

Direct pullout tests performed to compare epoxy-based and SC-CFRP+CBA NSM systems performance at ambient and thermo-mechanical conditions (Figure 3).

Thermo-Mech tests	Avg bond strength	Const Load 0.3Fu kN	T furnace	T surf	T CFRP*Top*	T CFRP*Mid*	TUF	CFRP depth mm	Failure T CFRP-mid/*Tg*
Epoxy1		8.2	537	285	80	72	21	18	1.24
Epoxy2	20.1	8.2	553	300	78	62	25	20	1.07
Epoxy3	MPa	8.2	513	275	76	65	19	20	1.12
Epoxy4		8.4	543	277	79	62	14	19.5	1.07
CBA1		4.8	804	634	152	139	37	18.5	0.71
CBA2	11.6	4.8	804	655	183	134	38	18	0.69
CBA3	MPa	4.9	804	637	146	144	38	19	0.74
CBA4		4.9	804	654	155	150	39	20.5	0.77

Figure 3. Comparing epoxy- and CBA-based NSM systems

Structural Performance

The performance of the inovative proposed system was compared in NSM strengthening of shallow RC slab strips of 1.5 m long (Figure 4).

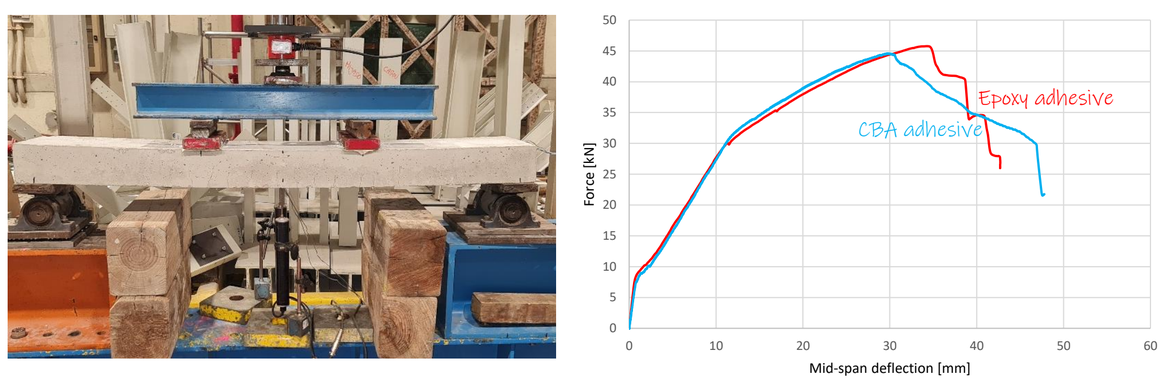

Figure 1. Flexural test of NSM strengthened RC slab strips

Fire tests

Comparing the structural performance of the two systems with the NSM strengthening systems applied to 2.6 m RC slab strips under standard fire test (ISO 834) condition (Figure 5). Results showed that, NSM strengthened systems with CBA materials could resist about 40 minutes more, compared to epoxy-based NSM systems. This occurred while about 15% of the bond length in each end were not directly heated and acted as cold anchorages.

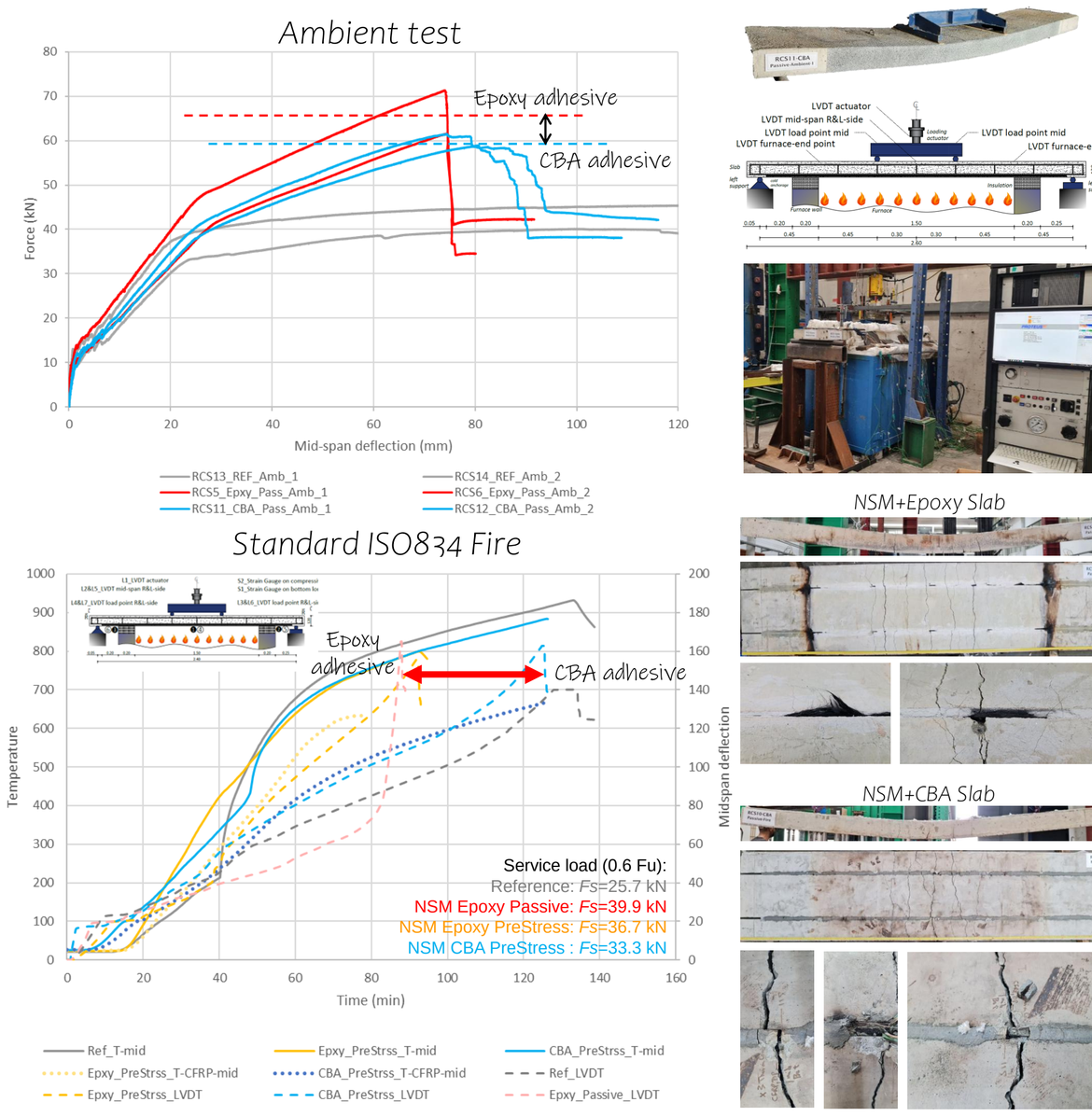

Figure 4. Fire tests of epoxy- and CBA-based NSM systems

Conclusions

Overall, the research study outcome shows the advantage of using SC-CFRP+CBA NSM systems over the conventional systems using epoxy resin, in fire scenarios. This advantage would be even more highlighted if the whole bonding length were exposed to the fire, as the epoxy resin degraded much earlier than the CBA adhesive. The promising prospect of integrating this novel strengthening system into practical use where fire safety is an issue, merits significant attention and consideration to further research on the field.