Chemical Prestress of CFRP Tendons with Expanding High Performance Concrete

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Background: limitation of the traditional prestress technology

Prestressing concrete is a method of providing high strength-to-weight ratio applied usually in primary structural concrete elements. By using **Carbon Fiber Reinforced Polymer (CFRP)** as reinforcement, slender and durable elements can be obtained. The conventional prestressing of CFRP-reinforced concrete requires very expensive prestressing beds and is very labor-intensive. These aspects limit the applications of the high-strength slender concrete elements.
This project proves feasibility of **chemical prestress (self-prestress) technology** for easy production of **affordable CFRP-reinforced high performance concrete elements**.

Motivation: (affordable) thin-walled concrete elements with CFRP reinforcement

CFRP tendons can be pretensioned solely by using high **expansion of concrete** without any need of special prestressing bed or anchoring of the tendons. This **simplifies the manufacturing** process compared to the traditional external prestressing (Fig. 1).

The slender, high-strength concrete elements can offer an **economical alternative** to externally prestressed concrete or steel e.g. in building facades, electricity poles, etc.

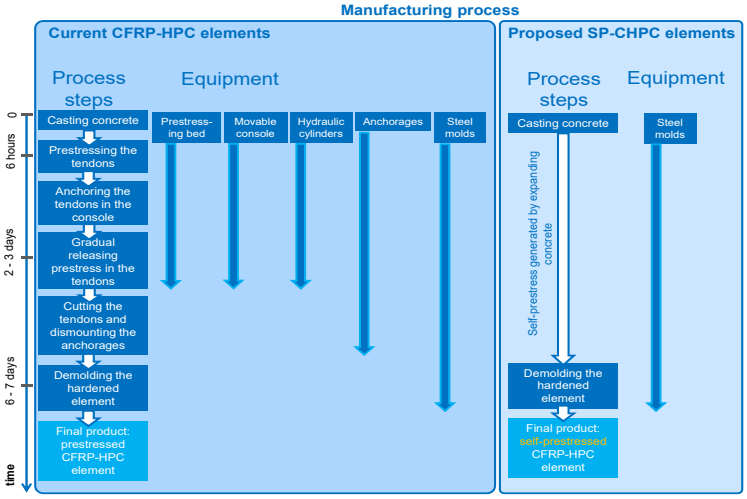


Figure 1: *Traditional, external prestressing technology (left) compared to the chemical-prestress (right).*

Higly expansive concrete

Thanks to the special combination of additives (Fig. 2), our proposed concrete composition allows to reach very high levels of residual, restrained expansion and maintain **very high strength and good durability [1,2].**

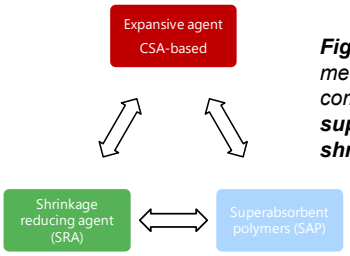


Figure 2: *Expansive concrete with high mechanical properties can be obtained by combining as additives: **CSA cement**, **superabsorbent polymers (SAP)** and **shrinkage reducing admixture (SRA)** [1].*

Chemical-prestress during hardening

After casting self-compacting concrete (Fig. 3) high levels of residual prestress can be obtained in the CFRP tendons just by expansion of concrete (Fig. 4). The elements with self-prestress can reach **cracking moment close to conventionally prestressed elements** (Fig. 5).

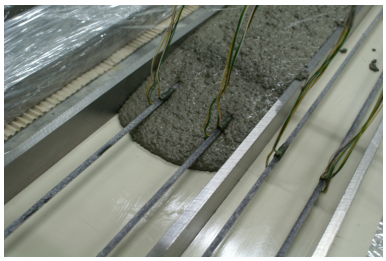


Figure 3: ***Self-compacting concrete*** *during casting*

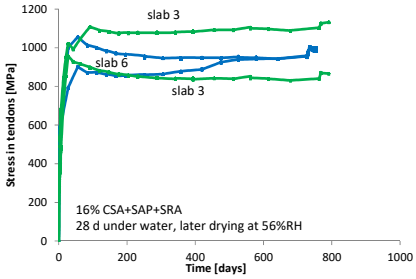
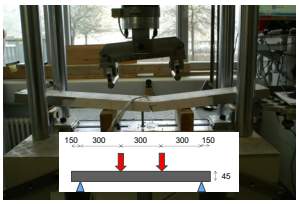


Figure 4: *Stress in the CFRP tendons reached solely by the expansion of concrete (beam 45×200 mm², two ø5.5 mm tendons)*

Improved cracking moment



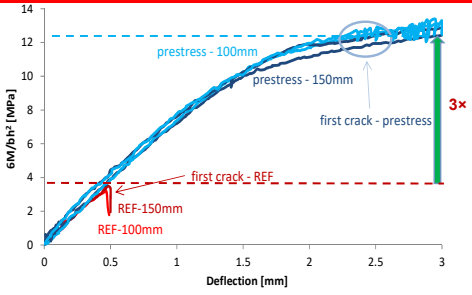


Figure 5: *Bending resistance (4-point bending) in reference element (passive CFRP reinforcement) and in concrete with chemical prestress [2].*

References

[1] M. Wyrzykowski, G. Terrasi, P. Lura, Expansive high-performance concrete for chemical-prestress applications, Cem. Concr. Res., 107 (2018)
[2] G. Terrasi, M. Wyrzykowski, P. Lura, Self-prestressed reinforced concrete elements, WO 2016/201587

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