

PhD offer on **The Fire behavior of Chemically Bonded Anchors in Concrete**

1. Background

In a building, connections between structural or non-structural elements can be ensured by chemical anchors glued inside the concrete. This type of connection is performed using polymer adhesives (epoxy, vinyl ester, polyurethane, ...) that create the bond between a steel bar/rod and a concrete element. Although these chemical bonds present high mechanical capacities at ambient temperatures (around 20°C), high temperatures lead to a rapid decay of the resistance (due to the vulnerability of the polymer adhesive when heated). For this reason, several studies have been performed during the last 10 years to guarantee a safe use of this bond technology in a building fire.

Research results are used to define: i) **assessment methods** to qualify the polymer adhesives that are put onto the market and ii) **design procedures** for safe use in civil engineering. These methods have been produced through the collaborative work between research institutes, Technical Approval Bodies (TABs) and manufacturers.

Although some methods have been recognized and accepted on a European level, there is still need to develop scientific knowledge to cover several phenomena linked to fire. **For this reason, CSTB and HILTI propose a PhD research topic on the thermo-mechanical behavior of these chemical bonded systems in a fire situation.**

- CSTB (Centre Scientifique et Technique du Bâtiment) is a French semi-public institute performing, research, evaluation, certification activities on building elements. It includes material, structure and fire laboratories equipped with unique testing devices ('Vulcain' Furnace). Research and evaluation engineers present expertise on the fire behavior of structures and fasteners.
- HILTI is one of the major manufacturers of fasteners and supports research to ensure product safety at an international level. Both CSTB and HILTI participate in the working groups (fib, CAMA, ACI, EOTA) for knowledge dissemination to the European and International communities.

2. Goals and research content

The goal of the research is to determine methods to predict the resistance of the bonding system (concrete, steel bar, adhesive) under different thermal and mechanical conditions.

Thermal conditions depend on:

- The heating curve used to represent the fire (European or USA standard fires),
- The cooling phase (for post-fire assessment),
- The presence of a protection material (to slow down the heating rate).

Mechanical behavior is directly linked to:

- The predominant failure mode of the system (bond pull-out, tension failure of the steel, concrete failure),
- The orientation of the loading (shear or tension or both),
- The type of bonding technology used (adhesive type vs. anchors casted-in concrete).

The PhD will perform applied research in the experimental and theoretical fields.

The experimental work will be carried out on:

- small bond samples (heated in gas or electric furnaces) to determine the influence of experimental parameters and generate data for models and tests configurations,
- large structural elements to validate models and design methods.

The theoretical work include will allow:

- justifying test devices and hypothesis to construct the assessment methods,
- establishing predictive models used to design the bond systems in fire.

A different range of tools (analytical formulations, finite differences, finite elements) may be used to describe the thermal and mechanical behavior.

3. Practical information

The PhD will **last 3 years** and will be **carried out mostly at the CSTB (Champs-sur-Marne)** near Paris. The student will be paid as a CSTB employee and will also be affiliated to an exterior university. Several meetings with HILTI (based in Shaan, Lichtenstein) will allow to follow the progress of the research.

The PhD may start between August and December 2019.

CSTB website: <http://www.cstb.fr/en/>

CSTB Fire Laboratory: <http://www.cstb.fr/en/test-facilities/fire-testing/>

HILTI website: <https://www.hilti.com/>

Previous PhDs on similar topics:

- Behavior of Post-Installed Reinforcement Bars in a Fire Situation

<https://ori-nuxeo.univ-lille1.fr/nuxeo/site/esupversions/de94303f-5d72-4f61-9183-515ff08b490b>

- Fire Behavior of Glued Rods in Timber and Concrete

<https://pastel.archives-ouvertes.fr/tel-01738712/document>

4. Requirements

- The applicant should have a Master's degree preferably in one of the following fields: civil engineering, mechanics, material science, thermodynamics.
- Written and oral communication skills in English are mandatory.
- Interest for both laboratory manual experimental work and theoretical modeling is recommended.

5. Contact information

To apply, please send a CV and motivation letter by email to Nicolas PINOTEAU (contact information below). It is encouraged to not hesitate to ask for more information if needed.

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