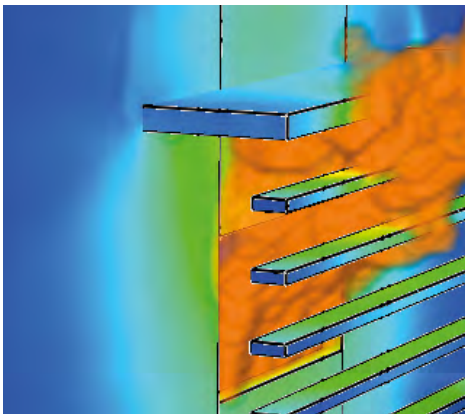
> **EXPERTISE**

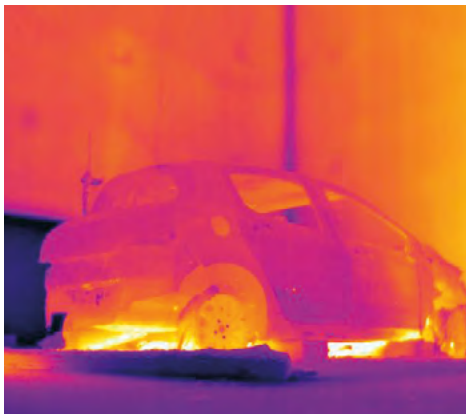
Fire Safety Engineering

Unleash design creativity while increasing the safety of structures

Architectural creativity, technical innovation, performance goals: obtain these results while ensuring fire safety in structures. The CSTB offers designers, project managers and project owners a range of specific engineering services that ensure the fire safety of their building works.

www.cstb.fr



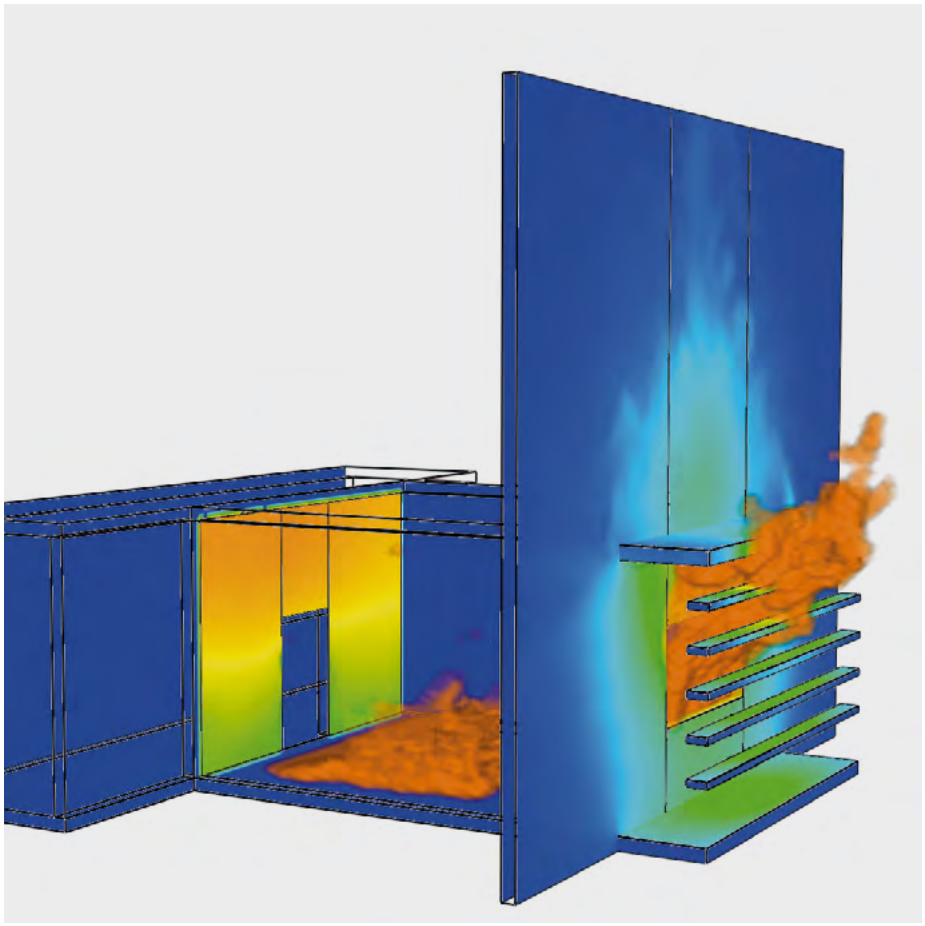


CSTB
le futur en construction

Fire Safety Engineering

Fire safety engineering makes it possible to design structures based on the impact of fire. It is an alternative to the predefined provisions set out in French regulations or international standards for buildings and exceptional works, and for renovation of the existing building stock. It incorporates protection and prevention provisions to achieve the desired level of safety. The CSTB provides project owners, consulting firms, architects and project managers with a proven fire safety engineering approach based on reference methods. This offers more freedom in the art of design and construction.

▼ Fire resistance study
Sun blinds of the new Princesse Grace de Monaco Hospital Center. Architects: AIA Associés and Natacha Morin-Innocenti.



COMPREHENSIVE ENGINEERING STUDY

Fire safety engineering may be applied to specific areas (reaction to fire, fire stability, smoke control, evacuation) or to entire structures. **The CSTB offers designers both approaches.**

The comprehensive approach combines various analyzes and adds organizational measures, which include fire department procedures, evacuation conditions, etc. To refine the analysis of fire scenarios that apply to a project, the CSTB can also add a **"probabilistic"** approach. This identifies the safety levels of the various elements in the analysis, such as people likely to be on the premises, emergency intervention and building type. It involves all fire scenarios and exceptional circumstances (open doors, broken glass, people who do not follow instructions, etc.), integrating their probability of occurrence.

This makes it possible to identify risks in terms of probabilities and resize spaces and facilities based on the results.

FIRE SAFETY ENGINEERING APPROACH

The regulatory scope was broadened by the French authorities in 2004, allowing designers with original concepts to use fire safety engineering to demonstrate the resistance of a building to fire. This performance-based approach rounds out the specifications approach designed to assess traditional solutions. Fire safety engineering is authorized by French authorities for smoke control and the fire stability of structures. The CSTB offers this service and anticipates needs. It applies fire safety engineering to analyses of the evacuation of people and reaction to fire, combining all approaches through comprehensive engineering studies, in collaboration with the stakeholders (project owners, project managers, safety committees, etc.).

REACTION TO FIRE

When the proposed design solution does not meet the specification requirements set out in safety regulations, reaction to fire engineering is an alternative that designers can use. Fire safety engineering enables you to study the impact of construction materials (main and secondary structures, coverings). It is based on an analysis of the behavior of materials in real fire situation and their impacts on the spread and escalation of fire.

Methodology

The methodology is based on a coupling of numerical simulations and experimental methods (single burning item (SBI) test, cone calorimeter test, ISO 9705 test, etc.). Several physical phenomena may be considered: time to reach flashover, rate of heat release, smoke production, production of flaming particles or surface flame spread.

EVACUATION

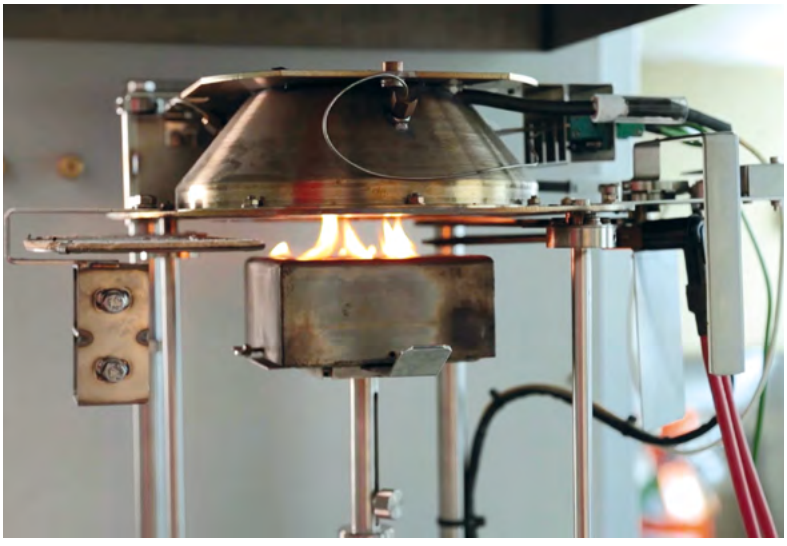
Evacuation engineering offers the latest options to help users implement safety procedures for their structures and develop evacuation strategies. Depending on the required accuracy, it is based on simple travel patterns and can include the effects of fire on people. If necessary, it can also incorporate a representation of human behavior, as well as interactions with street furniture (escalators, elevators, metro turnstiles, etc.).

Evacuation engineering makes it possible to:
· Quantify the total minimum time required to evacuate a building;
· Quantify various evacuation scenarios to optimize the building safety strategy.

The CSTB performs instrumented experimental campaigns to help operators improve their evacuation strategies.

▶ Evacuation
Fire engineering study for the ornithological park of Villars-les-Dombes, enabling validation of the optimal configuration for the evacuation of the tower, which reaches over 26 meters (85 feet) high.

▼ Reaction to fire
Specimen tested with cone calorimeter.



FIRE STABILITY

Fire engineering enables you to check whether the fire stability objectives of a building are met, using an approach based on scenarios of real fires. This makes it possible to determine construction solutions appropriate for the hazards, while considering the specific context of the structure.

It has a technical and economic value for:
· Low or very localized calorific potential
· External load-bearing structures (corridors, balconies, etc.)
· Large interior volumes and high ceilings (atria)
· Cultural heritage buildings
· Structures that are highly ventilated or open on the outside (parking lots)

Based on Eurocodes, fire engineering involves advanced calculation methods for determining the spread of fire, heat, and thermomechanical transfers.

The French specification approach for load-bearing elements in buildings requires specific fire stability times under conventional thermal stresses (ISO 834 curve, modified hydrocarbon (HCM) curve, hydrocarbon (HC) curve, Rijkswaterstaat (RWS) curve). Thanks to fire safety engineering, the measures offered to ensure the mechanical resistance of structures can be optimized while guaranteeing the level of safety expected in the event of fire.

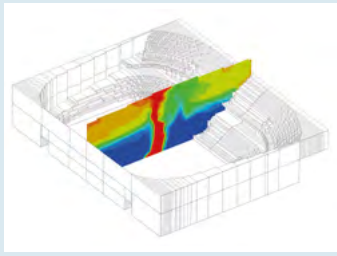
Methodology

The CSTB supports designers through a proven method:
1. Determination of safety objectives
2. Creation of real fire scenarios
3. Engineering studies (modeling, simulation, results analysis)
4. Findings on the fire stability of structures and proposals for technical solutions to increase safety, if necessary.

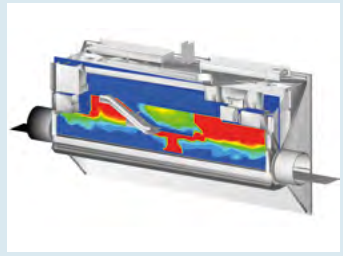
◀ First wooden parking lot in France
The Arbotech aboveground parking lot project with wooden superstructure, developed by Arbonis, in the heart of the Epamarne development site, is a first in France. The purpose of the CSTB fire safety study was to demonstrate the fire stability of the structure. This approach increased the reliability and safety of the process used because it included the effect of fire in the design of the structure.

▲ City of Paris mobile furnace
The CSTB has a mobile furnace that can perform *in situ* fire tests on tunnel walls. The City of Paris used this equipment to test two tunnels of the Boulevard Périphérique beltway. Objective: Document their fire resistance for review by public authorities, thereby saving millions of euros.

▲ Fire stability of the tunnel under the Suez Canal
The purpose of this exceptional study was to check the fire resistance of a full-scale tunnel lining segment under normal conditions of use. The Vulcain test facility at the CSTB can exert mechanical loads of more than 1000 metric tons horizontally and more than 200 metric tons vertically. It reproduced the highest compressive stresses exerted on the tunnel structure.



▲ Laval Performance Hall
To respect both the architectural vision and acoustic performance, smoke control engineering made it possible to work with project stakeholders to validate a protection solution that ensures a high level of safety for all, including people in upper areas of the bleachers, which would be heavily exposed to fumes in the event of fire.



▲ Extension of the Lyon metro line B
For this metro line extension project, smoke control engineering allowed for safety concerns to be merged with aesthetic and architectural guidelines, preserving areas of the station, even in the event of fire in a train car.

▶ University Hospital Center (CHU) of Chambéry
To optimize the smoke control system for the hospital lobby, simulations elucidated the conditions of practicability of the internal walkway, as well as the temperature in contact with the walls of the atrium, confirmed by *in situ* tests performed before commissioning of the hospital.

SMOKE CONTROL

Rehabilitating historic monuments requires complex modifications, just as creating original works requires specific constructive solutions for smoke control. Assessments using the fire safety engineering approach adapt to these specificities, describing them in detail and improving the results.

This approach enables better understanding of the reaction of structures in various situations: undersized outlet surface area, too long or voluminous smoke zone, insufficient air intake, excessive ceiling height, parking lot ventilation requirements not met, floor openings on several levels, non-isolated adjoining structures that must demonstrate independence, complex volumes, etc.

Smoke control assessments test the effectiveness of solutions by checking the evacuation conditions of the structure in realistic fire situations.

Fire safety engineering for smoke control makes it possible to:
- Assess the performance of various solutions and support the decision-making process
- Justify the continued usage of a smoke control solution when it does not meet the specification requirements set out by regulations

Methodology

1. Determine safety objectives and associated performance criteria
2. Create real fire scenarios
3. Model fire scenarios and analyze the evacuation conditions in the event of fire
4. Provide findings on the effectiveness of smoke control systems, and proposals to increase safety

Architects, consulting firms, project owners and operators call on the CSTB to perform fire safety engineering studies to achieve the optimal balance between cost and safety, consistent with the architectural concept and the planned use of a structure. CSTB experts have been supporting stakeholders in this procedure for more than 20 years.

Fire safety engineering applied to simple and complex projects involving all types of structures, whether in the design phase of construction projects, during renovation or for structures already in use.

ERP (Buildings open to the public: train stations, shopping malls, hospitals, performance venues, museums, libraries)

IGH (High-rise buildings)

INB (Basic nuclear facilities)

Tunnels

Stadiums

Arbotech Project by Arbonis

WHY FIRE SAFETY ENGINEERING?

Structures outside regulatory scope
Solutions offered by designers for renovations or new structures such as buildings open to the public and high-rises often stretch the limits of the regulatory scope. Fire safety engineering offers more flexibility in the application and implementation of innovative solutions, particularly for constructive solutions not covered by regulations.

Rehabilitation and innovative design
Fire safety engineering can enable validation of rehabilitation work on old structures and historical monuments for which existing methods are insufficient. It also makes possible the design of nonstandard, complex and innovative structures (bridges, stadiums, tunnels, high-rise buildings, etc.).

Environmental and financial optimization
Innovative designs now optimize sizing to reduce carbon footprint and lower the cost of materials. The approach to risks is changing accordingly, to maintain the required level of safety and ensure that buildings always provide shelter and safety to their occupants at reasonable financial and environmental costs.

Fire safety engineering: combining modeling and evidence

As a hub of advanced expertise and scientific resources, the CSTB develops an approach that combines computation and full-scale experimentation.

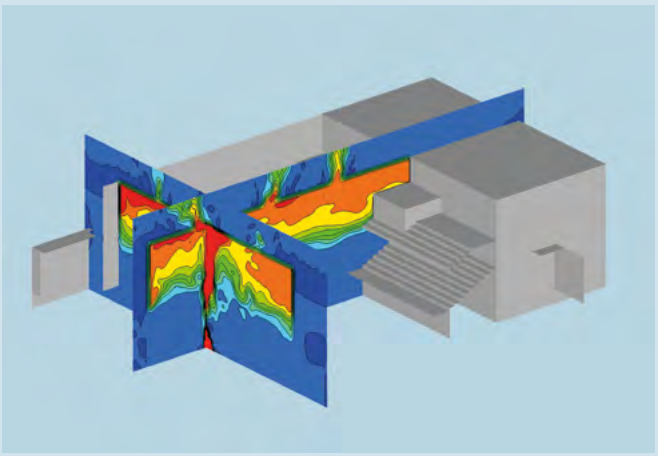
SPECIAL IN SITU TESTS OR REAL-LIFE ENVIRONMENTS

The CSTB can complement its consulting expertise by performing *in situ* tests in existing buildings or by reconstructing demonstrator buildings. The data from these real tests are incorporated into the digital model, which grows with the experiments, to get increasingly sophisticated assessments.

REPRODUCIBLE MODELS

Fire safety studies largely rely on modeling to describe phenomena and duplicate them repeatedly:
- **Simplified models:** analytic models, zone models
- **3D modeling of smoke flows:** computational fluid dynamics models

The CSTB has a 48-core calculation server enabling large-scale simulations.



▲ **Le Havre Convention and Exhibition Center**
The fire safety engineering study of smoke control combined simulation and real tests to check that the proposed solutions offered sufficient overhead clearance free of smoke and heat flows to allow evacuation.

CONTACT
Eric Gallet
eric.gallet@cstb.fr – +33 (0)1 61 44 81 80

CENTRE SCIENTIFIQUE ET TECHNIQUE DU BÂTIMENT
Head office › 84 avenue Jean Jaurès – Champs-sur-Marne – 77447 Marne-la-Vallée cedex 2
Tel. : +33 (0)1 64 68 82 82 – www.cstb.fr
MARNE-LA-VALLÉE / GRENOBLE / NANTES / SOPHIA ANTIPOLIS

CSTB
le futur en construction