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.

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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.

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.
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.

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.

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.
重组历史纪念碑需要复杂的修改，就像创作原创作品需要特定的结构解决方案一样。评估使用消防安全工程方法来适应这些特定性，详细描述它们，并改进结果。

这种方法使我们能够更好地理解结构在各种情况下的反应：出入口面积过小，烟区过长或体积过大，空气吸入不足，天花板高度过高，停车场通风要求未得到满足，多个楼层的地板开口，非孤立相连的结构必须证明其独立性，复杂体积等。

烟雾控制系统评估通过检查在现实火场情况下的疏散条件来测试解决方案的有效性。

消防安全工程用于烟雾控制，使其能够：
- 评估各种解决方案的性能并支持决策过程
- 当解决方案不满足由法规规定的规范要求时，证明其持续使用的合理性

**Methodology**
1. 确定安全目标和相关性能指标
2. 创造真实火场情景
3. 模型火场情景并分析火场中疏散条件
4. 提供关于烟雾控制系统效果的评估，以及提高安全的建议
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.

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.