The Interactive Development of Buildings and Fire Protection Engineering

PART ONE OF THREE

by Jie Zeng and Fang Li

Ongoing research and developments in architecture and design regularly pose new challenges that—in turn—lead to technological innovations in many areas, including fire protection. As such, the evolution of fire protection engineering may be outlined with relation to three major breakthroughs in the history of building design and construction.

High-Rise Buildings

Because the height of high-rise buildings makes the use of a traditional fire apparatus and outside firefighting methods realistically impossible, the fire protection strategy for such buildings relies on each facility's own fire protection systems and ability to resist fire. The development of high-rise buildings drove fire protection technologies from passive—such as fire separation distances, fire compartmentalization and fire resistance ratings—to the use of a wide range of new mechanical and electrical equipment. This led to a number of remarkable achievements, including the following.

- Means of fire protection evolved from a reliance on outdoor fire fighting to quick detection and response and the control of smoke in the early stages.
- Automatic fire detection and alarm systems and associated automatic equipment replaced traditional management systems using manual inspections and on-site manual operation.
- The creation of indoor mechanized systems such as automatic sprinkler systems and smoke exhaust systems promoted active fire protection.

Large Space Buildings

The development of "large space" buildings created a technical platform for fire protection analysis and research based on physiochemical mechanisms. There is no precise definition of a large space building: such categorization should be determined based on architectural features and potential fire characteristics via performance-based analysis. From a performance-based fire protection design perspective, a large space building can be understood as an architectural space that has a single function inseparable from a certain geometric scale and satisfies the following properties.

- The flame temperature of a fire will not cause the fire spread to continually impact other portions within the building and will not challenge the main structural element's fire-resistance rating or put its integrity at risk.
- In the comprehensive smoke analysis, available safety egress time should be longer than the required safety egress time.
- Active fire areas and stored fuel load accumulated together will not affect firefighting and rescue operations.

The characteristics of large space buildings push the research method of fire protection engineering from being empirically based on fire tests to a new stage of computerized fire modeling methods. Built on knowledge of fire dynamics and thermal equilibrium equations, this discipline develops its own theory basis. Combined with the rapid development of computer technology, a new research method has been generated to achieve the following.

- Determine the burn rate and heat-release rate of various construction materials and calculate the fire size of different buildings based on that information.
- Run fire models of different building space and ventilation conditions and describe the development of a fire in different architectural environments through numerical formulas.
- Simulate virtual fire scenarios that are difficult to test through empirical methods.

The Building City

The traditional layout of different-functioning buildings connected by streets and outdoor plazas is evolving into three-dimensional "building cities" (also known as super constructions or complex constructions) connected by indoor spaces such as elevators, hallways and atriums. At present, the definition of a building city can only be framed in qualitative or quantitative terms. For the purposes of this article, the authors propose the quantitative definition of a building city as a structure with at least three relatively independent functions, more than 200 meters in height, and with 300,000 square meters or more in total floor area or more than 20,000 square meters of floor area on each level.

A building city injects new characteristics into buildings, environments and fire protection systems. To address the additional challenges brought on by these high, open and multifunctional structures, fire safety engineering should adopt advanced information, control and system theory to conduct research on fire protection strategies that are more stringent and comprehensive, including the following.

Integrated Fire Protection Systems

Various technologies have their own advantages in either fire prevention or fire suppression. In the traditional building, the use of several key technologies can ensure the relative safety of the structure. However, because of its complexity and large scale, it is necessary to integrate various modern technologies to ensure the fire safety in a building city. Such integration can be achieved by forming an information chain or network and multilevel fire response systems through computer and internet technology.

Safety Redundancies

The determination of system design cannot depend on a single parameter or scope, and the fire protection system cannot aim at only a single fire type. Multifunctional fire

protection systems should be used to control and suppress fires of different grades under different circumstances. In the design of fire protection systems, possible failures and certain degrees of redundancy should be considered. The overall systems should serve to prevent all possible fire growth, maximize life safety for building occupants and minimize property loss.

Comprehensive Assessments

The concentration of social activities in a building city dictates that the quality of personnel and the capability of the management team play an important role in the event of a fire. The comprehensive study of fire protection strategies of a building city must take into consideration the local fire safety level as well as social and cultural factors. Fire protection management requirements and measures which are practical and acceptable to local communities can be achieved through reasonable assessments of their fire protection ability. ◆

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