



The Interplay between Passive and Active Fire Safety Strategies in Shaping Architectural Design

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Abstract

Fire safety affects how buildings are designed. Architects often center on beauty, shape, and functionality. However, safety is also a main concern. This ensures that buildings safeguard lives and property. This research looks at how passive fire safety methods work with active fire safety methods to influence architectural results. Passive fire safety methods encompass compartmentation, fire-resistant materials, and egress design. Active fire safety methods comprise sprinklers, smoke control, and detection systems. This work is based on international building codes, academic studies, and examples of high-rise, mixed-use, and cultural buildings. This research shows how these two types of fire protection interact during the design process. The results indicate that passive strategies hugely influence the shape and flow of buildings. Also, active systems offer the flexibility needed for architectural creativity. Instead of limiting design, fire safety acts as a driving force for innovation. The study ends with a framework for architects to balance safety, beauty, and sustainability in modern design.

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1 Introduction

Building fires affect how societies think about building design and regulated laws. The 1666 Great Fire of London caused tougher government regulations such as street widths, building materials, and firewalls. Fires caused damages to high-rise buildings. The examples are the US Empire State Building fire in 1945 and the Grenfell Tower fire in London in 2017. These have changed the views on fire safety. These incidents bring attentions that fire safety is not just a technical question; it is an important factor that impacts architecture at all levels. This affects a range of design, from choosing materials to managing spaces and designing facades [1,2].

Modern design is really a balancing act between three things. The first, it involves how a building looks (aesthetics). The second is how it works (functionality). The third is the most important, to keep people safe (safety). Fire safety falls into that last category, but it is not just a technical afterthought; it actually dictates a lot of the creative process [3]. Passive fire safety measures are those embedded in the architecture itself, such as fire-rated walls and stair cores) whereas active fire safety measures involve mechanical and technological systems such as sprinklers and alarms.

Most architects see fire codes as a limitation for creativity. It is hard to design a beautiful, open-concept space when it is forced to stick a giant concrete stair core or a bunch of clunky fire doors right in the middle of it. On the flip side, architects can lean heavily on active tech — like sprinklers and fancy smoke systems — to keep things open and airy, but then it may stuck with high maintenance and energy costs. The real challenges are to make the building's physical structure and the tech work together. It is not just about passing an inspection; it is about making those safety rules based on the passive and active methods to create architecture that is safe, functional, and inspiring.

The objectives of this study are to define and differentiate between passive and active fire safety strategies within the field of architecture, to examine passive fire safety measures on building form, spatial planning, and materials. Also, this study explores the mix of active fire safety systems into architectural and engineering design. Moreover, the study aims to assess case studies that the fit of both methods has influenced innovative architectural outcomes. Further, it proposes a design framework that aligns fire safety requirements with creativity and sustainability.

This research learns current architectural designs. It includes tall office buildings, hospitals, and cultural centers. It looks at global standards and how they relate to architectural work [6,8,11,13,18]. This study considers NFPA, IBC, and Eurocodes. The article does not give detailed technical guidelines for fire systems. However, it instead examines how these systems influence architectural choices.

Architects, engineers, and policymakers should understand the interplay of how passive and active fire safety methods work together. This research promotes viewing fire safety as a driver for design innovation. It also urges professionals to go beyond mere compliance and see safety as a creative aspect of architecture.

2 Literature Review

The evolution of architectural design has increasingly moved toward complex geometries, open-plan layouts, and sustainable materials. However, these innovations often clash with traditional fire safety paradigms. The fundamental tension in fire protection engineering lies in the integration of Passive Fire Protection (PFP) and Active Fire Protection (AFP). PFP focuses on the building's "bones", i.e. its structural integrity and compartmentation, whereas AFP relies on mechanical or electronic intervention, such as sprinklers and smoke detectors [10]. Both PFP and AFP give a good design opportunity for architectures and designers.

2.1 The Traditional Divide: Constraint vs Functionality

Historically, architects have perceived Passive Fire Protection (PFP) as a collection of inflexible limitations. Conventional methods, such as incorporating fire-rated stair cores and masonry compartment walls, frequently interrupt the visual flow of a space. Drysdale [22] observes that the intrinsic "permanence" of passive systems offers a significant level of dependability since they do not depend on power or mechanical activation. Nevertheless, the inflexibility of these systems may result in designs that resemble "fortresses," which can hinder natural light and airflow.

In contrast, the emergence of "Performance-Based Design" (PBD) has enabled architects to rely more on active systems. According to Meacham [24], PBD changes the emphasis from rigid code to safety results. With high-efficiency sprinkler systems and sophisticated smoke exhaust systems, designers can rationalize the elimination of non-load-bearing fire walls, resulting in the expansive, clear glass atriums that are characteristic of modern centers.

In early 2000s, the National Fire Protection Association (NFPA) and all building codes continued to stress active fire protection in the form of sprinklers and alarm and detection systems [19].

Researchers discovered that a very high number of buildings lacked sufficient passive fire safety measures. These buildings were often relying heavily on active systems. Only 65 percent of these buildings met acceptable fire safety standards [20]. This indicated a major need for improvement. This trend indicates that the traditional focus on active systems has resulted in the oversight of passive measures that are just as crucial for overall fire safety.

2.2 The Risk of Technological Dependency

Many studies cautions against relying too much on active strategies. Although AFP provides flexibility, it creates a "dependency chain." As Hurley et al. [23] point out in the SFPE Handbook of Fire Protection Engineering, active systems can fail due to mechanical issues, water supply problems, or power outages. On the other hand, passive solutions like intumescent coatings and fire-resistant glazing offer a "fail-safe" layer that works no matter the building's operational condition.

Maintaining active systems can poses a long-term financial problem. Chow [21] notes that while an AFP system may reduce initial construction expenses by using cheaper materials or allowing for open layouts, the "life-cycle cost"—which includes regular testing, sensor calibration, and energy use—can be greatly higher than that of PFP architectural elements.

2.3 Synergy and the Hybrid Approach

Many works are shifting towards a hybrid integrated method. This method views PFP and AFP not as competitors but as a complementary pair. For example, using a Digital Twin (DT) enables real-time observation of how passive barriers perform under heat while active sprinklers are in operation [26].

Moreover, the interplay is crucial for protecting cultural heritage buildings. Spinardi [25] noted that in historic buildings, demolishing walls to install fire-rated materials is often illegal or harmful to the culture. In such situations, subtle active systems (like water mist) are employed to "compensate" for the natural passive weaknesses of old timber or stone structures, allowing the architectural history to stay visible without compromising safety.

2.4 Designing for Resilience

The connection between passive and active fire safety is a careful balance of reliability and flexibility. Passive systems give the structural strength necessary to avoid complete collapse, while active systems deliver the precise control needed to tackle a fire right at its source, allowing for more creative architectural designs. As buildings evolve to be "smarter," the combination of IoT-based sensors with fire-rated building elements will probably shape the future of resilient design. The ongoing challenge for today's architect is to view these safety standards not as restrictions on creativity, but as a foundation for innovation.

3 Fire Safety Strategies

3.1 Passive Fire Safety Strategies

Passive fire protection (PFP) are built-in measures that helps stop or slow down the spread of fire and smoke. PFP ensures safe escape routes. Unlike active systems, PFP measures do not depend on outside power or human action. This makes them more dependable. Their design impacts go beyond safety, often influencing space layouts, movement patterns, and even the style of architecture.[4]

3.1.1 Compartmentation and Zoning

Compartmentation divides a building into fire-resistant zones, based on fire-rated walls, floors, and doors [5]. This technique limits fire spread, thus allowing occupants to evacuate safely. therefore, it gives firefighters more control. According to Buchanan and Abu (2017), compartmentation directly impacts building layout, as corridors, stairwells, and escape routes must connect and serve each zone efficiently. In high-rise buildings, vertical compartmentation in stair cores often defines building cores that influence façade composition and massing.[5]

3.1.2 Fire-Resistant Materials

PFP technique may consider materials with high fire resistance ratings, like reinforced concrete, gypsum boards, and fire-resistant glass. Meacham [24] discussed that choosing the right materials affects the strength of the structure and its visual appeal. For example, fire-rated glass provides visual clarity while adhering to safety standards, thus affects façade design by allowing for open atriums and glass walls without sacrificing safety.[10]

3.1.3 Egress Design

PFP covers safe evacuation paths. These are staircases, ramps, and hallways. The International Building Code (IBC, 2021) gives guideline about this. That is type of occupancy and building height affect egress dimensions, travel distances, and the number of exits. These egress requirements affect spatial planning by compelling architects to dedicate ample space to stair cores and corridors. That can affect the layout and structural design of the floor plan.[9]

3.1.4 Impact on Architectural Form

PFP measures inevitably influence the shape and volume of buildings. For instance, fire-rated shafts may extend into open-plan spaces, impacting ceiling heights or roof shapes. Atriums typically need smoke-proof separations or fire curtains, which can alter both the visual design and spatial experience. Therefore, PFP techniques are not just functional; they play a significant role in the architectural expression of the building.

3.2 Active Fire Safety Strategies

Active Fire Protections (AFP) involves active fire safety strategies that encompasses systems that need action either automatic or manual. It is in order to detect, alert, suppress/control, and extinguish fire. In contrast to passive measures, AFP represents a proactive technique aimed at controlling fire development and ensuring the safety of occupants. While AFP systems differ from PFP measures in that AFP requires power, monitoring, or human involvement. AFP gives more flexibility in architectural design. This enables risk mitigation without imposing strict spatial constraints. AFP examples include automatic sprinklers, smoke detectors, alarm panels & fire extinguishers.

3.2.1 Fire Detection and Alarm Systems

Modern structures combine smoke and heat detectors linked to alarms, warning residents to fire emergencies. AFP systems affect service arrangements, as where to place sensors in ceilings, ducts, and wall spaces. Sternberg (2018) notes that early detection can permit larger open spaces, as reliance on compartmentation alone becomes less critical. [7,14]

3.2.2 Suppression System

Sprinklers, water mist systems, and gas suppression systems are core AFP measures. These systems can much relax passive constraints, enabling open-plan offices, large auditoriums, and expansive atriums. For example, high-rise towers such as The Shard in London utilize extensive sprinkler systems to allow flexible floor plans without excessive firewalls.[8]

3.2.3 Smoke Management Systems

Smoke controls are things like extraction fans and smoke-proof stairwells. Smoke control keeps people safe during evacuations and protects buildings. When integrating AFP systems, it usually requires coordination with mechanical and HVAC systems. This affects ceiling heights,

service shafts, and openings in the façade. Designers are required to compare mechanical requirements with aesthetic intentions, for the design of galleries, theaters, and public atriums. [13]

3.2.4 Impact on Spatial Flexibility

Active systems allow architects to experiment with open spaces that would otherwise require multiple compartments. This flexibility fosters new ideas in shape, layout, and façade design. However, depending on AFP demands careful planning for system maintenance, redundancy, and reliability, which can subtly influence architectural choices/decisions.

3.3 Interdependence of Passive and Active Strategies

The most effective fire safety designs combine passive and active strategies to maximize safety, whereas architectural freedom is preserved.

3.3.1 Balancing Design Freedom and Safety

PFP measures establish baseline safety, defining the primary spatial and structural framework. AFP systems supplement these measures, allowing architects to push boundaries in openness and form. For example, atriums might have fire-rated walls (PFP) while sprinklers and smoke vents (AFP) reduce the need for additional firewalls.

3.3.2 Regulatory Implications

Performance-based codes increasingly encourage a holistic method. Rather than prescribing rigid compartmentation, codes allow architects to demonstrate that combined PFP and AFP systems achieve equivalent safety outcomes. Meacham [24] noted that performance-based design fosters creativity, as designers can propose innovative layouts backed by engineered fire safety solutions.[12]

3.3.3 Design Innovation through Integration

The combination of PFP and AFP strategies frequently leads to innovative architectural designs. This encompasses double-skin façades that are made for smoke management, atriums with regulated smoke ventilation that allow for impressive volumetric areas, and fire-rated materials that enhance interior beauty (like decorative intumescent panels). [9]

4 Methodology

4.1 Research Approach

This research uses a qualitative, case study method to explore how PFP and AFP fire safety strategies interact/influence architectural design. A qualitative method is appropriate. This is because it aims to understand design processes, spatial choices, and how regulations are integrated, instead of just based on numerical data. This study contains a literature review,

comparative analysis, and architectural assessment to find patterns, challenges, and creative solutions.

The research comes from the idea that fire safety should be seen as a key factor in design, not just a followed rule. By looking at actual architectural projects and how they incorporate both PFP and AFP fire safety measures, this study aims to show how safety aspects affect architectural shape, space arrangement, material choices, and overall aesthetic appeal.

4.2 Data Sources

The data for this research were gathered from both primary and secondary sources. The academic literature comes from peer-reviewed journals in architecture, engineering, and fire safety topics. In addition, information from books is topic on structural fire design, performance-based design, and architectural practice (for example, [10, 24]). The standards and codes referenced comprises NFPA 101 – Life Safety Code (2021), the International Building Code (IBC) (2021), Eurocodes for Fire Safety, and the Code of Practice for Fire Protection in Buildings No.646 from Baghdad, Iraq (1996). The case studies feature high-rise office towers, mixed-use buildings, and cultural structures that show how PFP and AFP fire strategies can be integrated. Also, this work uses architectural drawings, technical reports, and published design analyses. The visual and diagrammatic data consists of floor plans, sections, and façade diagrams that demonstrate how fire safety impacts architectural design. Some photographs illustrate the practical application of both PFP and AFP systems.

4.3 Case Study Selection

The research focuses on three types of buildings (Table 1) that feature different aspects of the interplay between PFP and AFP fire strategies. Case studies were selected using three criteria: complexity of fire safety integration, innovation in architectural design, and availability of detailed technical documentation.

Table 1: Examples of case studies used in this study.

Building type	Examples of case study
High-Rise Buildings	Burj Khalifa, Dubai, demonstrates how fire-resistant cores (PFP) combined with advanced sprinklers and smoke management (AFP) enable large open spaces and extreme building heights.
Mixed-use buildings	The Shard, London, UK. Mixed-use high-rise (offices, hotel, residences, public viewing gallery) demonstrates that integrating AFP systems allows open-plan office spaces while maintaining strict compliance with NFPA codes.
Cultural/Public Buildings	Marina Bay Sands, Singapore, combines fire-rated partitions with active smoke extraction to achieve visually impressive public atriums and circulation spaces.

4.4 Data Analysis

Data were analyzed using a qualitative content and comparative analysis method. The Passive vs. Active Integration Analysis helps this study pinpoint where passive fire safety measures

have impacted building design and layout. It also highlights where active systems have allowed for more flexibility and less dependence on strict compartments. For design implications, the analysis looks at how fire safety needs have affected the design of façades, ceiling heights, circulation patterns, and material choices. Through Comparative Analysis, different types of buildings and their geographic settings are compared to find common strategies and innovative solutions. Additionally, it points out the differences between prescriptive codes and performance-based design methods. Finally, for synthesis, design guidelines and conceptual frameworks are developed to show how passive and active strategies work together to shape modern architecture.

4.5 Research Limitations

The study does not provide engineering-level fire system calculations; it focuses on architectural aspects. Access is restricted to detailed internal technical documentation of case studies; this research relies on publicly available plans and analyses. The scope is limited to modern buildings; historic fire safety practices are referenced only to provide context.

4.6 Reliability and Validity

To ensure reliability and validity, data sources were cross-verified in different academic literature, building codes, & architectural documentation. Also, case studies were chosen to represent diverse building types, geographical contexts, and fire safety strategies. Further, diagrams & visual analyses were corroborated with official architectural plans & published images.

5 Analysis Results

5.1 Interplay of Passive and Active Fire Safety in Architectural Design

Contemporary architecture is progressively depending on a combined method for fire safety. Passive fire safety (PFP) sets up the building's spatial and structural design, whereas active fire safety (AFP) offers more design freedom. The equilibrium between these methods not only affects the safety of the people inside but also shapes the structure, arrangement, and visual appeal of buildings.

- Passive methods impact the main layout, compartmentalization, stairwell positioning, and structural zoning.
- Active methods deliver systemic support, including sprinklers, alarms, and smoke control, that allows for open areas, spacious atriums, and adaptable interior designs.

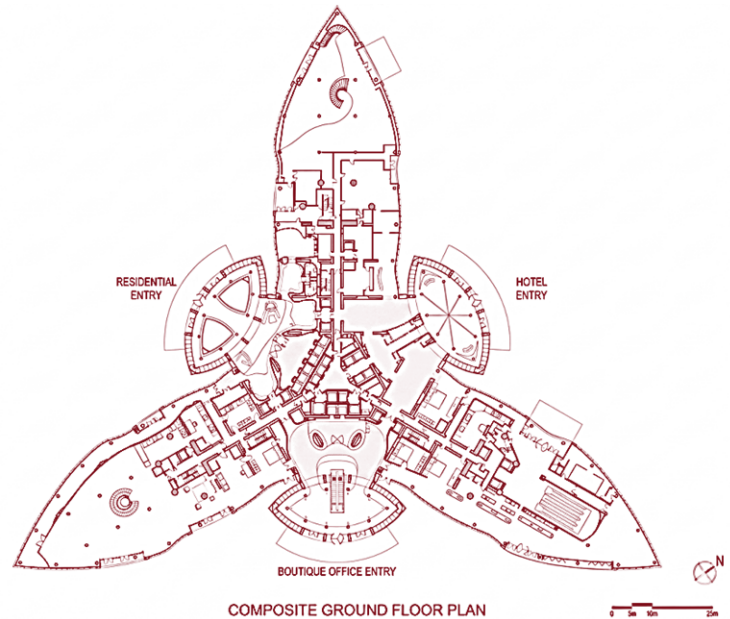
The vital aspect of effective integration lies in early collaboration between architects, fire engineers, and MEP (mechanical, electrical, and plumbing) designers. When considered simultaneously, PFP and AFP systems can reduce redundant constraints and give innovative architectural solutions.

5.2 Case Study#1: Burj Khalifa, Dubai

The Burj Khalifa is a megatall skyscraper in Dubai, United Arab Emirates. Designed by Skidmore, Owings & Merrill, it is the world's tallest structure, with a total height of 829.8 m and 163 stories (Figure 1). Table 2 analyzes of fire safety features of Burj Khalifa.



(a) Burj Khalifa building with a landscape view



(b): Burj Khalifa ground floor plan

Figure 1: Burj Khalifa, Dubai (courtesy of Google Gemini).

Table 2: Analysis of Fire Safety Features for Burj Khalifa Building.

Features	Details
PFP Fire Safety	<p>Fire-Resistant Core: The central reinforced concrete core provides structural stability and houses stairwells and elevators.</p> <p>Compartmentation: Floor slabs and fire-rated walls create discrete fire zones, limiting vertical fire propagation.</p> <p>Egress Design: Three main stairwells provide safe evacuation paths, strategically located within the core to maintain symmetry and accessibility. (Fig.2)</p>
AFP Fire Safety	<p>Sprinkler System: Fully integrated water-based suppression system covering all floors.</p> <p>Smoke Control: Mechanical smoke extraction in stairwells and pressurized shafts.</p> <p>Detection and Alarm Systems: Advanced heat and smoke detectors connected to centralized alarms for rapid response.</p>

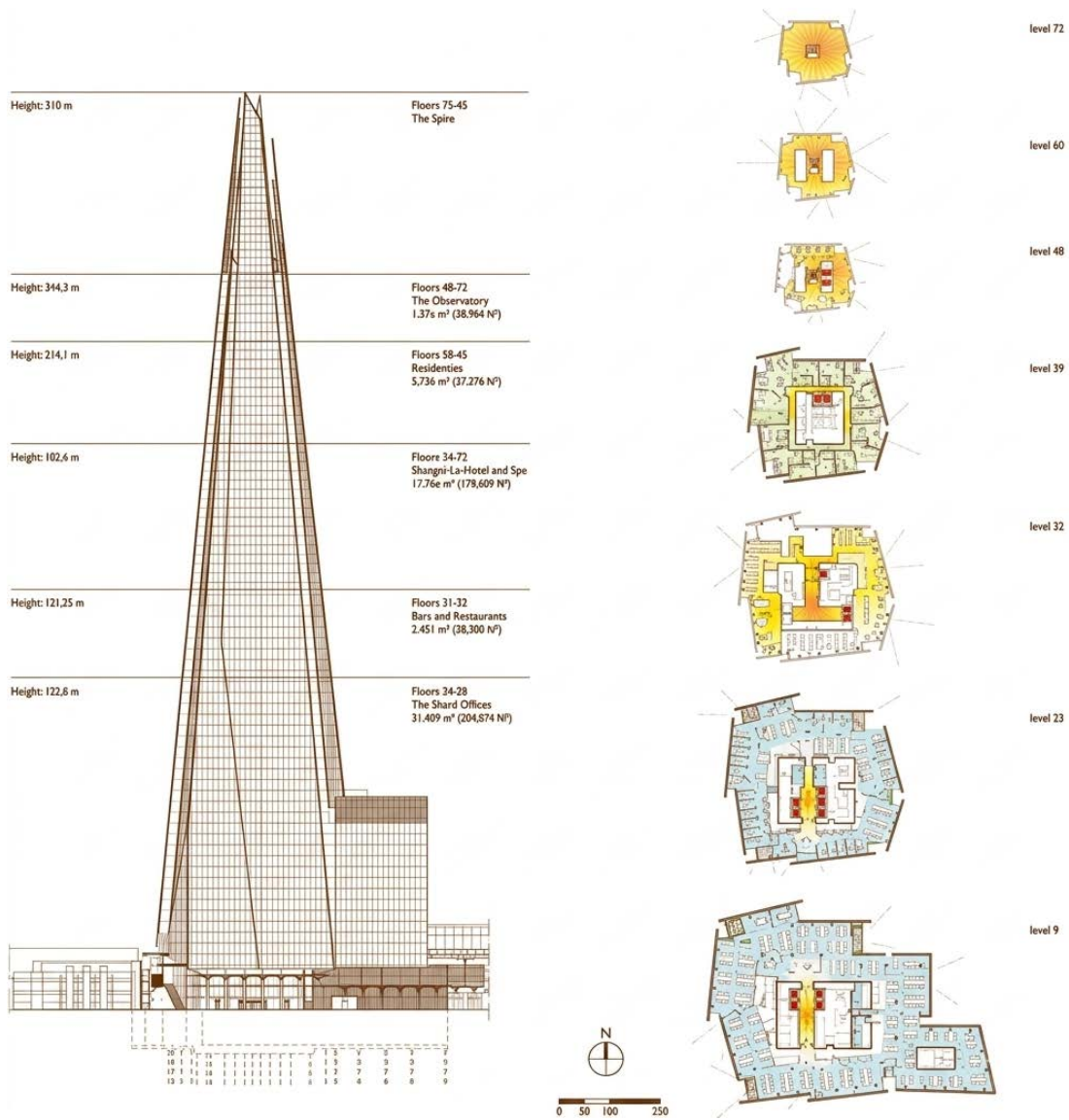
The PFP core features the main structure and layout of the space, whereas AFP systems made it possible to have open-plan offices and leisure areas without needing extra fire barriers. The design of the façade, which included curtain walls, used fire-resistant glass to keep a clear view while also providing safety. The flow of movement was shaped by PFP zones, but AFP allowed for impressive atriums and observation decks. For the illustrative diagram idea, a basic floor plan that displays where the core is located, the egress stairwells, and the sprinkler zones.

5.3 Case Study#2: The Shard, London, UK

Being the highest building in the UK with 306 meters height, the Shard (Figure 2) has 95 floors. It is in Southwark, London. It is also called the Shard London Bridge. The building was designed by the Italian architect Renzo Piano, to be used for different activities.



(a) View from the riverside, seeing The Shard, London.



(b): The Shard floor plans

Figure 2: The Shard, London, UK. (courtesy of Google Gemini)



Figure 3: The Shard ground floor plan (courtesy of Google Gemini).

Table 3: Analysis of Fire Safety Features for The Shard Building.

Features	Details
PFP Fire Safety	<p>Central Reinforced Concrete Core: The Shard’s fire safety is anchored by a massive central concrete core, which houses stairwells, elevators, and service shafts. This provides both structural stability and a fire-resistant refuge zone.</p> <p>Compartmentation by Function: The building is vertically divided into zones offices (floors 4–28), restaurants (31–33), hotel (34–52), residences (53–65), and the public viewing gallery (68–72). Each function is treated as a separate fire compartment.</p> <p>Protected Egress Routes: Multiple enclosed stairwells are located within the core, with pressurization systems to prevent smoke infiltration. These stairwells meet both UK Building Regulations and international standards.</p> <p>Fire-Resistant Materials: Floor slabs and structural concrete elements provide fire resistance for up to 120 minutes, ensuring safe evacuation even during major fire events.(Figures 2(a) and 3) [15,17].</p>
AFP Fire Safety	<p>Sprinkler Systems: Fully automated sprinklers cover every floor, including offices, hotel rooms, restaurants, and viewing platforms.</p> <p>Smoke Management: Pressurized shafts and extraction fans are installed in public areas, such as the restaurants and viewing gallery, to quickly remove smoke.</p> <p>Detection & Alarms: A centralized detection system monitors heat, smoke, and flame sensors across all zones, linked to a fire control center within the building.</p> <p>Refuge Areas & Firefighter Lifts: Refuge areas are provided on certain levels, and dedicated fire-fighting lifts allow emergency responders direct access.</p>

The concrete core strongly influenced the tower’s vertical organization, shaping the “stacked” design of different uses (offices, hotel, residences). AFP fire safety systems enabled large open-plan office floors and the dramatic glazed viewing galleries that would otherwise have required rigid compartmentation. Figure 3 shows the Shard ground floor plan.

The glass façade, a hallmark of Renzo Piano’s design, integrates fire-resistant glazing in key areas without compromising transparency. Public accessibility (restaurants, observation decks) was made possible through a combination of passive zoning and advanced active fire systems.[16]

The Shard shows how passive and active strategies complement one another in a super-tall mixed-use building. PFP systems create a robust safety backbone (the central core and compartmentation). AFP systems provide design freedom, allowing openness, flexibility, and a strong architectural identity. Together, they enabled Renzo Piano to design a slender, transparent tower that still complies with the strictest UK and international fire codes. Table 3 analyzes fire safety features for the Shard building.

5.4 Case Study#3: Marina Bay Sands, Singapore

Marina Bay Sands is a public building of a resort hotel & casino in Singapore. The complex is topped by the Sands Skypark skyway connecting the three towers (Figure 4).



Figure 4: Marina Bay Sands, Singapore, and its ground floor plan (courtesy of Google Gemini).

Table 4: Analysis of Fire Safety Features for Marina Bay Building.

Type of Fire Safety	Details
Passive Fire Safety Features	<p>Fire-Rated Partitions: Separating atrium and public circulation areas.</p> <p>Zoning: Compartmentation for hotel rooms, theaters, and casino areas.</p> <p>Egress Routes: Clearly marked stairwells and emergency exits comply with NFPA and IBC codes.(Figure 4)</p>
Active Fire Safety Features	<p>Smoke Extraction Systems: Large atrium spaces utilize pressurized vents for smoke control.</p> <p>Sprinklers: Coverage extends across public and private zones.</p> <p>Alarm Systems: Centralized system connected to the fire command center for coordinated response.</p>

Passive measures determined the structural and zoning framework of the building. Active systems enabled grand public spaces, expansive atriums, and visual continuity across floors. Façade transparency and lighting schemes were maintained while ensuring fire safety. Illustrative Diagram Idea: Atrium section showing smoke vents and sprinkler coverage.

5.5 Comparative Analysis

Table 5 shows how passive and active strategies complement each other, providing both safety and design freedom.

Table 5: A comparative analysis between passive and active measures across various aspects.

Aspect	Passive Measures (PFP)	Active Measures (AFP)	Combined Impact on Design
Layout & Circulation	Defines cores, stairwells, and fire compartments	Provides flexibility for open spaces	Optimized balance between safety and openness
Façade Design	Requires fire-resistant materials in critical zones	Allows glazing and transparency where sprinklers protect	Aesthetic freedom with safety compliance
Interior Space	Controls room size, corridor widths	Reduces need for redundant walls	Enables functional and spacious interiors
Cost & Maintenance	Low maintenance but rigid	Requires monitoring, maintenance, energy	A balanced approach reduces overall constraints
Innovation	Limited by rigid zones	Supports flexible planning	Encourages hybrid creative solutions

5.6 Discussion

PFP strategies often influence the fundamental architecture—core, structural elements, and compartmentation. AFP systems enhance flexibility, allowing innovative use of space and form.

Integration of both approaches (Figure 5) enables creative solutions, such as double-skin façades, smoke-controlled atriums, and open-plan interiors. Early collaboration between architects, fire engineers, and service designers is essential to maximize design potential. Performance-based codes encourage innovation, moving beyond prescriptive constraints.

Table 6: Framework for architects to balance safety, beauty, and sustainability in modern design

Feature	Passive Fire Safety (PFP)	Active Fire Safety (AFP)
Architectural Role	Structural Framework	Flexibility Enhancer
Core Components	Fire-resistant cores, compartment walls, egress routes	Sprinklers, smoke management, alarm systems
Design Influence	Informs massing, floor plans, and volumetric composition	Enables open-plan layouts and visual transparency
Primary Goal	Containment and safe evacuation	Suppression, detection, and smoke control
Synergy Result	Establishes the safe "skeleton" of the building	Optimizes interior functionality and aesthetic expression

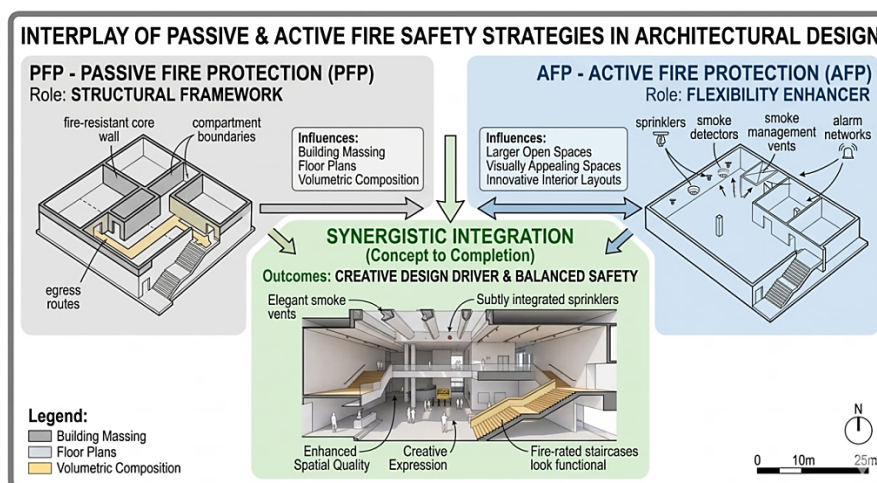


Figure 5: Interplay of passive and active fire safety strategies in architectural design.

6 Conclusions

This study explored the interplay between passive and active fire safety strategies and their influence on architectural design. The research demonstrates that fire safety should not be viewed as a mere regulatory requirement, but as a design driver that informs spatial organization, material selection, façade articulation, and circulation planning.

PFP measures involve compartmentation, fire-resistant cores, and egress routes to establish the primary architectural layout. These strategies inherently influence building massing, floor plans, and volumetric composition.

AFP measures involve sprinklers, smoke management systems, and alarm networks allow larger, open, and visually appealing spaces without compromising safety. AFP systems reduce reliance on rigid compartmentation, enabling innovative interior layouts and public spaces.

For synergy, the combination of both PFP and AFP strategies allows architects to balance safety with aesthetic and functional objectives. Case studies demonstrate that buildings achieve higher spatial quality and creative expression when both approaches are integrated from the design concept stage. Performance-based codes encourage architectural creativity by considering the combined effectiveness of PFP and AFP measures. Designers can propose non-traditional layouts or large open volumes, supported by engineered fire safety solutions.

This study confirms that fire safety is not a constraint but a design opportunity. Integrating PFP and AFP strategies effectively enables architects to achieve safe, functional, and aesthetically compelling buildings.

From the findings, recommendations are given. It should put fire engineering in the design process. Fire safety is part of the initial design phase. Both PFP and AFP systems are optimized without compromising on aesthetics. The design should adopt performance-based design methods. Performance-based codes give flexibility and creative layouts with safety goals. The design should also use innovative materials and technologies like fire-resistant glass, intumescent coatings, and advanced sprinkler systems, which help create unique spatial solutions while maintaining high safety standards. It should encourage teamwork from different fields. Effectively integrating fire protection systems into the design comes from close collaboration of involvers. Regular reviews and simulations should be conducted, such as virtual fire simulations and mock evacuation drills, to guide design changes and ensure the effectiveness of both PFP and AFP measures. Also, sustainability goals should be included. Fire safety systems need to be designed with energy efficiency and environmental sustainability in mind, ensuring they align with green building practices.

7 Availability of Data and Materials

All information is included in this article.

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