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The Impact of Architectural Design on Fire Risk in Hotel Buildings: A Design Error Taxonomy for Turkey

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Abstract

This study investigates the impact of architectural design decisions on fire risk in hotel buildings in Türkiye. While fire safety is often addressed through active systems and regulatory compliance, the role of spatial configuration such as plan typologies, atrium design, corridor depths, and means of egress in exacerbating fire and smoke spread is frequently overlooked. This research employs a multi stage method including literature review, analysis of the Turkish Fire Safety Regulation (BYKHY), and spatial analysis of case studies. Using FMEA and L-Matrix methods, the study aims to systematically identify and classify recurring architectural design errors that elevate fire risk. The primary outcome is the development of a novel design error taxonomy for hotels, providing an analytical framework to integrate fire safety into the early stages of architectural design, thereby bridging a critical gap in national literature and practice.

Keywords: Fire Safety; Architectural Design; Hotel Buildings; Risk Analysis; Design Error Taxonomy.

1. Introduction

Modern people spend a large portion of their lives indoors. Hotel buildings, which they use for accommodation, hold a significant place in terms of fire safety due to their high user density and complex layouts. Hotels are high-risk structures in case of fire because they accommodate people of different ages and physical abilities simultaneously, many of whom are unfamiliar with the building, and because many activities such as sleeping, resting, eating and drinking, and social activities take place at the same time. Therefore, minimizing loss of life in case of fire and ensuring the safe and rapid evacuation of users are among the fundamental safety elements in hotel architecture.

Fires can cause significant loss of life and property due to secondary factors such as smoke, toxic gases, and reduced visibility, in addition to the effects of the flames themselves. It is reported that approximately two million fires occur annually in Europe, with 90% of them taking place in buildings. Half of all fire-related deaths are attributed to inhaling smoke and toxic gases (Brushlinsky et al., 2020). In hotel buildings with high occupancy rates, complex layouts, and where occupants often lack sufficient knowledge about the building, the spread of fire and evacuation processes become even more critical. Therefore, evaluating various fire scenarios and identifying potential risks in advance plays a crucial role in preventing loss of life (Wang et al., 2021; Wehbe and Shahrour, 2021).

Hotel fires in Turkey and worldwide reveal that fires are not solely caused by technical problems or user error; architectural design decisions and planning flaws directly influence fire spread and evacuation processes. Spatial layout, the location and continuity of escape routes, corridor lengths, atriums and open spaces, vertical circulation elements, and fire compartmentalization strategies are among the key architectural elements that have a significant impact on fire development and user safety.

In current practices, fire safety is generally assessed based on compliance with laws, fire detection systems, extinguishing systems, and other technical measures. However, factors such as panic during a fire, unfamiliarity with the building among its occupants, and complex spatial arrangements cannot be controlled solely by technical systems. This makes it difficult to systematically address design-related fire risks in hotel buildings and often leads to the impact of architectural design on fire safety being overlooked.

This study aims to address the issue of fire safety in hotel buildings from an architectural design perspective. To this end, the phenomenon of fire and its causes, development, and effects within the scope of building safety are examined; subsequently, fire incidents in hotel buildings, their causes, and consequences are evaluated. Furthermore, bibliometric

analyses are conducted to reveal the development trends in scientific studies in the field of fire safety, and prominent research themes in the existing literature are identified.
Based on the findings of this study, it is emphasized that fire safety in hotel buildings should be evaluated not only within the framework of technical measures and legislation, but also in relation to architectural design decisions. Thus, this study aims to contribute to the holistic evaluation of the existing knowledge on fire safety in hotel buildings and to create a conceptual foundation for future design-oriented research.

1.1 Background and Context

Fire has long been one of the major risks to building safety and has caused significant losses, especially in structures with high occupancy. Today, fire safety is treated as a multidimensional issue directly related not only to technical systems but also to architectural design decisions.
Hotel buildings are among the types of structures critical in terms of fire risk due to high user density, diverse user profiles, and the presence of occupants unfamiliar with the space. In these buildings, design decisions such as spatial organization, escape routes, and circulation patterns play a decisive role in fire spread and the evacuation process.
Although the fire regulations in force in Turkey include important provisions, in practice the focus is usually on technical systems, and the impact of architectural design on fire risk is not addressed sufficiently holistically. This can lead to design-related risks being overlooked.
In this context, there is a need for holistic approaches to assess fire risk in hotel buildings through architectural design decisions.

1.2 Problem Statement and Research Gap

A significant portion of fires in hotel buildings in Turkey can be attributed to defects in the structural and architectural design process. Spatial organization, the arrangement of exit routes, the design of atria and voids, corridor depths, compartmentation decisions, and plan types are just a few architectural design elements that have not been sufficiently examined for their potential to increase fire risk; instead, fire safety is primarily assessed on the basis of regulatory compliance and technical systems. This situation hinders a comprehensive evaluation of design-induced fire risks in hotels and necessitates the development of a systematic identification, classification, and taxonomy of design errors to address these hazards. Due to features such as diverse user profiles, high human circulation, and occupants often being unfamiliar with the building, hotels pose serious challenges for evacuation and wayfinding during fires. In this context, spatial decisions made during the architectural design process have a major impact on how fires spread and how users behave. In Turkey, fire safety assessments for hotel buildings are mostly addressed within the framework of legal compliance, while risks arising from architectural planning and spatial arrangements remain secondary.
In the literature, while active fire systems and engineering solutions for fire safety are emphasized, the hazards created by architectural design are treated in an irregular, limited, and primarily isolated manner. This situation makes it difficult to detect design errors early in the design process and to implement preventive measures. Therefore, it is an important academic and practical need to systematically classify architectural design defects that increase fire risk in hotel buildings and integrate them into a conceptual framework.

1.3 Research Objectives and Hypotheses

The main objectives of this study are as follows:
In hotel buildings;
*To reveal the effects of spatial and planning decisions made during the architectural design process on the formation and spread of fire risk.
* Evaluate architectural design components such as spatial organization, escape route configuration, circulation patterns, atria and voided spaces, corridor depths, partitioning decisions, and plan typologies in terms of fire safety.
* Identify fire risk factors arising from the design and classify the types of design-related violations and deficiencies by linking these factors to the provisions of the Turkish Regulation on the Protection of Buildings from Fire (BYKHY).
* To reveal the cause-and-effect relationships of architectural design flaws that increase fire risk, based on expert opinions in the field of fire safety and spatial analyses of selected sample hotel buildings.
*Develop a Design Error Taxonomy focused on architectural design for hotel buildings based on the findings obtained. Conduct fire risk analyses in pilot hotel buildings selected to test the applicability of the developed design error taxonomy and reveal the impact of design errors on risk levels. Based on the study results, develop design recommendations to reduce and prevent fire risk in the architectural design process.
This study seeks to answer the following research questions:

1.Under which main categories can architectural design flaws that increase fire risk in hotel buildings be grouped?
2.How do spatial configuration components (partition choices, atrium and void designs, corridor depths, and escape route arrangements) affect the development and spread of fire hazards?
3.What are the most common fire hazards caused by architectural design in hotels in our country?
4.To what extent are fire risks identified as design-related associated with the current provisions of Turkey’s Regulation on Fire Protection of Buildings (BYKHY)?
5.According to the risk assessments conducted on the selected hotel buildings, which architectural design elements increase fire risk?
6.Based on the findings, is it possible to develop a design-oriented fire risk taxonomy for hotel buildings?
In this context, the hypotheses developed based on the research questions are as follows:

H1: Design errors in hotel buildings significantly increase fire risk.
H2: As the spatial depth of escape routes and the length of corridors increase, evacuation time during a fire becomes longer and fire risk increases.
H3: The danger of horizontal and vertical smoke spread during a fire is greater in hotel buildings with courtyards or large open spaces.
H4: Inadequately designed fire lobbies impair the evacuation performance of hotel buildings and increase the risk to user safety.
H5: The systematic classification of architectural design decisions that do not comply with BYKHY does not contribute to the development of a meaningful design error taxonomy for hotel buildings.

1.4 Significance and Structure of the Paper

This study is significant in that it emphasizes the need to evaluate fire risk in hotel buildings not only through technical systems but also through architectural design decisions. Unlike approaches in the literature that mostly focus on engineering solutions, this research aims to reveal the effects of spatial decisions made during the design process on fire safety. In this respect, the study aims to provide a holistic perspective on fire safety within the discipline of architecture and to raise awareness regarding the design process.

2. Materials and Methods

In this study, a multi-stage research method is followed to identify fire risks in hotel buildings arising from architectural design and to classify these risks within a design error taxonomy.
In the first stage, the literature and reports on hotel fires will be reviewed to evaluate the causes of fires, their patterns of spread, and their effects on life safety, and to reveal the role of spatial characteristics specific to hotel buildings in fire risk.
In the second stage, studies addressing the relationship between fire safety and architectural planning will be analyzed, and recurring design errors related to plan layout, circulation and escape configuration, spatial hierarchy, and façade decisions will be identified.
In the third stage, in line with performance-based approaches, the relationship between fire behavior and spatial organization will be evaluated; smoke spread, heat distribution, and the evacuation process will be examined at a conceptual level.
In the fourth stage, current fire regulations will be analyzed, and the relationship between architectural design decisions and regulatory provisions will be examined.
In the final stage, all findings obtained will be brought together, and in future processes, the development of a holistic design error taxonomy defining fire risks arising from architectural design in hotel buildings is aimed.

2.1. Risk Analysis Methods

2.1.1. FMEA

FMEA is a proactive risk analysis method that systematically identifies potential failure modes that may occur in advance in systems, designs, processes, or services, along with their possible causes and effects.
This method evaluates the identified failures through a risk prioritization mechanism and provides a systematic framework for planning preventive and corrective actions. Fundamentally, this method aims to identify and prevent possible failures in advance by asking the question, “What could go wrong here?” (DQS Türkiye, 2023) .
It seeks answers to questions such as “What failures may occur?”, “What would be the effect of this failure?”, “Why would it occur?”, and “How can it be prevented or its impact minimized?”

2.1.2. L-MATRIX Method (5x5 Risk Analysis)

An L-type matrix is an excellent method for identifying and independently analyzing risks in small businesses in terms of cause-and-effect relationships. With this method, the probability of an event occurring is first determined. If it occurs, its consequences are then measured and rated. The product of probability and risk severity gives the risk value (Doğan & Keskin, 2023).

2.2. Taxonomy

Taxonomy is a systematic classification method that aims to organize and classify elements in a complex information field according to specific criteria, thereby revealing the relationships between these elements (Nickerson et al., 2013). In this study, the taxonomy method is used to group architectural design flaws that increase the fire risk in hotel buildings according to their common characteristics and to explain the relationships between these groups of flaws.
In architecture, taxonomy refers to the systematic classification of the formal, functional, structural, and spatial components involved in the production of buildings and spaces according to specific theoretical and analytical criteria. This approach enables architectural data to be organized, compared, and interpreted, thereby allowing design processes to be understood and architectural problems to be addressed analytically. Although taxonomic classifications often present a hierarchical structure, they may also include network-based and multi-axial approaches due to the multilayered nature of architecture.

2.3. Literature Review

During the literature review process:
-Academic articles in the Web of Science database
-Books, conference proceedings, and relevant regulations , were evaluated.

2.2. Bibliometric Analysis
Bibliometric analysis was used to evaluate trends in the literature more comprehensively. Publications obtained from the Web of Science database were examined in terms of distribution by year, keyword density, relationships among authors, and research areas.

3. Results
The findings obtained in this study reveal that fire risk in hotel buildings is directly related not only to technical systems but also to architectural design decisions. As a result of the analyses conducted, it was determined that design components such as spatial organization, circulation layout, and the arrangement of escape routes have decisive effects on the spread of fire and the evacuation process.
In particular, it was observed that long and deep corridors, plan layouts with insufficient alternative escape routes, and complex circulation systems increase evacuation time and negatively affect user safety. Atriums and void spaces, on the other hand, were found to increase fire risk by causing smoke and heat to spread rapidly in the vertical direction. In addition, inadequate fire compartmentation and unsuitable plan typologies are among the significant design errors that make it difficult to bring a fire under control.
The evaluations indicate that although current fire regulations meet certain safety criteria, in practice these criteria are generally satisfied only at a minimum level and are not addressed through a holistic approach during the design process. This leads to the neglect of risks arising from architectural design and increases potential hazards.
Based on the findings obtained, architectural design errors that increase fire risk in hotel buildings have been classified under main categories such as errors in spatial organization, errors in escape routes and circulation systems, risks arising from voids and atriums, and inadequacies in fire compartmentation. This classification forms the basis of the design error taxonomy proposed in the study.
In conclusion, the findings show that decisions made during the architectural design process play a critical role in fire safety and that improvements made during the design phase will be effective in reducing fire risk.

3.1. Fire and General Concepts
This section will cover the basic characteristics of the fire phenomenon, starting with combustion chemistry, its stages of development, classifications, structural and human consequences, and the basic safety measures that should be taken in the event of a fire.

3.1.1. Definition and Characteristics of Fire
Combustion is a chemical reaction that occurs when a combustible material comes together with oxygen and an energy source that generates the necessary heat.
In other words, combustion can also be defined as the process in which a substance combines with oxygen within a short period of time, reaches its ignition temperature, and thereby maintains the continuity of the chemical reaction through the heat it produces itself (Kolak, 2004).
Causes of fire:
Combustible Material
Oxygen
Heat Source
The fire triangle is formed by the combination of combustible materials, oxygen, and a heat source. When one of the components of the fire triangle is removed, the fire triangle is broken. The reaction ends.
Combustible material: When heated to its ignition point, it interacts with oxygen. These are materials that are combustible and release heat. Hydrocarbon is the main element of combustible materials. It contains the following molecules: This chain of molecules, which produces combustible compounds (hydrogen and carbon), is released during the oxidation process, releasing heat energy. (Pehrson, 2004).
Any organic substance that causes a fire, other than a nuclear fire, is considered a combustible material. Phosphorus, nitrogen, carbon, sulfur, oxygen, and hydrogen are some of the elements found in the chemistry of combustible materials, which are divided into three categories: solid, liquid, and gas.
*Substances that burn in a solid state and release vapor or gas under the influence of heat are those that have a specific mass.
*Liquid combustible materials are substances that first evaporate when heated and then burn in liquid form.
*Gaseous ignitable substances are as follows: The rapid combustion reaction manifests itself in the following: leakage in enclosed spaces, sparks, and the possibility of other problems occurring. These substances may explode (Işık, 2020).
Fire risk refers to the possibility of a fire occurring when fire is considered a source of hazard. Studies conducted in the field of fire risk assessment are among the most valuable efforts in the firefighting sector. To reduce the potential damage that fires may cause, fire-related activities should be carried out in accordance with the findings of the risk analysis (Özmen, 2010).
Fire risk is directly related to loss of life, injury, and property damage. A risk assessment that only considers human life is insufficient to evaluate fire safety; it must also be carried out by the owners of buildings, organizations, and institutions. This is related to fire regulations. Therefore, managing and regulating elements at risk is necessary (Çatıkkaş Karadağ, 2021).

3.1.2. Types of Combustion
1. Slow combustion
2. Spontaneous combustion

3. Fast combustion
4. Flash-explosion

Types of Combustion

Table 1 : Types of Combustion - (Prepared by the author.).

Type	Characteristic	Condition	Example
Slow Combustion	Heat released very slowly	Insufficient oxygen	Rusting, respiration
Spontaneous Combustion	Self-ignition due to heat buildup	Heat trapped in material	Oily rags, coal
Rapid Combustion	Flame, heat, light released	Fuel + oxygen + ignition source	Wood, natural gas
Flash / Explosion	Sudden ignition / pressure wave formation	Gas/vapor + air + ignition	LPG leak, dust explosion

3.1.3. Stages of Fire

All fires start in areas with limited boundaries. The rate of combustion increases as the temperature rises due to the energy released during combustion (Nurtaş, 2016). A fire that can be extinguished with a glass of water initially may require a bucket of water within two minutes, and by the third minute, extinguishing the fire becomes even more difficult (Şahin, 2022). The heat radiating from the burning area, along with the dispersed hot gas, heats the air at the scene and the surfaces of surrounding components (floor, beams, columns, etc.) (Nurtaş, 2016).

Initial Stages

Preparation phase

The time period before anything catches fire. Examples of the preparation phase include the heating of the area where a cigarette falls and the heat generated in electrical wires. Even the slightest heat energy can start a fire, and a spark may be enough. It is important to remember that this can lead to an explosion.

Depending on the flammability of the material, this phase can last from a few minutes to hours, days, or even weeks (Şentürk, 2006).

Development phase

The moment the flame is first seen marks the beginning of this period. Fire spreads when it comes into contact with air. The heat produced by burning things is initially transferred to other objects through conduction. The fire then spreads through radiation. During this time, if the distance between objects is large and there is not enough air in the room, the fire starts and extinguishes itself. However, the flames are fed and spread by outside air entering through broken windows of the building. The breaking temperature of glass is typically 100 °C. During the development phase, objects are most vulnerable to damage, while the load-bearing structure of the building remains intact (Nurtaş 2016, Şentürk 2006).

Complete Combustion Phase

General Combustion Phase,

This is the stage where the fire spreads throughout the entire area, all combustible materials ignite, and the temperature rises rapidly. Significant temperature differences can be observed throughout the space. However, this difference is reduced through heating. Thanks to the convection created by the rising hot air, all combustible materials reach their ignition temperatures. All materials ignite at this moment (Özyurt, 2016). At this stage, the oxygen level drops below 15%, but if there is a sufficient amount of combustible material, combustion continues even in the case of oxygen deficiency. If oxygen enters the room uncontrollably, an explosion may occur (Nurtaş, 2016).

Continuous Combustion Phase, This is the phase where the temperature rises rapidly and the rate of heat spread is at its highest. At this point, the components of the structure begin to deteriorate. If the process continues, the load-bearing structure will be damaged, and collapses in roofs and floors will inevitably begin to occur. At this point, flames can be observed spreading from previously broken glass (Nurtaş, 2016).

Extinction Phase

During the extinction phase, the temperature increase stops. As there is less combustible material, the temperature drops, the flame shortens, and eventually extinguishes. However, this temperature decreases gradually and continues to affect the structure. Even at this point, disintegration is possible. The destruction of its components clearly leads to its spread to other areas. Since the combustion is close to the wall, the flames will follow the wall and advance upwards. This also highlights the importance of wall cladding materials. If the cladding material is easily flammable, the flames spread towards the roof and ignite easily. The materials are also readily available. However, if it is a material prone to combustion, it will start burning and the flames will rise even higher. (Şentürk, 2006)

3.1.4. Fire Classes

Table 2 : Fire Classes and Basic Characteristics (Prepared by the author using BYKHY as a source.).

Fire Class	Definition	Type of Combustible Material	Examples in Hotel Buildings
Class A Fires	Fires involving solid materials, generally of organic origin, that form embers during combustion.	Wood, paper, textile products, furniture, floor coverings	Furniture in hotel rooms, beds, curtains, carpets
Class B Fires	Fires caused by flammable liquids or solid substances that can become liquid.	Gasoline, alcohol, solvents, paints, oils	Hotel kitchens, technical areas, cleaning material storage
Class C Fires	Fires resulting from the combustion of flammable gases.	Natural gas, LPG, propane, butane	Gas installations in hotel kitchens, boiler rooms
Class D Fires	High-temperature fires caused by the combustion of flammable metals.	Magnesium, sodium, potassium, aluminum powder	Rare in hotels; workshops or specialized technical areas
Class F Fires	Fires caused by high-temperature cooking oils and fats (liquid or semi-solid).	Vegetable and animal oils	Industrial hotel kitchens, frying units

3.1.5. Fire Extinguishing Agents

All equipment and tools used in fire suppression intervention fall under the scope of fire extinguishing agents. The chemicals or substances to be used in extinguishing vary depending on the type and flammability of the fire.
The timing of interventions is entirely dependent on making the right choice at the right time to achieve positive and successful results.Among the substances used in interventions are foam, water, portable foam extinguishers, carbon dioxide extinguishers, portable water extinguishers, dry chemical powder extinguishers, and fire extinguishing balls (Kılıçarslan, 2022).

3.1.6. Fire Protection

Fire Safety Measures
There are various measures that must be taken during the design and construction phases to ensure fire safety in buildings. Measures that prevent or contribute to the spread of fire are necessary precautions. However, no matter how many precautions are taken, a momentary lapse of attention, uncontrollable behavior, etc., can occur. Regardless of contributing factors, you can never completely prevent a fire from starting. Consequently, after every measure that can be taken to prevent a fire from starting, steps must be taken to stop its spread and inform users as soon as it starts. Systems that make this possible are crucial. The entire chain of measures that constitute fire safety includes fire alarms, measures to prevent the spread of fire, evacuation of users from buildings, and fire department resources. As shown in Figure 1, fire safety measures are addressed as active and passive fire safety measures.

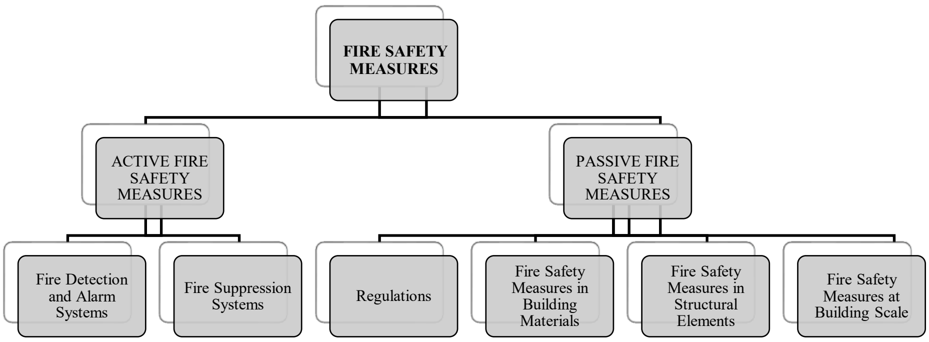

Figure 1 . Fire safety measures (Created using data from Baytemür, 2019.).

3.1.6.1. Active Fire Safety Measures

Active fire safety systems consist of mechanical and electronic components that aim to control and extinguish fires by directly intervening in the event of a fire (İmrel, 2019). These systems aim to prevent the spread of fire by performing tasks such as early detection of the fire, informing users, and quickly transmitting information to security authorities. Especially in hotel buildings, fire detection, alarm systems, and automatic extinguishing systems are critically important in reducing risks arising from high population density and complex building arrangements. These systems, which activate in the initial stages of a fire, help minimize loss of life and property (Gürsoy, 2021).
Active fire safety measures can be examined under two headings:
· Fire detection and warning systems,
· Fire prevention and extinguishing elements.

Fire Detection and Warning Systems

Fire warning and detection systems are automated systems that detect fires in the early stages, trigger signals, and activate other safety systems according to the scenario (Toker, 1997). The short time between the activation of the alarm and the onset of the explosion is extremely important for both product life and lifetime safety. Therefore, it is essential to store automatic fire alarm and detection analyses that do not require human interaction (Kılıç, 2003). These systems detect explosions using detectors that sense physical elements such as smoke, heat, and gas. Smoke detectors, in particular, are crucial for providing early warnings before a fire occurs, informing building occupants in time, and ensuring a safe evacuation.

Fire Suppression Systems

Fire suppression involves reducing heat to a desired level to prevent fires, removing combustible materials from the fire area, or preventing their contact with air. Extinguishing can be done automatically or manually. Many fires are extinguished by portable extinguishing systems used by people.

Appropriate fire suppression systems should be selected from the right places and using the right approach (Yavuz, 2006). Fire extinguishing devices used by people include fire cabinets and fixed pipes.

Equipment includes portable fire extinguishers, hydrant systems, and piping. Automatic extinguishing systems extinguish flames without requiring user intervention during a fire. These are functional systems. These include foam fire suppression and automatic sprinkler systems. Gas-based fire suppression systems also fall into this category.

3.1.6.2. Passive Fire Safety Measures

Passive fire protection measures are measures planned and constructed as part of the building design process, that can be immediately addressed, and that have a fundamental purpose. The effectiveness of safety measures depends on how well they are planned, implemented, and monitored throughout the building. The need for fire safety measures in buildings will decrease proportionally. The following elements are used to provide passive fire protection in buildings: Purpose

• Removal of smoke and harmful gases from the building,
• Design of escape routes, stairways, and meeting points,
• Creation of fire-resistant sections (partitions) in buildings,
• Use of non-combustible and smokeless materials with high smoke point,
• Preparation of escape routes that are easily understood by the user,
• High temperature resistance of the load-bearing system (Demirel & Başdemir, 2010).

3.2. History of Fire Regulations in Turkey

- "Istanbul Metropolitan Municipality Fire Protection Regulation" was enacted on January 16, 1992.
- "Regulation on Fire Protection of Public Buildings" was enacted on November 4, 1995. However, both regulations were valid for limited areas and buildings.
- "Regulation on Fire Protection of Buildings" was enacted on July 26, 2002.
- "Regulation on Fire Protection of Buildings" came into force on December 19, 2007. This is our current regulation.
- It came into force on December 19, 2007, with its publication in the Official Gazette No. 26735, following the letter No. 5098 dated November 1, 2007, from the Ministry of Public Works and Housing. - The "Regulation Amending the Regulation on Fire Protection of Buildings" was put into effect with the Official Gazette dated 09/09/2009 and numbered 27344.

3.3. Hotel Fires

Hotels are accommodations with high density and complex organizational structures where many people rest, socialize, and stay at the same time. This dense demographic and spatial structure necessitates maintaining excellent production efficiency in hotel buildings. However, case analyses from Turkey and different regions of the world show that this safety is threatened by systematic weaknesses in practice, and fire accidents can lead to significant losses and result in devastating material damage.

3.3.1. Examples of Hotel Fires

Bolu Grand Kartal Hotel Fire

On January 21, 2025, a fire occurred at the Grand Kartal Hotel in Kartalkaya, Bolu. The building, with approximately 17,000 m² of indoor space, was completely destroyed, and 78 people lost their lives. This fire serves as an important example regarding the adequacy of fire safety measures in hotel buildings and the impact of architectural design decisions on fire spread and evacuation processes (İMO, 2025).

Post-fire assessments revealed that the building had inadequate fire detection, alarm, automatic extinguishing, and smoke control systems; that escape routes and staircases did not meet the user load in terms of fire resistance, number, and location; that the flammability properties of the building and cladding materials used in the interior caused the rapid spread of the fire; and that periodic maintenance, inspection, and official audit processes related to fire safety were not effectively carried out, and changes made during the building's use were not re-evaluated from a fire safety perspective (İMO,2025).

Las Vegas MGM Grand Hotel Fire

On November 21, 1980, a fire that started in a restaurant on the ground floor of the 26-story MGM Grand Hotel and Casino in Las Vegas, USA, due to a problem in the electrical system, is remembered as one of the most destructive hotel fires of modern times. Although the fire was largely confined to the first floor, the inadequacy of the building's automatic water extinguishing system, the lack of fire compartments, the open-designed casino areas, right-angled openings, and ventilation systems resulted in the uncontrolled spread of smoke to the upper floors, killing 85 people and injuring more than 600. The majority of deaths were not directly from the flames but from inhaling smoke caused by carbon monoxide and other harmful gases. The MGM Grand fire demonstrated the vital importance of holistic consideration of smoke control methods, active and passive fire safety systems, fire compartments, material selection, and evacuation arrangements in high-rise hotels during the architectural design phase. This incident subsequently made significant contributions to the revision of hotel fire safety standards (Best and Demers, 1982; Canter, 1983; Meckler, 1987).

3.3.2. Causes of Fires in Hotels

Hotels carry a high fire risk due to their open spaces and ability to accommodate a large number of guests simultaneously. Guests spend approximately one-third of their time sleeping during their stay, creating a high degree of resilience for evacuation in the event of an explosion. During the time it takes to safely evacuate the building, loss of life can occur directly. Therefore, the number and characteristics of escape routes are extremely important, as these factors can greatly affect the number of people inside in an emergency (Günaydın, 2005).

In emergency situations, evacuation routes should lead directly to streets or wide open areas to enable people to leave buildings quickly and safely [Kılıç 2005].

Hotel fires are generally caused by mistakes made by guests or staff, or by problems in kitchen, heating, ventilation, and electrical systems. Poor maintenance and even intentional actions can also cause fires [Tenker 1995].

Table 3 : Causes of fires in hotels (NFPA 101 Life Safety Code, 2000).

Cause of Fire	Year-Round Open (360 Hotels)	Seasonally Open (127 Hotels)
Cigarettes	13%	8%
In Bed / Sleeping Areas	22%	21%
Electrical Systems	15%	16%
Installations	4%	5%
Engines and Household Appliances	8%	9%
Heating and Cooking Devices	13%	13%
Heating System	3%	4%
Faulty Oil Heater	3%	2%
Chimney	2%	1%
Faulty Gas Heater	1%	—
Faulty Coal Heaters	—	—
Various Cooking Devices / Residue in Flues	1%	2%
Other Causes	7%	5%
Sparks, Sudden Explosion	8%	1%

3.4 Literature and Bibliometric Findings

3.4.1. Web of Science Literature Search Findings

In this research, a comprehensive literature search was conducted in the Web of Science (WoS) database using the keywords “architectural design fire”, “building fire safety”, “fire safety design” and “occupant evacuation” with the “All Fields” option. As a result of the search, a total of 3,285 publications were found.

When the distribution by discipline is examined, it is seen that the vast majority of studies are concentrated in the field of Civil Engineering (463 publications), followed by Materials Science – Multidisciplinary (358 publications), Construction & Building Technology (281 publications), Engineering – Multidisciplinary (179 publications), Mechanical Engineering (73 publications), and Architecture (13 publications). This distribution reveals that building fire safety and evacuation issues are predominantly addressed within the framework of engineering disciplines, while studies in the field of architecture remain limited.

When publications are evaluated in terms of their distribution by year, it was determined that the oldest study dates back to 2000, and the most recent study to 2026. In line with the aim and scope of the research, 864 studies representing different disciplines and considered directly related to the subject were included in the analysis. The obtained dataset was evaluated bibliometrically through author, citation, journal, country, institution, and keyword analyses. In this study, only publications indexed in Web of Science were accepted as the database criterion, and the analyses were carried out within this framework.

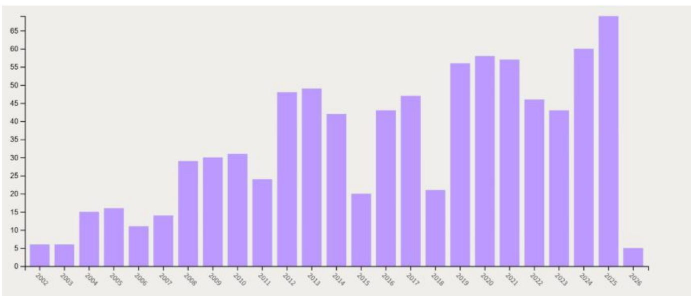

Figure 2. Distribution of Publications by Year (Created by the author.).

In recent years, many software programs have been developed for bibliometric analysis. Among these programs, VOSviewer, Citespace, and ScientoPy stand out. The bibliometric analyses of this research were visualized using

VOSviewer software. Developed by Van Eck and Waltman in 2010, VOSviewer offers higher quality bibliometric maps and graphs than most other computer programs. Furthermore, it is highly functional, particularly for enabling a more understandable interpretation of large bibliometric maps (Van Eck and Waltman, 2010). VOSviewer is a software program designed by the Centre for Science and Technology Studies at Leiden University (VOSviewer, 2023).

3.4.2. Bibliometric Analysis Findings

The results of the bibliometric analysis reveal that studies in the field of fire safety have increased in recent years and are moving towards an interdisciplinary structure. The analyses show that the literature mainly focuses on engineering and technical systems, while studies addressing the impact of architectural design on fire risk remain limited. Keyword and citation reviews also support this situation. These findings reveal that architectural design-focused fire safety studies constitute a significant research gap in the literature.

3.4.2.1. Co-authorship analysis

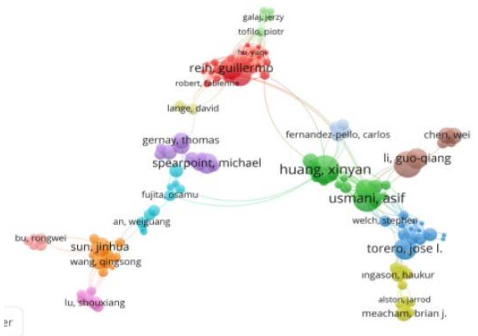

Figure 3. Co-author relationships demonstrating collaboration among authors.

Based on the co-authorship analysis of the authors, a network map was created using the criteria of having at least one publication and at least one citation to identify the authors showing the most connections and collaborations. The resulting image shows the output of an Inter-Author Co-authorship Network analysis obtained from the Web of Science database. The co-authorship network in the image reveals the collaborative connections and scientific interactions existing among researchers in the literature under review.

The analysis was performed using VOSviewer software, where the size of the nodes represents the number of publications by the authors, and the density of connections represents the frequency of collaborations. Groups shown in different colors represent research communities formed in the literature. Looking at the network structure, it is observed that authors such as Rein, Guillermo, Huang, Xinyan, Usmani, Asif, Torero, Jose L., and Spearpointe, Michael occupy a central position. This reveals that these authors are important and guiding actors in the advancement of the field.

3.4.2.2. Author Citation Analysis

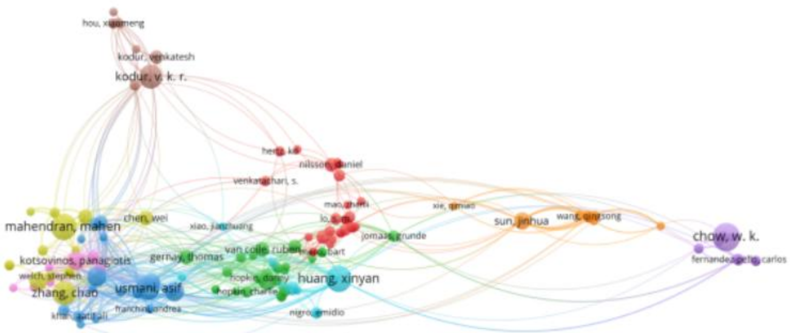

Figure 4. Authors' Citation Links.

To identify citation networks, a network map was created for author citation analysis using at least one publication and at least one citation criterion. This section examines which authors are most successful in the literature and around which topics research is concentrated. Large points represent the most cited authors in this field. The size of the nodes indicates the publication productivity of the authors, and the links indicate the frequency of collaboration. This shows that the topic encompasses many disciplines.The analysis was performed on 1086 interconnected units, identifying a total of 33 clusters, 6255 links, and 8212 link strengths. Among the most cited authors, Mahendran Mahen stands out with 652 citations, Kodur V.K.R. with 330 citations, and Usmani Asif with 520 citations. These three authors also rank in the top three in terms of total link strength.

3.4.2.3. Citation Analysis of Countries

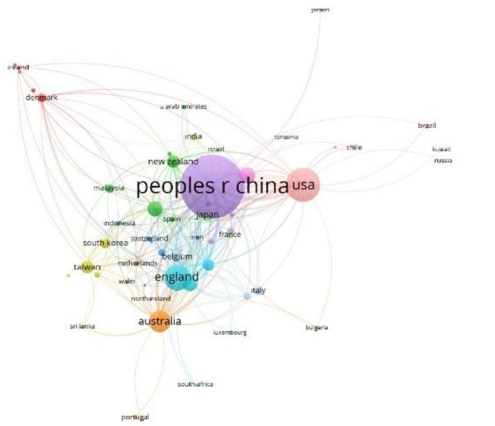

Figure 5 . Citation Links of Countries.

This study was conducted to create a network map of citations received by publications according to their country of origin. For this analysis, 58 observation units with relationships among countries that have published at least one work and received at least one citation were examined. In these analyses, 13 clusters, 266 connections, and 1145 connection strengths were identified. This visualization shows the inter-country academic interaction in the literature on fire safety and building-scale risk assessment.When the citation network is examined, it is seen that China and the United States are at the center of the field; while the United Kingdom, Australia, and European countries have strong relationships with these centers. The structure of the network reveals that the literature is concentrated in certain countries, while country-specific, local legislation and design-oriented studies remain limited.

3.4.2.4. Keyword Analysis (Co-occurrence of All Keywords)

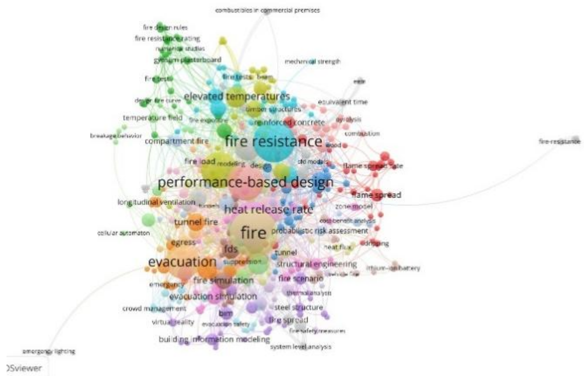

Figure 6 . Most Frequently Used Keyword Links.

The keyword network shows that the fire safety literature is predominantly focused on fire resistance, performance-based design, numerical modeling, and evacuation simulations. The central concepts of the network reveal that the studies are largely technical and engineering-oriented. Architectural design decisions and their relationship to national legislation are represented at a secondary level in the literature. In the research conducted, the most frequently repeated words were identified, provided they had at least 2 citations. Among these, "Fire" appeared 64 times, "Fire safety" 55 times, "Fire resistance" 51 times, "Performance-based design" 42 times, and "Fire safety design" 41 times. The analysis identified 24 clusters, 2041 connections, and a total connection strength of 2452.

3.4.3. General Evaluation of Bibliometric Analysis Findings

The bibliometric analysis conducted as part of the research highlights current structural and conceptual trends in the fire safety literature. As evidenced by the examination of 863 documents from the Web of Science database covering the period 2005-2025, the literature has largely taken the form of a performance-based, engineering-oriented paradigm. While most research focuses on quantitative and technical factors such as fire dynamics, structural resilience, and evacuation modeling, there are few studies that integrate this information with architectural design choices and spatial organization. Country-based citation analyses show that the USA, UK, and China are the primary sources of information in the literature, while Türkiye is only marginally represented. In particular, it was found that Turkish laws and practices related to BYKHY (Broad Fire Safety Regulations) are not sufficiently addressed analytically in the international literature.

This thesis is situated at the intersection of the two fundamental gaps mentioned above, offering a comprehensive approach that integrates fire safety knowledge, primarily focused on engineering, with the architectural design process. The Design Defect Taxonomy, developed using legal analysis and field observations centered on BYKHY (Fire Safety and Environment Prevention), treats fire risk not as a technical problem, but as a consequence of architectural decision-making processes. In this way, the approach aims to make a unique contribution by placing fire safety at the center of the architectural design field.

4. Discussion

The findings of this study reveal that fire risk in hotel buildings is not limited solely to technical systems; architectural design decisions also play a decisive role in fire safety. In particular, design components such as spatial organization, circulation patterns, and escape route planning have been found to have a direct impact on fire spread and evacuation processes.

While fire safety in the literature is mostly addressed through active systems and engineering solutions, the findings of this study support the idea that architectural design is a critical component that should not be neglected. Bibliometric analysis results also show that existing studies largely focus on technical systems, and research focusing on architectural design remains limited. This situation parallels the findings obtained and confirms the research gap in the literature.

5. Conclusion

This study aims to investigate potential risks in the architecture of hotel buildings in Türkiye, evaluating errors occurring during the design process through a systematic and holistic approach within the context of spatial organization and planning. Naturally, various architectural elements such as plan types, distribution systems, exit route arrangements, corridor depths, atrium and floor arrangements, and partitioning decisions will be selected, and their effects on fire and smoke spread and user evacuation will be examined.The research methodology includes a literature review, analysis of fire safety regulations, spatial investigations of selected hotel buildings, and evaluation of expert opinions. The collected data will be analyzed using Failure Modes and Effects Analysis (FMEA) and an L-type 5x5 risk matrix to measurably assess the risks generated by architectural design. Through these analyses, the risk levels of design flaws will be determined and prioritized.

The study will conclude that architectural design errors causing fire risk in hotel buildings are not random, but rather recurring and predictable errors. In this context, an original design failure taxonomy will be developed. This taxonomy will address the relationship between architectural design and fire safety within an analytical framework. It will fill a significant gap in the national literature in Turkey and provide a useful decision support tool for architects in the early design phase. In this respect, the study proposes a holistic approach that considers fire safety not merely a technical and regulatory issue, but an integral component of the architectural design process.

5.1 Evaluation of Key Findings

The findings obtained in this study have revealed that fire risk in hotel buildings is not solely dependent on technical systems, but that architectural design decisions also play a decisive role. In particular, it has been determined that spatial organization, the arrangement of escape routes, corridor lengths, and open spaces such as atriums have a direct impact on fire spread and evacuation performance. Furthermore, although existing fire regulations provide an important framework, it has been observed that in practice they are mostly addressed through minimum requirements and are not integrated holistically into the design process. This situation leads to the neglect of design-related risks. The design failure taxonomy developed in this study contributes to the systematic definition of these risks.

5.2 Recommendations and Future Studies

Based on the findings, it is recommended that fire safety be addressed from the early stages of the architectural design process and that design decisions be evaluated with a performance-oriented approach. Effective planning of escape routes, spatial simplification, strengthening of fire compartmentalization, and controlled design of open spaces are among the basic strategies for reducing risk. Future studies suggest comparative examination of different building types, the use of numerical simulation techniques, and support of analyses with larger datasets. Furthermore, increasing interdisciplinary studies that combine architecture and fire engineering disciplines will contribute to the development of more holistic solutions in fire safety.

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Conflicts of Interest

The author(s) report no conflicts of interest.

Data Availability Statement

No new data were created or analyzed in this study. Data sharing is not applicable to this article.

Institutional Review Board Statement

Ethical review and approval were waived for this study, as it did not involve human participants or personal data

CRediT Author Statement

Meryem Öztürk: Conceptualization, Methodology, Software, Formal Analysis, Investigation, Writing - Original Draft, Visualization.

Aslı Er Akan: Supervised the research process, contributed to the interpretation of findings, and critically reviewed the manuscript.

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