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Fire safety in historic buildings: A case study using the qualitative risk analysis method

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Abstract: Structural fires have long posed significant threats to human life, property, and societal stability. In the context of historic buildings, fires also risk the loss of irreplaceable cultural heritage. Ensuring fire safety in such structures requires a sensitive balance between risk mitigation and architectural conservation. This study investigates fire safety strategies in historic buildings through the restoration and renovation project of Bıçakçı Khan and Yıldız Cinema, two culturally significant structures in İzmir, Türkiye. Using Türkiye's Regulation on Fire Protection (TRFP) as the main guideline, a systematic fire safety control method was implemented through regulatory compliance checks, occupant load calculations, qualitative risk assessments (QRA), and evacuation route evaluations. The systematic fire safety control method adopts a two-step approach, in which the first step involves analysing occupant loads and architectural egress provisions, and the second step consists of conducting a qualitative risk analysis based on regulatory compliance. The study reveals that current fire safety regulations, while generally applicable, fall short in addressing the specific vulnerabilities of heritage structures. By applying a qualitative risk analysis, the research identifies the need for tailored strategies that prioritise both occupant safety and the preservation of architectural authenticity. Passive protection measures and low-impact interventions are proposed as effective means to enhance fire resilience in historic buildings. In conclusion, a systematic fire safety control method is proposed, emphasising minimal architectural intervention and the preservation of historical integrity. The study concludes with recommendations for revising current regulations and adopting performance-based approaches that integrate architectural, engineering, and conservation expertise, thereby ensuring both safety and cultural continuity.

Keywords: fire safety, historic buildings, performance-based approach, qualitative risk analysis, regulation, TRFP

1. Introduction

Structural fires cause significant loss of life and property in many countries worldwide. These losses occur for various reasons and can create serious vulnerabilities [1,2]. Global fire-related loss of life and property, fire causes, damage assessments, and outcomes vary considerably, highlighting the need for stronger fire safety strategies. Fire safety in buildings, a vital concern for all types of structures, encompasses various strategies to minimise the effects of fires. These strategies are generally divided into active and passive categories, each serving different purposes [3]. Active fire safety strategies are dynamic systems activated during a fire to intervene directly, such as fire alarm and warning systems, fire extinguishing systems, and emergency lighting systems. Passive fire protection systems are integrated into a building's structure to contain fire and smoke, ensuring compartmentalisation and maintaining the integrity of escape routes during an emergency. The main passive fire safety strategies include fire-resistant system and material specifications, firestops, fire walls, fire doors, and compartments [4-6]. Active and passive fire safety strategies provide the most effective protection when used together. While active strategies intervene in the fire, passive strategies limit and delay its spread. The correct and rational design of both strategies, combined with regular maintenance, ensures the highest possible level of fire safety. It is essential to analyse active and passive fire safety strategies for all buildings within an integrated design approach [3,7]. However, historic buildings often face difficulties in complying with the principles of active and passive fire safety strategies. For example, adding a protected fire staircase or altering the structural materials of a historic building may not be considered an appropriate conservation or restoration decision.

Fire safety strategies should be developed and detailed for historic buildings to ensure the rational transfer of cultural heritage to future generations without compromising the identity of the buildings. Performance-based fire safety strategies and principles, in line with regulations, should be adapted for historic buildings. There are several principles to be followed in performance-based fire safety approaches: (i) For fire safety strategies to be successful, fire safety objectives must first be clearly defined. These objectives should be appropriate to the organisation's needs and supported by achievable performance criteria. The criteria form essential reference points for evaluating the effectiveness of fire safety systems. (ii) The characteristics of the occupants and the property play a critical role in fire safety planning. The occupants' behaviour during a fire and their reaction to it should be considered key factors in assessing the property's risk level. In this context, training and informing occupants is important to increase their awareness of potential hazards. (iii) Potential hazards and risks must be defined in detail in fire safety planning. Different scenarios should be developed, with the potential consequences of each highlighted. At this stage, possible risk scenarios should be created by considering past fire incidents, current conditions, and environmental factors. (iv) It is important to use various tools and methods to assess fire safety performance. These assessments should be supported by modelling, simulation, and calculation methods based on available data and reasonable assumptions. Clear interpretation of the results will improve the reliability of the data obtained and demonstrate the effectiveness of the strategies developed. (v) Solutions proposed to achieve fire safety objectives should be based on the results of the assessments. This process should follow the principle of repeatability to test the applicability and effectiveness of each proposed solution. In this way, a continuous improvement process can be established, based on the results obtained at each stage [8-11].

Fires pose serious threats to the conservation of historical heritage and can cause irreversible losses. Throughout history, many important cultural assets have been severely damaged by fires, raising serious concerns about heritage preservation. Istanbul, in particular, has experienced frequent and widespread fires throughout its history, resulting in significant loss of life and property. The high number of fires, combined with their rapid spread and impact on surrounding areas, increases the overall risk [12,13]. Historic building fire incidents in Türkiye and other countries highlight the importance of further research. In 1986, the Hampton Court fire in England caused serious damage to important parts of the historic building, once again underscoring the need for heritage conservation [14]. At the historic Haydarpasa Train Station, a fire broke out on the roof in 2010, damaging most of the roof and parts of the fourth floor. The blaze, which occurred during roof improvement works, spread rapidly and became visible from many parts of Istanbul, causing significant damage to the station [15]. In 2011, all the wooden parts of the historic Kuyucak Mosque in Eskişehir, including the roof, were destroyed by a flame that leapt from the chimney. Only the walls and minaret, with thicknesses ranging from 80 to 85 cm, remained. The building was reused after an extended period of restoration [16].

In 2013, a fire broke out on the roof of Galatasaray University, causing major damage to the building. It is believed that electrical cables may have caused the fire. In addition, the absence of smoke detectors on the roof and the delayed fire notification were considered significant safety weaknesses [17]. In 2015, the Battersea Arts Centre fire in the UK destroyed an important venue for modern art, reigniting the debate on art conservation and fire safety [18]. Another tragic example is the 2018 fire at the National Museum of Brazil, in which approximately 20 million artefacts from the museum's archive were destroyed. These losses were a major blow not only to the objects themselves but also to the cultural memory of humanity [19]. In 2019, a fire broke out at Notre Dame Cathedral in Paris, causing severe damage to a building of great historical and architectural value, with devastating consequences such as the collapse of the bell tower. This incident again emphasised the urgency of protecting a significant building within the Paris World Heritage Site [20,21]. These fire incidents clearly illustrate the impact of fires on cultural heritage and reinforce the importance of fire safety strategies to prevent such events. Protecting cultural heritage means safeguarding not only historic buildings but also the collective memory of humanity.

Historic buildings are considered to be of great architectural or historical value, located in conservation areas, or of special interest because of their traditional form and construction [22]. They are important elements of our cultural heritage and unique works that must be preserved. The inadequacy of systems such as stoves, kitchens, and roof assemblies or chimneys at the time the buildings were constructed, combined with neglect, poor maintenance, and uncontrolled circulation due to high visitor numbers, increases the potential for fire in these structures [23,24]. The fire risks of historic buildings can be heightened by the flammability of building materials, structural complexity, and often limited opportunities for modernisation. Oil paints, decorations, and flammable materials such as wood and textiles used on ceilings and walls in historic buildings play a significant role in the spread of fire [25]. Factors that can make evacuation more difficult include the building being an unfamiliar space, its frequent use by tourists for assembly or accommodation, and escape routes that are insufficiently clear [26,27]. All these conditions contribute to increased fire risk. Therefore, fire safety in historic buildings is of critical importance. Ensuring it requires a delicate balance between modern safety requirements and preserving the historic fabric. For this reason, architects’ and engineers’ assessments should be sought to determine fire safety strategies and ensure compliance with fire regulations.

2. Materials and methods

In this study, a comprehensive restoration and renovation project of Bıçakçı Khan and Yıldız Cinema, part of the cultural heritage of the city of Izmir, Türkiye, was examined within the scope of fire safety strategies (Fig. 1). Bıçakçı Khan is being transformed into a complex with indoor and outdoor spaces for social and cultural events, while Yıldız Cinema is being redeveloped into a cinema museum with exhibition areas, a theatre hall with a capacity of 500 occupants, and a cinema hall with a capacity of 214 occupants. This study analyses the fire risks of Bıçakçı Khan and Yıldız Cinema, which are undergoing restoration and rehabilitation, with reference to TRFP compliance [28]. Through regulatory compliance checks and risk analysis, fire safety levels were assessed, with emphasis placed on mitigating high-risk factors during restoration. Fire safety arrangements were developed following the approval of the relevant stakeholders. The study evaluates historic buildings in the context of fire safety strategies, aiming to provide effective measures by creating qualitative risk assessments (QRA) for fire safety controls in historic buildings in accordance with regulations. With all these components, the research presents a comprehensive systematic fire safety control method and outlines future approaches. Process management highlights the planning and procedures developed in cooperation with relevant stakeholders, ensuring that fire safety strategies are effectively implemented.

Fig. 1. Current situation of Bıçakçı Khan and Yıldız Cinema. *Source:* [29,30]

Risk assessment is a process aimed at conducting qualitative or quantitative analyses of a system's risk factors and the probability of accidents, evaluating the system's risks and hazard probabilities, determining the necessary precautions, and formulating safety strategies. The goal of this process is to minimise potential hazards by adopting a system safety approach. In this research, the fire safety design practices of Bıçakçı Khan and Yıldız Cinema-historic buildings located within the same settlement and prepared under a joint restoration and renovation project-were examined. Qualitative risk assessment (QRA) methods were used, with TRFP serving as the primary reference. A checklist was created in accordance with TRFP requirements, and evacuation plans for the historic buildings were prepared. In the pre-step research phase, information about the buildings was reviewed, and site plan arrangements, interior designs, escape routes, and vertical and horizontal circulation areas were defined. The research was conducted in two steps. In Step 1, space- and floor-based occupant loads were calculated, and the suitability of existing exit doors, escape staircases, and final exit door widths was assessed. In Step 2, in accordance with TRFP principles, escape routes were incorporated into the architectural project, evacuation conditions were determined, and the qualitative risk analysis was carried out using the checklist (Fig. 2).

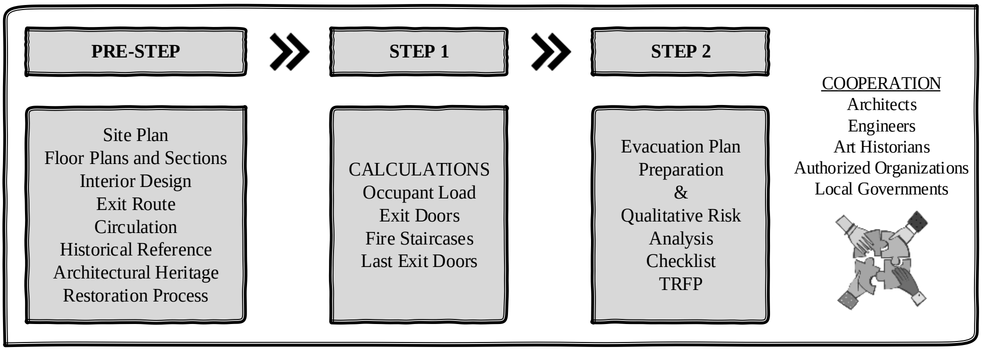

Fig. 2. Steps and process management of the research. *Source:* The authors

Bıçakçı Khan is a building constructed along the historic caravanserai route to accommodate merchants. Until the 1950s, it was used to store goods transported to and from the city, and for a period, it also served as accommodation for low-income citizens. The Khan has a rectangular plan and opens onto Kemer Street (*Kervan Köprüsü Street*) with its narrow façade. It contains a large courtyard measuring 65 metres in length and 10 metres in width [30]. This courtyard extends through the centre of the Khan, with masonry (stone) rooms arranged on both sides. The masonry walls of the courtyard feature doors and windows serving various spaces. Eventually, Bıçakçı Khan continued to be used as a warehouse by various institutions. Today, although it provides space for exhibitions and workshops, it is not used effectively.

The Yıldız Cinema building was originally designed as an open-air cinema by Ulvi Başman in 1950. In 1951, the municipality approved an indoor cinema project drawn by architect Ferrari, but it was never implemented. Instead, Şükrü Gökay's 1951 project was realised, and the present-day Yıldız Cinema was constructed. The building underwent major renovations in 1953 and 1956. Architect Yüksel Kazmirci believed that the columns in the centre of the project did not match the original design and decided to renovate them. The indoor cinema, designed and built by architect Erdoğan Tözge, opened in 1957. In 1989, under a renovation project, the cinema building was converted into a sports hall; the balconies were demolished, and the section (parterre seating area) with gradually rising seats was transformed into an artificial turf field [31-33]. The ceiling of Yıldız Cinema features opening and closing doors for ventilation. It is said that the cinema's name derives from the stars (*Yıldız*) visible at night when these doors are opened [34,35].

3. Results and discussion

In the fire safety strategies, fire brigade access to the buildings and facilities was evaluated using the site plan. According to Article 22-2 of the TRFP, in order to intervene in a building from the outside during a fire (for extinguishing and rescue activities), fire brigade access should be provided within 45 metres of the building. In particular, fire brigade access and intervention are possible via Gaziler Street and 1270 Street, as well as 1272-2 Street, where the main entrance façades of the historic Bıçakçı Khan and Yıldız Cinema buildings are located. In this renovation and restoration project, fire brigade access is planned to remain within the 45-metre limit.

The checklist created as part of the qualitative fire risk analysis enables the examination of historic buildings. For this purpose, a checklist was developed with safety strategies applicable to historic buildings in line with TRFP principles, and the two historic buildings (Bıçakçı Khan and Yıldız Cinema) were examined separately. Assessments were carried out using the checklist prepared in accordance with the requirements of the relevant regulation (TRFP). In the assessments, conditions suitable for historic buildings are marked with a ✓; requirements not relevant to historic buildings are marked as *Irrelevant*; and requirements that cannot be determined due to various special circumstances (uncontrolled or untested) are marked as *Uncertain*. In the qualitative risk analyses based on the regulation, no negative risk components were identified for the historic buildings examined (Table 1).

Table 1. Risk assessment of historic buildings. *Source:* The authors

Türkiye's Regulation on Fire Protection (TRFP-2007)		Bıçakçı Khan	Yıldız Cinema	Explanations
22	The access road to the buildings	✓	✓	
51	Assembly buildings	Irrelevant	✓	
138	Application concerning existing buildings	✓	✓	There are explanatory requirements.
139	Provisions applying to existing buildings where the intended use has changed	✓	✓	There are explanatory requirements.
140	Provisions not applicable to existing buildings	✓	✓	There are explanatory requirements.
141	Additional emergency exit and escape stairs	Irrelevant	Irrelevant	
142	Sprinkler system, fire-hose cabinet, and water inlet for fire brigade	Irrelevant	Irrelevant	
143	Detection or alarm system	Uncertain	Uncertain	A fire detection and alarm system should be used.
144	Taking the opinion of the authorised administration	✓	✓	Committee and fire department opinions have been received.
145	Stability of the load-bearing system of the building	✓	✓	
146	Emergency escape	✓	✓	
147	Exit capacity and escape distance	✓	✓	
148	Number and width of the emergency exits	✓	✓	
149	Fire safety hall	Irrelevant	✓	
150	Emergency exit requirement	✓	✓	
151	Location and arrangement of the stairwell of the emergency escape stairs	Irrelevant	✓	
152	Specifications of emergency escape stairs	Irrelevant	✓	
153	Exterior emergency escape stairs	Irrelevant	Irrelevant	
154	Winding stairs	Irrelevant	Irrelevant	
155	Ventilation of emergency escape stairs	Irrelevant	✓	

Türkiye's Regulation on Fire Protection (TRFP-2007)		Bıçakçı Khan	Yıldız Cinema	Explanations
156	Basement emergency exit stairs	Irrelevant	Irrelevant	
157	Doors of escape	✓	✓	
158	Residential buildings	Irrelevant	Irrelevant	
159	Emergency escape stairs and exits in the buildings according to their intended use	Irrelevant	✓	
160	Lifts	Irrelevant	Uncertain	Lifts should not be used during a fire.
161	Detection and alarm system	Uncertain	Uncertain	A detection system should be used in accordance with Article 75.
162	Cables	Uncertain	Uncertain	Cables should be used in accordance with Article 83.
163	Pressurisation system	Irrelevant	Irrelevant	
164	Fixed pipe system and fire hose cabinets	Uncertain	Uncertain	Fixed pipes and fire hose cabinets should be used in accordance with Article 94.
165	Sprinkler system	Uncertain	Uncertain	Sprinkler systems should be used in accordance with Articles 96 and 165-1d.
166	Water inlet installation for fire brigade	Uncertain	Uncertain	A water inlet installation should be used in accordance with Article 97.
167	Storage and use of hazardous materials	Irrelevant	Irrelevant	
167	Historical Buildings (Chapter Eleven)	✓	✓	

The lack of transitions or connections between the buildings, within the framework of fire evacuation facilities in the project, requires the evacuation capacities of the two buildings to be evaluated independently. The occupant load within the project's scope is considered space-based, as the single-storey spaces on the ground floor plan provide direct access to a safe area (outdoor environment). However, for the Yıldız Cinema building (ground, first, second, and upper hall floors), since common escape routes are used, floor- and building-based occupant load assessments were carried out. Total exit door widths, staircase widths, and final exit door widths were calculated based on the occupant load. Table Annex-5/B in TRFP was used to determine the required escape door and staircase widths. To apply Table Annex-5/B, it is necessary to calculate space- and floor-based occupant loads, which were determined using Table Annex-5/A [28]. The occupant load of Bıçakçı Khan was determined to be 942 occupants for the ground floor. The occupant load of Yıldız Cinema was calculated as 384 occupants for the ground floor, 309 for the first floor, 178 for the second floor, and 215 for the upper hall. The highest occupant load was recorded on the ground floor across all floors. Exit doors and escape staircases required for fire evacuation of the historic Bıçakçı

Khan and Yıldız Cinema were calculated separately for each floor plan. Calculations were performed using the following equation, and the total required exit widths were determined (Eq. 1).

$$Exit\ Width = ((Occupant\ Load) / (Number\ of\ People\ per\ Unit\ Width) * Unit\ Width) \quad (1)$$

The occupant load is calculated by dividing the gross or net area by the occupant load coefficient (Annex-5/A, TRFP), depending on the characteristics of the space (Eq. 2) [28]. The number of occupants per unit width should be taken from Table Annex-5/B in the regulation. Unit width is calculated using a fixed value of 50 cm (0.5 m if expressed in metres). Since Bıçakçı Khan has an architectural plan in which each space on the ground floor has its own escape route, the total widths of exit doors and escape staircases were not calculated. In this context, there is no cumulative occupant density serving multiple spaces. However, in the historic building, escape doors were checked against the occupant load of each space. According to the data in Table Annex-5/B, the minimum width of exit doors is set at 100 cm, while other doors and corridor doors must be at least 80 cm wide. The minimum width of escape staircases is set at 60 cm (TRFP, Table Annex-5/B) [28]. All door and staircase widths in the project were found to comply with these principles (Table 2).

$$Occupant\ Load = ((Area\ of\ the\ Space) / (Occupant\ Load\ Coefficient)) \quad (2)$$

Table 2. Total occupant loads and analysis of exit doors and escape staircases. *Source:* The authors

Buildings / Spaces	Occupant Load	Exit Doors (m)	Escape Staircases (m)
Bıçakçı Khan			
Ground Floor: Ateliers, exhibition spaces, working areas, event spaces, concert and conference halls, service areas, administrative units, video screening area, cafés and their kitchens, a large open space, and a social environment.	942 occupants*	-	-
Yıldız Cinema			
Ground Floor: Theatre hall (500 occupants), preparation units, entrance, foyer and service areas, cafés and their kitchens, storage.	384 occupants	Existing: 2.60 Required: 1.92 L.E.D.:** Existing: 3.55 Required: 1.54	-
First Floor: Theatre hall (500 occupants), cinema museum exhibition area, and preparation units (cafeteria, etc.).	309 occupants	Existing: 3.50 Required: 1.54	Existing: 2.50 Required: 2.06
Second Floor: Cinema museum exhibition area and preparation units (backstage, preparation rooms, etc.).	178 occupants	Existing: 1.80 Required: 0.89	Existing: 2.50 Required: 1.18
Upper Hall Floor: Cinema hall (214 occupants), storage.	215 occupants	Existing: 2.50 Required: 1.07	Existing: 2.50 Required: 1.43

* Spaces were designed independently from each other. The total occupant load was evaluated on a space basis.

** L.E.D.: It refers to the last exit door.

In the Bıçakçı Khan and Yıldız Cinema restoration and renovation project, the maximum allowable two-way travel distance with the use of sprinkler systems are set at 60 m, while the maximum one-way travel distances (*common path*) are set at 25 m (TRFP, Table Annex-5/B). The fire risk analysis was prepared on the assumption that sprinkler system design will be incorporated into the restoration and renovation projects. Fire evacuation for the historic buildings is based on Article 147-5 of the TRFP. In this context, if one of the two staircases in the project is a protected fire escape staircase, the two-way exit distances are evaluated for the entire building. Furthermore, Article 167/C-11 of the TRFP, which concerns the protection of the physical and visual integrity of historic buildings, states that existing staircases can be used as fire escapes. Based on these principles, the exit distances in all floor plans are within the required limits according to TRFP guidelines. In this study, potential fire and smoke scenarios were qualitatively evaluated for each structure in accordance with the guidelines of Türkiye's Regulation on Fire Protection [28]. The assessment was based on the architectural layout, material characteristics, and current restoration phases. As part of the qualitative risk assessment, fire spread scenarios were developed by identifying critical transmission pathways, such as vertical shafts, voids, and combustible historic timber elements. Based on these findings, passive fire safety measures that can be implemented without compromising structural integrity were proposed. These include creating fire-resistant compartments, installing fire-rated doors, protecting or reinforcing combustible materials using intumescent coatings, and integrating emergency signage and lighting systems supported by smoke-sealed solutions along escape routes. This approach enabled a realistic yet non-invasive evaluation of hazards, which is especially important in preserving the architectural authenticity of heritage structures. The assessment of storage-related risks took into account the functional zoning plan of the buildings. In both Bıçakçı Khan and Yıldız Cinema, areas such as storage rooms, service areas, kitchens, and auxiliary spaces were evaluated for their fire load potential. Storage practices were recommended to comply with compartmentation regulations, with fire-resistant enclosures provided where necessary. These measures aim to minimise ignition sources and delay fire spread in the event of an incident. In theatres, conference halls, seminar halls, and meeting halls, fixed seating arrangements should comply with Article 51 and Annex-6 of the TRFP. In the historic building, the distance between seats in the theatre hall designed for Yıldız Cinema was measured at 40 cm.

Bıçakçı Khan offers direct escape to the outdoor environment through its ground floor plan. A mezzanine floor at +5.00 level is planned for the exhibition hall and café. Escape routes for these added sections are indicated in the fire evacuation plans. Occupants in these spaces can reach the safe area directly according to both one-way and two-way exit principles. It has been specified that the system room, panel room, low-current room, and main panel room in the storage areas should be designed as fire compartments (blue colour) (Fig. 3).

Yıldız Cinema consists of ground, first, second, and upper hall floor plans. In addition to the ground floor, a basement level at –1.40 m was created solely for the fire water tank and pump room. There are two fire staircases and one open circulation staircase in Yıldız Cinema. Under the relevant regulations, the open circulation staircase is also used as an escape staircase during a fire. The cafés on the ground floor have direct exits. The theatre hall planned for performances has two fire escapes on the ground floor and one on the first floor. The width of the exit doors was calculated based on the occupant load distribution, and the corresponding requirements were determined. From the first floor, a wide terrace is accessible. The fire escapes and fire buffer zones on the ground and first floors are specified according to the required fire resistance rating (blue colour) (Fig. 4, Fig. 5).

Fig. 3. Fire evacuation on the ground floor in the historic Bıçakçı Khan (green lines indicate escape routes. The plan layouts on the right show the mezzanine floor plans at +5.00 m). *Source:* The authors

Fig. 4. Fire evacuation on the ground floor in the historic Yıldız Cinema (green lines indicate escape routes. The plan layouts on the right show the basement floor plans at –1.40 m). *Source:* The authors

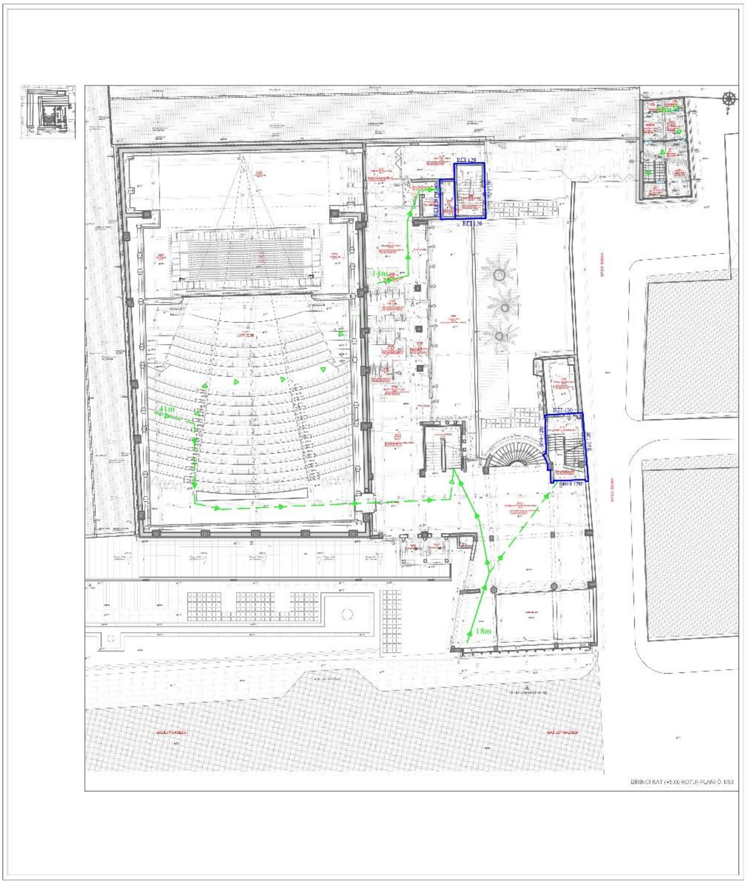

Fig. 5. Fire evacuation on the first floor in the historic Yıldız Cinema (green lines indicate escape routes). *Source:* The authors

Two different escape alternatives are provided from the cinema museum exhibition area on the second floor. There is no access to the theatre hall (main hall) from this level. For this reason, the backstage units and the cinema museum exhibition areas are designed as independent spaces. A large terrace is accessible from the foyer on the second floor. The fire escapes and fire buffer zones on the ground and first floors are specified according to the required fire resistance rating (blue colour) (Fig. 6).

Two escape alternatives are provided for the 211-capacity cinema hall located on the upper floor of Yıldız Cinema. The area behind the cinema curtain in the hall was designed as a soffit for the theatre hall. The cinema hall was constructed using a lightweight building technique. Protected fire staircases connect the inside of the cinema hall directly to the terrace, and from the terrace to the fire staircase. The ventilation openings in the ceiling of the hall have been preserved throughout its history. A large foyer area was created for the cinema hall, and from the foyer, a terrace is also accessible. The fire escapes and fire buffer zones on the ground and first floors are specified according to the required fire resistance rating (blue colour) (Fig. 7).

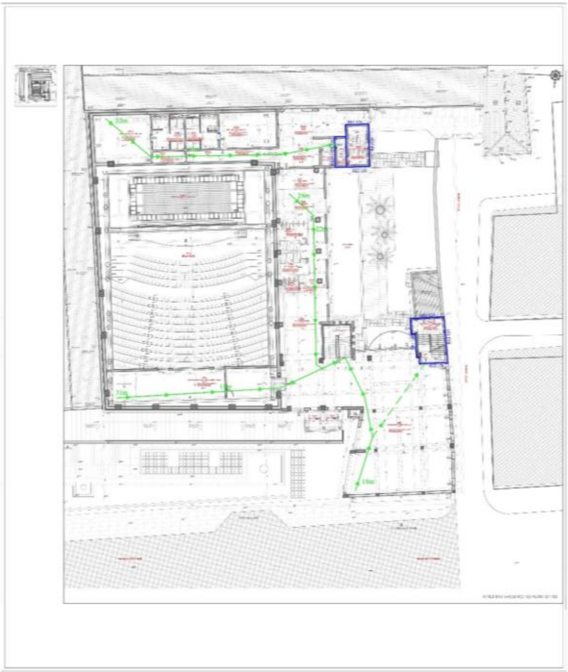

Fig. 6. Fire evacuation on the second floor in the historic Yıldız Cinema (green lines indicate escape routes). *Source:* The authors

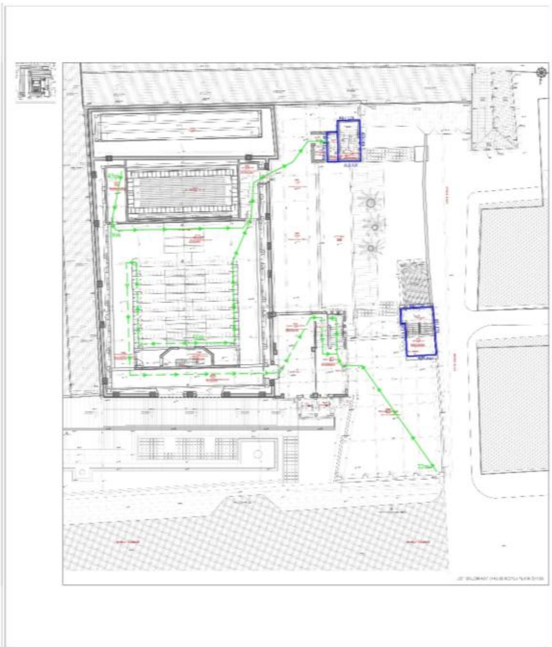

Fig. 7. Fire evacuation on the upper floor in the historic Yıldız Cinema (green lines indicate escape distances). *Source:* The authors

The systematic fire safety control method was applied to the Bıçakçı Khan and Yıldız Cinema buildings, planned after the restoration and renovation process, as part of the examination of fire safety strategies for historic buildings. The fact that the historic Bıçakçı Khan is a single-storey structure with direct exits was found to be appropriate in terms of fire safety strategies. In contrast, the multi-storey floor plans and high occupant load in Yıldız Cinema were identified as factors that increase fire risk. Based on the qualitative risk assessments (QRA) conducted for both Bıçakçı Khan and Yıldız Cinema, several key fire protection strategies were identified, aiming to balance regulatory compliance, occupant safety, and heritage preservation. These include the implementation of passive fire protection measures such as the creation of fire-resistant compartments, installation of fire-rated doors, protection or reinforcement of combustible materials using intumescent coatings, and integration of emergency signage and lighting systems. The analyses also revealed critical risks posed by vertical shafts and voids, which were addressed through tailored fire compartment strategies designed to avoid structural damage. At the same time, the planning of effective and rational escape routes was considered of great importance. Furthermore, based on prescriptive regulation-particularly the Provisions Applicable for Existing Buildings (Chapter 10) and Historical Buildings (Chapter 11) – fire evacuation plans were created in compliance with the regulation by meeting the necessary conditions and incorporating the consensus of various stakeholders. Multi-stakeholder participation in the planning process increases the likelihood of success in fire risk management [36]. Deficiencies in the TRFP regarding fire safety in historic buildings were identified. Issues highlighted in the regulation's checklist should be addressed by increasing the fire resistance of structural materials, creating compartments, limiting both fire load and occupant load, reducing the use of heat sources in the fire triangle, and enhancing active fire safety strategies [37-39]. This context underscores the need to develop national regulations and refine them through the application of different risk analysis methods.

Additionally, the diversity of historic buildings – in terms of construction systems, spatial characteristics, façades, roof assemblies, and other unique structural features – necessitates the adoption of performance-based regulations [40-42]. This research highlights the fire safety strategies that should be applied to Türkiye's historic building stock, particularly for functions with high occupant loads. It also emphasises the importance of developing tailored regulations for historic buildings and refining them with diverse risk analysis methods.

4. Conclusions

Fire safety in buildings requires an approach that not only prevents a fire from starting but also ensures it is quickly brought under control and ends with minimal damage. In this process, applying risk assessments and following the relevant legal requirements is essential. The coordinated implementation of risk assessments and legal procedures contributes to the protection of the building and to the safety of the lives and property of its occupants. Fire safety, particularly in historic buildings, is crucial for protecting cultural heritage and ensuring its transfer to future generations. In restoration, renovation, or reuse projects involving historic buildings, the building's historical nature imposes many restrictions. In critical areas such as fire safety, strategies must be meticulously planned to avoid damaging the building's original features. This process requires collaboration between multiple disciplines – art historians, architects, engineers, and relevant authorities – so that joint decisions can be made. Interventions should therefore be evaluated not only from a technical perspective but also in terms of cultural and aesthetic values.

In this study, the historic Bıçakçı Khan and Yıldız Cinema were analysed. The systematic fire safety control method, based on qualitative risk assessments (QRA) and regulatory principles, was developed using checklists and applied separately to each building. The occupant load of the historic buildings was also calculated, and the suitability of escape routes and exit widths was assessed. In the risk assessments carried out under the regulation, no negative risk components were identified for the historic buildings. However, this study's fire risk analysis was limited to the TRFP. Given that current fire regulations are primarily designed for modern buildings, it is evident that these regulations are often insufficient for historic structures. In particular, the regulations used in planning qualitative and quantitative fire risk assessments may fail to provide adequate safety strategies, potentially leading to negative outcomes in the event of a fire. When addressing fire safety in historic buildings, it is essential to develop solutions that involve minimal intervention to the structure. If strategies are inadequate or incomplete, the damage caused by fire to the building and its occupants could be far greater and more irreversible than any physical damage resulting from the intervention itself. In this context, building-specific risk assessments should aim to ensure maximum safety with the minimum intervention necessary to protect the building's historic value. Developing performance-based solutions and planning for buildings with flexible fire safety strategies is therefore essential.

For future research, it is recommended that performance-based analyses be conducted alongside prescriptive regulations in addressing fire safety in historic buildings. Determining the fire risks of historic structures should include an analysis of fire load, ensuring effective and timely evacuation of occupants, performing smoke analysis for possible fire scenarios, and investigating fire spread within the building to protect cultural heritage. Future studies should also consider applying different quantitative and qualitative risk analyses and comparing their results. In conclusion, applications should be developed with an approach that considers both the historical identity of the building and occupant safety, achieved through interdisciplinary cooperation and a comprehensive analytical process.

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