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Method for Determining Fire Risks at Urban and Building Scale on Hospital Facades

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Abstract: Facade fires pose risks to life and property safety for building users. This study aims to analyze the fire risks on hospital facades that pose a danger to the structure. Within the scope of the study, fire risk analyzes were carried out on the facades of four small-scale hospitals located in the Nilüfer district of Bursa, Turkey. In the study, a checklist was created within the scope of the (BYKHY) and an on-site current situation analysis and fire regulation compliance analysis were carried out. Based on this, fire risk analysis was carried out in the context of the facades of the buildings in question using the L-type Matrix Method, which is one of the quantitative methods. In the L-type matrix method, the probability of risks occurring and the severity of the consequences that may occur when they occur are graded between 1 and 5. Accordingly, 4 risk groups were identified as a result of the fire risk analysis conducted in the context of hospital facades with the L-type Matrix method. As a result of these headings, 11 possible risks were identified. The possible causes, degree and severity of these risks were studied. It is suggested that the main results be introduced.

Keywords: Hospital; Facade; Fire Risk; Fire safety performance; L-type Matrix.

ABBREVİATİONS:
BYKHY: "Regulation on the Protection of Buildings from Fire. In accordance with the Presidential Decree".
BF: Building Façade

1. Introduction

Facades play an essential role in the spread of fires in buildings. The first goal in firefighting is to prevent the risk from سoccurring, and when this is not possible, to suppress it where it starts, to prevent it from growing and spreading inside, outside or around the building, and to ensure that it is extinguished. For fire safety, which is attempted to be ensured under legal obligations in societies where security awareness is not fully developed, the locations, physical characteristics, planning decisions, user profiles, etc. of the buildings should be taken into consideration from the design stage) BEYHAN,2018) .

Buildings with materials that transmit flames, facades with dry and green plants that accelerate the progress of flames, and facades that transmit smoke and produce and store energy with a risk of ignition pose a safety risk for those living in them, as well as putting the safety of the city and nearby buildings at risk. It may also cause significant economic losses in case of a possible fire. For this reason, fire safety, which should have a leading role among the design concerns of architecture, is also important in terms of new facade structures that have started to be

widely used in buildings, especially in the context of facade geometry, selected structural system, construction materials and application details in ensuring the fire safety of multi-storey buildings with large surface areas requires great attention.

The risk of fire can be minimized by evaluating possible risks and taking precautions to protect buildings from fire. Assessment of fire risk in buildings is a process in which different methods can be used. to determine the acceptability level of risks and the appropriate measures that can be taken for unacceptable risks. When the literature is examined, it can be seen that there are various studies using the L-type matrix method in fire risk analysis. Many different methods can be used in line with this goal, such as "Fault Tree Analysis, Event Tree Analysis, 'What If?' Analysis, Cause-Effect Analysis, Fine-Kinney Method, Ridley Method, "L-Type Matrix Method, X-Type Matrix Method" (CEYLAN ve BAŞHELVACI S., 2011). By taking various precautions as a result of fire risk assessment, it is aimed to reduce the risk of fire and therefore undesirable consequences such as death, injury and material loss/damage as much as possible" (Baytemür Özlem , 2019) . In the studies conducted by Oruç (ORUÇ PINAR , 2023) The L-type matrix method analyzes fire risks in different building typologies. Accordingly, Kendir et al. (KENDİR et al , 2020) calculated the risk levels of each unit in a military facility regarding fire risk.

After determining the units with very high and high risk levels, suggestions are made for these areas, and it is emphasized that reducing the fire risk will be possible by increasing user awareness as a result of the study. Oruç (ORUÇ PINAR , 2023) carried out fire risk analysis using the L-type matrix method on the sustainable buildings he selected within the scope of the study. As a result of the study, it was determined that the most crucial parameter that increases the fire risk level is building design features. However, fire safety measures depend on many parameters. Building usage type, number of users and their characteristics, possible fire risks, structural characteristics of the building and its environment can be given as examples of these parameters (ŞİMŞEK, Z., AKINCITÜRK, N, 2023).

Therefore, evaluating structural, environmental and user-related parameters in a holistic manner is a criticalessential issue in terms of choosing appropriate analysis methods to determine the fire risk that may occur in buildings and taking appropriate measures to reduce the fire risk (YEMİŞÇİOĞLU, Ş., ŞİMŞEK, Z , 2023) .

Fires that have occurred on the facades of hospital buildings throughout history stand out in their different aspects, such as risk levels, causes, and deficiencies in the precautions to be taken. The poor fire behavior of facade materials is one of the factors that increase the fire risk, and therefore the fire risk categories (ŞİMŞEK, Z., AKINCITÜRK, N, 2023). The loss of life, injuries, and material damage reveal the issue's importance. In addition, in the examples examined, it is seen that deaths and injuries occur due to the rapid spread of fire from floor to floor through the facades. Facade fires engulfed the building within seconds, which made it unusable. Moreover, if it is not removed, it can quickly spread to Neighboring structures and cause complete burning of residential areas. In this context, fire risks in hospital buildings also need to be evaluated. This study aims to analyze the fire risks on the facades of hospital buildings based on sample structures and make recommendations. In the study, only facade features were examined according to fire regulations. The factors that will affect ignition and spread were determined, and based on these features, risks were determined and evaluated through 4 hospital structures located in the same district within the urban fabric and in a location that is effective in the spread of fire in terms of the BURSA city – TURKEY. For the study, primarily during the literature review phase, Fire regulations relating to fires, past fires and facades were examined. The facades of the hospitals selected within the scope of the study were examined on-site with a checklist created within the scope of the "Regulation on Fire Protection of Buildings" (BYKHY,2021), published in 2021, in the first phase.

Based on this, a fire risk analysis was carried out in the context of the fire front of the concerned hospital using the L-type Matrix Method, one of the quantitative methods. Fire risks were revealed, and suggestions were made.

2. Facade Fires

With the increase in building facade construction techniques and material types, the number of fires occurring on the facades has increased significantly. For this reason, the thermal insulation materials used on facades have

been limited and a trend has begun to emerge towards facade materials with high fire resistance (ÇOBAN ONUR, 2021). Factors affecting the formation and development of facade fires,

- Window opening ratio
- Use of flammable materials in adjacent buildings.
- Flammability of thermal insulation materials,
- Flammability of curtain wall materials,
- Spread of smoke and fire on double-layer facades,
- Use of energy production systems on the facade,
- Using green plants on the facades,

Parameters such as the details applied between the floors on the facade and the combustion properties of the insulating materials affect the spread speed of a fire that starts on the facade. For this purpose, exterior materials should be selected with the features specified in fire regulations, depending on the height of the building (YENIAY and ARPACIOĞLU ,2021)In addition to the thermal insulation materials used in the facade, the selection of curtain wall coverings and a transfer system that will not transmit fires, depending on the height of the building, is an important precaution that prevents the development of the fire. Firewalls that will stop the spread of fire to neighboring buildings are among other precautions that can be taken.

The window area ratio plays an important role in fighting fires because the expansion of the window area allows the fire to spread more quickly from one floor to another and because smoke spreads into the building through broken windows and window gaps along the facade due to the fire.

With sustainable construction, we see that heat production systems and green plants on the facade have begun to be widely used. While energy-producing photovoltaic panels and adaptive facades are the source of ignition, green facades are fuel for the fire's progress.

Types of facades that are created as a second addition to the facade of an existing building are called double-layer facades. There may be a twenty to two hundred centimeters gap between the outer and inner shells. In addition to providing air circulation, this space provides controlled ventilation according to summer and winter heating needs. In addition to providing natural ventilation, it contributes to thermal insulation, acoustic problems, and reducing the temperature coefficient. Considering the disadvantages, they include cost, overheating, and maintenance. In addition, what is most harmful in the event of a fire is that it creates a chimney effect in the air gap (YAMAN, M., DEMIREL, F,2020).

The division of facades into sections in double-layer facades is essential issue of fire safety. The spread of smoke and flame varies depending on the facade sections. The performance of each type of box, corridor, column, and multi-floor facade in the event of a fire varies.

The impact and importance of materials used in building facades in ensuring fire safety in buildings was once again revealed in the fire at "Gazi Osman Paşa" Training and Research Hospital. The fire, which broke out in the bottle waste bin located in front of the facade, spread to the entire facade in a short time and caused serious damage due to the use of materials and details that did not comply with the applicable regulations in the curtain wall and the regulations applied to the hospital facade. According to the report dated April 11 prepared by the Istanbul Metropolitan Municipality (IMM) European Side Fire Department; The fire, which occurred at approximately 17:00 on April 5, 2018, broke out in a bottle waste bin behind household waste containers facing the inner courtyard (morgue courtyard), where Blocks A and D and the connecting corridor between the morgue are located. Blocks from the border, opposite the entrance to the morgue in the second basement, it began when a person lit a fire source that he threw or dropped, Which led to the fire igniting In the trash around the money box (BEYHAN,2018) .

Figure (1). Gazi Osman Paşa Hospital fire.
Source; Figen Beyhan,Y. Evser Civelek,Sevinç Çetin) BEYHAN,2018) .

The fire spread in a short time, as the garbage ignited and spread to the external cladding materials and the insulating materials underneath. The whole exterior part of the blocks overlooking this section of the building was partially distributed over the interior and roof (BEYHAN,2018) .

3. Bykhy Provisions Relating to Facades

The Fire Protection Regulation for Buildings, which is still valid in our country today, came into force in 2002, and was renewed in 2007, took its final form with the "Regulation on Amendments

Table (1). Façade fire risk analysis in the context of BYKY provisions

BYKHY Related Article		Risk Groups		The Potential Risks	Probability Value	Severity Value	Risk Value
The Second Chapter /Third Part Article 27(1)		Building height more than 28.50 m.	Using flammable materials on exterior surfaces	spread of fire.			
		Building height is less than or equal to 28.50'.					
		Creating a surface filled without fire-resistant façade elements with a height of at least 100 cm vertically between unprotected spaces such as windows on two floors.		It becomes easier for the fire to move from one floor to another.			
The Second Chapter /Third Part Article 27(2)	A	Lack of certification with standards regarding the thermal insulation system, thermal insulation adhesive, nails or plaster mesh.		Spread of smoke and fire.			
The Second Chapter /Third Part Article 27 (2)	B	The exterior facade consists of a barely flammable material or system, and the 1.5 m distance above the level of natural or planer ground is not covered with any flammable material.		It becomes easier for the fire to move from one floor to another.			
		In buildings with a height of more than 6.50 m, fire barriers create with flammable materials with side edges of window and similar gaps more than 15 cm and the upper edge more than 30 cm.		It becomes easier for the fire to spread from one floor to another and spread easily throughout the building.			
The Second Chapter /Third Part Article 27(3)	A	Failure to insulate the joints of façade elements and floors that do not have gaps through which fires can pass.		Spread of smoke and fire.			
The Second Chapter /Third Part Article 27(3)	B	Facade and insulation materials used in buildings with open joints or ventilated curtain wall systems are flammable.		Spread of smoke and fire.			
The Second Chapter /Third Part Article 27(4)		The extensions made to the outside of the building are not fire resistant.		It threatens the lives of building users and causes fire to spread more easily.			
The Second Chapter /Third Part Article 42(2)		There is a gap in the curtain wall less than 3 meters from the external escape stairs.		Smoke and fires damage the fire escape, making evacuation difficult.			
The Second Chapter /Third Part Article 22(4)		The fire brigade should not approach within 45 meters.		Intervention becomes difficult			
The Seven Chapter / Second Part Article 97(1)		Fire brigade water supply connection is inadequate		Intervention becomes difficult			

(BYKHY ,2021)

to the Fire Protection Regulation for Buildings" in 2009, and was revised again in 2021 (BYKHY ,2021).

The regulation includes general principles, permissions and responsibilities, building use categories, building hazard classification, cabin characteristics, materials, escape methods, stairs, rules relating to building sections and facilities, installations and electrical systems, smoke control, fire extinguishing systems, storage and use of hazardous materials, and safety responsibility of fire and fire training, and provisions related to fire safety systems that will be applied in existing buildings. Under Presidential Decree No. 4825 dated 11/19/2021 published in the Official Gazette No. 31665 dated 11/20/2021, this regulation has been added to the Presidential Regulations section.

The fire fighting systems of the Republic of Turkey were evaluated in detail through the comparative analysis method. Within the scope of the review, façade materials, fire barriers, façade openings, distances between buildings, durability of external walls, automatic extinguishing systems and distances required for firefighter intervention were discussed (Table 1).

4. Materials and Methods

The study aimed to identify fire risks encountered on facades and create risk mitigation methods. The risk analysis of the facades was carried out in 3 stages and the proposed method was tested on the facades of 4 hospital buildings located in the dense tissue of the city in the Nilüfer district of Bursa in Turkey, where the risk of fire spreading to neighboring structures is higher.

1. In first Phase, the facades of the four most prominent hospitals in different regions of Turkey's Bursa province selected within the scope of the study (first Hospital, seconde Hospital, third Hospital and fourth Hospital) (fig 2.) were constructed within the scope of the "Regulation on Fire Protection in Buildings" (BYKHY, 2021) . A checklist was created and examined on site.

2. The second Phase: In this stage, fire risk analysis was carried out in the context of fire facades of the involved buildings, using the L-type Matrix Method, one of the quantitative methods. In the L-type matrix method, the probability of risks occurring and the severity of the consequences that may arise are graded between 1 and 5 (Tables 2 and 3). Afterwards, the probability and severity values are multiplied by the 5x5 matrix table to determine the risk levels as high, medium, and low (BUTURAK ve YAPICI ,2022) and (SELÇUK, S., HALUK, 2021) (Table 4). The hospitals selected within the scope of the study were examined on-site during work hours.

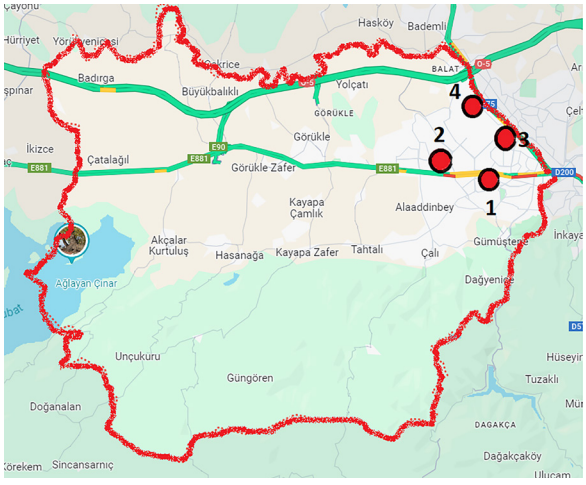

Figure (2). Map showing the locations of four hospitals in Nilüfer /BURSA

Table (2). Probability definition and values

Frequency	Definition of Probability	Probability Value
Once a year	Very small	1
Quarterly	Small	2
Once in a Month	Middle	3
Once a week	High	4
Every day	Very high	5

Table (3). Definition of the degree and values of fire violence

Incident	Definition of Violence	Value of Violence
Does not require first aid	Very light	1
Requiring outpatient first aid	Light	2
Inpatient treatment with minor injury	Middle	3
Long-term treatment with severe injury	Serious	4
Loss of life	Very serious	5

Table (4). Risk levels

		Violence				
		Very high	**Serious**	**Middle**	**Light**	**Very Light**
		5	4	3	2	1
Very high		**Very high**	**Very high**	**Very high**	**Middle**	**Light**
Possibility	**5**	25	20	15	10	5
	Serious	**Very high**	**Very high**	**Middle**	**Middle**	**Light**
	4	20	16	12	8	4
	Middle	**Very high**	**Middle**	**Middle**	**Light**	**Light**
	3	15	12	9	6	3
	Light	**Middle**	**Middle**	**Light**	**Light**	**Light**
	2	10	8	6	4	2
	Very light	**Light**	**Light**	**Light**	**Light**	**Light**
	1	5	4	3	2	1

On the other hand, the fact that the L-type matrix method can be applied at different scales, can be easily used on the data obtained, and can provide precautionary recommendations in more detail due to the risk factors being determined one by one, also supports the choice of this method.

When the literature is examined, it can be seen that various studies are using the L-type matrix method in fire risk analysis. For example, in the studies conducted by Kendirli et al. (KENDİR et al, 2020) and Oruç (ORUÇ PINAR , 2023), it is seen that fire risks in different building typologies are analyzed by the L-type matrix method. Accordingly, Kendir et al. (KENDİR et al, 2020) the risk levels of each unit in a military facility in terms of fire risk are calculated.

After determining the units with high and very high risk levels, suggestions are made for these areas. It is emphasized that reducing the fire risk will be possible by increasing user awareness due to the study. Oruç) ORUÇ PINAR , 2023) , carried out fire risk analysis using the L-type matrix method on the sustainable buildings he selected within the scope of the study. As a result of the study, it was determined that the most crucial parameter that increases the fire risk level is building design features. As a result of the fire risk analysis carried out in the context of hospital facades with the L-type Matrix method, four risk groups were identified.

- First risk group: properties of materials that facilitate the spread of fire.
- Second risk group: the relationship of the building facade with neighboring structures.
- Third risk group: openings in the building (doors and windows), fire escapes and openings in the building.
- The fourth risk group: factors affecting the rapid fire response process of fire brigades.

Table (5). Risk evaluation

Source of Danger	Group Name	Danger group		Possible Risks	Probability Value	Severity Value	Risk V.
Fcade Fres	properties of materials that facilitate the spread of fire	Building height is more than 28.50 m.	Using flammable materials on exterior surfaces	spread of fire.	3	5	15
		Building height is less than or equal to 28.50'.	Using flammable materials on exterior surfaces	spread of fire	3	4	12
		Creating a surface filled without fire-resistant façade elements with a height of at least 100 cm vertically between unprotected spaces such as windows on two floors.		It becomes easier for the fire to move from one floor to another.	3	4	12
		Lack of certification with standards regarding the thermal insulation system, thermal insulation adhesive, nails or plaster mesh.		Spread of smoke and fire.	3	5	15
		The exterior facade consists of a barely flammable material or system, and the 1.5 m distance above the natural or planer ground level is not covered with any flammable material.		It becomes easier for the fire to move from one floor to another.	4	5	20
		In buildings with height of more than 6.50 m, fire barriers create with flammable materials with side edges of window and similar gaps more than 15 cm and the upper edge more than 30 cm.		It becomes easier for the fire to spread from one floor to another and spread easily throughout the building.	4	5	20
		Failure to insulate the joints of façade elements and floors that do not have gaps through which fires can pass.		Spread of smoke and fire.	3	4	12
		Facade and insulation materials used in buildings with open joints or ventilated curtain wall systems are flammable.		Spread of smoke and fire.	4	4	16
	The relationship of the building facade with neighboring structures	The extensions made to the outside of the building are not fire resistant.		It threatens the lives of building users and causes fire to spread more easily.	3	5	15
	Openings in the building (doors and windows), fire escapes and openings in the building.	There is a gap in the window wall less than 3 meters from the external escape stairs.		Smoke and fires damage the fire escape, making evacuation difficult.	3	5	15
	Factors affecting the rapid fire response process of fire brigades.	The fire brigade cannot approach within ıeters.		Intervention becomes difficult	4	5	20
		Fire brigade water supply connection is inadequate		Intervention becomes difficult	3	5	15

Table (6). Risk value table after applying the Suggestions

Group Name	Risk V.	Suggestions	Probability Value	Severity Value	Risk V.
properties of materials that facilitate the spread of fire	15	Do not use flammable materials on external surfaces.	2	3	6
	12	Do not use flammable materials on external surfaces.	2	2	4
	12	Creating a surface filled with high fire resistant facade elements.	2	3	6
	15	There must be certification with standards regarding the thermal insulation system, thermal insulation adhesive, nails or plaster mesh.	2	3	6
	20	The exterior should be made of fire-resistant material or system.	2	3	6
	20	The side edges of the window and similar gaps should not be less than 15 cm, and the upper edge should not be less than 30 cm.	2	3	6
	12	The joints of facade elements and floors that do not have gaps through which fires can pass must be insulated.	1	5	5
	16	Do not use flammable materials on external surfaces.	2	3	6
The relationship of the building facade with neighboring structures	15	Extensions made to the outside of the building must be fire resistant.	2	3	6
Openings in the building (doors and windows), fire escapes and openings in the building.	15	The windoor or any gap İn the facade shoud be more than 3 meters away from the external escape stairs.	2	3	6
Factors affecting the rapid fire response process of fire brigades.	20	Fire brigade approaching 45 meters away.	2	2	4
	15	Fire brigade water supply connection is sufficient	1	5	5

As a result of these main headings, 11 sub-headings defining the risks were determined. A risk value was calculated for each determined heading. Accordingly, probability values are classified from 1 to 5, from very small to 5. Very high risk values were classified from 1 to 5, from very mild to very serious. Then severity levels were obtained by multiplying these two values within the range of the L-type matrix method. To protect hospital facades from fire. Accordingly, probability values are graded from 1 to 5, in the very small to very high range, and severity values are graded from 1 to 5, in the very mild to severe range. Then, in the context of the L-type Matrix method, risk levels were obtained by multiplying these two values. In the 3rd stage, the last step of the method, suggestions were made to reduce the risk values of the facades and the data were calculated again. As a result of the study, the factors that reduce the risks were determined and classified, and the problems encountered in reducing the risks were revealed.

5. Research Findings and Discussıon

In this section, the risks presented were tested on 4 hospital structures with the risk analysis table method obtained by multiplying the probability and severity values. (Table 7) displays structural information of buildings for the four selected hospitals in Bursa.

Table (7). Structural information of buildings

Building Information	**1. Hospital**	**2. Hospital**	**3. Hospital**	**4. Hospital**
Location	NİLÜFER Bursa	NİLÜFER Bursa	Mudanya Road Nilüfer/ Bursa	Osman gazi Bursa
Ordinance type	Separate System	Separate System	Separate System	Separate System
Structure Usage type	Hospital	Hospital	Hospital	Hospital
Date of Use	**2018**	**2004**	**2011**	**.....**
Number of floors	18 Building Height: 61,80 m	11 Building Height 35,80 m	7 Building Height 22,50 m	9 Building Height 28,50 m
Floor area	42,000 m^2	30.067 m2	21,000 m^2	.....
facade materials	metal, glass, concrete	metal, glass, concrete	metal, glass, concrete	metal, glass, concrete
Create a border	Empty	Empty	Empty	Empty
Heating Type	Natural gas	Natural gas	Natural gas	Natural gas
Usage Units	Orthopedics and Traumatology, Pediatric Cardiology. patient room, Pediatric Cardiovascular, Ophthalmology, Atomic laser, Pediatrics, Pediatric surgery, Check-Up Room, Dermatology, Internal Medicine, Cardiovascular Surgery, Pulmonary Diseases, Lung Laboratory, Allergy Unit, Brain Surgery, Cardiovascular Surgery, Cardiology Stress Test, Meeting room, Endocrinology, Psychiatry, Orthopedics and Traumatology, Chest Surgery, Gynecology, Oral and Dental Health, Plastic, Aesthetic and Reconstructive Surgery, Otorhinolaryngology and Head and Neck Surgery, Oduolali, Chest Diseases, Infectious Diseases, Nutrition and Dietetics Urology, Endocrinology, Reporting, International Patient Center, Medical Aesthetics, Patient Rights, Room Decoration, Breastfeeding Room, Hematology.			

Table (8). Risk evaluation

S. of D.	Group Name	Danger group		Possible Risks	Hospitals 1	Hospitals 2	Hospitals 3	Hospitals 4	Suggestions	Hospitals 1	Hospitals 2	Hospitals 3	Hospitals 4
					Probability Value * Severity Value					Probability Value * Severity Value			
					RV.	RV.	RV.	RV.		RV.	RV.	RV.	RV.
Fcade Fires	properties of materials that facilitate the spread of fire	Building height more than 28.50 m. Building height is less than or equal to 28.50'.	Using flammable materials on exterior surfaces	spread of fire.	2 5 **10**	2 4 **8**	-	3 5 **15**	Do not use flammable materials on external surfaces.	1 3 **3**	2 3 **6**	-	2 4 **4**
		Building height more than 28.50 m.	Using flammable materials on exterior surfaces	spread of fire.	-	-	3 5 **15**	-	Do not use flammable materials on external surfaces.	-	-	2 4 **8**	-
		Creating a surface filled without fire-resistant façade elements with a height of at least 100 cm vertically between unprotected spaces such as windows on two floors.		It becomes easier for the fire to move from one floor to another.	2 4 **8**	2 5 **10**	3 4 **12**	3 5 **15**	Creating a surface filled with high fire resistant facade elements.	1 3 3	2 3 6	2 3 6	2 4 **8**
		Lack of certification with standards regarding the thermal insulation system, thermal insulation adhesive, nails or plaster mesh.		Spread of smoke and fire.	1 5 **5**	2 5 **10**	2 5 **10**	2 4 **8**	There must be certification with standards regarding the thermal insulation system, thermal insulation adhesive, nails or plaster mesh.	1 2 **2**	2 3 **6**	2 3 **6**	2 3 **6**
		The exterior facade consists of a barely flammable material or system, and the 1.5 m distance above the natural or leveled ground level is not covered with any flammable material.		It becomes easier for the fire to move from one floor to another.	1 5 **5**	2 3 **6**	2 5 **10**	2 5 **10**	The exterior should not be made of fire-resistant material or system.	1 2 **2**	1 3 **3**	2 2 **4**	2 3 **6**
		In buildings with a building height of more than 6.50 m, fire barriers create with flammable materials with side edges of window and similar gaps more than 15 cm and the upper edge more than 30 cm.		It becomes easier for the fire to spread from one floor to another and spread easily throughout the building.	3 5 **15**	3 4 **12**	4 4 **16**	2 5 **10**	The side edges of the window and similar gaps should not be less than 15 cm, and the upper edge should not be less than 30 cm.	2 3 **6**	2 3 **6**	2 3 **9**	2 3 **6**
		Failure to insulate the joints of façade elements and floors that do not have gaps		Spread of smoke and	3 4	3 4	3 5	**3 4**	The joints of facade elements and floors that do	2 2	2 2	2 3	1 5
		through which flames can pass.		fire.	**12**	**12**	**15**	**12**	not have gaps through which flames can pass must be insulated.	**4**	**4**	**6**	**5**
		Facade and insulation materials used in buildings with open joints or ventilated curtain wall systems are flammable.		Spread of smoke and fire.	3 4 **12**	2 5 **10**	3 5 **15**	**3 4** **12**	Do not use flammable materials on external surfaces.	2 3 **4**	2 3 **6**	3 3 **9**	2 2 **4**
	The relationship of the building facade with neighboring structures	The extensions made to the outside of the building are not fire resistant.		It threatens the lives of building users and causes fire to spread more easily.	3 5 **15**	3 4 **12**	4 5 **20**	4 5 **20**	Extensions made to the outside of the building must be fire resistant.	2 3 **6**	3 2 **6**	3 3 **9**	3 3 **6**
	Openings in the building (doors and windows), fire escapes and openings in the building.	There is a gap in the window wall less than 3 meters from the external escape stairs.		Smoke and fires damage the fire escape, making evacuation difficult.	1 5 **5**	3 5 **15**	3 5 **15**	3 5 **15**	There is a gap in the window wall more than 3 meters away from the external escape stairs.	1 4 **4**	2 3 **6**	2 4 **8**	3 3 **9**
	Factors affecting the rapid fire response process of fire brigades.	The fire brigade should not approach within 45 meters.		Intervention becomes difficult	2 4 **8**	4 4 **16**	3 5 **15**	4 5 **20**	Fire brigade approaching 45 meters away..	1 3 **3**	2 3 **6**	3 3 **9**	2 4 **8**
		Fire brigade water supply connection is inadequate		Intervention becomes difficult	1 4 **4**	2 5 **10**	3 4 **12**	3 5 **15**	Fire brigade water supply connection is sufficient.	1 2 **2**	2 2 **4**	2 3 **6**	2 4 **8**

Table (9). Analysis of Risk Levels in Hospitals

Risk Levels	1. Hospital		2. Hospital		3. Hospital		4. Hospital	
	Risk Groups (11)	%	Risk Groups (11)	%	Risk Groups (11)	%	Risk Groups (11)	%
Very High	2	18%	2	18%	7	64%	6	55%
Middle	5	45%	8	73%	4	36%	5	45%
Very light	4	37%	1	9%	0	0%	0	0%

Table (10). Risk Groups at Hospital facedes

Hospitals	First and second group								Third group	Fourth group	
	1	2	3	4	5	6	7	8	9	10	11
1. . Hospital											
2.. Hospital											
3.. Hospital											
4.. Hospital											

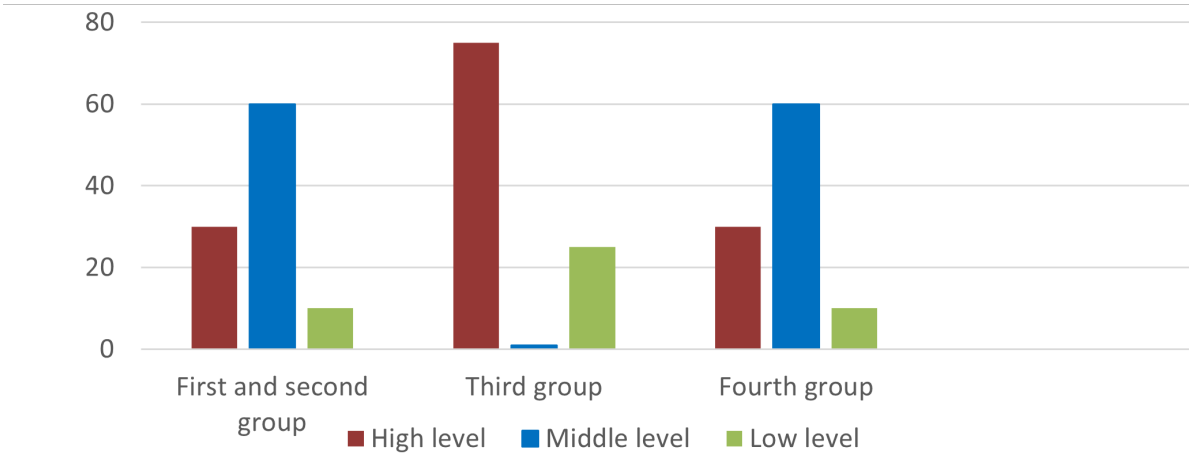

Figure (3). Average risk levels for risk groups at the hospital interface

5.1 Hospital -1

The risks from the danger groups identified in the first hospital can also be classified according to their levels. 18% of the risks are in the high-level risk group, 45% in the medium-level risk group, and 37% in the low-level risk group.

The high degree of risk on the hospital facade is due to deficiencies in several risk groups, in particular the first group (5,6), the second (7), and the fourth (10), shown in Table 11.

5.2 Hospital -2

In the second hospital, risks that may be caused by danger groups can also be classified according to their levels. 18% of the possible risks are in the high level risk group, 73% in the medium level risk group and 9% in the low level risk group. The reasons for the high degree of risk on the hospital facade are due to deficiencies in a number of risk groups, in particular the first group (1,5,6), second (8), third (9) and fourth (10), shown in Table 12.

Table (11). Explains the Reasons for the High Risk Level in the hospital -1

	1. Risk Group Properties of materials that facilitate the spread of fire.	**2. Risk Group** The relationship of the building facade with neighboring structures.	**3. Risk Group** Openings in the building (doors and windows), fire escapes and openings in the building.	**4. Risk Group** Factors affecting the rapid fire response process of fire brigades.
Hospital -1	• Failure to insulate the joints of façade elements and floors that do not have gaps through which fires can pass. • Facade and insulation materials used in buildings with open joints or ventilated curtain wall systems are flammable.	In addition to the presence of flammable materials (oxygen tanks) next to the building, non-fire resistant, unapproved materials have been identified as some of the obstacles that firefighting teams will encounter in case of intervention.	There were no deficiencies in this group.	There was not enough space on the rear and south facades for firefighters to intervene in case of fire.

Table (12). Explains the Reasons for the High Risk Level in the hospital -2

	1. Risk Group Properties of materials that facilitate the spread of fire.	**2. Risk Group** The relationship of the building facade with neighboring structures.	**3. Risk Group** Openings in the building (doors and windows), fire escapes and openings in the building.	**4. Risk Group** Factors affecting the rapid fire response process of fire brigades.
Hospital -2	• The height of the building exceeds 6.50 meters, which required the presence of fire barriers made of non-combustible materials, which, according to visual inspection, were not present in the building. • Application of mechanical system aluminum composite panel + Mechanical system compact laminate panel + Glass cladding easily flammable material combination.	Extensions made to the outside of the building, especially fabric coverings, are not fire resistant.	There was no clearance in the window wall of less than 3 meters from the exterior escape staircase.	There are no deficiencies in this group

5.3 Hospital -3

The risks that may be caused by the danger groups determined in the third hospital can also be classified according to their levels. Accordingly, in general, 64% of the possible risks are in the high level risk group, 36% in the medium level risk group and 0% in the low level risk group. The reasons for the high degree of risk on the hospital façade are due to deficiencies in a number of risk groups, in particular the first group (1,5,6,7), second (8), third(9) and fourth (10,11), shown in Table 13.

5.4 Hospital -4

The risks that may be caused by the danger groups determined in the fourth hospital can also be classified according to their levels. Accordingly, in general, 55% of the possible risks are in the high level risk group, 45% are in the medium level risk group and 0% are in the low level risk group. The reasons for the high degree of risk on the hospital's facade are due to deficiencies in several risk groups, in particular the first group (1,3,6,7), the second (8) and the fourth (10), shown in Table 14.

Table (13). Explains the Reasons for the High Risk Level in the hospital -3.

	1. Risk Group Properties of materials that facilitate the spread of fire.	**2. Risk Group** The relationship of the building facade with neighboring structures.	**3. Risk Group** Openings in the building (doors and windows), fire escapes and openings in the building.	**4. Risk Group** Factors affecting the rapid fire response process of fire brigades.
Hospital -3	• Application of mechanical system aluminum composite panel + Mechanical system compact laminate panel + Glass cladding easily flammable material combination. • Facade and insulation materials used in buildings with open joints or ventilated curtain wall systems are flammable.	Extensions made to the outside of the building at the back and sides of the building are not fire resistant.	There was no clearance in the window wall of less than 3 meters from the exterior escape staircase.	The fact that the hospital is located in a crowded residential area and the side streets are narrow will make it difficult for fire brigades to intervene.

Table (14). Explains the Reasons for the High Risk Level in the hospital -4

	1. Risk Group Properties of materials that facilitate the spread of fire.	**2. Risk Group** The relationship of the building facade with neighboring structures.	**3. Risk Group** Openings in the building (doors and windows), fire escapes, and openings.	**4. Risk Group** Factors affecting the rapid fire response process of fire brigades.
Hospital -4	• The height of the building exceeds 6.50 meters, which required the presence of fire barriers made of not flammable materials, which, according to visual inspection, were not present in the building. • Mechanical system aluminum composite panel + Air intake chimneys + Mechanical system compact laminate panel + Glass cladding application of easily flammable material combination. • Not creating a surface filled with fire-resistant facade elements with a height of at least 100 cm vertically between unprotected gaps such as windows on two floors.	The presence of flammable materials (oxygen tanks and central air conditioning units) next to the building, non-fire resistant and unapproved materials, flammable materials and obstacles that firefighters will face in case of fire intervention have been determined as obstacles.	There is no clearance in the window wall of less than 3 meters from the external escape staircase.	The hospital's location in a crowded residential area and the narrow side streets will make it difficult for fire brigades to intervene.

As a result of the fire risk analysis conducted with the L-type Matrix method in the context of hospital facades, 4 risk groups containing a total of 11 potential risks were identified. The first and second groups contain 8 danger elements, the third group contains two danger elements, and the last group contains one danger element.

When the risk groups are evaluated separately, it becomes clear that the first and second risk groups are at high levels in all four hospitals, especially the element group indicating that materials are required (1, 2, 5, 6, 7, and 8). Thermal insulation systems, thermal insulation adhesives, nails, or plaster mesh are not certified by the relevant standards, and the facade and insulation materials used in buildings with open joints or ventilated curtain wall systems are flammable. Hospitals 1, 3 and 4 have the highest risk rate in this regard, as shown in Table 15.

The third risk group is not present in the first, second and third hospitals with the highest level (distance exceeding 3 meters between fire escapes, windows, doors or visible areas on the facade).

The fourth risk group (10, 11), which deals with facilitating the rapid response process for fire brigades and providing adequate water resources for firefighting; Average risk grades indicate that the third and fourth hospitals have the highest risk rate in this regard. The fact that hospitals (3rd and 4th) are located in a crowded residential area and the side streets are narrow will make it difficult for fire brigades to intervene.

6. Conclusion

Due to developing construction systems and technologies, different facade materials and design suggestions are emerging day by day. What is expected from experts in the field is to determine the fire performance of the materials and to ensure that they are used in accordance with the requirements of the project. Analyzing the façade fire dynamics and determining the material behavior during fire are also important in this regard.

Knowing the material's fire reaction degree and fire behavior within the system is the most basic requirement for correctly designing the façade fire safety measures. Measures against the emergence and spread of fire should also be considered and evaluated within the facade fire safety measures framework and transferred to the project.

As a result of the fire risk analysis carried out using the L-type matrix method in the context of hospital facades, 4 risk groups were identified containing a total of 11 potential risks. The first and second risk groups carry the highest risk because they relate to the elements that cause the greatest spread of fires in hospital facades such as thermal insulation, thermal insulation adhesives,

Table (15). Explains the reasons that give the highest risk rate.

Hospital-1	Hospital -3	Hospital -4
a) Failure to insulate the joints of façade elements and floors that do not have gaps through which fires can pass. **b)** Facade and insulation materials used in buildings with open joints or ventilated curtain wall systems are flammable. **c)** In addition to the presence of flammable materials (oxygen tanks) next to the building, non-fire resistant, unapproved materials have been identified as some of the obstacles that firefighting teams will face in case of intervention.	**a)** Application of mechanical system aluminum composite panel + Mechanical system compact laminate panel + Glass cladding easily flammable material combination. **b)** Facade and insulation materials used in buildings with open joints or ventilated curtain wall systems are flammable. **c)** Extensions made to the outside of the building at the back and sides of the building are not fire resistant.	**a)** The height of the building exceeds 6.50 meters, which required the presence of fire barriers made of non-combustible materials, which, according to visual inspection, were not present in the building. **b)** Application of mechanical system aluminum composite panel + Air intake chimneys + Mechanical system compact laminate panel + Glass cladding easily flammable material combination. **c)** Not creating a surface filled with fire-resistant facade elements with a height of at least 100 cm vertically between unprotected gaps such as windows on two floors.

nails or gypsum meshes that are not approved by the relevant standards, in addition to the insulation materials used on facades in buildings with open joints or ventilated curtain flammable wall systems.

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طريقـة تحديـد مخاطـر الحريـق على المسـتوى الحضري ومجـال البنـاء على واجهات المستشفيات

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قدم للنشر في ١٥/ ٣/ ١٤٤٦ هـ؛ وقبل للنشر في ٧/ ٦/ ١٤٤٦ هـ.

ملخص البحث. تشكل حرائق الواجهات مخاطر على سلامة الأرواح والممتلكات لمستخدمي المباني. تهدف هذه الدراسة إلى تحليل مخاطر الحرائق على واجهات المستشفيات التي تشكل خطراً على الهيكل. في نطاق الدراسة، أجريت تحليلات مخاطر الحرائق على واجهات أربعة مستشفيات صغيرة الحجم تقع في منطقة نيلوفر في بورصة، بتركيا. في الدراسة، تم إنشاء قائمة مراجعة في نطاق (BYKHY) وتم إجراء تحليل للوضع الحالي في الموقع وتحليل الامتثال للوائح الحرائق. بناءً على ذلك، تم إجراء تحليل مخاطر الحرائق في سياق واجهات المباني المعنية باستخدام طريقة مصفوفة النوع L، وهي إحدى الطرق الكمية. في طريقة مصفوفة النوع L، يتم تصنيف احتمالية حدوث المخاطر وشدة العواقب التي قد تحدث عند حدوثها بين ١ و٥. وفقاً لذلك، تم تحديد ٤ مجموعات مخاطر نتيجة لتحليل مخاطر الحرائق الذي أجري في سياق واجهات المستشفيات باستخدام طريقة مصفوفة النوع L. نتيجة لهذه العناوين، تم تحديد ١١ خطراً محتملاً. وقد تمت دراسة الأسباب المحتملة لهذه المخاطر ودرجتها وشدتها، وفي ختام البحث يتم تقديم النتائج الرئيسة التي تم التوصل إليها وأسبابها.

الكلمات المفتاحية: المستشفى، الواجهة، خطر الحريق، أداء السلامة من الحرائق، مصفوفة من النوع L.