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THE PRECEDENCE OF FIRE SAFETY IN ARCHITECTURAL EDUCATION

MİMARLIK EĞİTİMİNDE YANGIN GÜVENLİĞİNİN ÖNEMİ

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ABSTRACT

This study examines how students perceive fire safety during the architectural education process and the solutions they make for it. The scope of the study consists of the projects designed by the architecture students who took the "Fire Safety in Buildings" course in the Fall Semester of the 2020-2021 and 2021-2022 Academic Years at Ondokuz Mayıs University, Department of Architecture. Within the scope of the study, 91 student projects were discussed in the context of fire safety in line with the principles in the Regulation on the Protection of Buildings from Fire. The study findings showed that the student projects needed to improve regarding the measures taken against fire. According to this research, the measures taken for fire safety in the projects of architecture students are caused by insufficient and incomplete reading. Such deficiencies can be eliminated with minor corrections in most designs if the regulations are examined. For this reason, it has been determined that at the very beginning of the design phase, measures for fire safety -including legislative readings- should be included in the design stage. As a result, the findings from the student projects were discussed, and some general suggestions were made on fire safety.

Keywords: Architecture, Architectural Education, Fire, Fire Safety

ÖZET

Bu çalışmada, öğrencilerin mimarlık eğitimi sürecinde yangın güvenliğini nasıl algıladıkları ve buna yönelik ürettikleri çözümler irdelenmektedir. Çalışmanın kapsamını Ondokuz Mayıs Üniversitesi Mimarlık Bölümü 2020-2021 ve 2021-2022 Akademik Yılı Güz Yarıyılında "Binalarda Yangın Güvenliği" dersini alan mimarlık öğrencilerinin tasarladıkları projeler oluşturmaktadır. Çalışma kapsamında Binaların Yangından Korunması Hakkında Yönetmelikte yer alan esaslar doğrultusunda 91 öğrenci projesi yangın güvenliği kapsamında ele alınmıştır. Her bir öğrenci projesi, yönetmeliğin 44 farklı maddesi çerçevesinde fiziki şartlar açısından yangın güvenliği kapsamında değerlendirilmiştir. Çalışma bulguları, yangına karşı alınan önlemler konusunda öğrenci projelerinin geliştirilmesi gerektiğini göstermiştir. Bu araştırmaya göre mimarlık öğrencilerinin projelerinde yangın güvenliği için alınan önlemler yetersiz ve eksik okumalardan kaynaklanmaktadır. Yönetmelikler incelenirse çoğu tasarımda bu tür eksiklikler küçük düzeltmelerle giderilebilir. Bu nedenle, tasarım aşamasının en başında, mevzuat okumaları da dahil olmak üzere, yangın güvenliğine yönelik önlemlerin tasarım aşamasında yer alması gerektiği belirlenmiştir. Sonuç olarak öğrenci projelerinden elde edilen bulgular tartışılmış ve yangın güvenliği konusunda bazı genel önerilerde bulunulmuştur.

Anahtar Kelimeler: Mimarlık, Mimarlık Eğitimi, Yangın, Yangın Güvenliği

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1. INTRODUCTION

Architectural education and profession are in the change created by the globalizing world (Nalçakan & Polatoğlu, 2008). Architects are trained to consider various design objectives related to both the form and function of a building. However, fire safety is one of the least considered variables that can fundamentally affect and change building design (Habbal, 2020). For centuries, fire safety has played a central role in the building design process (Maluk et al., 2017). Adequate implementation of fire safety is essential to improving the built environment (Fire Safety Engineering Education Report, 2019). There is always a fire hazard in buildings, and the measures to be taken against this danger are within the scope of the architectural profession. Recently, the subject of fire safety has been covered in architecture schools and has begun to be embedded in education content (Hong & Lee, 2018). In addition, interdisciplinary communication regarding fire safety is relatively weak (Woodrow et al., 2020).

Fire safety can be defined as (1) preventing fire, (2) limiting fire development and smoke spread, and (3) creating a safe evacuation area for those exposed to fire (Wang et al., 2015). Fire safety has three primary purposes: (1) to prevent the ignition of building materials and their contents, (2) to control fire development, and (3) to protect those exposed to fire (Sanni-Anibire & Hassanain, 2015). There are two types of fire safety: (1) passive measures (fire-resistant construction, escape routes for occupants, etc.), and (2) active measures (detection and early warning of a fire, operation of smoke management systems and emergency lighting, etc.) (Chow, 2005). Although the threat to life and property cannot be eliminated, fire safety management is to minimize the fire risk with active and passive design features (Sanni-Anibire & Hassanain, 2015).

Architects' academic career consists of three stages: theory, design and integration, and application knowledge (César et al., 2013). Architects must be aware of the basic principles of fire safety as people who design buildings (Ebenehi et al., 2016). Statistical studies show that fires frequently occur in buildings (Brushlinsky et al., 2022). Fires that occur remind architects of their responsibilities to minimize fire risks in buildings (Abrahams & Stollard, 1999). However, although most architects do not have the technical knowledge or necessary skills, the responsibility for fire safety still rests with the architects (Woodrow et al., 2013). In general, there is no building with complete fire safety (Sanni-Anibire & Hassanain, 2015), but proper fire safety knowledge helps to create fire-resistant buildings (Habbal, 2020; Korkmaz, 2016).

Compared to the number of universities providing architectural education in Turkey, the number of separate courses on fire safety is relatively low (Bodur, 2019). However, measures to be taken for fire safety are tried to be included in some other courses. On the other hand, it is the architect's responsibility to ensure that fire safety objectives are integrated with the more general objectives of architectural design for the architectural design to be successful (Abrahams & Stollard, 1999).

According to Bodur (2019), the driving force of architectural education in Turkey is based on architectural studios, and fire safety plays a minor role (Bodur, 2019). The main things that students focus on are visual and aesthetic conditions and user need rather than fire safety. Fire protection is considered an engineering issue and is often neglected in architectural education (Habbal, 2020). Given the perception that architects place greater emphasis on aesthetic expressions, it is acceptable not to focus on fire safety. However, an adequate level of fire safety is required in building designs, regardless.

This study examined the perception of fire safety in the architectural education process and the solutions adopted for it. It is essential for architects in Turkey with a strong emphasis on fire safety to acquire comprehensive fire safety knowledge and training right from the beginning of their architectural education. Therefore, the main focus of this study is the importance of integrating fire safety knowledge into architectural education and its incorporation into student projects.

2. METHODOLOGY

The scope of the study consists of the architectural projects designed by the students who took the "Fire Safety in Buildings" course in the Fall Semester of the 2020-2021 and 2021-2022 Academic Years at Ondokuz Mayıs University, Department of Architecture. The Fire Safety in Buildings course aims to give information about what should be done against fire and measures to protect buildings from fire. The lesson has been given since the Fall Semester of the 2018-2019 Academic Year. Ondokuz Mayıs University, Faculty of Architecture, Department of Architecture students acquire detailed information on fire safety as a separate course for the first time with this course. Ondokuz Mayıs University Faculty of Architecture Department of Architecture has 82 students each year, the same for 2019, 2020, and 2021 (URL-1). In the Fall Semester of the 2020-2021 Academic Year, 53 students and in the Fall Semester of the 2021-2022 Academic Year, 46 students chose the course, and a total of 91 student projects were included in the study.

While students from the 7th semester can choose the lesson, other students with the necessary conditions can also take it. For this reason, student projects can consist of different periods and topics. In this study, the building designs, and the end-of-term studies of the students in the architectural project courses, were analyzed regarding fire safety. 4th-semester projects were designed as 2 or 3 floors, 6th-semester projects were designed as 3 to 5 floors, 7th-semester projects were designed as 6 to 7 floors, and 8th-semester projects were designed as three floors. The 4th-semester projects include 6 nursing homes and 24 educational facilities (music school, kindergarten, cooking school). The 6th-semester projects include 30 cultural centers, 18 lifelong education centers, 5 Turkish Textile Institutes, one museum, one archive building, one education and research center, and one trade, food, and entertainment service building. The 7th-semester projects consist of 2 hotel projects, and the 8th-semester projects consist of 2 cultural center buildings.

In developed countries, building fire safety measures are evaluated based on standards (Wakamatsu, 1989). In Turkey, although it is new in this regard, significant progress has been made, and the "Regulation on the Protection of Buildings from Fire" came into force in 2007. For this reason, the analyzes and evaluations made in the study were made within the framework of the relevant articles of the Regulation.

At first, students were asked to upload information such as floor plans and sections about the projects they designed in architectural project courses to the Google Classroom system as an end-of-term report. The end-of-term study had four parts: (1) introduction, (2) architectural project information designed by the student, (3) evaluation, and (4) conclusion and suggestions. The introduction gave information such as fire and the importance of fire safety. The fire safety requirements that should be found in buildings with similar use to student projects were presented in this section. In addition, this information was requested to be supported with photographs. The project information section has added the architectural concept, design approach, plans, sections, and 3D visuals. In the evaluation part, the spaces in the projects were asked to be examined in terms of compliance with the principles in the fire code. Students discussed the projects within the framework of 44 articles in the Regulation regarding physical features such as structural systems, firewalls, flooring, facades, roofs, escape routes, escape stairs, shelter, etc., and detection and warning systems. The conclusion and suggestions section discussed the results that emerged from the course administrator's analysis of the student's project. In doing so, the contribution of student studies to the studies carried out in architectural project courses was evaluated, and suggestions were made on fire safety.

3. FINDINGS

This study analyzed 91 architectural students' projects concerning fire safety following the sections and principles outlined in the Regulation on the Protection of Buildings from Fire. Like other international standards (Fire Safety Engineering Education Report, 2019), the Regulation in Turkey classifies buildings based on their usage class. The projects examined in this study were classified into the following categories:

1. Educational facilities (kindergarten, cooking school, music school, lifelong education),
2. Institutional buildings (nursing homes),
3. Storage facilities,
4. Entertainment places (cultural center, trade, food, and entertainment center),
5. Structures for gathering purposes (museums and exhibition places),
6. Accommodation facilities (hotels).

The load-bearing system of the designed buildings primarily consisted of reinforced concrete. The selected projects were categorized as medium hazard-1 (educational facilities, health care buildings, hotels), medium hazard-2 (museums), medium hazard-3 (entertainment venues), and medium hazard-4 (exhibition halls).

Regarding the accessibility for firefighting operations in case of fires, the distance required for firefighters to approach the fire environment and extinguish the fire should be at most 45 meters. Although the projects designed in different periods generally met the requirements for firefighting intervention, some projects needed improvement, particularly in the width of internal roads, which should be 4 meters but were designed as 3 meters in some cases. Furthermore, trees in inner gardens, retaining walls, and vehicles parked on the side roads were identified as factors hindering firefighting intervention in potential fire situations.

The fundamental requirement for a fire-resistant building is to ensure that the building's load-bearing system remains intact, allowing safe evacuation of occupants. While most student projects featured reinforced concrete structural systems, some included only steel or hybrid carrier systems, where steel and reinforced concrete were used together. According to the Regulation, for reinforced concrete or reinforced concrete-steel composite elements to be fire resistant for 120 minutes according to Annex-3/B, the net concrete dimension, which is the distance between the outer surface of the outermost steel profile or reinforcement and the outermost concrete fiber, must be at least 35 mm in columns, 25 mm on beams and at least 20 mm on floors. Since the students did not design the projects as application projects, they needed to produce solutions to the requirements specified in the Regulation.

Fire compartments in a building should be designed to prevent fire and post-fire smoke from spreading within the building. The Regulation regulates the existence and size of fire compartments based on the buildings' usage classes. However, in the examined projects, compartments were not designed in facilities where the height of the building is within the limits of the Regulation. Some areas should be allocated to fire compartments in some projects, such as nursing homes and projects where fire compartment necessity arises. At the same time, this situation was not considered in the designs. Since the general fire compartment requirement is optional in the projects, the Regulation is complied with, but this is different from the result that the students think. Additionally, the importance of firewalls in conjunction with fire compartments was evident. Nevertheless, the firewall could not find its place in the designs, and deficiencies stood out when the projects were examined.

Floors, facades, and roofs are critical elements for the fire safety of buildings. The solutions and precautions related to green roofs in the "Fire Safety in Buildings" course have been thoroughly analyzed, explained, and taught. Students have gained valuable insights into designing green roofs that prioritize fire safety, including selecting fire-resistant materials, incorporating fire barriers, integrating fire suppression systems, and providing easily accessible escape routes. Unfortunately, these aspects were not given sufficient consideration in terms of fire safety during the design phase of most projects. Flooring materials, solutions to prevent fire spread on facades, facade coatings, and using wooden materials for sunshades were identified as factors that increase fire risk. Proper attention must be given to fire safety in roof construction, which should be a priority in the design process. In some projects, students opted for green roofs. Although this type of roof is not directly referenced in the Regulation, it should be acknowledged that tree branches and leaves can propagate flames rapidly, necessitating additional precautions for this type of roof. The Regulation explicitly prohibits using highly flammable construction materials in buildings. From this point of view, the fire safety design at the material scale in the buildings designed by the students needed to be revised.

One of the critical features of a building is to have measures in place that allow occupants to leave the hazardous area promptly during emergencies. While student projects met some of these conditions for safe evacuation from classrooms in school buildings, they needed to comply with regulation criteria in areas such as the cafeteria and multi-purpose halls. Additionally, provisions for the evacuation of disabled individuals, such as ramps for wheelchair users, were not adequately addressed in the designs. There needed to be more complete solutions regarding the number and width of stairs, the direction of escape doors opening opposite to the escape direction, and the design of only automatic doors at building exits.

Fire protection in buildings necessitates safe escape routes. Buildings should be designed with an approach that ensures occupants can reliably and directly reach the outside without encountering any hindrance from any point inside the building that has such precautions. Overall, student projects demonstrated attention to escape routes. However, when examining the exit capacities and escape distances in the designs, it was observed that some projects displayed a sufficient understanding of fire safety, while others needed to improve. Although the location of the building entrances is given importance in the designs, it was observed that an insufficient number of exits is given during the escape.

Another critical issue regarding fire safety is the design of fire safety halls. In the Regulation, constructing a fire safety hall is sometimes mandatory, while it is not allowed in others. Nevertheless, this aspect must be considered in building designs where a fire safety hall is required based on the intended use. However, fire safety halls were generally not included in the designs. Furthermore, the designed fire safety halls did not comply with size and smoke evacuation system requirements.

A fundamental requirement for fire safety is that building exits should be easily accessible, unobstructed, and open. While the designs featured clear exits, there were deficiencies regarding easy accessibility. An essential shortcoming was that exit doors only had an automatic opening and closing system, and no wing doors were next to them. However, more than automatic doors are required to meet the requirements of escape routes. Moreover, a significant design error related to fire safety was that exit doors primarily opened in the opposite direction of the escape route.

Stairs in buildings must possess certain features to be used for escape. In addition, escape stairs were found in only a few designs to escape circulation, particularly in the 4th-semester projects. A leading ladder was considered an escape ladder in plans without escape stairs. However, this differs from the fire safety requirements and poses a significant risk to users in case of a possible fire.

According to the Regulation, each building should have at least two exits and, in some cases, at least three exits. These exits should be spaced far from each other and serve as alternatives. While most student projects had two exits, buildings with more than 500 occupants still required a minimum of 3 exits. However, the designs with sufficient exits should have considered them as alternatives to each other. Escape stairs should be positioned to allow easy access to the main foyer and ensure the dispersion of people. While most students positioned the stairs around the center of their designs, they should have been arranged alternatively. In designs where the escape staircase and the main staircase were located close to each other, the reason for this choice should be examined, as it may be due to the ease of design. Some student projects did not include an escape ladder. In projects with escape stairs, the stairs only opened to the outside of the building from the ground level in a significant part of the cases. However, circular staircase solutions should have been present in the designs. Similar to escape ladders, escape ramps are also crucial for fire safety. The Regulation allows escape ramps to be used as an alternative to escape stairs, subject to certain conditions and features. Despite this, very few projects included escape ramps, and this is another aspect that needs to be addressed.

Another issue deserving attention and inclusion in the designs is the ventilation of escape ladders. If escape stairs are intended to serve basement floors, they must meet all the specified requirements. However, there were no safety halls in the designs for the basement floor, which should have had a fire safety hall. Like escape stairs, escape route doors must have certain features such as width and height. In the projects examined, while the width and size of the doors comply with the regulations, there were errors in the direction of escape.

Interestingly, in almost all designs, the doors opened against the direction of escape. On the other hand, some designs used a revolving or automatic gate. Besides the revolving/automatic door, it is necessary to use a swing door for fire safety, but it was not included in the designs.

The fourth part of the Regulation includes special regulations for fire safety according to the intended use of buildings. As mentioned above, the designed projects have different services and should consist of various rules regarding fire safety measures according to the intended use. When the designs are examined in terms of special arrangements, inadequacies in seat distances in the multi-purpose hall, single exit in the volumes where at least two outlets are required, and measures to prevent smoke spread are striking.

Some measures in the Regulation regarding places such as boiler rooms, shelters, kitchens, and generator rooms are significant in building fire safety. However, there are no boiler rooms that should be in the projects, and they were not considered in almost all of them. There is no solution to projects with a boiler room following the Regulation. Sections such as kitchens and teahouses were not resolved in the projects under the criteria required in the rule. Stoves and chimneys, which should be designed within the project's scope, were not included in the designs as a significant shortcoming. Shelters are one of the places that should be in buildings, so there are special regulations for shelters. It is necessary to build a shelter with at least two exits in places with more than 50 people. In most student projects, covers are not included in the design. In the designs with shelters, it is seen that the size, smoke evacuation system, and output capacities are not taken into consideration.

As areas that meet users' needs, parking lots needed more capacity in student projects and displayed deficiencies in fire safety. The projects did not consider fire cabinets and mechanical smoke evacuation systems. Furthermore, roofs, although areas with less frequent user traffic, are vital spaces to be considered for fire safety. When examining the projects, students who designed steel roofs did not comply with fire safety precautions for steel materials.

Elevator systems and their features are crucial factors that need to be emphasized concerning the fire safety of a building. Especially during emergencies like fires, elevators should automatically close for use and not accept incoming calls. In basements, elevators should not be directly accessible but should be accessed from a separate and protected area. Additionally, elevators should not open to the fire escape slot. Evaluating the student projects based on elevator designs, the requirements of the Regulation were mainly met, especially in the elevator designs descending to the basement floor. However, a solution for warning systems in emergencies was not considered. Furthermore, systems such as lightning protection installation, emergency lighting and guidance, lighting of escape routes, and emergency lighting system, which are essential for fire safety, were facilities that needed to be addressed within the scope of the projects. Smoke control is one of the most critical aspects concerning building fire safety, and it becomes even more crucial in places with high fire risks, such as boiler rooms, generator rooms, kitchens, and car parks. Unfortunately, the student projects did not propose adequate solutions or ideas for smoke control. Additionally, sprinkler systems, which are mandatory in buildings where a water extinguishing system is required, were absent from the designs.

4. CONCLUSION, DISCUSSION AND IMPLICATIONS

This study examined the measures to be taken for building fire safety, especially regarding what should be done at the architectural design stage. It was determined at what level these measures were involved in the design at the architectural education stage, and evaluations were made on the subject. To make these evaluations, readings were done on the projects of architecture students. On the other hand, since this study is limited to student projects, it is essential to examine the problem more comprehensively and to reach more outputs in future studies.

As can be understood from the findings of the study, it is seen that student projects have many shortcomings in terms of measures taken against fire. Detailed solutions should have been considered in the designs and carrier system solutions. The fire compartment and the firewall were not designed as they are not required in most projects in the Regulation. They were also not considered. When designing floors, facades, and roofs, fire safety must be sufficiently considered. Despite this, escape routes were designed more successfully. Escape stairs and exits needed to be increased in number and location. It has been determined that the fire safety halls are missing or not designed in the designs where the escape doors do not open in the evacuation direction. It has been observed that the measures taken against fire in places such as multi-purpose halls, boiler rooms, and shelters, which should be given special attention in terms of fire safety, need to be revised. The study showed that the precautions taken for fire safety in student projects in architectural education are caused by insufficient and incomplete reading. Such shortcomings can be eliminated with the corrections made in the designs if the regulation rules are examined.

For this reason, it is clear that at the very beginning of the design phase, measures for fire safety – including legislative readings – should be included in the design. The objectives of fire safety measures are:

1. To prevent a fire
2. To prevent the spread of smoke in the event of a fire and to ensure that it moves away from the building in a controlled manner
3. To minimize the loss of property
4. Ensure that the user in the building gets away from the fire area as soon as possible.

Buildings not designed with a reasonable and practical approach towards these measures will not resist fire. For this reason, fire safety measures should be included in the building design process within architectural education, and the consequences of the fire should be prevented from worsening. Suggestions developed around the findings obtained from the study are listed below.

A building in the design phase must follow the regulations in force, such as the fire code. Therefore, knowing the rules of fire safety is a must. For this, the compliance of the projects designed by the architect candidates with the regulations gains importance.

Academics who give fire safety courses should be in contact with firefighters when necessary and should seek support from them in their lessons. Thus, working with experts, such as firefighters, will contribute to developing these criteria while ensuring that they are more conscious of applying the existing fire safety criteria. In addition to fire safety, it is crucial to include other essential topics such as floods, shelters, and earthquake safety in the curriculum. These subjects play a significant role in shaping students' perspectives during their education and project planning. Introducing real-world application examples for these topics will also be beneficial.

While it is obligatory to meet the user needs in the building design, the number of people who will use the building is also a piece of information that should be known regarding fire safety. Especially in architectural project courses, the number of people who will use the designed buildings should be known by the students. At least, they should be aware of it, and a framework should be determined to evacuate these people.

Making the entrance of a building visible from the immediate surroundings is one of the architectural design conditions. At the same time, it is known that in situations requiring emergency evacuation, such as fire, the exits become more critical than the entrances of the buildings, and the leaves must be fully operational. To this end, students should be made aware of whether the number and place of exits of the buildings are sufficient, especially in architectural project courses, and they should be ensured to comply with these rules in their designs. Thus, graduates can find faster solutions in architectural practice and have careers in more professionally satisfying jobs.

According to the results of this study, the graduates of the architecture department have limited and insufficient knowledge in terms of fire safety due to the process in the education phase. Therefore, teaching architecture students the concepts of fire and how to deal with them in the event of a fire will produce good results in their professional life regarding smoke control, evacuation, and reduction of other damage to property.

Fire safety should be given the utmost importance in architectural design. Architects must design buildings to be the safest when planning them in terms of fire safety. In a design, the emerging variables for fire safety should become the design variable and form an essential part of the design together with the architectural solutions. Since active fire precautions are complementary to passive fire precautions, passive fire safety measures should be taken in buildings, mainly including design-oriented inputs.

Architects should work with other professional groups, such as engineering, with an interdisciplinary approach in the measures to be taken against the fire safety of the buildings they design. With the technical support and input of other professional groups, a holistic design approach will be put forward, and better solutions for fire safety will be produced.

Architects should increase the fire safety performance of the buildings they have designed at the design stage through passive fire safety measures. For this reason, it is imperative for architects to acquire the knowledge and design skills needed for fire safety and to be conscious of the necessity of having this information. It should be accepted that this situation, that is, having knowledge and skills for fire safety, is an integral part of the design process rather than professional development.

Indeed, the fire risk cannot be eliminated. At this point, control mechanisms for the least possible and acceptable fire risk should aim to monitor and address several measures to prevent fire rather than reveal errors in design and use.

Architectural education should provide students with practices that enable a good and harmonious architectural environment suitable for today's conditions. The understanding of how the learned knowledge will be used in practice should be addressed within the education method. It should be remembered that the information given in the educational content depends on the skills and attitudes of the students. These skills and attitudes will undoubtedly be formed by efforts to gain a level that can produce recognition, perception, and appropriate solutions for economic, social, technical, and environmental problems. As a result, the way to cope with dangerous events such as fire is through well-trained professionals who are aware of dangers and have an interdisciplinary perspective.

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