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AN ANALYSIS OF MITIGATION MEASURES FOR FURNITURE IN EDUCATION BUILDINGS TO PREVENT EARTHQUAKE HAZARDS

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Abstract

Earthquakes are among the most deadly and destructive natural disasters. They have catastrophic consequences for human life. Every year, thousands of people worldwide are affected by earthquakes, struggling with psychological and physical damage. Educational buildings, which are especially used by students, are damaged by structural and non-structural elements during earthquakes, and individuals caught in the earthquake are injured and even lost their lives. Furniture, which is classified as non-structural elements, can reduce non-structural risks caused by earthquakes with measures to be taken. As a result of the study's keyword search, a literature review was conducted by the use of different academic search engines. The fundamental interior spaces of educational buildings were defined with 7 different definitions. Literature sources found as a result of keyword analysis were used to define the furniture in the interior spaces and 7 fundamental pieces of furniture were defined. Accordingly, 6 different earthquake risk mitigation measures for furniture were analyzed and evaluated.

Keywords: Educational buildings, school buildings, non-structural elements, furniture, earthquake

1. INTRODUCTION

Educational buildings, where all individuals spend the sometime of their lives beginning at a young age, are an essential part of social life. These structures, which require special consideration and attention among public structures, serve a variety of functions. Educational buildings serve multiple functions, including educational activities, social and cultural events, sports competitions, emergency and disaster relief, and public activities. Educational areas, on the other hand, with their basic functions, are places where activities like reading and focusing attention on the monitors consume a significant amount of time (Mihai and Iordache, 2016). In today's modern societies, educational activites take places called “schools” and in detail "classrooms". As a consequence, in addition to instructor behaviors, students' interests and talents, attitudes toward the course, and course content,

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environmental (school building) conditions are added to the elements impacting educational activities (Aydoğan, 2012). Educational buildings should be designed in such a way that they not only meet the need for accommodation, but also aid in learning, provide environments where imagination, technique, and knowledge come together, and have physical conditions that benefit both students and teachers. The most important users of educational structures are educators, staff, technicians, and students. Students, who make up the majority of educational building users, are among the most vulnerable groups during an earthquake. The presence of kindergarten and primary school students, particularly those of a younger age, has a significant impact on their exposure to danger. The design of an educational structure, as well as its resistance to potential disasters, has considerable effects on the development of students and their levels of social, cultural, artistic, and academic achievement. Natural disaster planning ensures that schools are safer, more prepared, and resilient. Consequently, the advantages of being sure of the seismic safety of the school extend beyond the school. Schools can help improve health, well-being and quality of life for an entire community (FEMA, 2017).

Earthquake is a type of natural disaster that cannot be predicted in terms of location, time, or intensity. Earthquakes can catch people in their sleep, as well as in their schools, hospitals, workplaces, or while driving (Fugate, 2010) and like most natural disasters, they cause significant damage to vital infrastructure as well as loss of property and life (International Finance Corporation, 2010). They are a constant in the lives of people who live in earthquake-prone areas. Every year, more than 400 natural disasters strike the world, and an average of 1.003 people are killed by earthquakes, and 7,094 buildings are destroyed (Aytöre, 2005). Earthquakes killed approximately 750,000 people worldwide between 1998 and 2017 and affected over 125 million people during this period. These consequences include injury, homelessness, displacement, and evacuation (World Health Organization, 2023). In earthquake-prone areas of the world, an earthquake can happen at any time. Because the interval and frequency of earthquake occurrences can vary greatly, it is extremely difficult to predict earthquakes in advance. It occurs more suddenly than many other types of disasters and can catch people off guard. Individuals may be caught in educational structures because of this disaster, which cannot be predicted at what time of day or where it will occur. Because students are required to attend school and spend their days there, including weekends, special days, and all weekdays, governments must ensure the safety of learning environments. The fact that schools can be used as emergency shelter spaces after disasters such as earthquakes prioritize the building's performance during an powerful earthquake (Berry and Gruhn, 2015). Education, too, should not be disrupted during a large, severe, and effective earthquake, and it is one of the service areas that should be prioritized. Survivors should be able to continue their education and training opportunities prior to the disaster without interruption.

Many studies in literature examine the damage to structural/non-structural elements and large earthquakes. Approximately 11,000 schools were destroyed or severely damaged because of the earthquake that struck Pakistan in 2010 (Chuang, Pinchoff and Psaki, 2018). The university campus during a Japanese earthquake was severely damaged because of the earthquake. 28 buildings on campus have been determined to be unsafe for use and require structural and non-structural improvements (Aoki and Ito, 2014). The 2010 Haiti earthquake damaged 4,000 schools and destroyed nursing and midwifery institutions (United Nations Population Fund, 2010). Many educational structures were damaged in Turkey during the 1999 Marmara Earthquake, 2010 Elazığ Earthquake, and the 2011 Van Earthquake (Soyluk and Gerek, 2016). In the study conducted with emergency departments on the causes and rates of injuries of people after the 2003 North Miyagi earthquake in Japan, injuries from non-structural elements had an average of 50%, with furniture accounting for 35% of this rate (Sato, Motosaka and Mano. 2006). It is true that an earthquake cannot be prevented because it is a natural disaster. However, it should not be overlooked that the damage caused by this disaster is inversely proportional to people's level of consciousness. The focus is on structural and non-structural elements, with measures that individuals can take by themselves, including in educational institutions, by forming a life triangle, moving into the fetal position, and performing the drop-cover-hold movement. Healthy settlement/building and structural damage reduction should be the primary safety factors against earthquake risks (Akgüngör, 2014).

Non-structural elements, which can cause death and injury during an earthquake, are just as important as structural elements. Non-structural elements made up of various components such as mobile systems, equipment, and furniture can endanger people's lives during an earthquake. However, when designed and applied correctly, these elements can create a safe area, particularly for disadvantaged individuals. Furniture can provide a safe shelter for the elderly, disabled, and children in dangerous situations, increasing their chances of survival. According to past earthquake experiences, interior organization and geometry, wall, ceiling, and floor finish lines, lighting elements, furniture and accessories are the most important factors in creating earthquake-safe spaces (Demirbaş, 2008). Non-structural elements damage can cause an extensive number of avoidable injuries and fatalities. Furthermore, it may result in the closure of escape routes and the halting of rescue operations during an earthquake. In this regard, following the study's literature review and keyword analysis, the fundamental interior spaces of educational buildings were identified, as well as the furniture used in these spaces. Subsequently, the measures that can be taken are presented for the specified furniture.

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2. EDUCATIONAL BUILDINGS AND EARTHQUAKE

Educational buildings are used by young people, which is a widely held belief among the public, suggests that the buildings are resistant to natural disasters. Despite popular belief, educational buildings may be more vulnerable to natural disaster damage than other types of buildings. Schools, for example, frequently have large meeting rooms, such as gymnasiums and conference rooms, which are more vulnerable to damage during natural disasters like earthquakes and hurricanes. Furthermore, school buildings can often be used longer than other types of public buildings. The planning and building of educational buildings in Turkey and across the world must take earthquake safety into account. First and foremost, the characteristics of the users they have depending on their functions (intensive use by children and young people from vulnerable and disadvantaged groups), the task they will undertake to provide the need for emergency response, administration, and temporary shelter after the earthquake, and the spatial need to work towards minimizing social trauma, especially after the earthquake, must be able to afford it. Because of these qualities, the planning and building of educational buildings is critical in terms of earthquake safety (Akbulut, 2007). While building codes are constantly changing and evolving as professionals learn more about designing disaster-resistant structures, many school buildings are decades old and thus built to past building code standards (FEMA, 2017). A study conducted by Şimşek (2007) resulted with 40 students randomly selected from the first, fourth, sixth, and eighth grades of primary school show a negative image of the earthquake phenomenon is formed in the minds of the students, which is due to a lack of knowledge. Students can provide rational answers to the earthquake's causes, but no one can fully and scientifically explain it. Furthermore, while students' knowledge of earthquake protection varies, it is believed that it is insufficient. Ceilings, equipment, light units, air conditioning systems, furniture and interior finishes are all often damaged in schools. During the Anchorage America earthquake, it was standard procedure to secure all large and heavy furniture that belongs to classrooms to the walls of educational buildings, therefore there was very little content damage that could have resulted in significant injury to young people. Unfixed furniture has been observed to tip over in a few instances. Books and school supplies have been shown to fall often, and falling books can cause concussions (Hassan, Rodgers, Motter and Thornley, 2022). Overturning of storage furniture and bookshelves, falling ceilings, and lighting fixtures are common damages in almost every earthquake in schools. Many earthquakes damage reconnaissance reports state that school occupants are likely to be injured if the incident occurs during the school day (FEMA, 2017). There are many non-structural elements in schools. Glass panels on the walls, lecterns, cabinets with glass doors, and projection devices cause non-structural risks in classrooms. During the earthquake, some non-structural elements can

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cause death, injury, or property loss and damage. This type of risk is known as "non-structural risk" (Boğaziçi University Kandilli Observatory and Earthquake Research Institute, 2005). Furthermore, chemicals in science, physics, biology, and chemistry laboratories, as well as glassware and electronic devices in computer laboratories, can cause serious harm. Disaster And Emergency Management Presidency states that these risks can be reduced by following general rules and practices, so that earthquakes cause the least damage to schools (AFAD, 2011). Regulations will also be decisive and guiding in the measures to be taken against non-structural elements. Stabilizing what should be done against risks that may occur outside the structural system through regulations and legal sanctions, particularly when non-structural measures are not taken in public places (school, hospital, library, museum, etc.), will reduce risks (Bayraktar, 2015). Therefore, non-structural elements are as important for human life as structural elements during earthquakes.

3. NON-STRUCTURAL ELEMENTS AND FURNITURE IN THE EARTHQUAKE

Non-structural components are those in a building that are not part of the structural frames and walls. These constitute architectural, mechanical, electrical and plumbing systems, furniture, fixtures, equipment and other contents (FEMA, 2017). FEMA (2012) defines furniture, fixtures and equipment elements such as furniture, bookshelves, file cabinets, storage units, chemical materials etc. Non-structural elements are structural components that are movable and replaceable in the spaces. As a result, during an earthquake, items and furniture can injure and harm people, building elements, or each other. It is not the item itself that is the source of the danger. It is caused by a collision with another person, object, or location (Boğaziçi University Kandilli Observatory and Earthquake Research Institute, 2005). Risks arising from non-structural elements after the earthquake include material, life, service and work loss with injury and psychological problems. Damages and hazards caused by structural elements can be minimized with proper material selection and use, quality workmanship, and engineering practices (Akbalık, 2020). According to Winkler and Meguro (1996), while advances in engineering technology and interior design have reduced structural damage during earthquakes, furniture and other items that could be dislodged or overturned during the shaking continue to create a risk. Non-structural hazards continue to be minor in terms of how they can be avoided, such as falling unfixed items or falling objects blocking the road and preventing escape, but they remain for major reasons in terms of the danger and risk they may cause. According to previous earthquake research, although structural factors are generally responsible for loss of life, property, and injuries, the effect of non-structural factors is also significant. According to Kadıoğlu (2008), The most straightforward and cost-effective precaution to take before an earthquake is to prevent the damage caused by non-structural components. In the 1999 Kocaeli earthquake, non-structural elements contributed 50% of the people's injuries and 3% of fatalities. By simply fixing cabinets, showcases, and large electronic devices with simple methods, it is possible to reduce 50% of post-earthquake injuries and 3% of deaths. Furthermore, the simple measures outlined above can prevent 30% of the financial losses that survivors will face (AFAD, 2011). According to one study, the following items were damaged by the earthquake: 10.8% kitchen cabinet, 18.9% coffee table, 8.1% wardrobe, 5.4% chandelier / lamp, and 10.2% other. It has been claimed that the furniture blocks escape routes and create an impediment in the form of hitting the furniture (Ulay and Bekiroğlu, 2016). According to Demirarslan (2005), building collapses and human deaths are uncommon in Japan, which experiences large or minor earthquakes almost every day, and that the injuries were caused by the overturning of items and equipment in the space. Even if the buildings are not destroyed by the slightest shaking, most people suffer physical harm because of the overturning of belongings in the space and the ensuing panic. An analysis about the non-structural components was created to offer risk reduction and recommendations (WJE, 2005). However, only the fastening procedures applied inside structures designed with anti-seismic requirements have been demonstrated to be valid in Japanese cases. Non-structural element studies, on the other hand, are inadequate when used in a historical architectural setting, for example Italian architecture, where there is widespread doubt regarding the behavior of structures (Galloppo, Mascitti and Pietroni, 2019). The damage caused by an earthquake generally comes rapidly and within seconds. People's emotions and needs must be accommodated in the layout of the furniture framework, such as the simple pulling and pushing of the door, which provides for easy escape in the case of a tragedy. When an earthquake occurs, most individuals who live indoors will build a shelter out of their most valuable items. Furniture is critical at this point (Chen, Jiang, Liu and Lyu, 2015). Furniture of all shapes and sizes can be placed in spaces. During the earthquake, furniture with wheels is likely to move around. Depending on the size of the furniture, medium-height objects can slide, wobble back and forth, or tilt over; long and narrow furniture is more likely to tip over. Narrow shelves placed on high surfaces can tip, slide, tilt over, or collapse. Tilted shelves can injure people and obstruct doorways and escapes. Books, documents, and medical data are all susceptible to falling and becoming misplaced or destroyed. Released items can take hours or days to clean up and reorganize, causing costly business interruptions (FEMA, 2012). According to the findings of an earthquake survey conducted by Ertürk (2003) on people who have been affected by an earthquake, the low fixation rate of furniture is a clear indication that people who have been in an earthquake are still not fully conscious. He stated that to get rid of these disasters compelling measures should be taken during building planning and construction, or by imposing some manufacturing restrictions on furniture manufacturers.

4. MATERIAL AND METHOD

Many country-based literature studies on earthquakes have been conducted, particularly in Turkey, Japan, Italy, and the United States. Keyword analysis with the Vosviewer program was used to select the keywords to be included in the study's literature search on Google Scholar, Scopus, and Web of Science. Scopus was used to find academic studies with keywords. Firstly, the search terms "earthquake" AND "educational building" were entered into the Scopus search bar by using the common search code as TITLE-ABS-KEY. Because of the search, studies having these terms in their titles, abstracts, or keywords were included (Figure 1). The terms "earthquake" AND "school building" were then searched, resulting in 584 articles. To avoid potential confusion in the keyword map, 25 or more repeated words were included (Figure 2). Following that, "earthquake" AND "school building" AND "furniture" was searched, and 3 results were found (Figure 3). The words "earthquake" AND "educational building" AND "furniture" was searched in the final step, but no results were found.

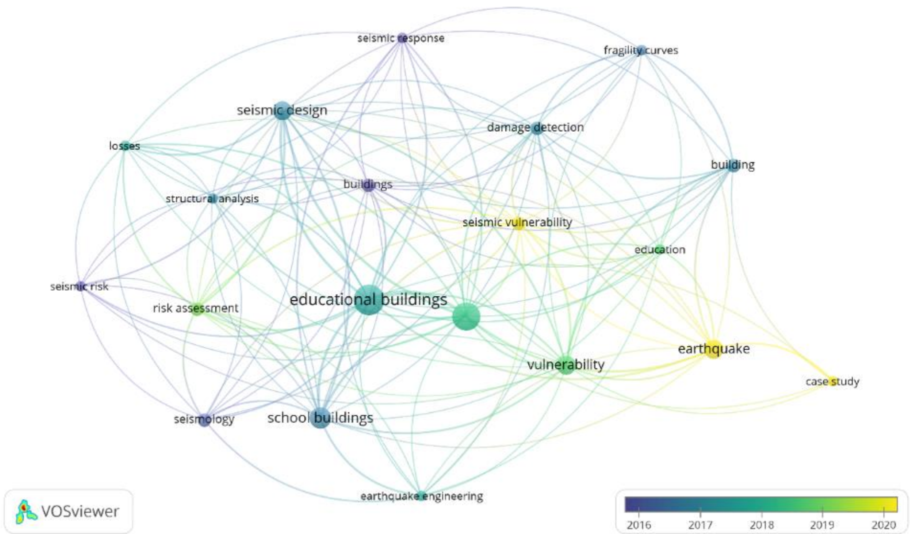

Figure 1. Results of “earthquake" AND "educational building" keyword analysis (Vosviewer)

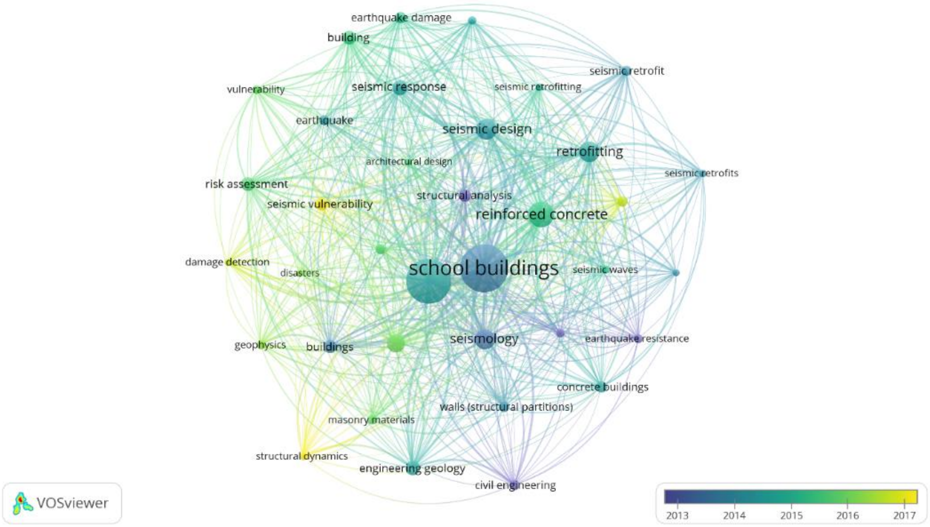

Figure 2. Results of "earthquake" AND "school building" keyword analysis (Vosviewer)

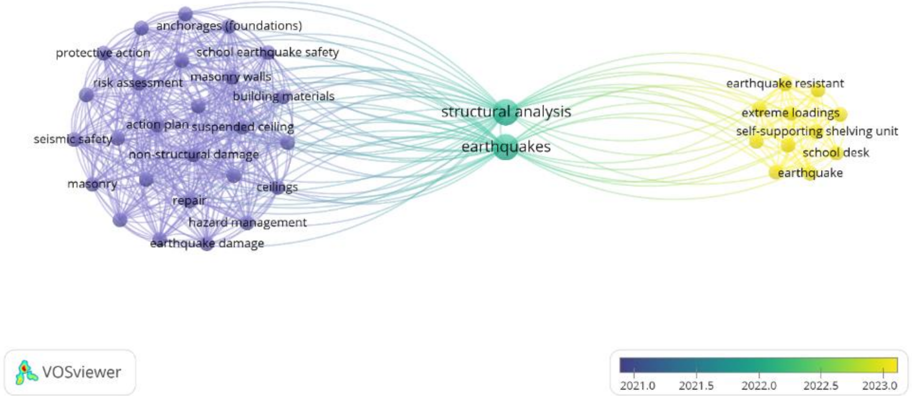

Figure 3. Results of "earthquake" AND "school building" AND “furniture” keyword analysis (Vosviewer)

Words from the keyword analysis were used to conduct searches in academic search engines for literature review. The guide called “Educational Buildings Minimum Design Standards”, which uses general definitions was chosen to define the interior spaces of educational buildings (Figure 4). According to the classification of the National Education Ministry of Turkiye (2015), the main interior spaces of the educational buildings are listed as follows: administrative spaces, classrooms (kindergarten/kindergarten classrooms, educational buildings classrooms, music classrooms, visual arts classrooms, laboratories), common areas (library, multi-purpose hall, performing arts and conference hall), place of worship (masjid), sports and physical education hall, canteen-cafeteria) circulation areas (entrance halls, corridors, closed break area, ramps, stairs, fire escapes, elevator, gallery spaces), wet areas and technical spaces (heating center, electric room, generator room, ventilation plant, system room, technician and servant rooms, warehouses, water tank, shelter). Furthermore, the literature sources examined as part of the keyword analysis were used to define the furniture in the interior spaces (AFAD, 2011; FEMA, 2012; Boğaziçi University Kandilli Observatory and Earthquake Research Institute, 2005) additionally, 7 basic furniture were defined (Figure 4).

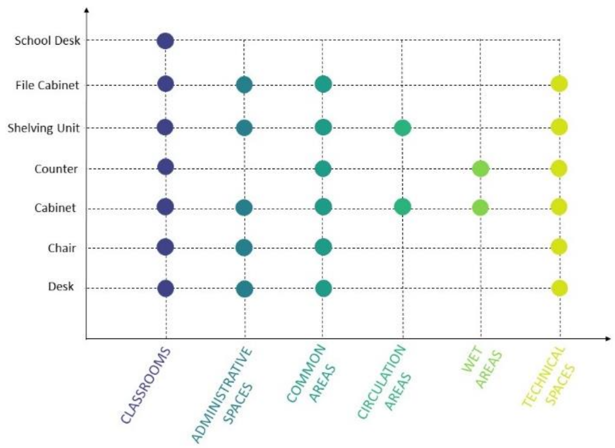

Figure 4. Fundamental interior spaces and furniture of educational buildings

The interiors of educational buildings examined with keyword analysis in online and printed literature, as well as the furniture in these interiors, are shown in figure 4. The study excluded sleeping rooms, parent meeting/waiting areas/rooms in primary and kindergarten schools, as well as interior types with different functions such as drama and music rooms in high school and secondary schools. The basic interiors of educational buildings from primary school to university level, as well as the furniture in these interiors, are classified in the study.

School desks, which are generally preferred in classrooms, differ from instructor desks. School desks are frequently used for students to hide under, are among the first places students think of for shelter during an earthquake. In almost every earthquake, falling ceilings and lighting fixtures are common damages in schools (FEMA, 2017). In this scenario, with proper material selection and positioning, they can protect students from non-structural risks caused by the ceilings. Behaviors such as drop-cover-hold and fetal position, which can save lives in the event of an earthquake, can also be performed next to the school desk, preventing injuries and loss of life.

File cabinets are typically long, narrow, and heavily loaded, and are found in administrative units, classrooms, laboratories, and archive areas. These cabinets typically lean over during earthquakes;

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the time necessary to find and reorganize information can be a considerable corporate expenditure and result in reduced efficiency (FEMA, 2012). Therefore, the right material selection of the file cabinets, the right fixing and connection elements, and the protection of the center of gravity are important in preventing the risks that may occur to protect important data and prevent loss of life and property.

Shelving units can be found in libraries, classrooms, technical rooms, storage areas, and laboratories. Loose things housed on shelves, storage cabinets, or cupboards are especially dangerous during earthquakes (FEMA, 2012). Before the items are placed in the shelving units, the unit itself must be stable, safe, and motion-resistant during an earthquake. Library shelves, for example, are typically made up of many heavily loaded, back-to-back tall shelving units. The earthquakes resulted in numerous costly failures of library shelves, including both unfixed and poorly fixed shelving units.

Desktops or workbenches support many items of office and laboratory equipment (FEMA, 2012). Furthermore, counters are commonly used in school cafeterias and canteens. Microwaves, microscopes, and laboratory equipment, which are electronic and mechanical items on these tables, may threaten human life and cause material damage if the counter is not properly fixed. Furthermore, the risk of fire after an earthquake may increase because of chemical hazards.

Cabinets are the most common type of furniture found in educational buildings' interiors. It is the use of special fasteners designed for earthquake safety to secure items such as cupboards, wardrobes, bookshelves, buffets, and refrigerators that are at risk of overturning. Furthermore, cabinet doors should be kept closed with special security locks (Aytöre, 2005).

The relationship of the chairs to the windows, which may cause injuries during the earthquake, should be reviewed. It is also critical to select the appropriate material for this type of furniture, which can meet the urgent need for protection by going under the tables.

Desks, which are commonly used in educational buildings, have the potential to protect users, particularly from dangers caused by the ceiling. Individuals who are protected by going under a solid and fixed table will be less likely to be injured after the earthquake.

5. FINDINGS

Non-structural elements have a connection with attitudes and behaviors about taking preventive measures related to reducing non-structural risks. In other words, it is the fixation of inflexible items such as lighting, heating, ventilation systems, furniture, and other components that do not belong to

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the building structural system, as well as the fixation of items that will cause a life threat by slipping and falling, and the determination of the building's safe and dangerous areas (Yakut, 2003). Nonstructural seismic mitigation measures can be divided into three categories: 1. very simple “do it yourself” activities; 2. activities at the level of repairmen or maintenance personnel; 3. professional contractor level activities. Level 1 involves moving furniture to clear exit routes or fixing shelves to walls with small steel corners. Level 3 requires expertise in electrical or mechanical systems, roofing or heavy construction. A common exercise, both practical and educational, is to conduct a "hazard hunt" in class, especially for Level 1 items (FEMA, 2017). Elements that do not belong to the building but make our lives easier may fall, slide, release, or overturn because of the buildings' moving and shaking during an earthquake. The displacement of such items in any moderate to severe concussion is associated with the following characteristics: 1. size (items with a height that is 1.5 times greater than their width or depth) 2. weight (items with a heavier top than a lighter bottom) 3. equipment (wheeled items) 4. location (books on the shelf or products in the market) (AFAD, 2011). In this regard, the following safety measures for furniture, which is a non-structural element, can be listed as: fixation, location, structural/non-structural element for fixation, joint/fixing element, center of gravity/balance, and material.

5.1. Fixation

Fixing the furniture is one of the most basic measures that can be taken to protect it from earthquakes. Furniture anchoring is a disaster mitigation strategy that requires heavy appliances and furniture to be fastened in order to avoid them from accidentally tipping over. Furniture fixing is a disaster prevention approach that lowers the human effect of an earthquake. All kinds of furniture and items that cause injury or death by falling on people in an earthquake can be minimized with the fixing method and elements to be applied. The height of shelving units and cabinets as well as loading them with more than they can carry, can cause damage due to the release and falling of materials inside. Although it is critical to secure the furniture, if it is secured loosely or with a gap between the walls, it will constantly hit the wall during an earthquake. As a result, fixing and securing the items tightly, leaving no gaps, and filling any gaps with filling material protects both the furniture and the wall. Furthermore, where and how the furniture will be fixed is an important consideration when fixing (Figure 5). At this point, the furniture is secured in this manner by selecting the location where the furniture will move the most during the tipping action. Improper or incomplete fixation application may not be enough to prevent damage

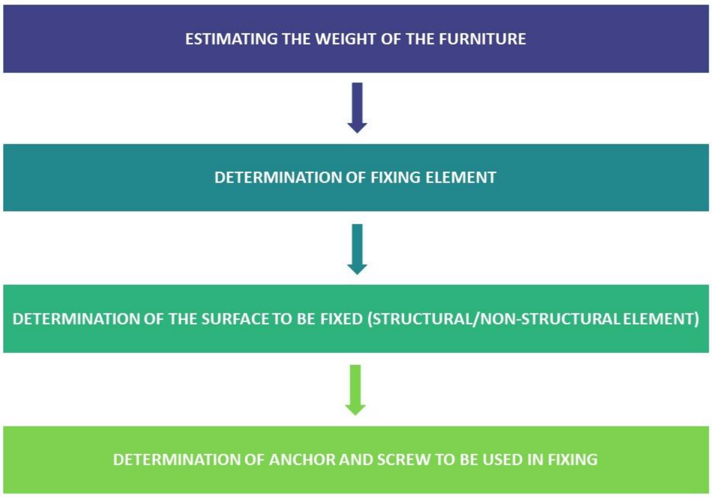


Figure 5. Steps before the fixation process (Boğaziçi University Kandilli Observatory and Earthquake Research Institute, 2005).

It should be determined which way and in which direction the furniture is to be fixed is likely to move or tip over. Consequently, the furniture is secured from the point where it will begin to move during tipping and falling.

5.2. Location

The most basic and least expensive method of mitigating non-structural risks is to relocate items. To reduce the risk of furniture overturning during an earthquake, the "fixing position" where the strongest fixation will be made is first determined, considering the location of the furniture to be fixed in the environment. Then, if necessary, changes are made to the interior space's positioning. This location is determined by factors such as the type of wall behind the furniture and the proximity of the window. The fixing element is then chosen based on the type of furniture, its weight, and its distance from the wall. Location related measures can be listed as: moving heavy and tall items to a more secure location, shielding occupied furniture from windows, using thick curtains on windows to protect against potential risks, placing items that are heavy on the lower shelves that are high, getting rid of unnecessary items. First, the best fixing position for the item to be fixed should be determined. This location is determined by factors such as the type of wall behind the item, the parallelism of the item to the wall, and the proximity of the window to the item (AFAD, 2011).

5.3. Structural/Non-Structural Element for Fixation

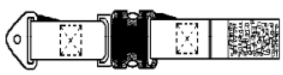
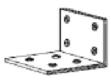
The main purpose of repairing the furniture is to keep it from swinging inside the building and to allow it to move with the structure. Under the right conditions, furniture can be attached to load-bearing elements and solid non-structural elements made of strong materials. Unless necessary precautions are taken, drywall, conventional infill, aerated concrete, rubble stone, and adobe walls are not suitable surfaces for fixing items. Brick walls built with adequate mortar provide suitable and solid surfaces for fixing items, despite being non-structural elements (Boğaziçi University Kandilli Observatory and Earthquake Research Institute, 2005). When properly equipped, they can be used to secure items weighing up to 75 kg (AFAD, 2011).

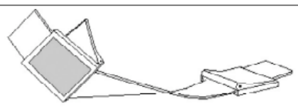
5.4. Structural/Non-Structural Element for Fixation

The fixing elements used with the materials, as much as the material itself, influence the tendency of furniture to shake or break down during an earthquake. If the material used in the main structure is incompatible with the fixing material, no matter how strong, the product will inevitably be damaged over time. As a result, the relationship between the main material and the fixing element must be properly built (Aytöre, 2005).

The following fixing elements are listed by AFAD (2011) and Boğaziçi University (2015); woven strap, metal L profile, plastic clip strip, and self-adhesive hook and loop tape, mechanical locks, child safety locks, snaps and magnets (Table 1).

Table 1.
Fixing Elements to Reduce the Earthquake Hazards of Furniture

Woven Strap	
	• Selected according to the weight of the items to be fixed • Used for wheeled furniture that needs to be moved regularly for its function or maintenance, and for all sizes of white goods and electronic devices that can rotate or slide
Metal L Profile	
 	• Used for fixing furniture • Different sizes are preferred according to the width, height and weight of the furniture

Plastic Clip Strip	
	• Used for light-weight items that are placed on a furniture surface
Self-Adhesive Hook And Loop Tape	
	• Used for fixing low, not heavy, devices that do not have the risk of tipping
Mechanical Locks, Child Safety Locks, Snaps and Magnets	
	• Used for mechanical or child safety locks, especially in cabinets containing heavy objects

The type of fixing element used varies depending on the characteristics of the furniture and equipment as well as the location where it will be fixed. The goal is to secure the furniture and equipment to the location where it will be secured with the chosen element (Ertaş Beşir and Dereci, 2021). Different materials are used to fix items depending on their properties and where they will be fixed. The goal is to secure the item to the location where it is fixed using the fixing element of choice. For example, if a cabinet is not firmly fixed to the wall with a steel rope, it will move apart from the wall and break at its weakest point, where it was fixed during an earthquake. Even though a very strong fixing element, such as a steel rope, is used in this case, there is no effective fixing. Depending on the type and weight of the item, using an appropriate number of L-profiles and, if necessary, filling material may be sufficient for a firm fixation (AFAD, 2011). One of the most critical issues is opening cabinet doors and drawers during an earthquake; items made of heavy, sharp materials inside cabinet doors can cause serious harm to those nearby. Mechanical door lock systems with manual intervention are used to prevent cabinet doors from being opened during an earthquake (AFAD, 2011). Damage from overturning and releasing the contents during an earthquake can be avoided by using mechanical locks, child safety locks, snap-buttons, and magnets for cabinet doors. Currently, such applications are primarily used for aircraft, luxury yachts/boats, ships, caravans, buses, and so on. It is used in furniture and to decorate the interiors of moving vehicles. Cover accessories with magnetic and snap fixings secure the covers in the event of sudden movements such as earthquakes. The type and number of appropriate accessories should be determined by considering the cover dimensions and weight

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when selecting these accessories. Drawer holder accessories are used in furniture with drawers in addition to the precautions to be taken in furniture with doors (Ulay, 2013). According to Aytöre (2005), cabinet doors should be kept closed with special security locks. This way, potential hazards and damage are avoided.

5.5. Center Of Gravity/Balance

It is necessary to maintain the balance of furniture to be fixed within the scope of the earthquake mitigation measures. If an item or accessory is attached to a piece of furniture, the furniture should also be attached to the nearest wall or a solid non-structural element, as such items can tilt over much more easily (AFAD, 2011). Because each load added to the furniture may cause the furniture's center of gravity to shift and its balance to deteriorate.

5.6. Material

An important portion of the deaths and injuries caused by earthquakes or great shaking are caused by falling objects on people or by closing exit routes and preventing escape. As a result, the materials of the furniture are important in the context of a variety of factors. With a moderate shake, a heavy and unstable piece of furniture can tilt over and cause serious injury. On the other hand, the fact that the furniture material is unprotected against disasters such as fire that may occur after an earthquake is an important factor in the selection of furniture material.

6. CONCLUSION

Countries along the world's earthquake-prone areas including Turkey, Japan, Italy, Haiti, and the United States, are always at risk of earthquakes. In contrast to other types of disasters, earthquakes occur unexpectedly and catch people off guard. Educational buildings, where students, educators, and employees spend most of their days, are at risk of earthquakes, just like other public buildings. Furthermore, due to the unfounded belief that schools are safe in most countries and the use of old buildings without renovation, educational buildings may be more vulnerable to earthquakes than other public buildings such as hospitals and government buildings. The consequences of an educational building collapse highlight the importance of school buildings with earthquake resistant and safe non-structural elements. It also emphasizes the importance of better understanding the underlying factors. Although the measures available for preventing the earthquake are divided into structural and non-structural elements, the destructive effect of the earthquake can be mitigated with changes that require less labor and budget to be applied for furniture in educational buildings. Earthquake risk can be gradually reduced in educational buildings through various methods such as do-it-yourself activities,

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specialist changes, and hazard hunting. Changing the position of the furniture or attaching it to solid structural/non-structural elements with simple fixing elements can help to avoid potential damage and injury. The number of non-structural elements used in educational structures is growing in response to changing global conditions and technological developments. Regardless of the severity of the earthquake, all non-structural elements used in educational buildings should be made earthquake resistant, necessary measures should be taken, and any losses should be minimized. An education building that has taken measures against non-structural elements can be evacuated in much less time during an earthquake, reducing the loss of life and allowing it to begin operations earlier due to the reduced repair time of the damages.

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Conflict of Interest Declaration

The authors declare no conflict of interest.

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The authors declare that they have contributed equally to the research.

REFERENCES

AFAD, (2011). *Depreme Karşı Yapısal Olmayan Risklerin Azaltılması*, İstanbul: TC Başbakanlık Afet ve Acil Durum Yönetimi Başkanlığı.

Akbalık, S. (2020). *Eğitim binalarının yapısal olmayan elemanlarında deprem risklerinin değerlendirilmesi: Bolu ili örneği* (Master's Thesis, Düzce University, Düzce). Available online:https://tez.yok.gov.tr/UlusalTezMerkezi/tezDetay.jsp?id=zDI3Us9qHHrhb6tgN6ZroQ&no=TE0o5ADsTzNTedu5VllT4g

Akbulut, M. T. (2007). Depreme dayanıklı yapı tasarımı eğitimi yaklaşımı. *International Earthquake Symposium Kocaeli 2007*, 22-26 October 2007, 586-592.

Akgüngör, Ç. (2014). Sarsıntı başladığında: kitlesel afet eğitimi ve deprem anıida birey davranışı örneği. *Siyasal: Journal of Political Sciences*, 0 (49). Available online: https://search.trdizin.gov.tr/tr/yayin/detay/157003/

Alıcı, M. (2019). Deprem unsuru açısından mobilya kullanımının incelenmesi. *International Anatolian Journal of Social Sciences*, 3 (2), Available online: 4-15. https://dergipark.org.tr/tr/pub/ulasbid/issue/51581/563198

Journal of Interior Design and Academy
INda 2023, 3(1):77-95
e-ISSN: 2791-7436

Aoki, T. and Ito, K. (2014). Lessons of the great east japan earthquake: what .s the role of universities in disaster response, recovery, and rehabilitation? focusing on our disaster victim identification project. *IEEE Communications Magazine*, 52 (3), 30-37. doi: 10.1109/MCOM.2014.6766081.

Aydoğan, İ. (2012). Okul binalarının özellikleri ve öğrenciler üzerine etkileri. *Milli Eğitim Dergisi*, 42 (193), 29-43. Available online: https://dergipark.org.tr/tr/pub/milliegitim/issue/36181/406760

Aytöre, S. (2005). Depolama ve üretim biçimleri açılarından seri üretilen mobilyaların deprem karşısında insan üzerindeki etkileri, *Deprem Sempozyumu*, Kocaeli, 23-25 March 2005, 1251-1260.

Bayraktar, H. (2015). Yapısal olmayan elemanların afet riskleri açısından incelenmesi. *Düzce Üniversitesi, Ulusal Mühendislik Araştırmaları Sempozyumu (UMAS'15)*, Düzce, Türkiye.

Berry, D.L. and Gruhn, S. (2015). *Identifying Potential Earthquake Dangers to Alaska's Students and Schools: A Pilot Project Screening Matanuska-Susitna School District Buildings*. Anchorage: AK: BBFM Engineers, Inc.

Boğaziçi Üniversitesi Kandilli Rasathanesi ve Deprem Araştırma Enstitüsü. (2005). *Afete Hazırlık Eğitim Birimi, Yapısal Olmayan Tehlikelerin Azaltılması El Kitabı*, İstanbul.

Chen M., Jiang L., Liu D.Z. and Lyu, J. (2015). Furniture innovative design with earthquake self-rescue function: from furniture form and structure perspective. *International Conference on Informatization in Education, Management and Business (IEMB 2015)*, 35-40. DOI: 10.2991/iemb-15.2015.7

Chuang, E., Pinchoff, J., and Psaki, S. (2018). How Natural Disasters Undermine Schooling. Brookings. Available online (23 April 2023): https://www.brookings.edu/blog/education-plus-development/2018/01/23/how-natural-disasters-undermine-schooling/#:~:text=Following%20damage%2C%20repairs%20to%20schools,who%20have%20experienced%20climate%20shocks. /

Demirarslan, D. (2005). Türk ve japon konut iç mekanlarında depremsellik açısından konut ve eşya kullanım alışkanlıklarının irdelenmesi. *Deprem Sempozyumu Kocaeli 2005,* 23-25 March 2005, 728- 737.

Demirbaş, Ç. (2008). *Deprem bölgesi konutları için iç mekanların güvenlik analizi ve çözüm önerileri (*Master's Thesis, Karadeniz Technical University, Trabzon*)*. Available onlie: https://tez.yok.gov.tr/UlusalTezMerkezi/tezDetay.jsp?id=NBj1O6jCkOMr5jSzwU7R4g&no=iboPDRQKXUzb2A9O2ZuFIg

Ertaş Beşir, Ş. and Dereci, Ş. (2021). Deprem sırasında konut iç mekanlarında yapısal olmayan elemanların yarattığı riskler ve alınabilecek önlemler. *Social Mentality and Researcher Thinkers Journal (Smart Journal),* 7 (42), 350-360. DOI : 10.31576/smryj.818

Ertürk, F. (2003). *17 Ağustos 1999 İzmit depreminde evi zarar gören ailelerin geçici ve kalıcı konutlardaki yaşamlarının bina-mobilya açısından incelenmesi ve sonuçları* (Master's Thesis, Kocaeli University, Kocaeli). Available online: https://tez.yok.gov.tr/UlusalTezMerkezi/tezDetay.jsp?id=wfN_eIvnFc08Dfx-y62hhg&no=onffQITCy99NhvectBXUGA

FEMA, (2012). *Reducing the risks of nonstructural earthquake damage—A practical guide*. FEMA E-74. Washington, DC: Federal Emergency Management Agency, 482-571.

Journal of Interior Design and Academy
INda 2023, 3(1):77-95
e-ISSN: 2791-7436

FEMA, (2017). *FEMA P-1000, safer, stronger, smarter: A guide to improving school natural hazard safety*. Washington, DC: Federal Emergency Management Agency.

FEMA, (2005). *Earthquake hazard mitigation for nonstructural elements*. Washington, DC: Federal Emergency Management Agency, 1-48.

Fugate, W.C. (2010). Developing and Maintaining Emergency Operations Plans Comprehensive Preparedness Guide (CPG) 101 Version 2.0. Available online (23 April 2023): https://www.fema.gov/sites/default/files/202005/CPG_101_V2_30NOV2010_FINAL_508.pdf

Galloppo, D., Mascitti, J. and Pietroni, L. (2019). *Design strategies for the development of life-saving furniture systems in the event of an earthquake,* In Guarascio, M., Passerini, G., Garzia, F. and Lombardi, M. (eds), WIT Transactions on The Built Environment, (189), Southampton (UK): WIT Press, 67-77. Available online (23 April 2023): witpress.com/elibrary/wit-transac-tions-on-the-built-environment/189/37350

Hassan, W.M., Rodgers, J., Motter, C. and Thornley, J. (2022). Structural performance of buildings during the 30 november 2018 m7.1 anchorage, alaska earthquake. *Earthquake Spectra*. 38 (1), 200-234. DOI: 10.1177/87552930211043539

International Finance Corporation (IFC), (2010). *Disaster and emergency preparedness: guidance for schools*.

Kadıoğlu, M. (2008). Modern, bütünleşik afet yönetimin temel ilkeleri. *Afet Zararlarını Azaltmanın Temel İlkeleri* (pp.1-34), Ankara: JICA Türkiye Ofisi.

Mihai, T and Iordache V. (2016). Determining the indoor environment quality for an educational building. *Energy Procedia,* (85), 566-574. DOI: 10.1016/j.egypro.2015.12.246

Ministry of National Education (Milli Eğitim Bakanlığı), (2015). *Eğitim yapıları asgari tasarım standartları kılavuzu 2015*, Ankara: T.C. Milli Eğitim Bakanlığı.

Sato, T., Motosaka, M. and Mano, A. (2006). Investigation of human injuries during the july 26, 2003 northern miyagi earthquake with focus on furniture overturning. *Journal of Natural Disaster Science*, 28 (1), 15-24. Available online: https://www.jsnds.org/jnds/28_1.html

Şimşek, C.L. (2007). Children's ideas about earthquakes. *Journal of Environmental & Science Education*, 2 (1), 14-19. Available online: https://eric.ed.gov/?id=EJ901261

Soyluk, A. and Gerek, A. E. (2016). Türkiye'deki ilköğretim yapılarının deprem dayanımının incelenmesi. *Journal of the Faculty of Engineering and Architecture of Gazi University*, 31 (3), 0-0 . DOI: 10.17341/gummfd.44283.

Ulay, G. (2013). Depreme karşı iç mekan donatılarındaki çözümlemeler, *II.Ulusal Mobilya Kongresi Denizli*, 11-13 April 2013, 618-627.

Ulay, G. and Bekiroğlu, M. S. (2016). Deprem faktörünün mobilya kullanımı üzerine etkisinin incelenmesi . *Yuzuncu Yil University Journal of the Institute of Natural and Applied Sciences*, 21 (1), 43-54. Available online: https://dergipark.org.tr/tr/pub/yyufbed/issue/24188/256525

United Nations Population Fund, (2010). Midwifery and Nursing Schools Destroyed by Haiti Earthquake. Available online (23 April 2023): www.unfpa.org/news/midwifery-and-nursing-schools-destroyedhaiti-earthquake

Journal of Interior Design and Academy
INda 2023, 3(1):77-95
e-ISSN: 2791-7436

Winkler, T. and Meguro, K. (1996). Response of interior rigid body assemblies to dynamic excitation. *Eleventh World Conference on Earthquake Engineering*, 581. DOI: 10.1002/eqe.4290241008

World Health Organization (2023). Earthquakes. Available online (23 April 2023): https://www.who.int/healthtopics/earthquakes#tab=tab_1

Yakut, İ. (2003). Toplumun deprem tehlikesine hazırlıklı olması ve yerel toplumsal gruplarla etkileşim (İzmit Saraybahçe'de yapılan alan araştırması). *Kocaeli Üniversitesi İletişim Fakültesi Araştırma Dergisi*, (4), 83-111. Available online: https://dergipark.org.tr/tr/pub/kilad/issue/69074/1093480