MAKÜ FEBED
ISSN Online: 1309-2243
http://dergipark.gov.tr/makufebed
DOI: 10.29048/makufebed.377482

Mehmet Akif Ersoy Üniversitesi Fen Bilimleri Enstitüsü Dergisi 9(1): 55-62 (2018)
The Journal of Graduate School of Natural and Applied Sciences of Mehmet Akif Ersoy University 9(1): 55-62 (2018)

Araştırma Makalesi / Research Paper

Spatial Design Approaches to Prevent Damages from Earthquake inside the Buildings

Latif Gürkan KAYA[1], Cengiz YÜCEDAĞ[1], Hüseyin Samet AŞIKKUTLU[1*], Hale ÇOKYİĞİT[2]

[1] Mehmet Akif Ersoy University, Faculty of Engineering and Architecture, Burdur
[2] Mehmet Akif Ersoy University, Graduate School of Natural and Applied Sciences, Burdur

Geliş Tarihi (Received): 11.01.2018, Kabul Tarihi (Accepted): 05.02.2018
Sorumlu Yazar (Corresponding author): sasikkutlu@mehmetakif.edu.tr*
+90 248 2132790 +90 248 2132704

ABSTRACT

The facts that a large part of Turkey is located on Anatolian earthquake fault and that many earthquakes have occurred in recent years have forced earthquake-resistant housing designs. The main objective is to ensure the safety of life by preventing structural migrations. In this study, the parts of house are conceptually designed against the collapse of the upper floor at the time of an earthquake and these design concepts are illustrated. The design concepts have been done by using the 3ds Max program. The most important point in these designs is that all the elements of space fix to wall and are functional. Thus, earthquake damages can be minimized. In addition, it is important that furniture used in the interior areas should be aesthetic and multifunctional. In conclusion, earthquake-resistant design is not only a static process, but also it is constantly evolving.

Anahtar Kelimeler: Spatial Design, Earthquake, Functional Design Concept, Building

Bina İçlerinde Depremin Zararlarını Önleyici Mekansal Tasarım Yaklaşımları

ÖZ

Türkiye'nin büyük bir bölümü Anadolu deprem fayı üzerinde yer almaktadır ve son yıllarda birçok deprem meydana gelmiştir; bu da depreme dayanıklı konut tasarımları anlayışını zorunlu kılmıştır. Ana hedef, yapısal göçleri önleyerek hayat güvenliğini sağlamaktır. Bu çalışmada, konut iç mekânı deprem anında üst katın çöküşüne karşı kavramsal olarak tasarlanmış ve bu anlayışla tasarım konseptleri geliştirilmiştir. Tasarımlar, 3ds Max programını kullanarak yapılmıştır. Bu tasarımlarda en önemli nokta, mekânın tüm unsurlarının duvara sabitlenmesi ve işlev kazanmasıdır. Böylece, deprem hasarları en aza indirgenebilir. Buna ek olarak, iç mekânlarda kullanılan mobilyaların estetik ve çok fonksiyonlu olması önemlidir. Sonuç olarak, depreme dayanıklı tasarım sadece statik bir süreç değil, aynı zamanda sürekli gelişen bir süreçtir.

Keywords: Mekansal Tasarım, Deprem, İşlevsel Tasarım Konsepti, Bina

INTRODUCTION

Natural parts of the earth’s actions, Earthquakes, have come to understand by the study of plate tectonics. Earthquakes fall under a few classifications according to their generating mechanism; for example, terrestrial, volcanic, oceanic (JIA - JAO, 2012). Of the 500,000 or so detectable earthquakes that occur each year on planet Earth, people will "feel" about 100,000 of them and about 100 will do damage. Although most earthquakes have a moderate size and destructive potential, a severe earthquake occasionally hits a community that is under-prepared and loses thousands of lives and billions of dollars in economic investment (FEMA, 2010). They cause enormous disturbances such as crustal deformation, slope failure, contamination, earthquake damage, fires, tsunamis and tsunami fires. During an earthquake, it is important to prevent furniture and furnishings from falling over and falling to prevent injury or death (JIA - JAO, 2012).

As earthquakes are joint in many parts of Turkey (Gülkan and Langenbach, 2004), in the twentieth century a few serious earthquakes struck the Anatolian peninsula, causing both significant material damage and strong accidents. The major earthquake disasters causing more than 20.000 collapsed residential buildings can be listed as follows; the 1939 Erzincan earthquake with 135.000 collapsed residential buildings, the 1942 Niksar earthquake with 32.000 collapsed residential buildings the 1943 Havza/Ladik earthquake with 40.000 collapsed residential buildings, the 1944 Bolu/Gerede earthquake with 50.000 collapsed residential buildings, the 1966 Varto earthquake with 20.000 collapsed residential buildings and the 1999 Marmara earthquake with 285.000 collapsed residential buildings (Şener and Altun, 2009).

Legislation does exist in the form of building regulations, codes, guidelines and standards in most countries, but legislation is insufficient without regular, strategic, informed and reliable inspection to provide its enforcement. Earthquake-responsible development can achieve more by adopting earthquake awareness through all sectors; micro-zoning of earthquake risk can be used to modify population occupancy and to modify construction norms (Lewis, 2003). One of the key ways a community protects itself from potential earthquake disasters is by adopting and enforcing a building code with appropriate seismic design and construction norms (FEMA, 2010).

Since 1970s there have been on urban, professionally designed housing, there has been suitable attention given to low-cost, self-build, rural, domestic building construction, in efforts to facilitate resistance to the forces of natural risks. However, processes of urbanization have continued to compose the demand from many, and opportunities for some, for rapid construction of multi-story buildings for domestic housing (Lewis, 2003). In recent research, it is showing that the unhealthy planning after the earthquakes is affecting the lives of people. The natural and structural deterioration of the fields leads to unhealthy results. In this plan, there is a problem in one way houses that healthy planning will be more effective planning (Brooks and Cetin 2012; Brooks and Cetin 2013a, b; Cetin 2015; Cetin 2016; Cetin et al., 2017) . In the last example of studies that take a sample at the planning council of his work, which was originally from the local government. By all means, legal regulations can create examples (Cetin 2015; Cetin 2016; Cetin et al., 2017; Yucedag et al., 2018).

After a critical earthquake city planners and engineers typically study the causes of damage, develop strategies for avoiding or reducing damage in similar earthquakes, and design regulatory actions to implement these strategies (Von Winterfeldt et al., 2000). Today most recommended persons to take shelter under the table or door frame during earthquake. According to the simulation experiments when building collapses and the roof comes down, tables are crushed and pressed, thus, those who have taken shelter under tables lose their lives too. Also door frames are crooked either on the inside or the outside and those under them lose their lives (Ahmadnejad and Darbandi, 2015). Actually, it is convenient that the user is aware of the danger that can happen in the case of an earthquake about all these elements and thereby put solution either possible fastening elements to prevent the damage that these elements may cause (Anonymous, 2017a).

On the other hand, because of the contradiction between the technical and artistic matters of design, the artistic quality of design might grow and develop, whilst the technical consciousness may decrease. If a building is designed for change, then interior architects should redesign the interiors of it first by removing and/or adding lightweight infill walls. The most common tectonic feature of modern structures, such as frame systems, is their flexibility; they are open for change. Although this characteristic is a big advantage in collation to the inflexible masonry structures of the past, it might also compose some important problems, such as e.g. the lack of safety in the event of an earthquake, if the flexibility is not used consciously by architects and interior designers (Hurol, 2014).

MATERIALS AND METHODS

In this study, the living room and bedroom of a house are conceptually designed against the collapse of the upper floor at the time of an earthquake by using the 3ds Max program and these design concepts are illustrated. The most important point in these designs is that all the elements of space fix to wall and are functional. In addition, principles of the triangle of life are considered. These principles are as follows (Ahmadnejad and Darbandi, 2015):

- Protection next to objects instead of below objects,
- Resistant objects must be stretched against the wall,
- Stronger and larger with less compression, objects are better suited,
- The ceiling should be combined.

RESULTS AND DISCUSSIONS

The layout was planned according to the possibility of any destruction that may occur during the earthquake (Figure 1). The seating arrangement and the section where the TV unit and the bookshelf are located are in a mutually supportive manner in accordance with the possibility of collapse of the upper floor during an earthquake.

Figure 1. The views from the layout of living room (concept design)

Glasses of falling frames can cause injuries. Frames were made more robust by inserting a hook screw into the anchor plug placed to the wall and hanging the hook of the frame on the hook screw (Figure 2). Suspended ceiling panels are connected to each other.

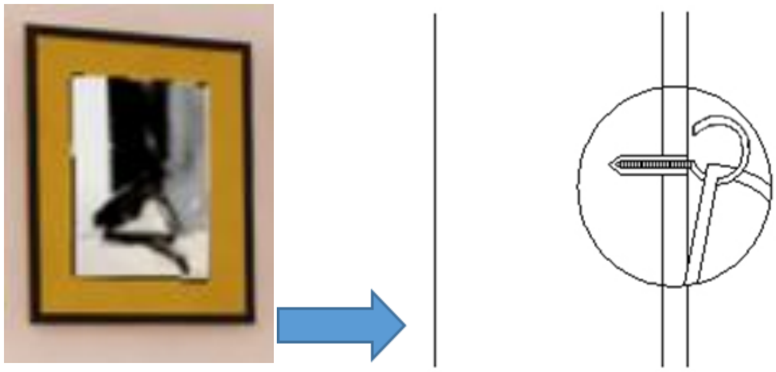

Figure 2. Reinforcement of the frame

Separate doors were made for each section of the bookshelf. The reason for this is to reduce the book load that will pressure the doors during an earthquake. The lock system designed for bags is used for the doors. The bookshelf is placed zero to the false floor. On both sides of the bookshelf, there are suspended ceilings and fixed flowerpots. In addition, the spots placed in the bookshelf contribute both to the illumination of the salon and to decorative purposes. The TV unit in the middle of the bookshelf runs with an earthquake sensor and its doors prevents the TV from falling (Figure 3).

Figure 3. Concept design of bookshelf and TV unit

The part on the back of seat can be used as a lightening element in daily life. Actually, its main purpose is to start lightning automatically and firstly at the time of an earthquake and to show its location under debris (Figure 4).

Figure 4. A lighting element on the back of seat (concept design)

In addition, lightening element has a steel shutter system that protects against earthquakes. During the earthquake, the loudspeaker in the front of the furniture will be heard, and after 10 seconds, the steel mechanism inspired by the mussel shell will start to work. Then the mechanism on the sides of the seat will move upwards. It places to the steel on the ceiling and supports it. Opposite curvatures in mussel shells provide the shells to withstand very high pressures despite being thin. Finally, the shutter system in the lighting element works goes down and locks itself up. The shutter system, which can be controlled from inside, can be unlocked and opened after the earthquake (Figure 5). The ventilator automatically works when the shutter runs.

Figure 5. A steel shutter mechanism inspired by the mussel shell (concept design)

The seat frame is made of steel and its outside is a wooden cover for design aims. Steel structures in a seismic zone have flexibility and low weight and are usually light in comparison to those constructed using other materials. As earthquake forces are associated with inertia, they are related to the mass of the structure and therefore reducing the mass inevitably leads to lower seismic design forces (Anonymous, 2017b). The seat is fixed to the furniture frame. On the seats there is also a lighthouse, spare battery, an electronic connection unit that sends SOS signals to the rescue team's radios, a lightening battery, an early warning system, a ventilation unit and a need section that can save the water, food and first aid kit. The steel mechanisms on the sides of the seat place on top of each other after the black glass covers on both sides of the seat slip sideways during the earthquake (Figure 6).

As to bedrooms, wardrobe should be fixed. If possible, they should be placed where they can stay at a 45-degree angle. The bedhead should not be placed on the edge of window. In order not to panic at the time of an earthquake, it must be planned and treated accordingly. In the bedroom design, nightstands should be fixed to the wall. In the same way lightening element should be mounted on the wall, or if the lampshade is preferred, it should be fixed on the nightstands. The nightstand doors must be push-open doors. Led lightening should be used instead of pendant lightening.

According to Azimi and Asgary (2013), conducting on the designs of earthquake-resistant houses, the average resident preferred larger houses with better interior and exterior designs to more earthquake-resistant houses, and is willing to spend more on these features than earthquake safety. Surely, there has been an evolution of the houses, as well as the evolution of the models of families or styles of interior (Anonymous, 2017a).

CONCLUSION

This study is a preliminary study to look for solutions that helps to decrease the damages during an earthquake. Even if it is expensive, it should be paid attention to the interior designs of houses against an earthquake. Further studies need to be elaborated the designs of earthquake-resistant houses in more detail and the obtained results should be simulated.

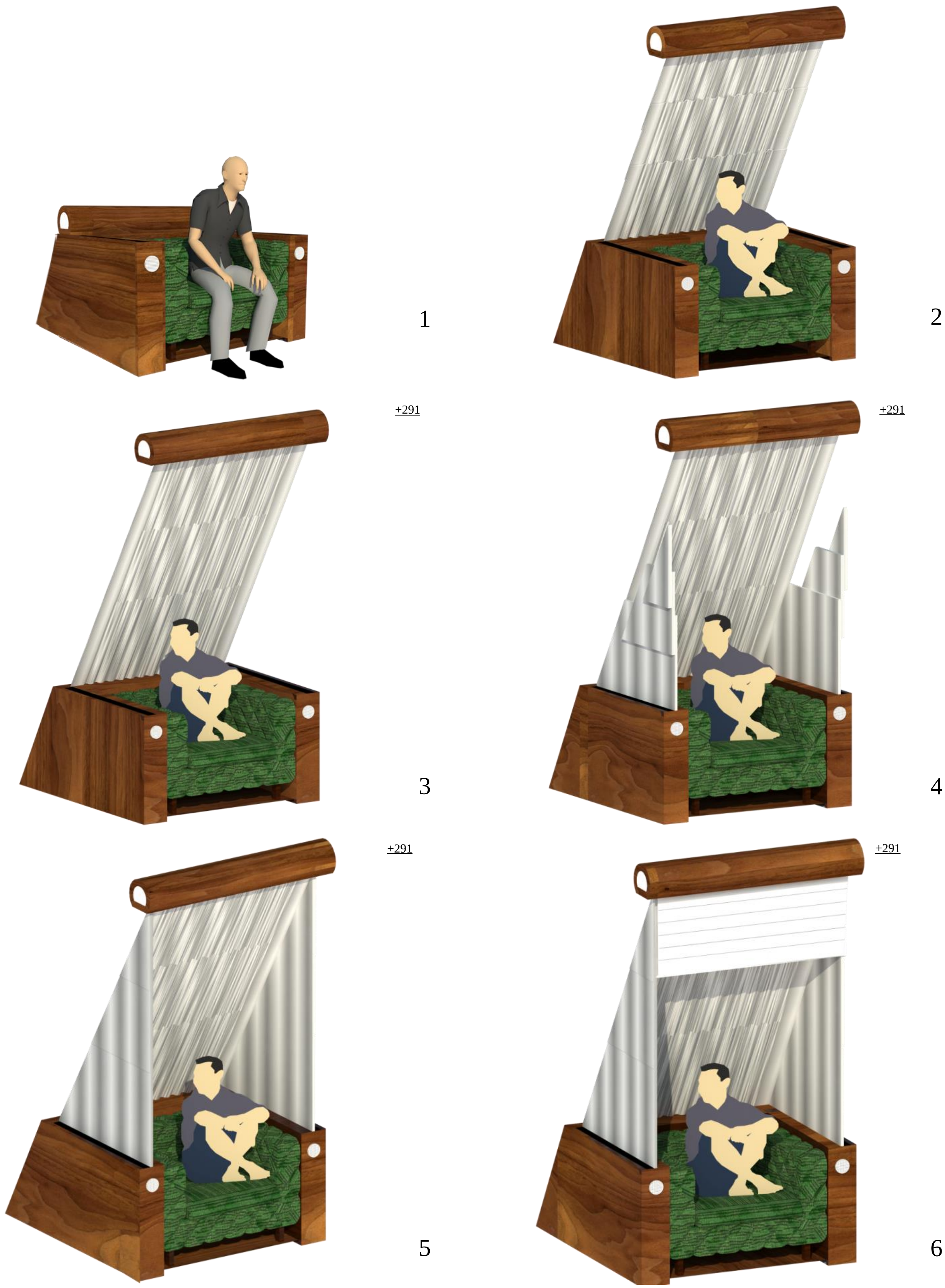

Figure 6. The mechanisms of the seat (concept design)

REFERENCES

Ahmadnejad, M.S., Darbandi, M. (2015). Study of Safe Design Against Earthquake With The Furniture in Kindergarten, Based on the Idea of the Triangle of Life. *Current World Environment*. 10 (Special Issue 1): 831-834.

Anonymous, (2017a). Houses and Interiors Report. Sismile project. http://sismileproject.com/pdf/DESCRIPTION%20OF%20HOUSES%20AND%20THEIR%20INTERIORS.pdf. (Access date: 05.07.2017)

Anonymous, (2017b). Earthquake Resistant Steel Structure. http://constructalia.arcelormittal.com/files/Earthquake_EN-30417e866429d8b43c667cbab068084c.pdf. (Access date: 05.07.2017)

Azimi, N., Asgary, A. (2013). *Rural Residents and Choice of Building Earthquake-Resistant House: Results of a Choice Experiment Study.* Environmental Hazards. 12 (3-4): 240-257.

Brooks, R.M., Cetin, M. (2012). Application of Construction Demolition Waste for Improving Performance of Subgrade and Subbase Layers*. International Journal of Research and Reviews in Applied Sciences*, 12(3), 375-381.

Brooks, R.M., Cetin, M. (2013a). Determination of the Influence of Vehicles Weight Ratio on the Initial Velocity Using the Accident Reconstruction Engineering Principles. *International Journal of Emerging Technology and Advanced Engineering*. 3(3), 927-931.

Brooks, R.M., Cetin, M. (2013b). Determination of the Influence of Skidded Distance on the Initial Velocity using the Accident Reconstruction Engineering Principles. *International Journal of Research and Reviews in Applied Sciences*, 15(3), 225-229.

Cetin, M. (2015). Chapter 55: Using Recycling Materials for Sustainable Landscape Planning, *Environment and Ecology at the Beginning of 21st Century*, ST. KLIMENT OHRIDSKI UNIVERSITY PRESS, SOFIA, Eds: Recep Efe, Carmen Bizzarri, Isa. Curebal, Gulnara N. Nyusupova, ISBN:978-954-07-3999-1: 783-788.

Cetin, M. (2016). Determination of bioclimatic comfort areas in landscape planning: A case study of Cide Coastline, *Turkish Journal of Agriculture - Food Science and Technology*, 4(9): 800-804.

Cetin, M., Mossi, M.M.M., Akbudak, K.Y. (2017). Chapter 35: Visual Examination of Natural and Cultural Landscape Values in Kastamonu City Center for Sustainable Spatial Development. *Ecology, Planning and Design*. Eds: Irina Koleva, Ulku Duman Yuksel, Lahcen Benaabidate, St. Kliment Ohridski University Press, ISBN: 978-954-07-4270-0, pp. 465-477.

FEMA. (2010). Earthquake-Resistant Design Concepts. Report number: FEMA P-749. Report of Federal Emergency Management Agency of the US Department of Homeland Security By the National Institute of Building Sciences Building Seismic Safety Council. Washington, DC.

Gülkan, P., Langenbach, R. (2004). The Earthquake Resistance of Traditional Timber and Masonry Dwellings in Turkey. 13th World Conference on Earthquake Engineering, August 1-6, 2004, Vancouver, Canada, Paper No: 2297.

Hurol, Y. (2014). On Ethics and the Earthquake Resistant Interior Design of Buildings. *Science Engineering Ethics*. 20:171-181.

JIA - JASO. (2012). *Earthquake-resistant Design for Architects*. The Japan Institute of Architects and Japan Aseismic Safety Organization. Shinkosha Printing Co. Tokyo.

Lewis, J. (2003). Housing Construction in Earthquake-prone Places: Perspectives, Priorities and Projections for Development. *The Australian Journal of Emergency Management*, 18(2): 35-44.

Şener, S. M., Altun, M.C. (2009). Design of a Post Disaster Temporary Shelter Unit. *ITU A|Z*, 6(2):58-74.

Von Winterfeldt, D., Roselund, N., Kitsuse, A. (2000). Framing Earthquake Retrofitting Decisions: The Case of Hillside Homes in Los Angeles. PEER Report 2000/03. Pacific Earthquake Engineering Research Center College of Engineering University of California, Berkeley.

Yucedag, C., Kaya, L.G., Cetin, M. (2018). Identifying and Assessing Environmental Awareness of Hotel and Restaurant Employees' Attitudes in the Amasra District of Bartin. *Environmental Monitoring and Assessment,* 190: 60. https://doi.org/10.1007/s10661-017-6456-7