A STATISTICAL STUDY ON THE HARMONIZED UP-TO-DATE TURKISH BUILDING STOCK

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ABSTRACT

A STATISTICAL STUDY ON THE HARMONIZED UP-TO-DATE TURKISH BUILDING STOCK

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In Turkey, where three significant fault lines locate, earthquakes with a magnitude greater than 6.5 happen in every 10 years (Azak et al., 2014). In this sense, to estimate damage on building stock and fatalities accurately, real characteristics of Turkish building stock (TBS) should be known well. Gathering TBS portfolio is previously studied but these studies have focused on relatively smaller areas or have been outdated or both. This study made an comprehensive search on available data sources and detailed investigation on two sources: 2000 Building Census and Building Occupancy Permit Statistics disseminated by Turkish Statistical Institute. Then, the available databases including TBS is harmonized to generate a consistent and complete building stock data for its use in earthquake loss estimation studies. The attributes, which are considered as primary earthquake risk parameters, are the location (in province-scale resolution for İstanbul and region-scale and city-scale resolution for all other places in Turkey), the construction year, the function, the structural system, the number of stories, the material of infill walls, the number of dwelling units and total produced floor area. This study examined 9394841 buildings in total and presented the distribution of TBS characteristics with respect to the parameters and their relation. To conclude, this study presents gathering of the harmonized up-to-date Turkish building stock portfolio and investigations on building characteristics. The aim of this study is to provide a reference building database for Turkey and corresponding statistics to be used for earthquake loss estimation studies.

Keywords: Harmonization, Up-to-date Turkish Building Stock, Function of Building, Structural Systems, Number of Stories

ÖZ

UYUMLAŞTIRILMIŞ GÜNCEL TÜRKİYE BİNA STOKU ÜZERİNE İSTATİSTİKSEL BİR ÇALIŞMA

Talas Soylu, Gizem Nur
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Üç önemli fay hattı bulunan Türkiye'de, büyüklüğü 6.5'dan büyük olan depremler her 10 yılda bir yaşanmaktadır (Azak ve ark., 2014). Bu bağlamda, bina stokunda meydana gelebilecek hasarın ve can kayıplarının gerçekçi tespiti için bina stokunun özelliklerinin bilinmesi gerekir. Geçmiş çalışmalarda da Türkiye'deki bina portföyü birçok kez incelenmiştir, fakat bu çalışmalar ya küçük bir bölge için yapılmıştır veya güncelliğini yitirmiştir. Bu tez çalışması elde edilebilir veri kaynakları hakkında kapsamlı bir tarama ve detaylı bir araştırma yapmaktadır. Bu veri kaynakları, TUİK'den elde edilen 2000 Bina Sayımı ve Yapı İzin İstatistikleridir. Çalışmada ulaşılabilir güncel Türkiye bina stoku verisi uyumlaştırılmaktadır. Bu işlem, deprem kayıp tahmini çalışmalarında kullanılmak üzere tutarlı ve bütüncül bir veri oluşturmaktadır. Bu çalışmada incelenen tüm özellikler -öncelikli deprem risk parametreleri- konum, (İstanbul için ilçe ölçeğinde, bunun dışındaki yerler için bölge ve şehir ölçeğinde), yapım yılı, kullanım amacı, taşıyıcı sistemi, kat sayısı, dolgu malzemesi, daire sayısı ve toplam kat alanıdır. Çalışmada toplam 9394841 binanın verisi elde edilmiş ve binaların nitelikleri ile bu niteliklerin birbiriyle ilişkisi istatistiksel olarak incelenmiştir. Sonuç olarak, bu çalışma geçmişten günümüze bağdaştırılmış güncel Türk bina stoku portföyünü ve binaların özelliklerini sunmaktadır. Çalışmanın amacı, Türkiye'deki bina verisiyle ilgili bir kaynak sunmak

ve deprem kayıp tahminlerinde kullanılmak üzere bina portföyü ile ilgili istatistiki veri oluşturmaktır.

Anahtar Kelimeler: Uyumlaştırmak, Güncel Türkiye Bina Stoku, Bina Fonksiyonu, Taşıyıcı Sistem, Kat Sayısı

To My Family

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TABLE OF CONTENTS

LIST OF TABLES

TABLES

LIST OF FIGURES

FIGURES

LIST OF ABBREVIATIONS

ABBREVIATIONS	
BUC	Building Census
BOP	Building Occupancy Permit
CB	Concrete Block
CSB	Calcium Silicate Brick
DBELA	Displacement Based Earthquake Loss Assessment
HCB	Hollow Concrete Block
GEM	Global Earthquake Modelling
GIS	Geographic Information System
LP	Light Panel
METU	Middle East Technical University
NA	Unknown / Not Available
RC	Reinforced Concrete
RCD	Reinforced Concrete Dual
RCF	Reinforced Concrete Frame
RCW	Reinforced Concrete Shear Wall
RCU	Reinforced Concrete Unknown
Steel F	Steel Frame
SP	Steel Plate
SW	Shear wall

TBS	Turkish Building Stock
TUİK	Turkish Statistica Institute (Türkiye İstatistik Kurumu)

CHAPTER 1

INTRODUCTION

In this chapter, the motivation, the research question, the aim and the objectives of the thesis are explained. The disposition of the thesis is given at the end of this chapter.

1.1. Motivation

Turkey is located in an area where three major fault lines intersect; North Anatolia, West Anatolia and East Anatolia Fault lines. In addition, earthquakes with a magnitude greater than 6.5 happen in every 10 years in Turkey (Azak et al., 2014). Therefore, the risk of casualties caused by an earthquake is relatively remarkable. In this sense, to estimate real damage on building stock and real life lost, real characteristics of Turkish Building Stock (TBS) should be evaluated well. That can be possible by evaluation of harmonized Turkish building stock with significant earthquake parameters

Contrary to most of the countries, in Turkey, significant earthquake code changes were applied only after major earthquakes (Bal, 2007). Figure 1.1 shows the relationship between the past earthquakes in Turkey and the re-lose dates of the building design codes for seismic effects. Although, there had been some earthquakes with a magnitude greater than seven before 1949, the first seismic code was published in 1949. Two earthquakes had occurred in 1957, and new regulations for the structures built in disaster areas were published in 1962, after 5 years. On the other hand, an earthquake with 7.4 magnitude happened just 20 months in 1999 in Gölcük and Düzce after the issuance of the earthquake code on 1st of January 1998.

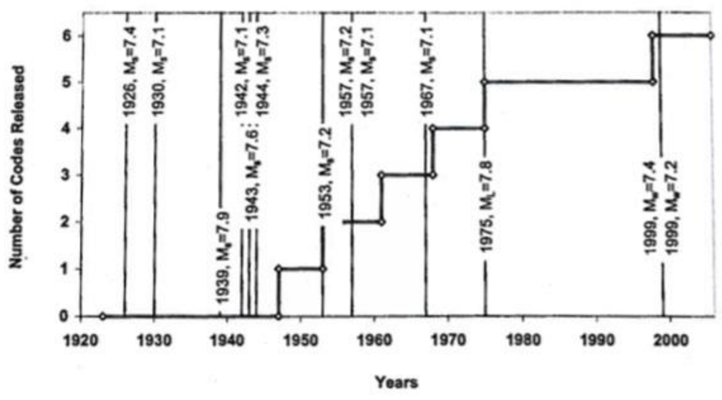


Figure 1.1. Demonstration of the relationship between the code development and the major earthquakes (Bal, 2007)

Before 1975, the codes were used just as a supplement in construction, thus they were not used for calculations and as quantitative rules of construction in detail. However, the earthquake codes were become obligatory after 1975. On the other hand, it was realized after Gölcük and Düzce earthquake in 1999 that the developed codes might have been not enough to provide the safety in real world experiences (Bal, 2007).

Earthquake is a natural disaster. It cannot be prevented, but the resulting damage could be minimized. To estimate the risks of damage on the building stock in Turkey, building characteristics is the major topic of this thesis study.

1.2. Problem Statement

After the 1998 code (1st January 1998) and the earthquakes with high magnitude in Gölcük and Düzce in 1999, the statistics of building inventory became important. They turn out to be critical for loss and damage assessment studies and losses, which can be used to develop earthquake codes in future (Bal, 2007). Before another big earthquake, the Turkish building stock is examined in this thesis in order to provide data for future researches: damage and loss estimation of building stock.

On the other hand, this thesis provides real TBS data to researchers and professionals such as the architects and civil engineers. Although, they are familiar with materials and structural system types by the time they graduated; they have limited knowledge of which ones are being used frequently in relation with location and time in Turkey. This study supplies the knowledge of building stock evolution by up-to-date constructed buildings. That represents the development of construction materials and methods to the architects and civil engineers.

Gathering TBS portfolio is previously studied but these studies may not demonstrate the TBS potentially due to some causes they have. Firstly, some of them has focused on relatively smaller areas such as building stock of Balçova and Seferihisar in İzmir (Kahraman et al., 2013). As the second issue, they can be limited to building characteristics; for instance, only reinforced concrete (RC) buildings are investigated in eastern Turkey (Işık et al., 2017). Lastly, they have been outdated. The last extensive study for TBS is 2000 Building Census (BUC) issued by Turkish Statistical Institute (In Turkish: Türkiye İstatistik Kurumu, TUIK). When nearly 6% buildings of the total building stock constructed in the last 10 years was considered, there has to be significant increase in building stock. Therefore, examining the current TBS can be critical for well demonstrating of TBS portfolio.

1.3. Aim and Objectives

The aim of this study is to provide a harmonized building database for Turkey by demonstrating the real data so that it could be used by:

- Disaster management groups,
- Insurance companies and
- Urban renewal groups

Moreover, harmonized characteristics of building stock is an important issue for utilizing proper earthquake loss models. As already mentioned, previous studies have focused on relatively smaller urban areas or regions; therefore, the data of building stock is limited and outdated to be used for estimating today's stock. In addition, they are single studies, which means their classification systems are used individually for themselves. The previous studies cannot become together for generating a consistent and complementary TBS. This study harmonizes buildings stock with potentially current and consistent categorization systems to determine useful database of up-to-date building stock portfolio of Turkey. That can be used for future earthquake loss assessment and vulnerability studies.

1.4. Disposition

This thesis is composed of five chapters.

In the first chapter, the motivation, research question, aim and objectives of the thesis and the disposition are introduced. In turkey, most of the predecessor studies about building stock has limited research area or they have been outdated. To provide current building portfolio of overall Turkey, this study evaluates harmonized up-to-date Turkish building stock that helps to estimate the damage on building stock more accurately.

In the second chapter, the literature survey is presented. The literature survey consists of information on urban or regional researches about building characteristics of Turkey. That chapter demonstrates the critical and significant role of this thesis.

The third chapter includes the detailed explanations of the material and method of the study. The TUIK data is presented as the material, and the method of the study is explained. The challenges encountered during the compilation building attributes and classifications in a consistent way are mentioned by using excel sheets and QGIS program, which is a professional geographical information system (GIS) application. In addition, the need of questionnaire and its results for determination of proper structural system designation, another challenging task in this study, are presented in this chapter in detail.

In the fourth chapter, the results of the study are delivered with comments. These results and comments are related to the Turkish building characteristics such as the building function, the structural system, the number of stories, the material of infill walls, the number of dwelling units and total floor areas. These features are studied individually and integrated with respect to the year, and the location as region-scale, city-scale and as district-level for only İstanbul.

In the last chapter, a brief outline of the study, the summary of the results, conclusions, limitations of the study and propositions for further researches are given.

CHAPTER 2

LITERATURE REVİEW

This chapter comprises of the issues from the literature survey in two sections. First section presents previous studies about building stock in Turkey. TBS is investigated in three parts. In the first part, publications that focus on the building stock in a city are explained, called as urban researches. The second part is about the publications focused on the building stock in a region. In the third part, publications about building stock of whole country are mentioned. In the final section, a critical review of the literature is presented with respect to building characteristics. In addition, the significance of this study is explained.

According to Global Earthquake Modelling Building Taxonomy Version 2.0 (Brzev et al., 2013), which is a report about building taxonomy for global earthquake model in order to describe and classify buildings in a uniform manner, building characteristics that affect their seismic performance are

- direction,
- material of the lateral load-resisting system,
- lateral load-resisting system,
- height,
- date of construction or retrofit,
- occupancy,
- building position with a block,
- building plan shape,
- structural irregularity,
- exterior walls,
- roof,

- floor and
- foundation system.

Similar to global previous studies, most of the previous studies about TBS in literature investigate building stocks with the features mentioned above.

2.1. Building Stock in Turkey

This section deals with Turkish building stock and the observations about it. That must be mentioned there that during literature research many studies about building stock have reviewed, whereas only studies mentioning building stock characteristics are explained below. For instance, the studies of Dolsek and Fajfar (2001), Akkar et al. (2005), Crowley and Bommer (2006), Strasser et al. (2008), Özşahin (2013), Birinci (2013) and Akhoundi et al. (2016) are reviewed for Turkish building stock but not mentioned about them in this study.

2.1.1. Urban-Scale Researches

In literature, some statistics on characteristics of Turkish building stock is represented. However, these studies are proportionally much small for the assumption about whole TBS. For example, building stock of İzmir Balçova and Seferihisar districts are gathered and controlled by 84 civil engineers who had joined a course about building classification systems. After the course, civil engineers made a survey study in Balçova and Seferihisar for constitution of building identity information and estimation of building vulnerability. Then, zoning information data is supplied with the help of the public settlement documents for İzmir Balçova and Seferihisar districts. These documents are proprietorship certificate, boundary survey, numbering document, zoning status document, building license, building occupancy permit, approved architectural drawings, and burned and demolished buildings document. In Balçova, 7628 buildings are investigated whose structural systems are reinforced concrete, 4968, and masonry, 2660; however, only 2922 buildings are examined in Seferihisar. The number of reinforced concrete and masonry buildings are 1384 and 1538 respectively. According to Kahraman et al. (2013), 5947 buildings in Balçova, 4498 of RC and 1449 of masonry, and 2302 buildings in Seferihisar, respectively 1116 and 1186, are defined as the buildings with high earthquake risk. In other words, 8249 buildings have earthquake risks, though 10550 buildings are researched in totality.

As another city scaled research, masonry buildings in Antakya are examined for their earthquake performance (Demirel et al., 2013). In order to analyze typical and common masonry buildings in Hatay, a building placed where common masonry buildings are located is chosen as the primarily case study building. This building and a building, which is derived from primarily building, are modeled in SAP2000, structural analysis program. The models are tested for the wall proportions, material features and number of stories. Evaluations of models demonstrate that masonry building with one story, having more area of wall, is safer than the masonry building with one story, which has less wall area. Moreover, the analysis indicates that masonry buildings with three stories are critical ones for building fragility. To conclude, the results indicate that building fragility is related to ratio of wall area on one direction to ground floor area, material quality and number of stories.

As another study about masonry buildings, seismic safeties of the buildings in Dinar, rural area, and Zeytinburnu, urban area, are evaluated with major structural parameters. That are number of stories, load bearing wall material, regularity in plan and the arrangement of walls. The building database of Dinar has been gathered by Middle East Technical University team. The latter database is obtained from İstanbul Master Plan study. As the first parameter, masonry buildings with one or two stories mostly exposit enough resistance under seismic action; though, the buildings with more and or equal to three stories are damaged severely. Because of that reason, in accordance with Turkish Earthquake Code in 1998, masonry buildings are permitted with maximum two stories in seismic zone one, most severe zone, like zone of Dinar; although, it becomes three in seismic zones 2 and 3, like zone of Zeytinburnu. The number of story distribution in that study demonstrates that in Dinar 46% of the buildings and in Zeytinburnu 36% of the buildings do not allowed by code. After determination of the other structural parameters, fragility-based assessment of masonry buildings and damage estimation are examined for buildings in Dinar and Zeytinburnu. The results show that damage state possibilities are effected by number of stories, regularity in plan, strength of wall material, length of wall and arrangement of openings on wall significantly (Erberik, 2008).

In another study, structural defects and disorders of the Eskişehir building stock is examined for reinforced concrete buildings located in the pilot area, which includes eight districts. The building stock database is taken from Eskişehir Tepebaşı Municipality. Then, the buildings are investigated with site surveys at their non-used basement floors. That point must be mentioned that all of the RC buildings in Eskişahir cannot be investigated because some inhabitants did not allow the examination and some of the drawings of buildings did not taken from Tepebaşı Municipality. So, only 310 buildings from 709 buildings are mentioned in that study. These buildings is examined in terms of their building age and structural irregularities. Building age is divided into two groups as before 1997 and after 1997 due to the regulations for the structures to be built in disaster areas issued in 1997. In totality, 54% of the buildings were constructed before 1997, the rest, 46%, were built after 1997. Kaplan et al. (2015) provide statistical ratios on the problems of lack of earthquake joint between the buildings as 90%, combination of strong beam and weak column as 9%, frame discontinuity as 41%, and also some rural discontinuity of A4 as 86%, B1 as 30% and B2 as 30%. According to regulations for the structures to be built in disaster areas (2007), A4 discontinuity is the situation of nonparallel vertical structural elements in plan view to the orthogonal earthquake directions. If the ground floor of building is used as shop floor, the area of openings of that floor is greater than that of upper floors, and that kind of discontinuity is called as weak floor or B1 discontinuity. When the story height of ground floor is higher than that of upper floors, that problem is called as soft story or B2 discontinuity.

Albayrak et al (2015) investigated the building stock in Eskişehir Tepebaşı by street surveying of educated observers and calculated of Earthquake Risk Scores of the buildings. During the street survey, the observers recorded the attributes of buildings, which were age of the building, number of stories, soft story, short column, heavy overhang, pounding effect, topographic effect, visual construction quality and local soil conditions. The building age groups determinate 2007 Turkish Earthquake Code, 1999 Marmara Earthquake, 1997 Turkish Seismic Design Code and 1975 Construction Disaster Zones Code. Therefore, the building age is investigated in 5 groups; 0 to 5 years, 5 to 10 years, 10 to 20 years, 20 to 30 years and more than 30 years. In totality, building age is distributed as 11.7%, 8.8%, 35.8%, 30.1% and 13.6% respectively. Furthermore, number of stories are investigated under five groups: 1 to 3 story, 4 to 5 story, 6 story, 7 story and more than or equal to 8 story. Their percentage are 32.1, 43.3, 5.3, 6.5 and 12.8 respectively.

While Erdik et al. (2003) assess earthquake risk for İstanbul metropolitan area, they use two independent methodology starting with earthquake scenario definitions. During the explanation of methodology, built environment included buildings and lifeline systems are used. For building inventory, the classifications of

- construction type as reinforced concrete frame (RCF) building, masonry building, RC shear wall (RCW) building (including tunnel formwork systems) and precast building,
- number of stories including basement within 3 groups as low-rise (1-4 stories), mid-rise (5-8 stories) and high-rise (more than 8 stories) and
- age of building within 2 groups as before 1980 and after 1980

are obtained. These attributes are used with building inventory in terms of footprints based on aerial photos taken from 1995 and 1998 in each İstanbul district by geometrical information system (GIS). The results demonstrate that in İstanbul low-rise RCF buildings constitute 46% (13% constructed before 1980 and 33% constructed after 1980) of total building stock. In addition, the percentage of mid-rise RCF buildings is 29 (7% and 22% respectively) in totality. These results are only implements of that study, physical and monetary building damages, and casualties are calculated with intensity-based and spectral displacement-based earthquake loss studies.

As another study, Konukçu et al. (2007) determinate building age determinated with aerial and satellite images to analyze earthquake damage in İstanbul. In order to deal with earthquake-resistant design of the structures, buildings have new aspects caused by Turkish building codes. Therefore, those codes are used for primarily source to determine the building age. In addition, dates of aerial images of İstanbul, which are 1966, 1982, 1996, 2004, 2007 and 2013, provide also detection of building age. The structures being not used for building purposes have been omitted during the study. As a result, the number of buildings on air photo is inferred as that building stock in İstanbul has been increased 1095% from 1968 (98656 buildings) to 2013 (990584 buildings). These buildings and construction years are divided into 6 groups as:

- pre-1968 with 82828 buildings,
- between 1969 and 1982 with 330489 buildings,
- between 1983 and 1996 with 391008 buildings,
- between 1997 and 2004 with 114480 buildings
- between 2005 and 2007with 46336 buildings and
- between 2008 and 2013 with 35443 buildings.

According to Konukçu et al. (2007), another mentioned feature, 80% of the buildings were used for residential purposes in 2013. The variation on number of buildings at district level with respect to building ages can also be reachable at that study. In European side, the oldest buildings are generally located in Fatih; whereas they are mostly stayed in Kadiköy and Üsküdar in Asian side. Furthermore, the highest increases in number of buildings between the years 2008 and 2019 are happened in Esenyurt, Büyükçekmece, Arnavutköy, Sarıyer and Zeytinburnu at European part, and in Tuzla, Sancaktepe, Pendik, Ataşehir, Çekmeköy at Asian part.

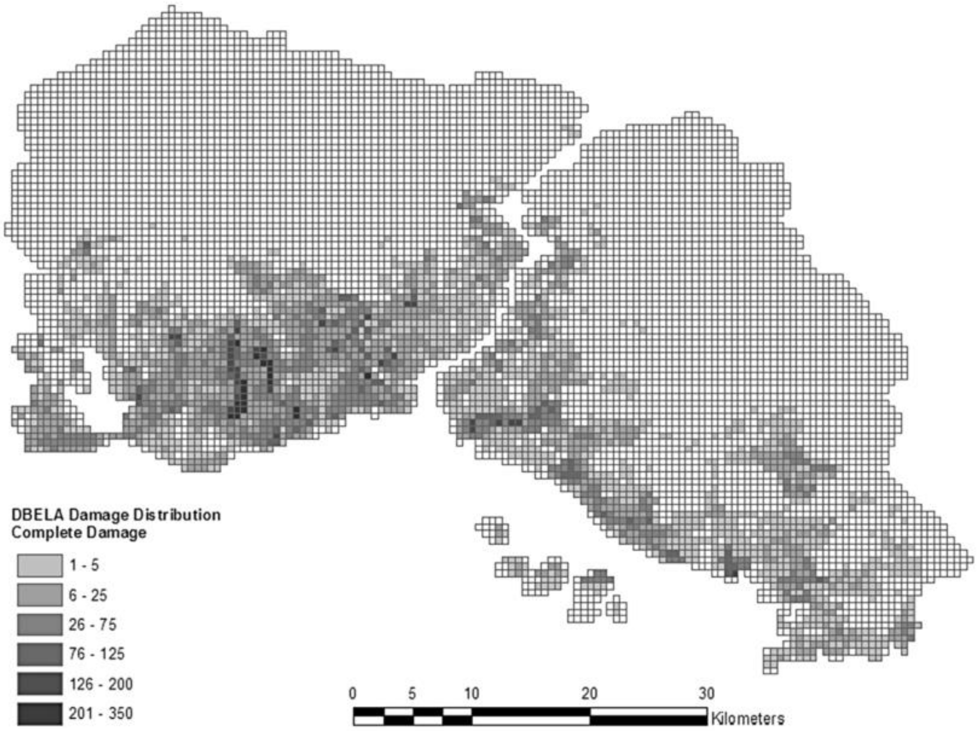


Figure 2.1. Spatial distribution of complete damage to all buildings in the Istanbul Metropolitan Municipality (Bal et al., 2008)

In another study, displacement based earthquake loss assessment (DBELA) methodology is applied for Istanbul. The building stock is modelled with varying geometrical and material properties. The building stock database was taken from Bal et al. (2007, 2008) studies, explained in the next subsection. A set of masonry building data is used for DBELA scenario in İstanbul. The geometrical characteristics of RC buildings, mean values of regular story height, ground floor story height, beam length, beam depth, column depth at ground floor and number of stories with four groups as one to three stories, four stories, five stories and more than or equal to six stories, and geometrical characteristics of masonry buildings, mean values of regular story height and ground floor pier height, are taken from building stock database. Then, material and limit state properties, and also building classes within building attributes such as age, material of infill walls and number of stories are defined to predict damage distribution and social losses for an earthquake scenario with M_w 7.5. The results represent that 400000 buildings would experience none or slight damage, 81000 buildings would have extensively damage, and also 47000 buildings, 6.4% of total building stock, would collapse (Bal et al., 2008). The distribution of damage can be seen in Figure 2.1.

Another research, Bitlis is investigated in order to estimate loss and rate of earthquake risk. Bitlis is divided into 12 regions, sub-districts of the city. Işık et al. (2017) examine only RC buildings because RC buildings have highest proportion (86%) in total building stock. The proportions of story number in each sub-district is investigated in that study. In all areas, building with one story has the highest percentage that presents 30% of total stock in Bitlis. Moreover, building with two stories follows that with 20% in totality. At last, Displacement based earthquake loss assessment (DBELA) methodology is used on six different earthquake scenarios, then the result are obtained that 3.2% to 7.2% of the existing buildings totally or partially may collapse.

2.1.2. Regional-Scale Researches

Since İstanbul is the most crowded and big city in Turkey, an earthquake affected İstanbul is a huge question for the whole country. To answer this question, building stock in Istanbul is investigated by urban and/or regional scaled studies. For instance, Northern Marmara of Turkey is examined by Bal et al. (2007, 2008) according to the design and material characteristics of the buildings stock. The building stock information is obtained by 2000 Building Census (BUC) that includes

- construction type as frame, masonry and other systems,
- building function as residential, mostly residential and mostly commercial,
- number of stories as 1, 2 , 3 ,4 ,5 ,6, 7 to 9, greater than 10 and unknown,
- construction year as up to 1929, 1930-1939, 1940-1949, 1950-1959, 1960-1969, 1970-1979, 1980-1989, 1990-2000 and unknown.

The statistics of building stock in Northern Marmara Region- İstanbul, Kocaeli and Düzce- show that the most common building type has RCF structural system with clay brick or block infill as 73.4% (Bal et al., 2007, 2008). In addition, total RC buildings presents 75.9% of Northern Marmara Region building stock. On the other hand, masonry buildings with clay brick or block represent 15% of the total stock as the second most common structural system. The common construction types, RCF and masonry, are gathered at province-level for İstanbul, Kocaeli and Düzce with respect to function of building, construction year and number of stories individually. The results demonstrate that most of the buildings in each city are used for residential purposes. The construction year parameter cannot make huge differences between the provinces. In fact, the proportion of RCF buildings has increased sharply since 1960 in all cities; however, masonry buildings proportion became peak point in the years between 1970 and 1989. As last parameter, while the number of stories is increasing, the percentage of masonry building is decreasing. That provides the opinion of that masonry system is not appropriate for tall buildings. On the other hand, the percentage of RCF buildings in İstanbul with respect to number of stories differs from percentage of RCF buildings in Kocaeli and Düzce. In RCF buildings in İstanbul, common number of stories are two to six; however, buildings with two and three stories have the highest percentage in Kocaeli and Düzce. The reason of that difference can be being highly populated of the urban areas. The RCF building of taken data, 2000 BUC, are divided into 8 groups with four information levels that are good or poor quality, frame or dual structures, emergent or embedded beams. The building constructed before 1998 Earthquake Code or built illegally after 1998 is classified as poor in quality. In contrary, buildings constructed after 1998 legally is classified as good quality. After that classification, the building stock is also investigated for structural properties and non-structural elements. The structural properties are

- floor properties with their regular and ground story height, and
- structural elements as
    - columns with their depth,

- beams with their length,
- RC structural walls with their length and thickness and
- slabs with their thickness.

Then the irregularity defined by code and other irregularities are mentioned with frequencies and number of buildings having that irregularity.

In another study focused on fairly similar region, which includes Düzce and Zeytinburnu, Küçükçekmece, and Bakırköy districts of Istanbul, 33773 RC buildings, 29945 buildings in Küçükçekmece, 3034 buildings in Zeytinburnu, 461 buildings in Düzce and 333 buildings in Bakırköy, are observed for geometrical properties by Azak et al. (2014). That study comprises buildings with number of stories between three and eight. When the distribution of number of stories is examined with number of buildings for that city and those three districts, one can infer that the most common number of story is various in each area. That means that most common buildings are with five stories in Düzce, with four stories in Küçükçekmece, with six stories in Zeytinburnu and with seven stories in Bakırköy. That should be noted that the number of buildings with three stories is much close to peak. As other geometrical parameters, story heights of ground and normal story are investigated to define their mean values, 3.01 m and 2.71 m respectively, and standard deviations, 0.39 m and 0.20 m. To evaluate plan dimension parameter, as another parameter, two dimensions –short and long plan dimension- are considered because the obtained buildings are generally rectangular. The mean values are 9.58 m and 13.73 m in short and long directions; in addition the standard deviations are calculated as 3.64 m and 7.84 m. When the plan dimensions are examined in terms of number of stories, one can infer that buildings with eight stories has the highest mean value in short and long plan dimensions. On the other side, number of continuous frames, span length, and geometry and orientation of columns parameters are also researched in that study. The results represent that most of the columns are rectangular. Moreover, 47.5% of the columns is oriented along short direction of the building, while 48.2% of them is oriented along long direction. The rest, 4.3%, has circular or square cross-section. That point should be said that buildings having six and more stories are classified as mid-rise buildings by the authors.

2.1.3. Country-Scale Researches

Although, the aim of several studies of decades are earthquake loss estimation of Northern Marmara, especially İstanbul, there are other regions that should be investigated to look at the whole building stock evolution in Turkey. Furthermore, most of the studies in literature on earthquake loss assessment in Turkey include limited information on Turkish building stock characteristics. For instance, vulnerability of low-rise and mid-rise buildings in Turkey is examined for only RCF structures by Ay and Erberik (2008). Beyond these researches, an evolution of building characteristics between 2002 and 2015 is investigated by Ay et al (2016) to compile changing characteristics for loss estimation model development. Building Occupancy Permit (BOP) information has stored in TUIK database since 1964; however, this system has been standardized in 2002. Therefore, the evolution is investigated for the buildings constructed between 2002 and 2015. The building database including totally 1135452 buildings is taken from TUIK and analyzed with primary parameters influencing seismic performance of the inventory. That are function of building, structural system, number of stories and material of infill wall. Function of building is categorized as residential and non-residential. The mixed type of building is classified according to which usage type has at least half of the building purpose. For instance, if at least half of a building is used for residential, that building is classified as residential building. As a result, 84.99% of the building stock is used for residential purpose. As another parameter, structural system is divided into 6 groups: masonry, steel frame, wood frame, RC frame, composite and prefabricated. The statistics show that the proportion of RC frame is the highest in residential and non-residential buildings. The differentiation is seen in the second level. The second most common building structure is masonry for residential buildings; although, it becomes steel frame for non-residential buildings. If the statistics of variation of annual structural system for these two types of building function is examined, one can infer that masonry residential buildings and RCF non-residential buildings have had decreasing trend for 10 years. Moreover, the proportions of total floor area, in totality $1159x10^6$ m for 14 years, and dwelling unit number, 5950962, are obtained for residential buildings with respect to structural systems. The highest proportions of these two features are belong to RCF buildings; in addition, the following ones are masonry for both of the building usage types. On the other hand, number of story information of residential buildings is classified as low-rise (1 to 3 stories), mid-rise (4 to 6 stories) and high-rise (7+ stories). This attribute is investigated about annual variations of each categories and proportional variations at province-level. The statistics demonstrate that the percentage of low-rise building is decreasing while others are increasing through the years. At province-level variation of low-rise and mid-rise buildings is inferred that more than half of the buildings constructed between the years 2002 and 2015 is mid-rise that fortifies crowded population can dominate story number of building stock. As the last parameter, material of infill wall is categorized into nine groups as hollow concrete block, brick stone, wood, concrete block, calcium silicate brick, stone, adobe, light panel and other. Because RCF is generally constructed with brick and brick is used for load bearing material in masonry buildings, the most common infill wall material is brick. The following material is hollow concrete block. When the annual variation of infill wall materials in RCF and masonry buildings is examined, the percentage of brick changes slightly, nearly does not vary during the years. If material of infill wall is reviewed with respect to structural system, brick is seen as primarily material for all infill walls except wood frame buildings. In contrary, wood is used as common material in wood frame buildings. That point should be sad that the study of Ay et al (2016) is the main source of this thesis with mentioned building characteristics parameters and the correlation between them.

2.2. Inferences Drawn From Literature

As mentioned before, Turkish building stock is researched previously; however, these studies investigate limited areas such as urban areas or limited building characteristics. As the difference, this study reviews all available Turkish building stock with obtainable building attributes, earthquake risk parameters, in detail. These attributes are building function, building age, number of stories, structural system, material of infill walls, total floor areas and number of dwelling units. That are investigated previously with dissimilar categorizations.

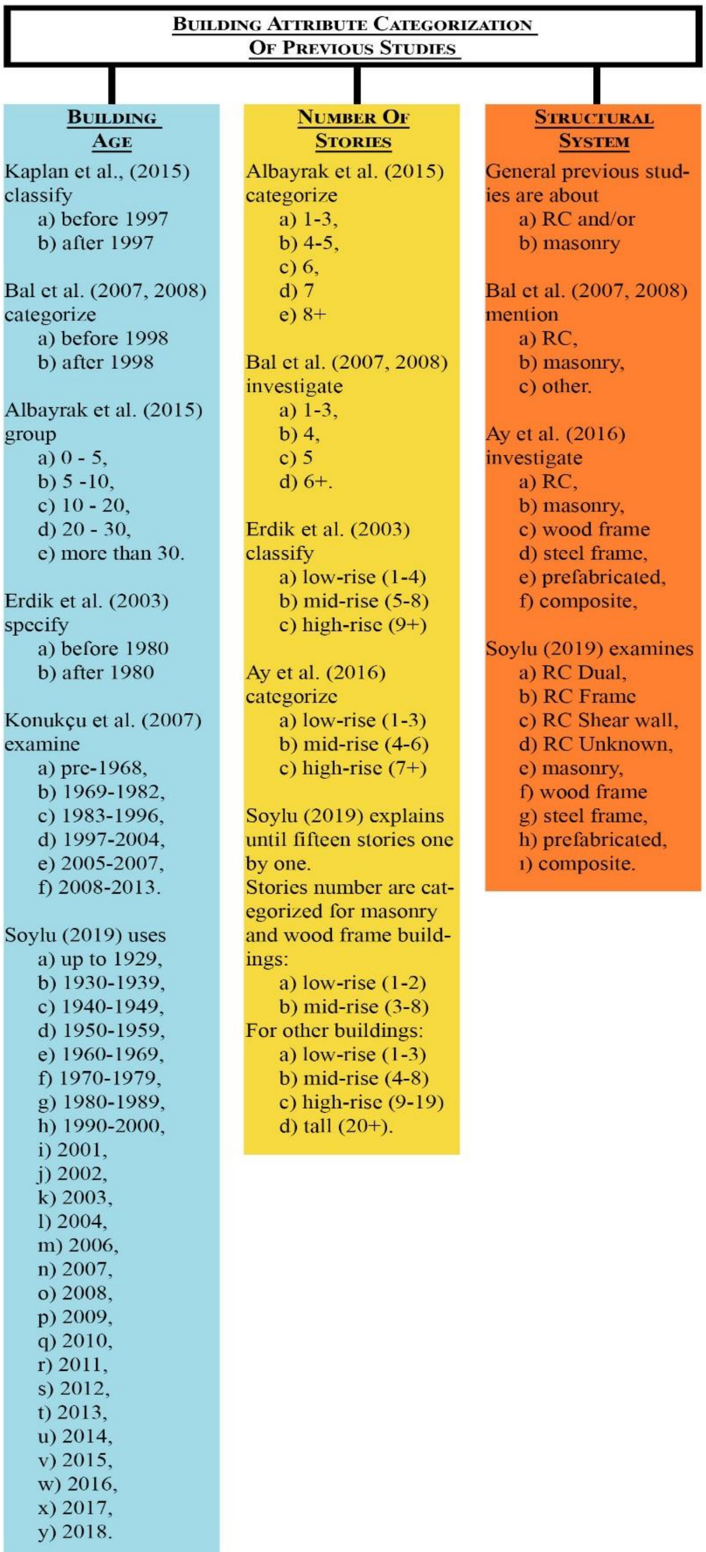


Figure 2.2. Literature survey studies and their classifications

Figure 2.2 demonstrates the literature survey studies and their scopes and/or classifications of building attributes. The classification of building age varies according to viewpoint of the authors. Kaplan et al. (2015) arrange the age of building as before 1997 and after 1997 based on the 1998 earthquake regulation code. Similarly, Bal et al. (2007, 2008) categorize the buildings as good and poor within their construction year. Buildings constructed after 1998 is named as good, the rest is classified as poor. On the contrary, Albayrak et al. (2015) pay attention to 2007 Turkish Earthquake Code, 1999 Marmara Earthquake, 1997 Turkish Seismic Design Code and 1975 Construction Disaster Zones Code. Therefore, building age is grouped within 0-5, 5-10, 10-20, 20-30 and more than 30 years. On the other hand, Erdik et al. (2003) specify building age of İstanbul as before 1980 and after 1980, because examine building stock with aerial photos of İstanbul from 1995 and 1998. Konukçu et al. (2007) examine building age in six groups, which are pre-1968, 1969-1982, 1983-1996, 1997-2004, 2005-2007, 2008-2013. These groups are caused from the earthquake codes and aerial photos used in their research. In this thesis, building age is represented without any classes constituted at this study. Buildings constructed before 2000 are taken from 2000 BUC. Therefore, the year of construction are explained as up to 1929, 1930-1939, 1940-1949, 1950-1959, 1960-1969, 1970-1979, 1980-1989 and 1990-2000. On the other hand, buildings constructed after 2000 are taken from BOP database; so, their construction year is demonstrated without any group.

Other characteristic of the building stock, number of stories is classified variously in the previous studies. Albayrak et al. (2015) make 5 groups of stories number as 1-3, 4-5, 6, 7 and more than or equal to eight stories. Bal et al. (2007, 2008) investigate number of stories with four classes, which are 1-3, 4, 5 and more than or equal to six stories. On the other hand, Erdik et al. (2003) give three names to the stories number. That are low-rise for buildings with one to four stories, mid-rise for buildings with five to eight stories and high-rise for buildings having more than eight stories. In contrast, Ay et al. (2016) categorize buildings with one to three stories as low-rise, four to six stories as mid-rise and more than or equal to seven stories as high-rise. In this thesis, number of stories are demonstrated until fifteen stories one by one at first. Then, stories number are categorized into four classes. Buildings with one to three stories are classifies as low-rise building; however, low-rise masonry and wood frame buildings have only one or two stories due to their less seismic capacity. Mid-rise buildings are buildings with three to eight stories for masonry and wood frame and with four to eight story for the others. In addition, high-rise and tall buildings have nine to nineteen stories and more than or equal to twenty stories, respectively.

The structural system of TBS is not researched comprehensively. That means, general previous studies are about the buildings, which have RC and/or masonry structural system; although steel frame, wood frame, prefabricated and composite buildings are constructed in Turkey, too. Bal et al. (2007, 2008) mention the rest as the name of “other”. Only, Ay et al. (2016) explain the whole structural systems of Turkish buildings stock. This thesis statistics presents TBS portfolio by the structural systems of RC, masonry, steel frame, wood frame, prefabricated, composite and unknown (NA). RC system covers RC Dual, RC Frame, RC Shear wall and RC Unknown. Some statistics are given with these subgroups occasionally. The buildings whose structural system is called as unknown is not taken into statistics since its proportion is only 1.4% in the whole building stock database.

CHAPTER 3

RESEARCH MATERIAL AND METHODOLOGY

This chapter explains the research material and methodology of the thesis in four sections: The first part provides an introduction. The second one clarifies the material of the research, and the method of the research is presented in the third part. At the final part, the content of the questionnaire is explained.

3.1. Introduction

This study can be used as guide about Turkish building characteristics. The significance of this study is the harmonization of up-to-date building stock. The last extensive study for TBS is 2000 BUC issued by TUIK. After 2000, the Turkish building statistics obtained from BOP are issued yearly by TUIK. There are some dissimilarities in the classification of building attributes between these statistics and the statistics of 2000 BUC. In other words, there are some inconsistencies between data format of 2000 BUC and BOP statistics. This study harmonizes these two building stock database format in order to provide a consistent and integrated TBS format.

After the harmonization of TBS, this study may be primarily source for the social and physical risks of an earthquake estimation researches. The estimations on loss of housing and corresponding number of victims that need urgent, temporary and permanent housing, the number of damaged/demolished schools or hospitals or any other social buildings, and planning the helping methods for servicing are social risks factors after an earthquake. Moreover, the number of damaged or demolished buildings used for educational or health purposes and the like are the physical risks of an earthquake.

3.2. Research Material

The first source used in this study is 2000 BUC. The second database is Building Permit Statistics, which are the processed data of the occupancy permit forms that is compulsory since 6 October 2001 (TUIK, 2011). They are archived and issued by TUIK.

TUIK processes raw data of occupancy permit forms meanwhile they lost some important information such as structural system detail and district information. Furthermore, in Turkey, these forms have been obtained electronically by most of the Turkish municipalities since 2007. Then all Turkish municipalities started to use online electronic data flow system in 2012. Thus, this study relies on processed data of TUIK before 2012; whereas raw data is used for the buildings constructed after 2012 in order to eliminate potential inconsistencies resulted from the lack of electronic and online electronic data flow. In fact, because TUIK omits structural system details and neighborhood information during processing, this study does not use processed data for all years in order to investigate the structural system more consistently and the location in district-level.

Occupancy Permit Statistics are available on TUIK website (https://biruni.tuik.gov.tr/yapiizin/giris.zul?dil=ing). At every turn of the website, only data on one parameter or two parameters could be obtained for only one year. These statistics can be about the whole country, only one city or only one municipality. Therefore, preprocessing of the research might take a long time; in addition, one cannot obtain the whole building characteristics in detail since the obtained statistics includes only one or two attributes in every turn. Moreover, TUIK website service can discard one’s web ip-number for quite a while, if a good many data/statistics are requested at the same time. Therefore, TUIK data progressing department provided the material of this study by request. That includes information about the construction year, the number of buildings, the location (city, district and neighborhood reachable for the buildings constructed after 2012), the function, the number of total stories, the structural system, the structural system details (taken only by raw data of building occupancy permits), the material of infill walls, the number of dwelling units and total produced floor areas.

When gathering the archived Turkish building stock data, inconsistencies between data formats were seen. At this point, it should be said that this study is not a guarantor whether TUIK data is reliable or not. However, TUIK data is comparatively well preserved and also easily accessible compared to other data sources. Some failings and contradictions can be observed, but data taken from TUIK can represent the whole building stock at best. Overall characteristics of more than 9 million Turkish buildings are provided in TUIK 2000 building census and occupancy permits data; there is no other available data like that. In other words, TUIK data is the most easily available data set for overall building stock that may also be most extensive, widest and unique data set in the whole area.

3.3. Research Methodology

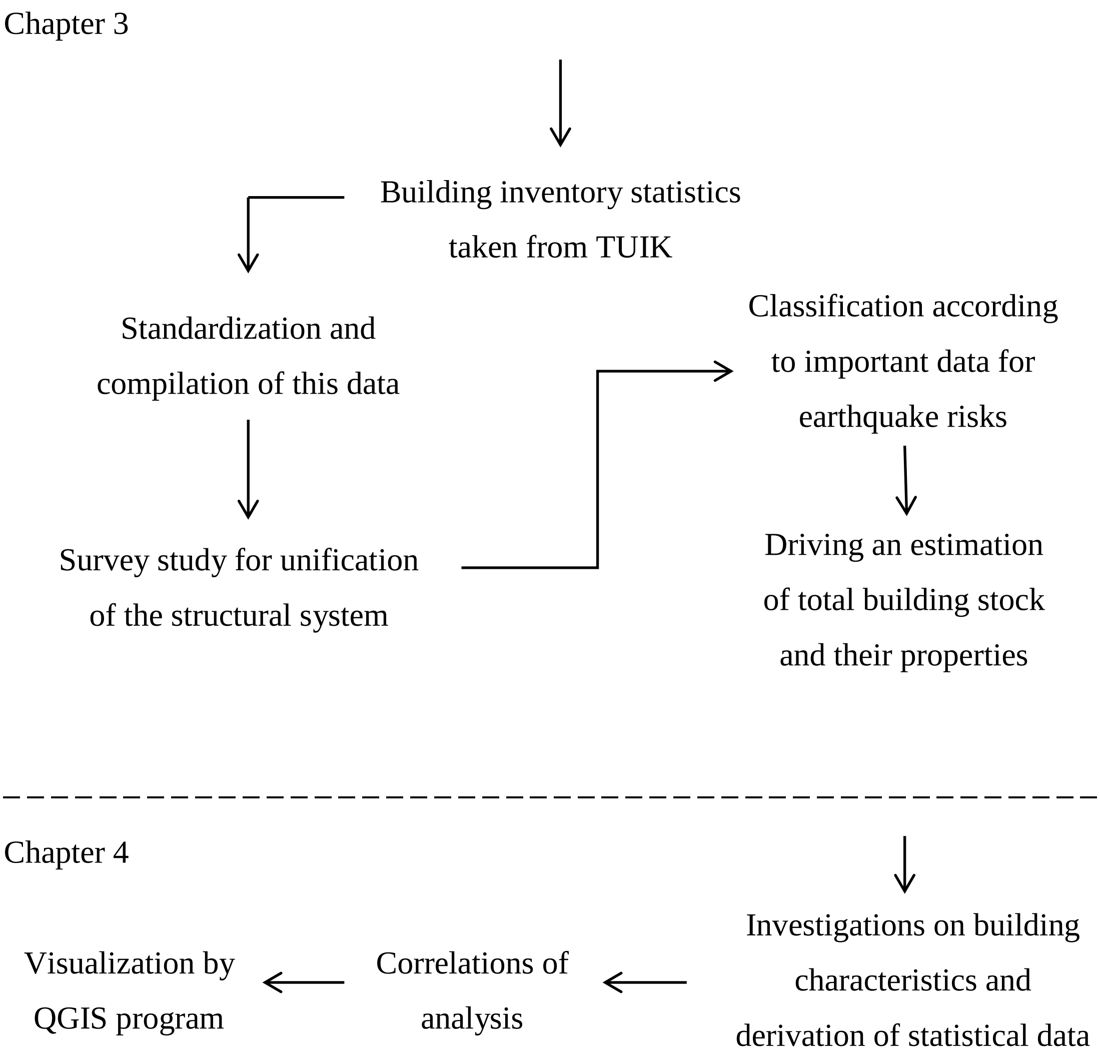


Figure 3.1. Chart of the Research Process

The following steps are followed in the methodology:

- Firstly, data taken from TUIK includes:
    - Construction year
    - Number of buildings,
    - Location (city, district municipality and neighborhood),

- Function of building,
- Number of total stories,
- Structural systems,
- Material of infill walls,
- Number of dwelling units and
- Total produced floor areas.

- Secondly, data taken from TUIK is not uniform. It is not collected, classified and reported in a consistent way. These challenges are mentioned in detail in the next sub-section.
- Thirdly, as the last part to organize TUIK data, a questionnaire was prepared. That will be explained in the upcoming sub-section.
- Fourthly, during driving an estimation of total building stock and their properties, the research parameters are examined in totality, in region-level and in province-level. After the province-level research, the statistics of the parameters are investigated according to the Turkish areas. On the other hand, the percentages of province-level are used to estimate the variety according to city administration in Turkey. Cities are classified into two groups. First one is big city, which includes the metropolitan cities in Turkey. Whether a city is metropolitan or not is decided by Turkish government. The list of metropolitan cities was taken from the website of ministry of environment and urban planning of Turkey. The second group covers the other cities, named as other. The statistics of the research parameters provide the percentages of total Turkey building stock database at first in the results section. Then, the percentages of all city have been calculated individually to estimate the mean and standard deviation values of Turkey and with respect to city administration. The Box and Whiskas charts show that values in the results chapter.
- Fifthly, to investigate the building stocks in detail, the resolution of the location information in cities is not fine enough for loss estimation studies. However, excessive amount of data requires an optimization. Thus, the

database is gathered in different resolutions but statistical investigations are made at city level except Istanbul where the statistics are derived at district level since İstanbul is the most crowded city with probably highest vulnerability to earthquake damage.

- Sixthly, a geographic information system program is used for presenting the variation of percentages in province-level with respect to research parameters. This program is QGIS that is a professional geographic information system application. QGIS is a licensed free and open source software, can be downloaded from its official website (https://www.qgis.org/tr/site/forusers/download.html). The tutorials for QGIS is available in YouTube website. Therefore, for this thesis study, QGIS was downloaded and learned to use. The maps of Turkey in province-level and İstanbul in district-level were derived from online available maps. For obtaining a figure by QGIS, the map was prepared in QGIS. The map had information sheet in its properties section. After the percentages of investigated parameters were calculated for each city in Microsoft Excel program, the excel sheet and properties of map sheet were combined in QGIS. For a good joint of these sheets, they should have included a same column. After this combination, the colorization might have done by QGIS program easily.

3.4. Analysis of TUIK Data

In Turkey, there are nearly 15 million existing buildings; however, database taken from TUIK has 9394841 buildings. Therefore, approximately 2/3 of the building stock was obtained from the sources. The reason of that may be the coverage of BOP documents. They do not include the squatter houses in large cities and the buildings without permits in sub-districts and villages (TUIK, 2011). Nevertheless, these sources are the most available and useable ones for determination of TBS portfolio.

To harmonize features of Turkish building stock, data taken from TUIK has been changed in a consistent and integrated way by using survey study and classification methods. This section includes the challenges encountered and solutions produced during the classification of the buildings in 2000 BUC and BOP for harmonization of each features. While the harmonization of database, much more classification systems were tested and controlled to have clearer and more contradictory database. In this section, only the last methods, which have been considered as the most stable ones for having reliable guide of Turkish building stock, are explained.

During the control of taken database, some unrealistic buildings were observed. Number of their stories are much bigger than they can be. To illustrate, according to database, a building constructed with 806 stories in İstanbul in the years between 1980 and 1989. As another example, a building with 44 stories had finished between the years 1990 and 2000 in Malatya. These were unrealistic in that time. Buildings like the examples are excluded from the statistics, and then the examination has begun. In totality, 85 buildings constructed before 2001 and 11 buildings constructed after 2000 are excluded. Those are respectively 0.00108% and 0.00045% of these databases; in addition, they represents only 0.00098% of total stock.

For number of stories parameters, one thing must be said that the TBS database demonstrates total number of stories. That includes total floors below the ground and above the ground. Therefore, the number of stories is bigger than as its seen for the buildings stayed on sloppy grounds or the buildings with buried basement floors.

In this study, the variation of number of stories are represented one by one with the exception of stories more than or equal to 15. They are demonstrated with only one group with the name of “15+”. Furthermore, the number of stories are categorized for clearer and easily understandable results with respect to seismic safety. Because wood frame and masonry buildings have less seismic safety (Demirel et al., 2013), buildings with one and two stories are classified as low-rise. In addition, buildings with three and eight stories are categorized as mid-rise. In contrary, for the buildings with other structural systems, low-rise is called for one to three stories (Ay et al., 2016). Buildings with four to eight stories are grouped as mid-rise. High-rise and tall buildings have nine to nineteen stories and more than or equal to twenty stories respectively. Table 3.1 represents the height categorization for the masonry and wood frame buildings. In addition, Table 3.2 indicates the height categorization for buildings with other structural systems.

Table 3.1. *Height categorization for masonry and wood frame buildings*

Number of Stories	Height Categorization
1-2	Low-rise
3+	Mid-rise

Table 3.2. *Height categorization for buildings with other structural systems*

Number of Stories	Height Categorization
1-3	Low-rise
4-8	Mid-rise
9-19	High-rise
20+	Tall

Another observation from BOP database is seen in Table 3.3. n, m, k and p represent a number, more than or equal to one. The first row, number of building and dwelling unit are bigger than zero, is already expected data; however the rest need further explanation. BOP reports have been approved and given by a municipality. That does not mean that the building is constructed surely. If it has not been constructed, TUIK database represents it like the second row, where both column is zero. If some dwelling units are added to already exist building, it is processed as the third row. In there, number of building is zero, because there is not any new building. However, number of dwelling unit column is equal to the number of added dwelling unit. A building complex can be approved with only one BOP document; although, it has more than one building. In this situation, to supply true information about the building total number, the missing building/s is/are added like the last row. In there, number of building column is more than or equal to one, while second column is equal to zero.

Table 3.3. *Situations of number of building and dwelling unit*

Number of Building	Number of Dwelling Unit	Explanation
n*	m*	Data is already expected
0	0	Building has been not constructed
0	p*	Some dwelling unit is added to already existed building
k*	0	The missing building is added

*a number which is more than or equal to one

Before the analysis of location, one point should be explained that, as mentioned before, TUIK processes occupancy permit forms to obtain BOP statistics meanwhile neighborhood information is omitted. BOP have applied since 2001; though, electronic system was started to be used by all municipalities after 2012. So, processed BOP data related to the years before 2012 is used in this thesis due to the lack of electronic raw data of the years until 2007 or lack of complete raw data about the building stock between the years 2007 to 2012. The raw BOP data is used for building stock constructed in 2013 to 2018. In other words, the processed but relatively brief data is used for building stock of 2001 to 2012 whereas raw but more detailed data is used for 2013 to 2018 in this study.

Using processed or raw data affects the information of location. The processed data includes name of district municipality; however, raw data generally further provides information about the neighborhood. The exceptions where raw data do not have neighborhood information happen only if the occupancy permits are approved by the metropolitan municipality. The neighborhood and municipality columns are significant for definition of district in İstanbul. Building stock should be studied as highest resolution as possible in order to have more accurate estimations on physical and social risks of the earthquake. Information about the neighborhood of buildings was added to obtained data, because borders of municipalities have changed and some of them have joined with other one. In other words, one year, one neighborhood was depended on a municipality; however, after some years, that district is enlisted under another municipality. These out-of-date data are identified and the municipality is updated according to the Ministry of Interior data at "https://www.e-icisleri.gov.tr/Anasayfa/MulkiIdariBolumleri.aspx".

The information of construction year is explained without any classification for this study. The year data classifies the buildings constructed before 1929 as up to 1929 in 2000 BUC. In addition, the construction year is demonstrated at decade intervals. So, the year is obtainable as 1930-1939, 1940-1949, 1950-1959, 1960-1969, 1970-1979, 1980-1989. For the final decade, it includes the year between 1990 and 2000 in 2000 BUC. On the other hand, in BOP database the construction year is represented one by one from 2001 to 2018.

With the year of construction and location information, the building stock features have some contradiction in the parts of the function of building, the number of stories, the structural system, and the material of infill walls. As the first feature, the function of building is classified according to its occupancies as residential and non-residential. The multi-functional buildings are categorized as at least half of its using type. If at least half of a building is used for residential purposes, that building is classified as residential. Similarly, online data at TUIK website contains two types of building usage namely residential and non-residential building, but 2000 Building Census includes:

- Residential
- Mostly residential,
- Miscellaneous except residential,
- Commercial
- Mostly commercial,
- Cultural building,
- Administrative building,
- Health-care building,
- Social building,
- Sport center,
- Religious building,
- Agricultural building,
- Industry building,
- Educational building,
- Other
- Unknown

According to classification of this thesis, top two items are classified as residential, whereas the others are categorized as non-residential buildings.

Moreover, BOP data includes ten usage types that are:

- Residential buildings – with one apartment,
- Residential buildings – with two and more apartments,
- Residential buildings – public access,
- Non-residential buildings – civil entertainment, educational buildings, hospital and maintenance organization,
- Non-residential buildings – offices,
- Non-residential buildings – hotels and the like

- Non-residential buildings – industrial buildings and storages
- Non-residential buildings – wholesale and retail trading buildings
- Non-residential buildings – traffic and communication buildings,
- Non-residential buildings – other non-residential buildings.

Top three items are called as residential buildings; the rest are classified as non-residential in this study.

The second challenge is to get organized and compiled structural system statistics. As mentioned before, this study harmonizes 2000 BUC and two types of BOP statistics. The first has structural system and material of infill walls information; moreover, the rest related to 2001 to 2012 includes material of infill walls, structural system as classified by TUIK. In addition, raw BOP document related to 2013 and 2018 involves the information of structural system details.

Because of the potential inconsistency between structural system and structural system details, a survey study, explained in the next sub-section, was applied. This survey study can supply to categorize the structural system of TBS database by responders, who already research on TBS or are interested in structural system classification of TBS. They are generally academic staff in universities.

Taking the decision of questionnaire applying is hard because some arrangements should be done before the applying. That takes time and time is critical for a master student; however, questionnaire can be the best choice for eliminating potential inconsistencies of structural system investigation. During the preparing of questionnaire, that point should not be forgotten that it must be clearly understandable and easily answered. In addition, it may not have too many questions and too much writing for not being tiresome for responders. Moreover, before applying a survey study, one have to take ethics committee approval. The hard copy of created questionnaire and application form are delivered to ethics committee for approval. That process also takes time and labor force. After getting approval, the survey can be enforced. This study use online questionnaire due to easily reachable way to the responders and easily controlled way for the organizer. For responder members 81 people were selected according to their research areas. The online questionnaire was sent to the selected people by e-mails. Their e-mail addresses are obtained from their websites or the website of their universities. The sent e-mail includes short information about the organizer and survey, and the link for reaching to the online survey. Unfortunately, the questionnaire was answered by a small group of people at that time. Then, a reminder e-mail was sent to increase the number of responders. In the end, the survey was closed after a while. In totality, the survey was open for contribution more than 3 months; though only 20 people joined to this survey. The questionnaire covers building stock in processed BOP database for the years between 2001 and 2011, and buildings in 2000 BUC document. To conclude, the questionnaire covers 91% of the all parameters used in the building stock database taken from TUIK. The answers provide a new structural system classification for statistics of this study. The rest (9%) of the database includes buildings constructed after 2012. Their structural system is derived from structural system details in raw TUIK database.

For the building database between 2012 and 2018, used raw BOP data includes only material of infill walls and structural system details. The structural system details information is transferred to the new structural system classification for this study due to being raw document.

The material of infill wall feature has also some contradictions. This parameter did not been specified in 2001 at BOP documents, because of that the variation of material of infill wall statistics cannot be obtain for the year of 2001. That situation can be seen in results section.

3.5. Questionnaire

3.5.1. Content of Questionnaire

Before the questionnaire, the respondents take an information of TUIK definitions and classification system in their native language, Turkish. While the whole questionnaire is attached in Appendix A, the information represents in English below.

"TUIK has categorized structural system and material of infill walls according to harmonization work of European Union (TUIK, 2011):

The classification of structural system includes:

- Masonry: The weight of the building is transported to the foundation by the help of the walls.
- Skeleton or skeleton (frame): The weight of building is carried or transported to the foundation by a frame of steel, reinforced concrete or wood. The non-structural wall material is inserted to that frame.
- Tunnel form system: Reinforced concrete structural walls (shear walls), carrying the building weight, and floors of buildings are cast-in-place together and at the same time. Unlike skeleton structures, building weight is not transported by columns and beams.
- Composite: Two and more materials, providing different features, are used together.
- Prefabricated: Standardized members or prefabricated and unified in accordance with definite plan elements, such as wall, structural column and beams, are applied in this construction type.
- Other: Construction system differs from above-mentioned systems.

The material of infill walls contains:

- Steel plate: Material that is applied at walls in steel structural systems.

- Concrete block (CB): Cast-in-place concrete or prefabricated concrete block that is used for wall material.
- Hollow concrete block (HCB): Material that is applied for wall material.
- Brick: Material of walls, including brick.
- Wood: Material of walls.
- Stone: Material of walls provided by stone.
- Adobe: Material of walls consisted of adobe.
- Calcium silicate brick (CSB), light panel (LP), unknown (not available, NA) and others are presented in the obtained data taken from TUIK but not defined by it.

Structural system details represent 87th item of Building Occupancy Permit (BOP). This covers:

- Skeleton (Frame), which contains
  - Wood
  - Reinforced Concrete
  - Reinforced Concrete – Frame + Shear wall Structures
  - Reinforced Concrete – Frame Structures
  - Reinforced Concrete –Shear wall Structures / Tunnel Framework
  - Steel
- Composite
- Prefabricated
- Other
- Self-Prefabricated
- Masonry”

TUIK processes BOP information data and then publishes them in accordance with its structural system classifications, which causes confusion. For instance, structural system of a building is cast-in-place, but its structural system detail is prefabricated or masonry. This causes ambiguity about structural system.

All of the information about structural system, material of infill walls and structural system details is identified and listed in order to determine the whole stock. Because there are so many different building categorizes, the similar building features are combined together in only one question. Then, the questionnaire has only 44 combination of building stock attributes. The semicolons in the table of questions are used for identify other categorizes. For instance, the structural system is defined as RC; RC-other in question three. That means that structural system of the buildings is RC or RC-other. The symbol of "-->"is using in the TUIK database.

The questionnaire presented in Appendix A. The developed questionnaire specifies

- structural system, classified according to TUIK standardization,
- material of infill walls and also
- structural system details derived from BOP.

3.5.2. Results of the Questionnaire

Although the questionnaire was sent to 81 people, only 20 responds were obtained. The questions and corresponding responds with its number are listed in Table 3.4. In this study, the choice, which has the biggest number in its respond, has defined the structural system of its group. Note that, in most of the cases 2/3 of the respondents selected the same option.

Table 3.4. *Questionnaire and number of responds*

Question Number	TUIK Structural System	Material of Infill Wall	Structural System Detail	Masonry	RC Frame	RC Dual	RC Shear wall	RC Unknown	Steel Frame	Prefabricated	Composite	Wood Frame	Total
1	Wood Frame	Wood	NA; Other; Skeleton (Frame); Skeleton (Frame) --> Wood Frame						1			18	19
2	Wood Frame	HCB; Other; CSB; LP; Adobe; Brick	NA; Skeleton (Frame) --> Wood Frame	2					1		2	14	19
3	RC; RC-Other	CB	NA; Skeleton (Frame); Skeleton (Frame) --> RC		15	1		3					19
4	RC; RC-Other	NA; HCB; Other; CSB; LP; Brick	NA; Skeleton (Frame); Skeleton (Frame) --> RC		14	3		3					20
5	RC; RC-Other	Stone	NA; Skeleton (Frame); Skeleton (Frame) --> RC	3	9	3		2			2		19
6	RC; RC-Other	Wood	NA; Skeleton (Frame)	1	14	1		3					19

7	RC	NA; HCB; Other; CSB; LP; Brick	Skeleton (Frame) --> RC --> Dual		7	12							19
8	RC	NA; HCB; Other; CSB; LP; Brick	Skeleton (Frame) --> RC --> Frame		17	2							19
9	RC	CB	Skeleton (Frame) --> RC --> Frame		16	2		1					19
10	RC	NA; HCB; Other; CSB; Brick	Skeleton (Frame) --> RC --> Shear wall		4	13	2						19
11	RC	CB	Skeleton (Frame) --> RC --> Shear wall		1	13	5						19
12	Steel Frame	Wood	NA; Skeleton (Frame) --> Steel Frame						19				19
13	Steel Frame	HCB; Other; CSB; LP; Brick	NA; Other; Skeleton (Frame) --> Steel Frame						19				19
14	Steel Frame	CB	Skeleton (Frame) --> Steel Frame						16				16
15	Other	NA; HCB; Other; CSB; LP; Brick	NA; Other	10	1			3	3				17
16	Other	CB	NA; Other	6	2			5	1	2			16

17	Skeleton; Skeleton (Frame)	HCB; CSB; LP; Brick	NA	4	7			2	1	1	2		17
18	Skeleton; Skeleton (Frame)	Adobe	NA	9	2				2		2	2	17
19	Skeleton; Skeleton (Frame)	CB	NA	2	7			3	1	1	2		16
20	Skeleton; Skeleton (Frame)	Stone	NA	8	5				1		2	1	17
21	Skeleton; Skeleton (Frame)	Wood	NA	3	2				3		2	7	17
22	Skeleton; Skeleton (Frame)	Other	NA	4	4			3	2		2		15
23	Skeleton	SP	NA						15	2			17
24	Composite	HCB; Other; CSB; LP; Brick	NA; Composite	2	1				1	1	14		19
25	Composite	Wood	NA; Composite	2					1	1	14	1	19
26	Composite	CB	NA; Composite	1	1				1	1	15		19

27	Prefabricated	NA; HCB; Other; CSB; LP; Brick	NA; Other; Skeleton (Frame); Prefabricated							18			18
28	Prefabricated	Wood	NA; Prefabricated							19			19
29	Prefabricated	CB	NA; Prefabricated							19			19
30	Prefabricated	NA; HCB; Other; LP; Brick	Half Prefabricated							17	2		19
31	Tunnel Frame-work System	CB; HCB; CSB; LP; Brick	NA				18			1			19
32	Cast-in-Place	NA; HCB; Other; LP; Brick	NA; Other; Skeleton (Frame); Skeleton (Frame) --> RC		15	2		2					19
33	Cast-in-Place	Stone	Other; Skeleton (Frame); Skeleton (Frame) --> RC	2	10	2		5					19
34	Cast-in-Place	CB	NA; Other; Skeleton (Frame); Skeleton (Frame) --> RC		13	2		4					19

35	Cast-in-Place	HCB; Other; CSB; Brick	Skeleton (Frame) --> RC --> Dual		3	15	1						19
36	Cast-in-Place	CB	Skeleton (Frame) --> RC --> Dual		3	15		1					19
37	Cast-in-Place	HCB; Other; CSB; Brick	Skeleton (Frame) --> RC --> Frame		16	3							19
38	Cast-in-Place	CB	Skeleton (Frame) --> RC --> Frame		16	2		1					19
39	Cast-in-Place	Stone	Skeleton (Frame) --> RC --> Frame	3	15	1							19
40	Cast-in-Place	CB; HCB; Other; CSB; Brick	Skeleton (Frame) --> RC --> Shear wall		2	13	4						19
41	Cast-in-Place	HCB; Other; CSB; ;LP; Brick	Prefabricated	1		2				16			19
42	Cast-in-Place	HCB; Other; CSB; Brick	Masonry (Stone)	17		1		1					19
43	Masonry	HCB; Other; CSB; LP; Adobe; Stone; Brick	NA; Other; Masonry (Stone)	15		1		1			2		19

44	Masonry	Wood	NA; Masonry (Stone)	17		1							1	19

CHAPTER 4

ANALYSIS AND RESULTS

This chapter presents the results and discussions of the Turkish building stock characteristics with the statistics. In the following sub-sections, the stock features are demonstrated briefly with some maps by QGIS program and graphs by Excel.

The building stock is investigated in totality and also in city by city. Then the percentage (%) and standard deviation is estimated for some orders such as according to cities administration as big cities, metropolitans, and others, and according to regions as Marmara, Aegean, Mediterranean, Central Anatolia, Eastern Anatolia, Southeastern Anatolia and Black Sea Regions. Moreover, due to the importance and significant role in the building stock of Turkey, İstanbul is examined separately.

4.1. Function of Building

To standardize the taken data, function of building has been classified in two types, namely, residential and non-residential. For 2000 Building Census data, residential and mostly residential buildings are called residential. Moreover, residential buildings are classified as residential buildings with one apartment, with two and more apartments, and public access in BOP database. Non-residential buildings include also mostly non-residential purposes used ones. This section involves commercial, industrial, educational, social and administrative buildings, and also buildings used for health, sport, religion, agriculture, storages, hotels and the like, traffic and communication, and another.

4.1.1. Function of Building in Turkey

In totality, 85.97% of produced buildings are used for residential purposes in Turkey. Moreover, this ratio become 86.58% for total big cities, and 84.24% for other cities. The percentage of residential building is also calculated for each city individually. Then the cities are classifies according to city administration as metropolitan and not metropolitan. As mentioned before, this study calls them as big city and other respectively. The standard deviation and mean value for each categories and for Turkey is calculated from the percentage of each city. Figure 4.1 indicates the percentage (%) and standard deviation of residential buildings in Turkey and also in big cities, metropolitans, and other cities. As one can infer from the graph, the mean values of each category differ slightly from their values in totality. The mean value and the standard deviation of total cities in Turkey are calculated as 84.30% and 4.84 respectively. The total residential building gets 85.80% for mean value and 2.07 for standard deviation for big cities. Moreover, for other cities as one can infer from the figure, the mean and standard deviation values are 83.5%, and 5.05. Moreover, the figure also demonstrates that the alteration according to city administration is much little, so building function percentage cannot be influenced a lot according to city size.

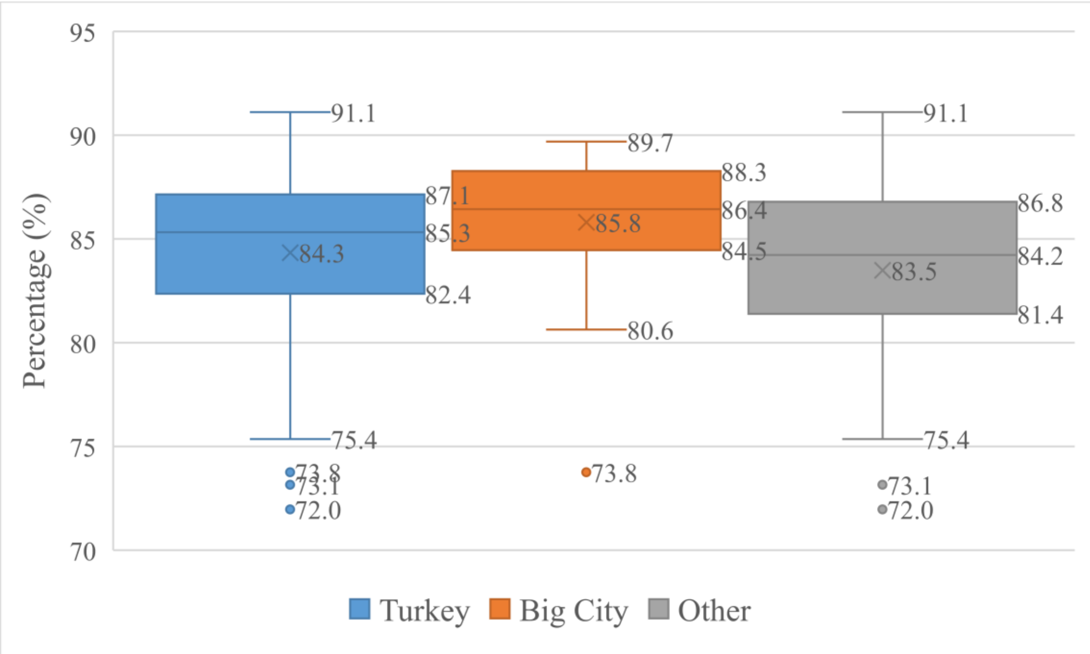


Figure 4.1. The percentage (%) and standard deviation of residential buildings

Considering Turkish areas specially, in Marmara 88.14%, and in Aegean, Mediterranean and Southeastern Anatolia Areas around 86.5% of the buildings are used for residential purposes. Central Anatolia Area follows them as 84.30%. Then Black Sea Area (83.18%) and Eastern Anatolia Area (82.37%) come after. Beside these values, the mean value and standard deviation of residential buildings to the produced building stocks in terms of areas in Turkey is represented in Figure 4.2. To calculate these values, residential building percentage of each city is defined singly, as explained before.

One can infer from Figure 4.2 that standard deviation of Marmara Regions' residential buildings proportions is around 1.82; moreover, it is 1.88 in Southeastern Anatolia, 2.14 in Mediterranean, 2.43 in Central Anatolia and 2.55 in Aegean areas. On the contrary, this is 5.11 for Eastern Anatolia and 5.13 for Black Sea Area. In other words, while the proportions are similar, standard deviations of the north and east parts of Turkey Areas are higher than the others are. That means that there is much difference on the proportions of residential purposed buildings city by city in Black Sea and Eastern Anatolia regions. It should be noted that for these areas or municipalities where the standard deviation is small, mean values can be used with larger confidence levels.

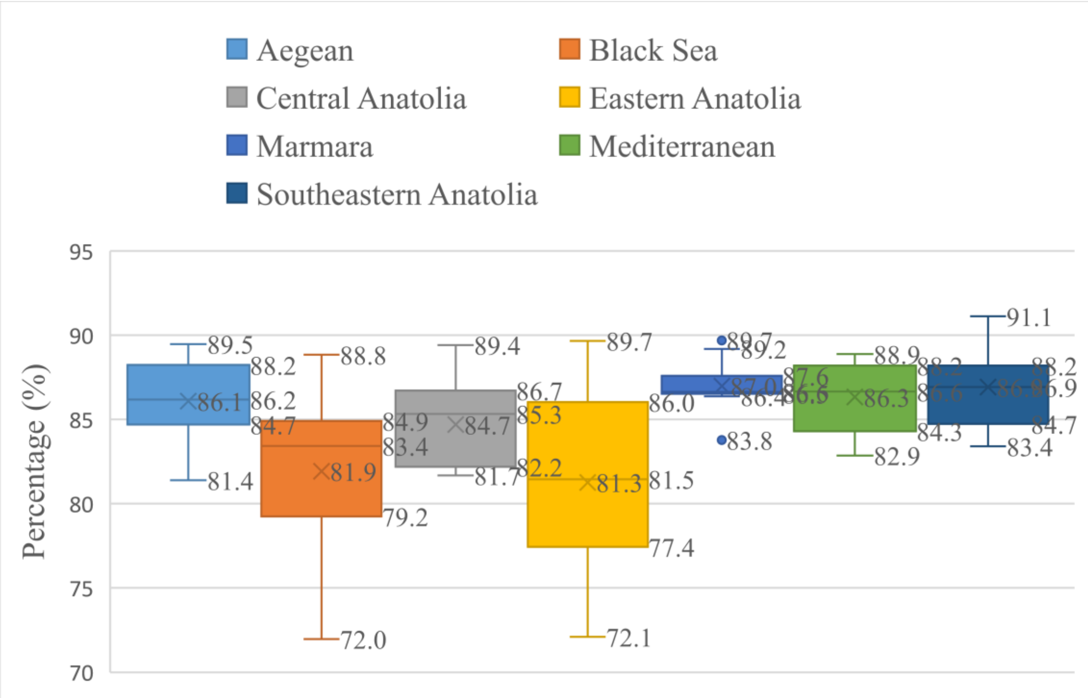


Figure 4.2. The mean value of percentages and standard deviation of residential buildings with respect to regions

Figure 4.3 demonstrates residential buildings stock percentages in terms of city population. Group one presents cities, those population is less than or equal to 500 thousand. Cities with population bigger than 500 thousand and less than or equal to one million are represented in group 2. Bigger than one million and less than or equal to five million populated cities are stated as group 3. Lastly, group 4 indicates only one city, İstanbul, whose population is more than 15 million.

For group 1, the residential buildings percentage of mean values is 83.2%. On the other hand, that become 84.4% for group 2 and 86% for group 3. Then 89.7% of the buildings are used for residential purposes in İstanbul, group 4. That demonstrates that non-residential buildings percentage is inversely proportional to the inhabitants' number. In other words, non-residential buildings proportion to the produced building stock in the high-populated cities is lower than the proportion in the small-populated ones.

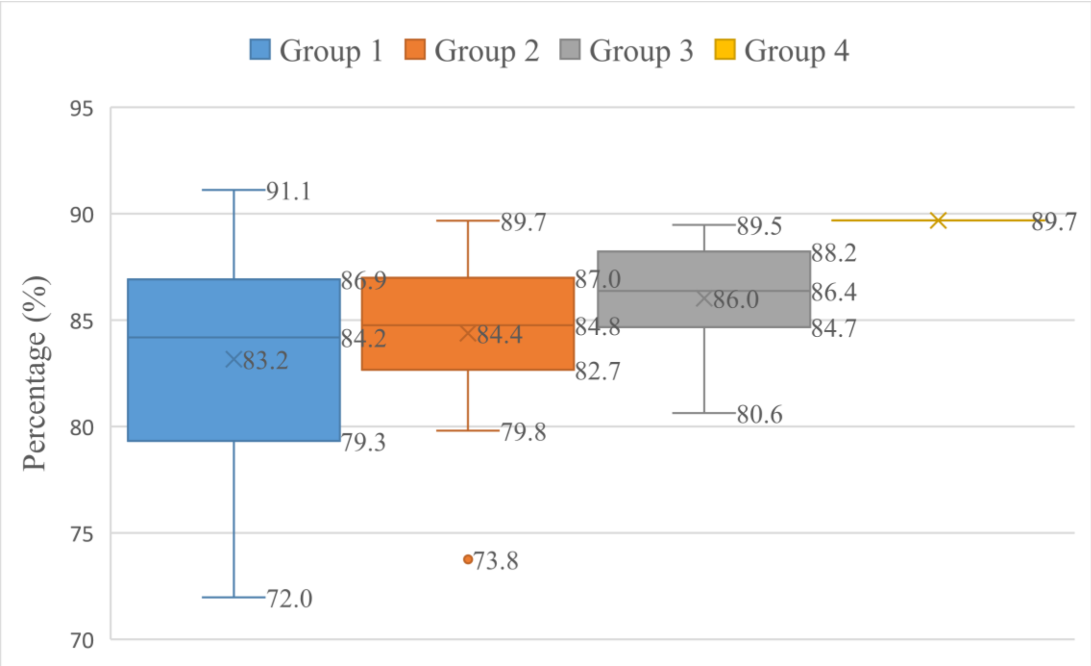


Figure 4.3. The mean value of percentages and standard deviation of residential buildings with respect to population

4.1.2. Function of Building in İstanbul

As mentioned before, researched building stock data contains also neighborhood information. That serves to assign their districts for the most crowded city in Turkey, İstanbul, researched in this study privately. In totality, buildings are 89.68% residential and 10.32% non-residential. As seen in Figure 4.4, number of buildings used for residential purposes is limited in Fatih as 70.15%. On the contrary, Sultangazi with 97.6%, Çekmeköy with 95.32% and Sarıyer with 95.11% are proportionally higher residential building stocks districts.

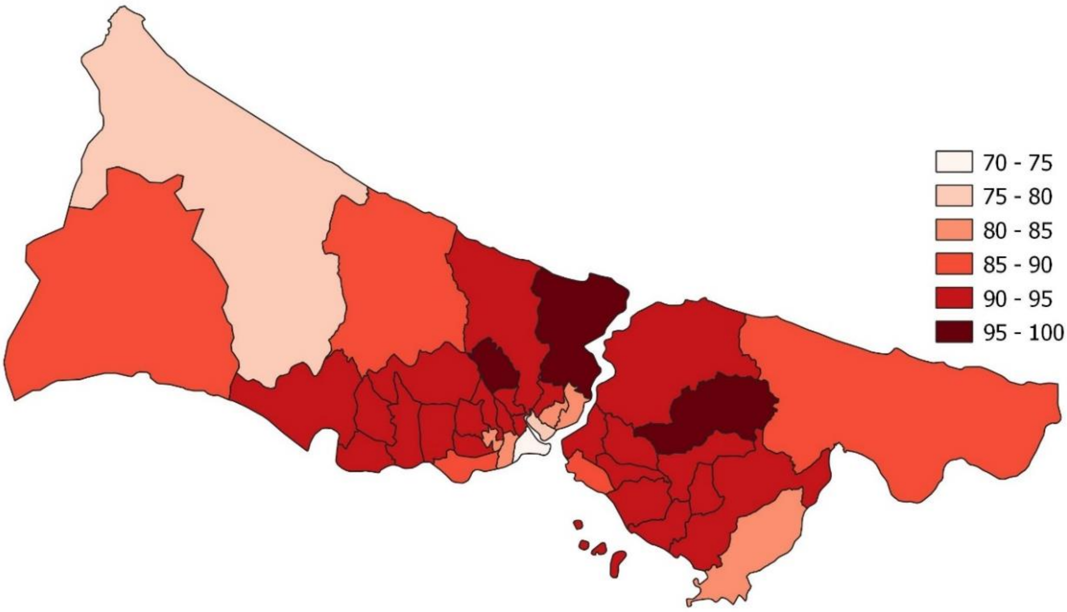


Figure 4.4. The percentage (%) of residential buildings in İstanbul

4.2. Structural System

4.2.1. Structural System in Turkey

Structural system is a significant parameter for building stock information in this thesis. As mentioned before, a questionnaire is applied to provide inconsistent and valuable statistics; and then, structural system data is classified by the answers. As one of the RC type, RC frame system is a common structural system in Turkey; furthermore, RC shear wall system has built since 1980. In addition, RC dual system come in light with used building permit data between 2012 and 2018. Due to that reasons, RC frame, RC dual and RC shear wall systems are mostly combined and called as RC in this section.

At Table 4.1, structural system percentages for Turkish building stock is indicated with respect to function of building types. Although, masonry structural system is a conventional and expectably common system in Turkey; reinforced concrete systems passed it and become the most current structural system in residential and also non-residential buildings. The difference between those systems is very few in non-residential buildings, unlike the residential ones. On the other hand, these two types of structural system can form the whole stock, because other types constitute only as a little part of the total stock as 1.52%.

If the proportion of each structural type is searched in city by city and then the mean value of total building stock is investigated, these two values of structural systems might vary. For residential buildings, the mean value of masonry buildings is 44.93%; while buildings with RC systems are 38.18%. For non-residential usage, the mean values are 38.18% for RC systems and 7.5% for masonry buildings. In this section, various structural systems are viewed at province level later.

Table 4.1. *Structural system percentages (%) with respect to function of building*

Building function / Structural System	RC	Masonry	Steel Frame	Prefabricated	Composite	Wood Frame	NA	Total
Residential	46	38.95	0.03	0.20	0.07	0.34	0.36	85.97
Non-residential	7.41	5.86	0.22	0.27	0.07	0.09	0.12	14.03

Table 4.2 represents the disaggregation of RC structural system. RC Frame structures is the most widespread RC system. The reason for that may be the oldest type of this system. Moreover, RC dual, has the second bar strikingly. Buildings with RC unknown structural system are nearly not-exist in the stock.

Table 4.2. *RC structural system percentages*

Building function / Structural System	RC Frame	RC Dual	RC Shear wall	RC Unknown	Total
Residential	82.95	2.75	0.41	0.02	86.12
Non-residential	13.53	0.28	0.07	0.00	13.88

Figure 4.5 shows the annual percentage of various structural systems through years. The proportion of each type have been calculated with the annual total, because the total numbers of each year fluctuate. Upper chart of this figure demonstrates the trend in residential building stock in Turkey, where the lower panel represents the non-residential ones. Both of them highlight the inverse proportion between masonry and RC structures. Although the number of masonry buildings decrease, other types increase when the slope of the trend at RC buildings is more than the other structural systems. For residential buildings, the years up to 1929 and between 1960 and 1989 have been critical points about building stock variation; however, the trend almost alters in every year for non-residential structures.

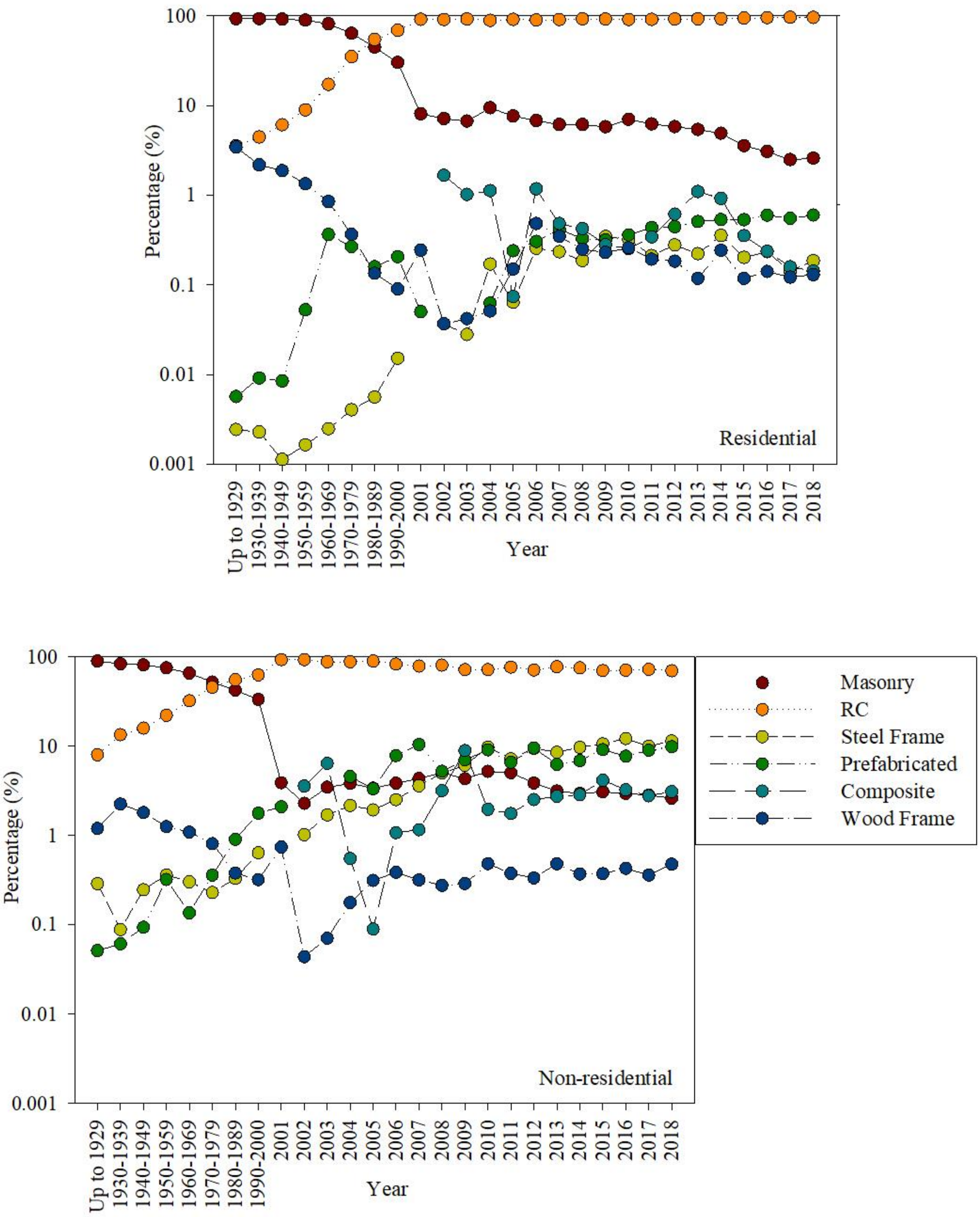


Figure 4.5. Annual structural system percentages with respect function of building

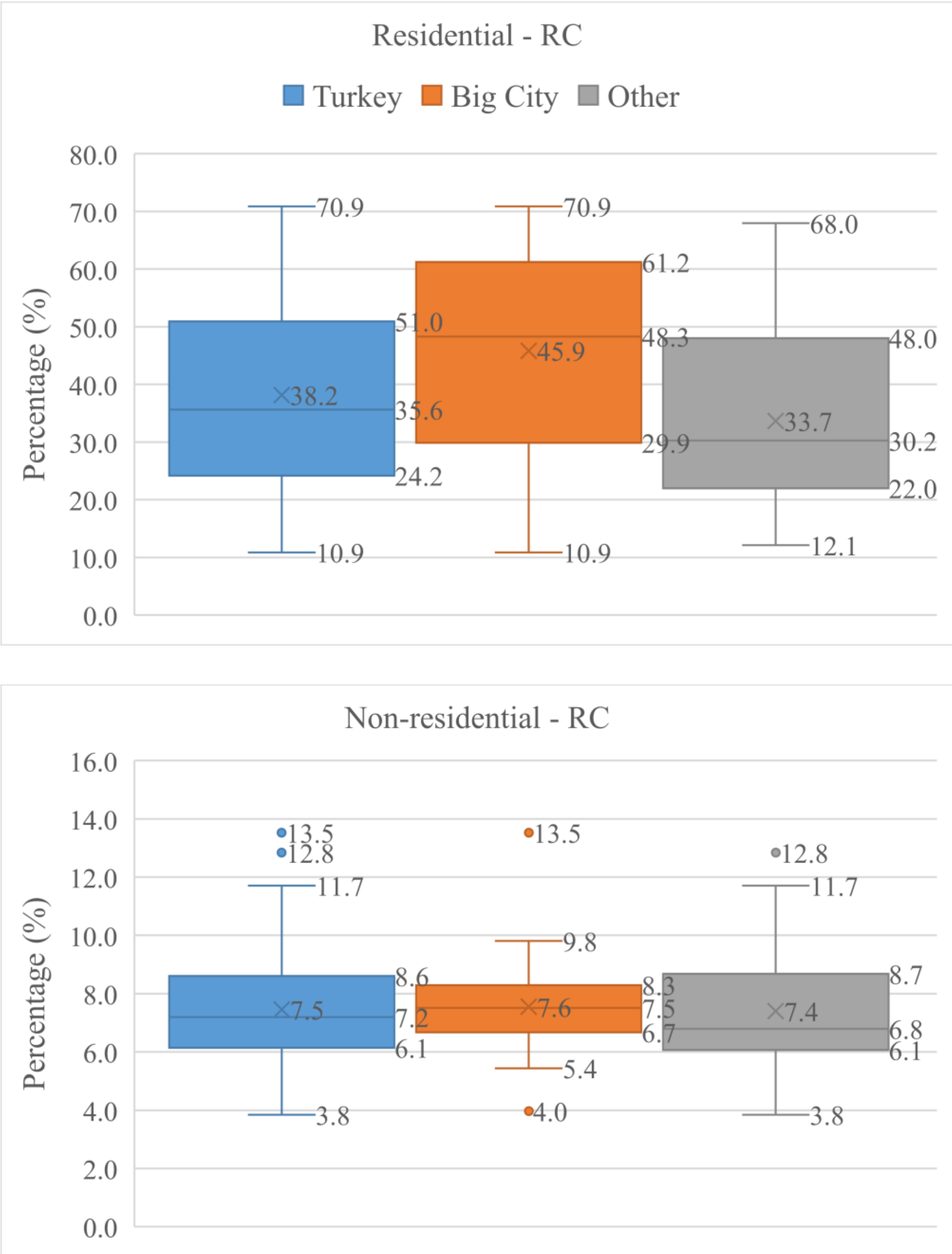
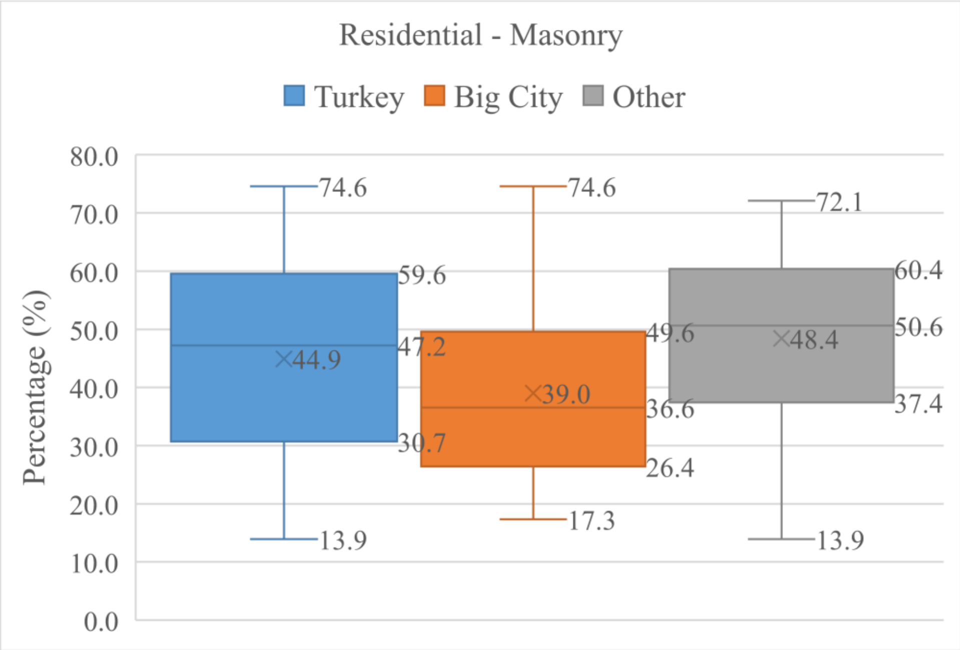


Figure 4.6. The percentage of RC structural system for residential and non-residential buildings with respect to Turkish cities polity

Figure 4.6 represents the variation in percentage of residential and non-residential buildings having RC structural system in general and in city administrative scale.

Figure 4.6 signalizes the increasing trend for residential buildings in metropolitans, whose reason can be migration from rural to urban. On the other hand, small trend for RC non-residential buildings might be caused by application of steel frame, composite and prefabricated for construction a building.

Figure 4.7 presents masonry buildings alteration in percentage for residential and non-residential buildings with respect to Turkish city administration. Contrary to the mean value of RC buildings percentages, masonry buildings percentages in big cities is smaller than that value of the other cities. This may show the usage trend of masonry system in small cities because number of stories are fewer mostly. On the other hand, the mean value of small cities is closer than this value of big cities to the mean values of total percentages in Turkey.



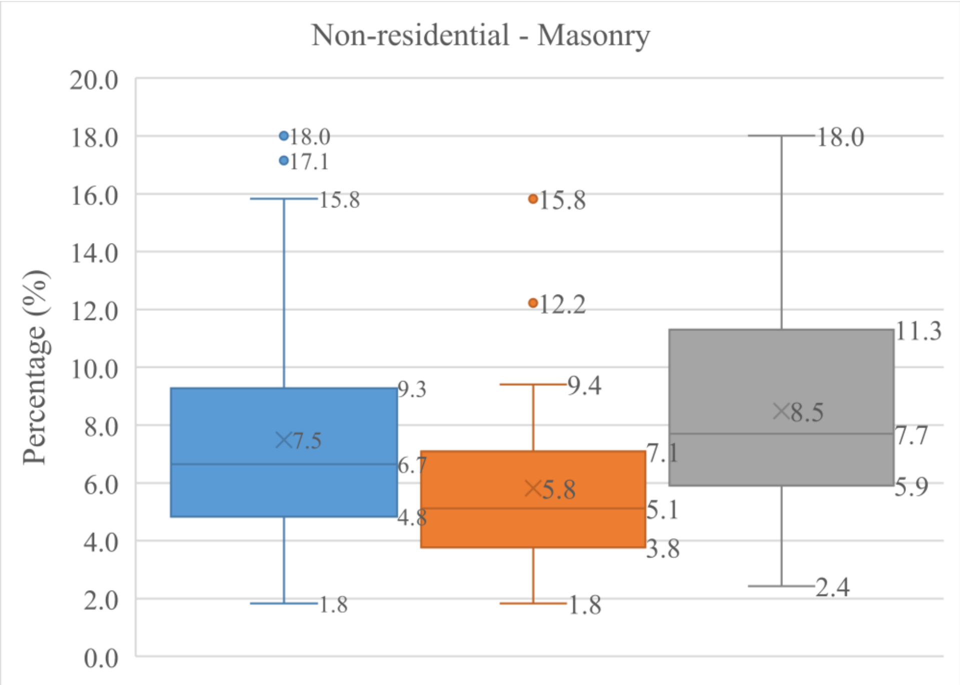


Figure 4.7. The percentage of masonry structural system for residential and non-residential buildings with respect to Turkish cities polity

The percentage of Turkish building stock trend for RC and masonry structures are investigated with respect to the Turkish areas. For residential buildings, the percentages of RC buildings in Central Anatolia and Eastern Anatolia are less than the average of the other areas; whereas the percentages of masonry buildings in Central Anatolia and Eastern Anatolia are higher than the other areas have. Further statistics can be seen in Appendix B in Figure B.1 and B.2.

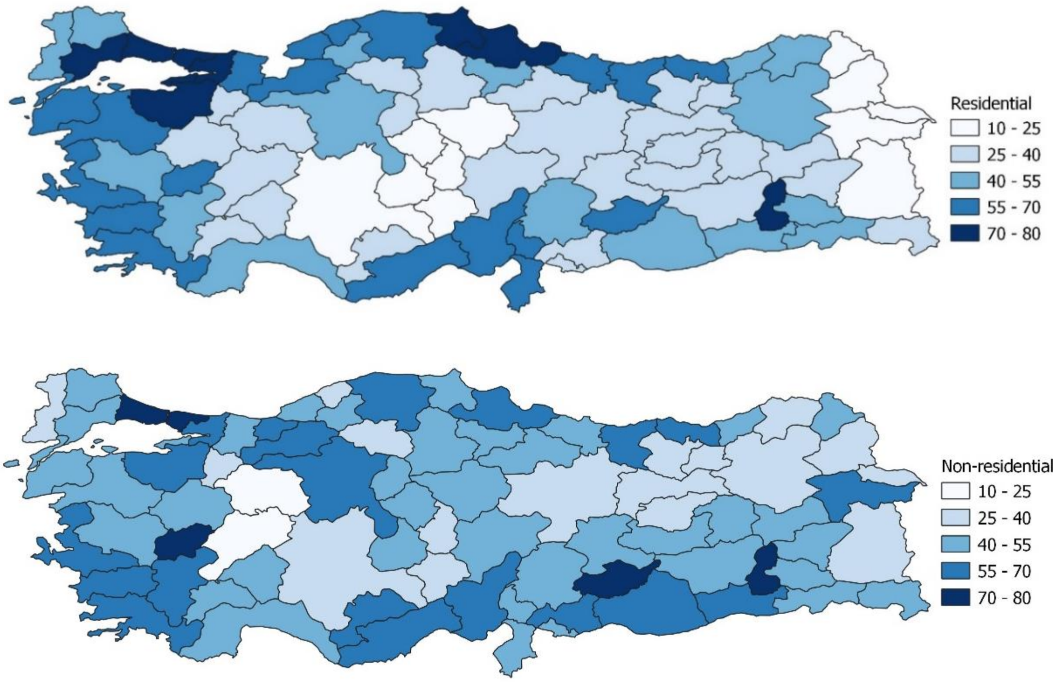


Figure 4.8. The percentage of RC structural system for residential and non-residential buildings at province level

Figure 4.8 shows the percentage of RC structural system for residential and non-residential buildings at province-level. The percentage of each city have been calculated with the total buildings in the city with respect to the function of building, because the total numbers of the buildings in each city differ from each. RC structural system for residential building is most common system, higher than 75% of entire residential buildings in the city, in İstanbul, Tekirdağ, Kocaeli, Yalova, Samsun and Düzce. On the contrary, Nevşehir around 14.79% and Van around 12.69% have limited ratio on residential RC structures.

Non-residential RC buildings graphic depicts the highest percentage on Batman, around 78.25%, İstanbul, around 73.08%, and lastly Adıyaman, around 73%. Furthermore, Eskişehir has the least proportion, around 22.87%. Afyon (2.89%), Sivas (27.37%), Erzincan (28.91%) and Artvin (29.21%) align after Eskişehir.

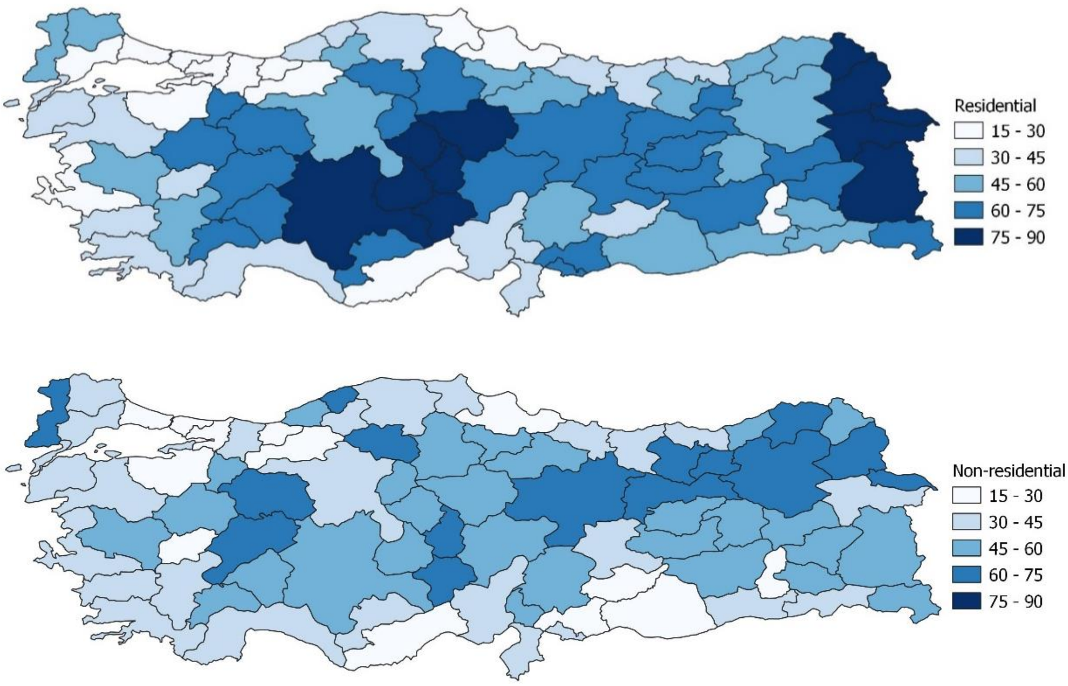


Figure 4.9. The percentage of masonry structural system for residential and non-residential buildings at province level

Figure 4.9 indicates the percentage of masonry structural system for residential and non-residential buildings at province-level that have been estimated as the below graphs. Residential masonry building is most common in two areas in Turkey as seen in the maps. Firstly, Kırşehir, Konya, Nevşehir Niğde and Aksaray belong to the center part. Later, Ağrı, Kars, Van, Yozgat, Aksaray, Ardahan and Iğdır lay at east edge of Turkey. The proportions of all of the below mentioned cities are higher than 75%; on the other part, there is no city, whose percentage is less than 15%.

For percentages of non-residential masonry buildings, Afyon around 71.82% has the peak level. Moreover, Eskişehir, Sivas, Erzincan, Artvin, Iğdır, Gümüşhane, Nevşehir, Niğde, Kars, Çankırı, Bartın, Bayburt, Edirne and then Erzurum come after. Like the residential ones, the least ratio is bigger than 15%. That belong to Kocaeli around 16.91%. Then, Düzce around 17.72% and Batman around 20.54 follow Kocaeli.

4.2.2. Structural System in İstanbul

As noted before, İstanbul, most crowded city, is researched privately at this study because of the significance role of Marmara earthquake risk in Turkey. Figure 4.10 represents the alteration in percentage of buildings of various structural systems through years. Since 1929, the percentage of RC building had increased gradually, and then the number has almost stayed same since 2001 while masonry structure declines. The other structural systems flutter through years.

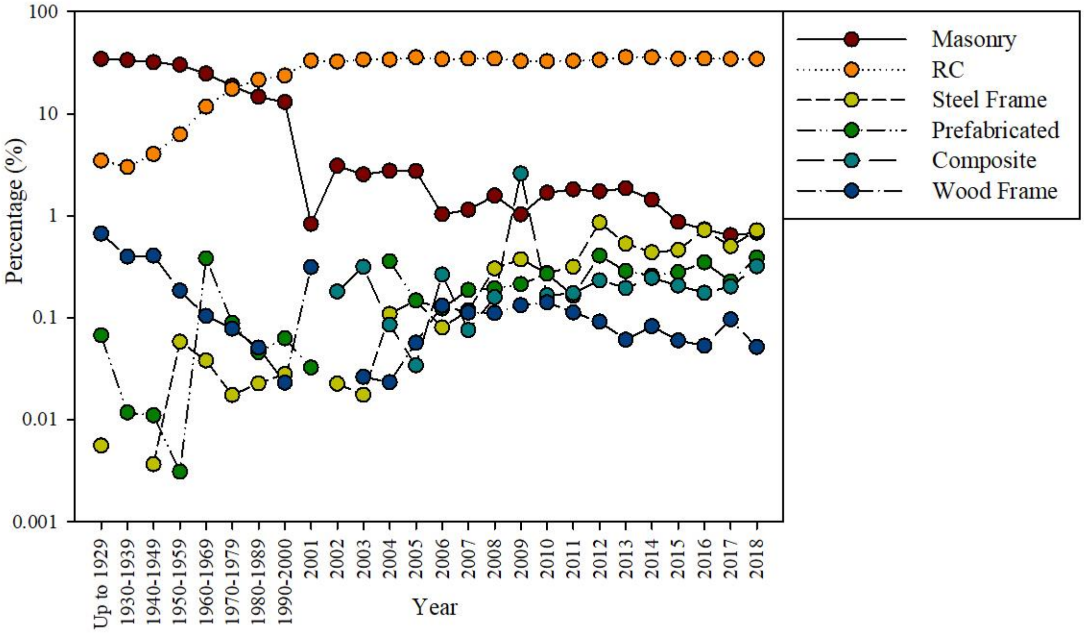


Figure 4.10. Annual structural system percentages in İstanbul

When the annual structural system percentages are investigated with respect to the building functions, Figure 4.11 is obtained, whose residential panel is similar to overall stock graph, Figure 4.10. Especially, the percentages of most usage systems, masonry and RC, are nearly same; however, proportions of steel frame and composite have some various. On the other part, non-residential structural system percentage with respect to years is provided in the below part of the figure. Unlikely to the residential buildings, percentages of masonry and RC structures go down and then remain constant nearly. Steel frame and composite non-residential buildings have upward trend, but the slope is relatively small.

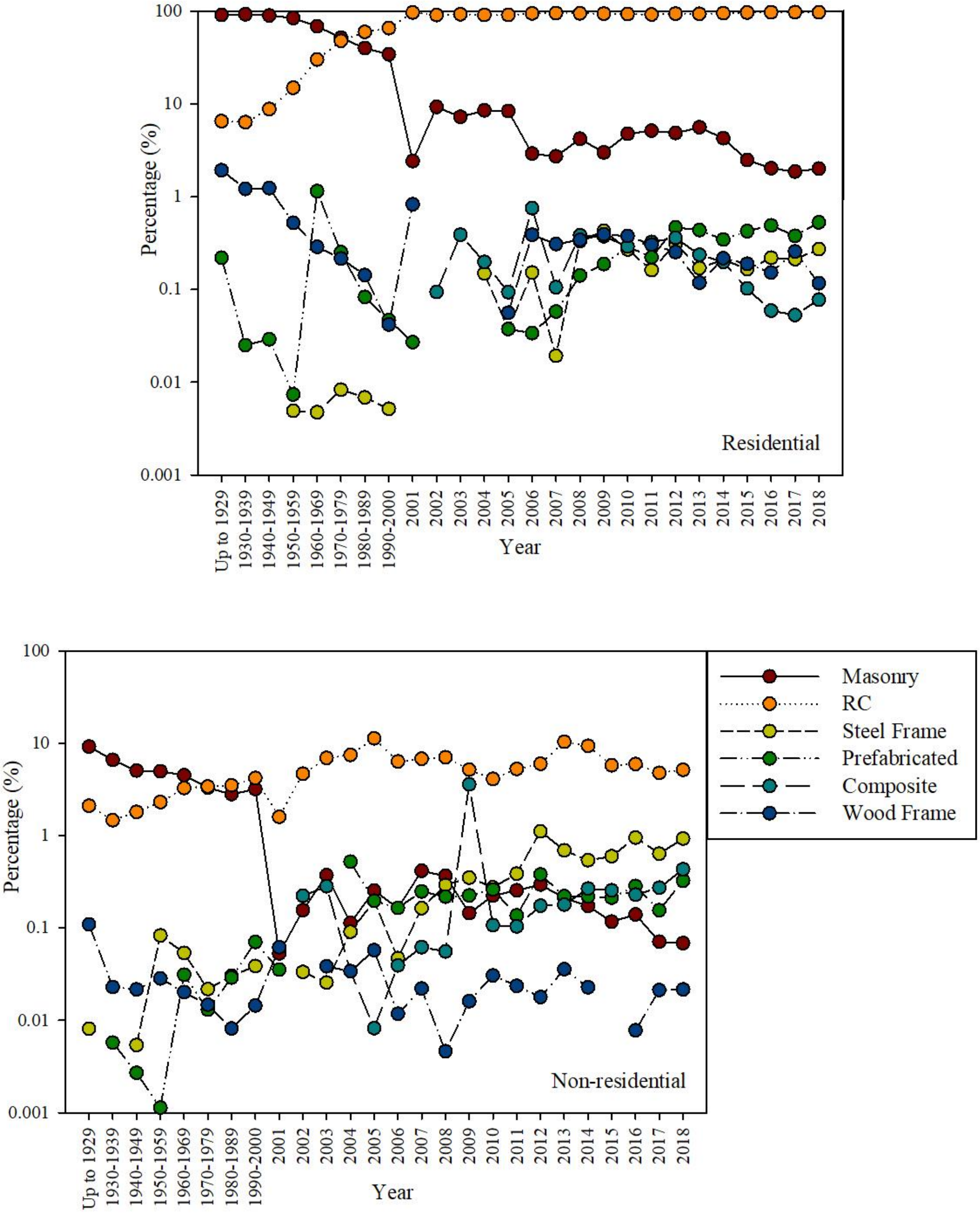


Figure 4.11. Annual structural system percentages in İstanbul with respect to function of building

As mentioned previously, RC building stock can separate four sub-classes with respect to the questionnaire of this study and raw BOP database. Figure 4.12 depicts the variation percentage of RC buildings yearly. RC frame system is the oldest structural system, for this reason that is the most common one. One can infer from the figure, in 1980 first RC shear wall building was constructed in İstanbul, while RC dual system became in the statistics in 2012. It must be said that the tendency to RC frame building protects its popularity despite coming in sight of RC dual and RC shear wall systems. There is not any buildings with RC Unknown structural system in İstanbul. The percentages of all RC systems with respect to the function of building in İstanbul are also represented in Table 4.3.

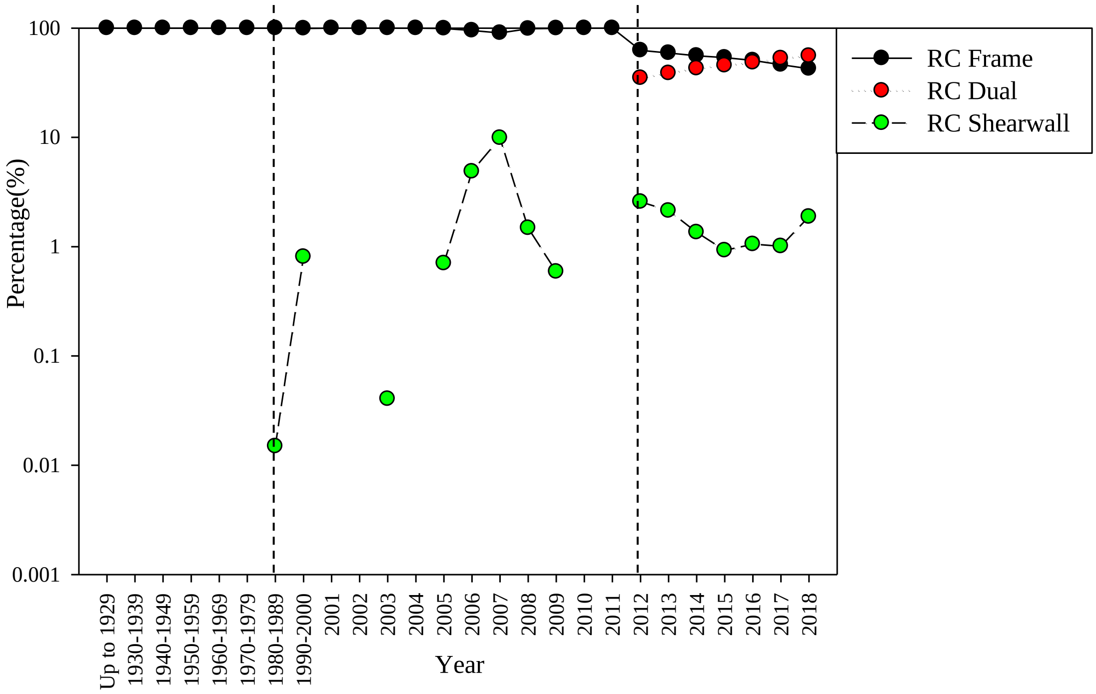


Figure 4.12. Annual RC structural system percentages in İstanbul

Table 4.3. RC Structural system percentages (%) with respect to function of building in İstanbul

Function / RC System	RC Frame	RC Dual	RC Shear wall
Residential	97.77	1.65	0.59
Non-residential	97.51	1.97	0.52

Figure 4.13 demonstrates the percentage of RC structural system for residential and non-residential buildings in İstanbul at district level. As noted before, in totality, higher than 75% of residential buildings in İstanbul has RC structural system. Similarly, this ratio is higher than 75% at 11 districts. Those are arranged from up to low as Sultangazi, Bahçelievler Ataşehir, Avcılar, Güngören, Bağcılar, Esenler, Büyükçekmece, Zeytinburnu, Esenyurt and Bakırköy; while minimum percentage is 45.68% in Adalar. Similar to residential buildings, RC system also mostly preferred for non-residential buildings. Sultangazi (96.63%), Esenler, Esenyurt, Güngören, Bağcılar and Ümraniye (91.15%) have the highest number in sequence; although, the ratio of Adalar around 21% and Çatalca around 31.49% are the lowest ones.

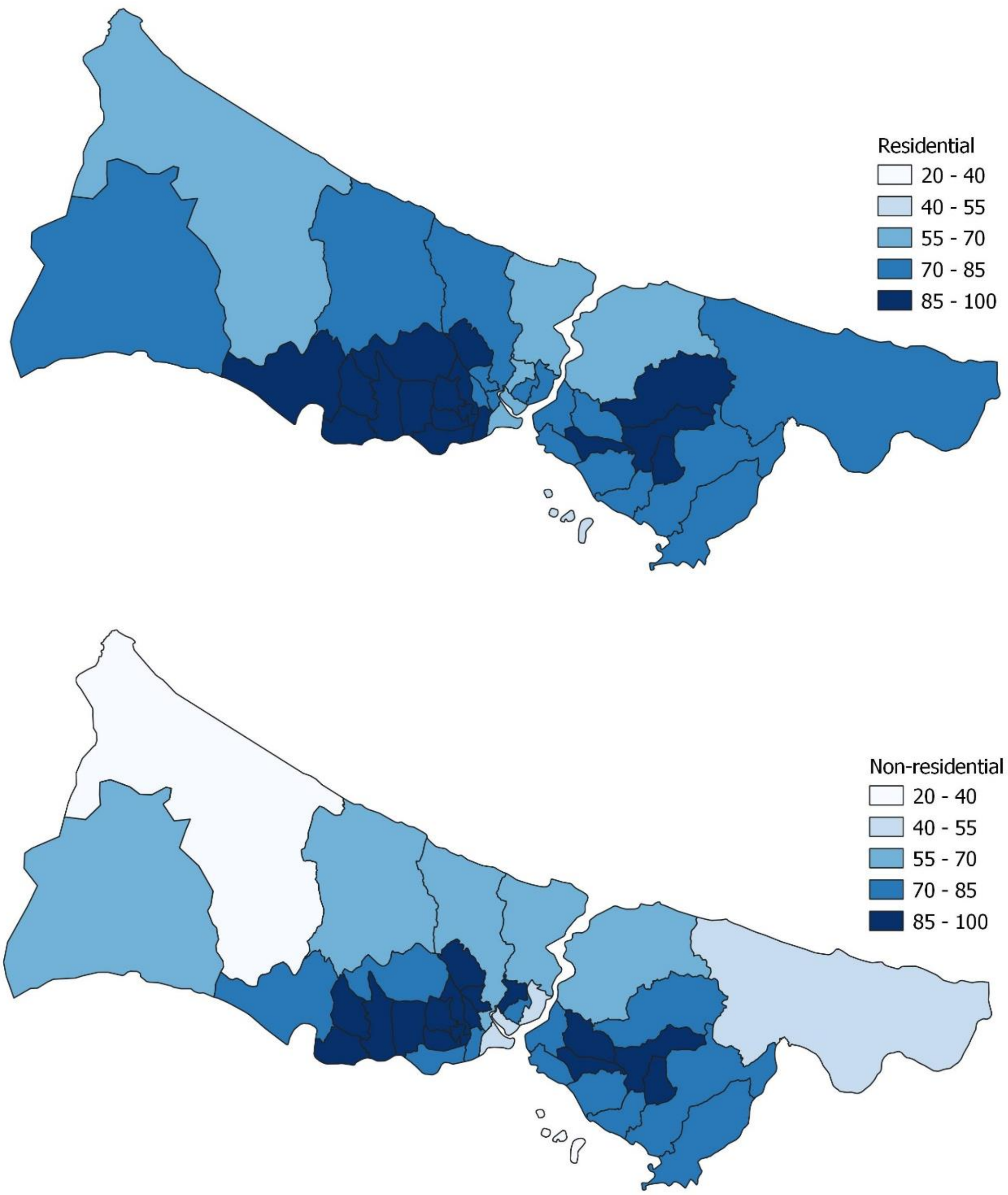


Figure 4.13. RC structural system percentages in residential and non-residential buildings in İstanbul at district level

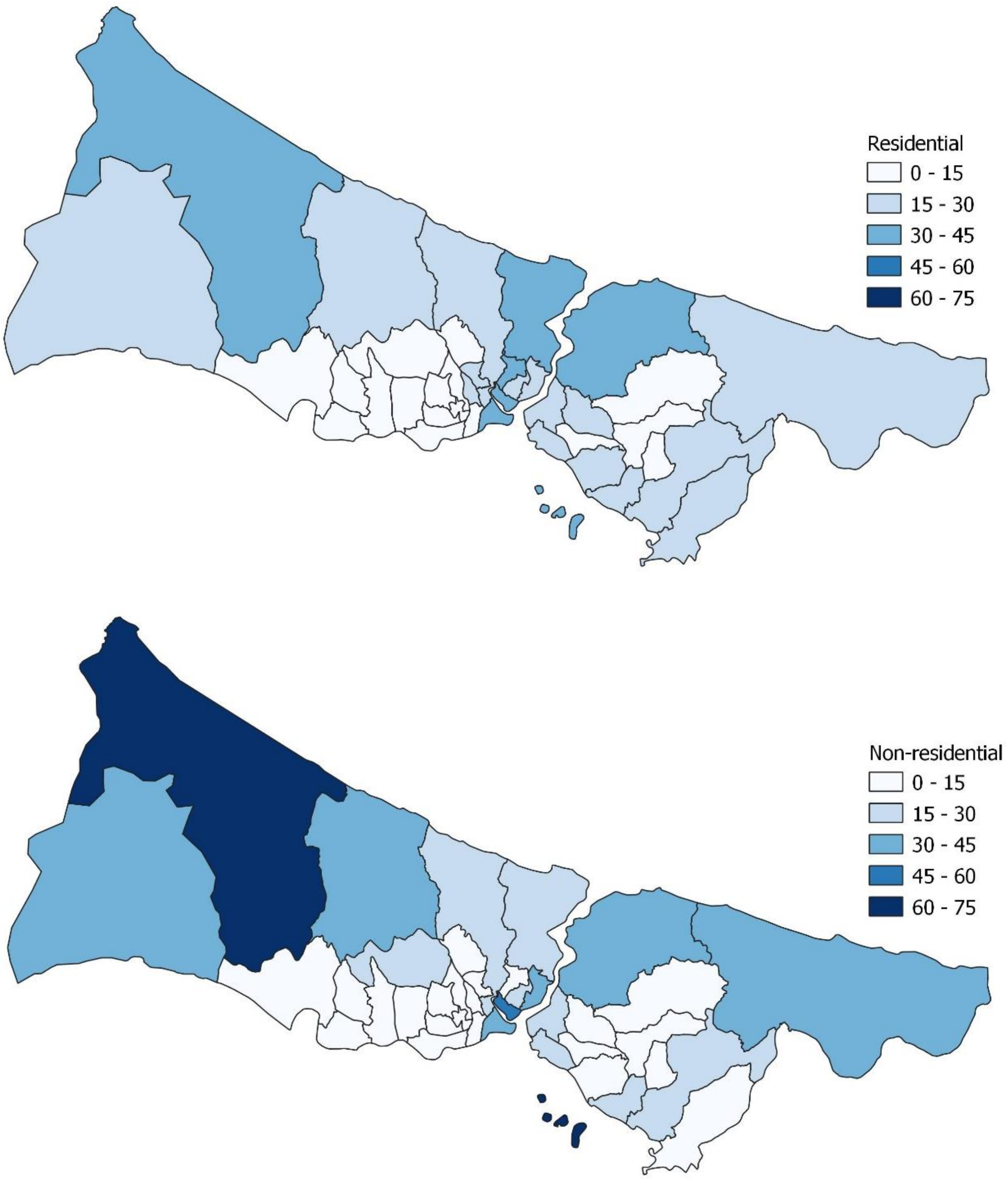


Figure 4.14. Masonry structural system percentages in residential and non-residential buildings in İstanbul at district level

Figure 4.14 depicts masonry systems percentages in residential and non-residential buildings in İstanbul at district level. In totality after RC systems, masonry systems are the second most used structural system in İstanbul, where the difference is not very few. At district-level, the highest level belongs to Beyoğlu around 44.19%, and then Çatalca comes back with 43.69%. In contrast, the lowest ratios are in Sultangazi around 0.14% and Ataşehir around 0.44%. On the other hand, the percentage of non-residential masonry buildings is peak at Adalar around 70.47%. Then Çatalca around 64.55% becomes as the second district. By contrast, Sultangazi around 1.12% has the deepest level, and Ataşehir around 1.4% is too close to the smallest number.

4.3. Number of Stories

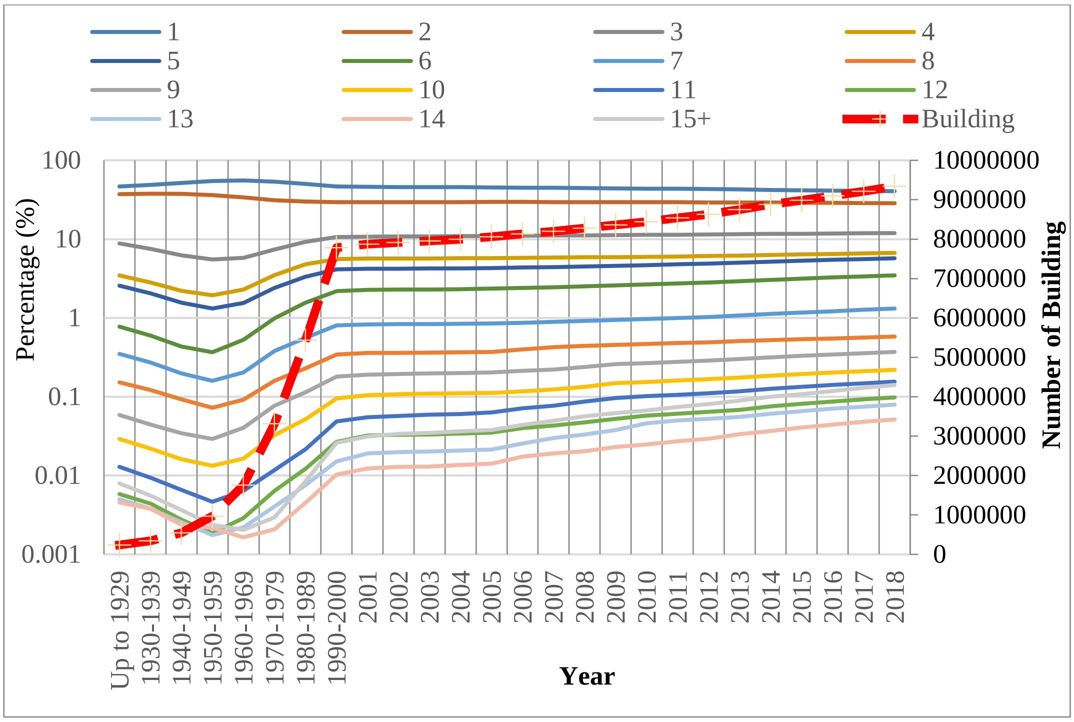
Number of story is a significant parameter for building stock information data. In this study, sum of the basement ground, regular and roof floors gives the number of story information because TUİK processed data cannot be separated.

Considering predecessor studies on building stock data and providing more clear information this thesis classifies buildings as low-, mid-, high-rise and tall. That was explained in method section. Low-rise buildings are buildings with one and two story for masonry and wood frame buildings, which have less seismic capacity, and with one to three story for other structural systems. In addition, buildings with three or more stories for masonry and wood frame, and with four to eight stories for others are classed as mid-rise. Moreover, buildings with nine to nineteen and more than or equal to twenty stories are categorized as high-rise and tall, respectively.

4.3.1. Number of Stories in Turkey

In Turkey 44.37% of the building stock is with only one story. The second common building become with two stories (29.47%); moreover, building with three stories follow them with 5.86%. Therefore, one can infer from these statistics that the most common height class in Turkey is low-rise.

Figure 4.15 represents the cumulative percentage of buildings with various story numbers annually with continues lines. In addition, the dashed red line demonstrates cumulative number of building constructed until that year. The percentages are calculated from annual total number of buildings. The upper graph demonstrates annual variation of number of stories. In fact, buildings with 15 and more floors are shown in one category due to their little rate at total stock. The percentage of buildings with one and two stories have decreased slightly in cumulative statistics; though, the others have increased. Furthermore, yearly variation, not cumulative, of the percentages of number of stories is attached in Appendix B as Figure B.3. One can infer from the Figure B.3, buildings with one floor, picked in 1950-1959 years, had have the biggest percentage until 2001. In 2001, they dropped sharply, and then the percentage nearly remains constant. As another common building type, buildings with two stories has downward trend, too; however, this decreasing is less than the former one. The reason of these decreasing can be the falling trend of masonry buildings, which are mostly constructed with one story or two stories such as shanty houses. On the other hand, trend of buildings with more than or equal to three stories rises slightly year after years, since increasing trend of other structural systems, especially RC systems.



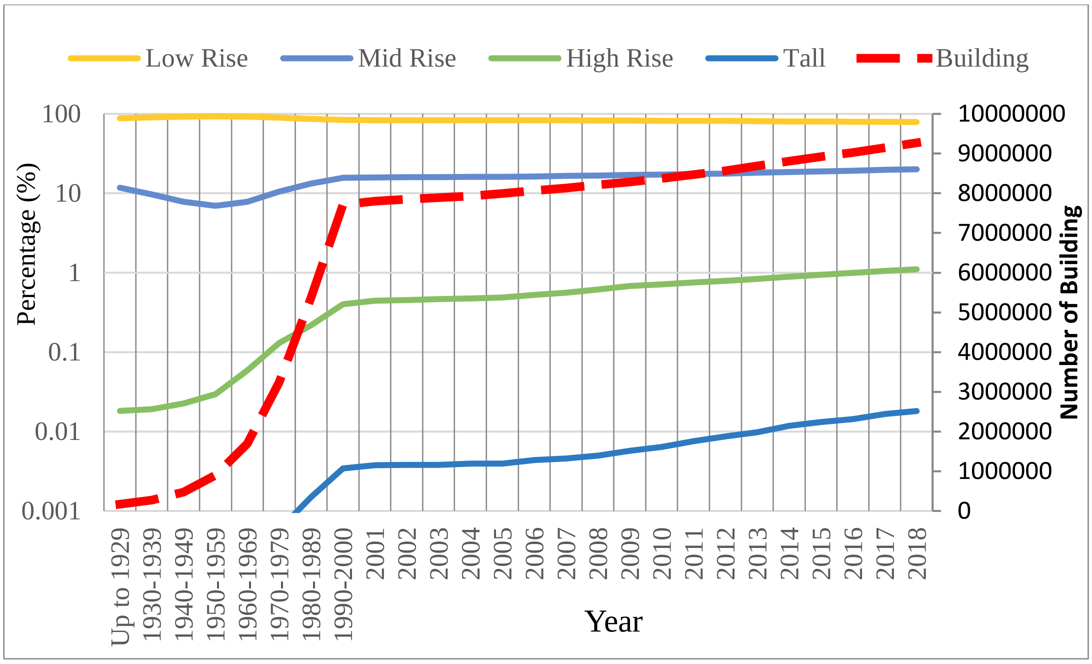


Figure 4.15. *Annual variation of number of stories percentages and number of total building*

The below graph of Figure 4.15 shows annual cumulative variation of height classes percentages. In Appendix B in Figure B.3, the inverse relationship between percentages of low- and mid-rise buildings appears clearly; however, that difference cannot be seen in cumulative statistics, Figure 4.15. On the other hand, construction of tall buildings has started to be favored since 2000 in Figure B.3, whereas the trend slightly increases in Figure 4.15 because the spread of tall building is only in a few big cities such as İstanbul, Ankara, İzmir. In most cities there is no tall structures. For this reason, the low-rise and mid-rise buildings percentage are still the biggest ones in Turkish total building stock.

If the height classes is investigated with respect to function of building, the trends become much similar. However, one point can be presented that there was not any tall building constructed in 2005 for non-residential purposes in Turkey.

Figure 4.16 provides height classes of buildings according to structural system variation. In order to assign percentages, the number of buildings of each height classes have been standardized with total buildings with same structural system type. As seen in figure, low-rise building is most common height class for all structural systems. In other words, for all structural systems more than 85% of produced buildings are low-rise. As the second common height class, the percentage of mid-rise buildings are over 30% in total RC and masonry structures; in addition, the percentage of mid-rise buildings is around 11% in wood frame buildings. Moreover, RC, composite and steel frame structural systems have also high-rise and tall buildings in TBS.

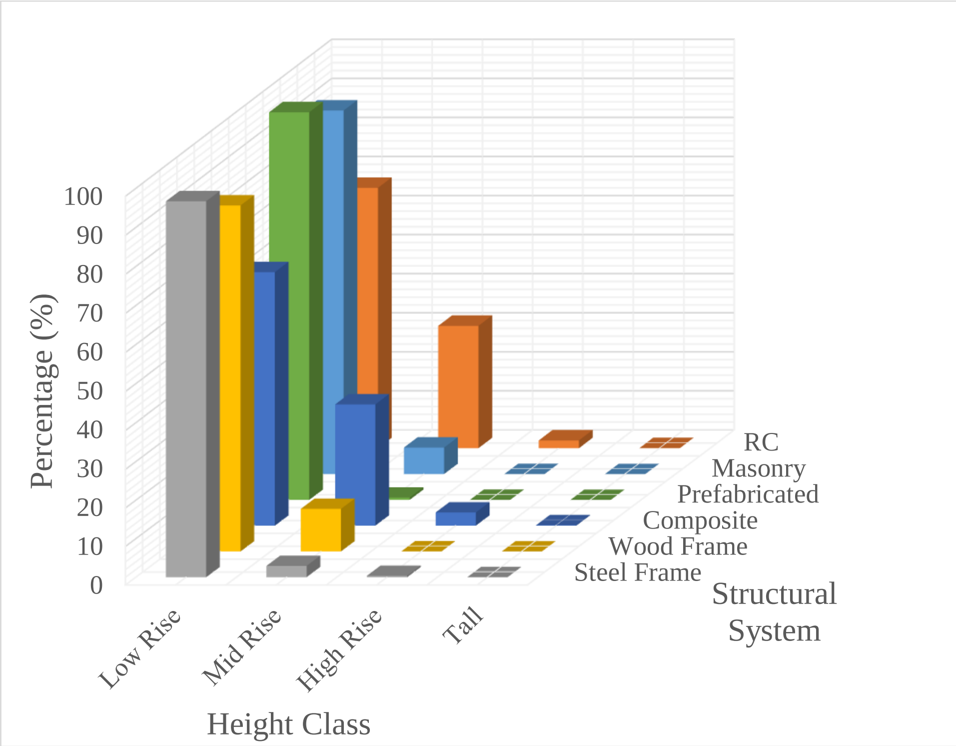


Figure 4.16. Variation of low, mid, high-rise and tall buildings in Turkey with respect to the structural system

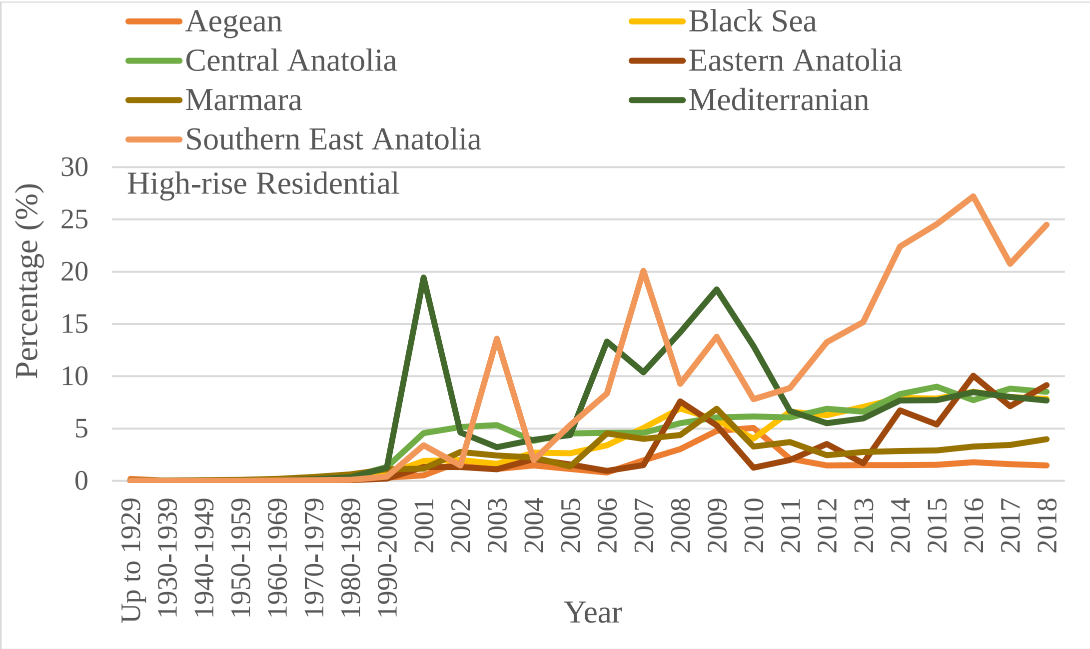
If the alteration of low-, mid-, high-rise and tall buildings in Turkey with respect to structural systems is searched about building function, some constants exists, represented in Appendix B in Figure B.4. First, as the most dissimilar one, percentage of low-rise composite residential buildings is less than mid-rise composite buildings; whereas percentage of low-rise non-residential composite buildings is around 90%. That can be the reason for high percentage of low-rise in total composite buildings. Further, the ratio of high-rise composite residential buildings is also surprisingly over 6%, which is the biggest percentage for high-rise buildings. Another contrast is about high percentage of RC low-rise non-residential buildings. That means that low-rise are frequent in RC systems as similar to other structural systems. In addition, mid-rise is also most familiar in non-residential RC buildings.

4.3.2. Number of Stories in Turkish Areas

For detail research, building stock is investigated according to Turkish areas in order to examine whether geological position and cultural states affect the trends in number of story or not. The percentages are supplied for each year according to total constructed building in that time.

Annual variation of low-rise and mid-rise buildings with respect to function of building types in Turkish areas is investigated in this study. The trend of low-rise residential buildings in all areas are almost same to total TBS trend. That means that the trends of low-rise residential buildings in all areas have decreased year by year. On the contrary, the trends of mid-rise residential buildings in all areas have increased. These trends go similar for non-residential used buildings; however, the decreases and increases of the proportion of non-residential buildings in all areas have been more slightly. Corresponding graphs has been given in Figure B.5 and B.6.

Figure 4.17 is about high-rise building in Turkish areas according to residential and non-residential usage. Especially for Southeastern Anatolia and then for Mediterranean area high-rise building percentages are higher than others have. Although, in Mediterranean Area high-rise building may become normal by considering the culture of inhabitants and trade of the cities such as hotels, convention centers; high-rise building percentage is unusual in Southeastern Anatolia Area.



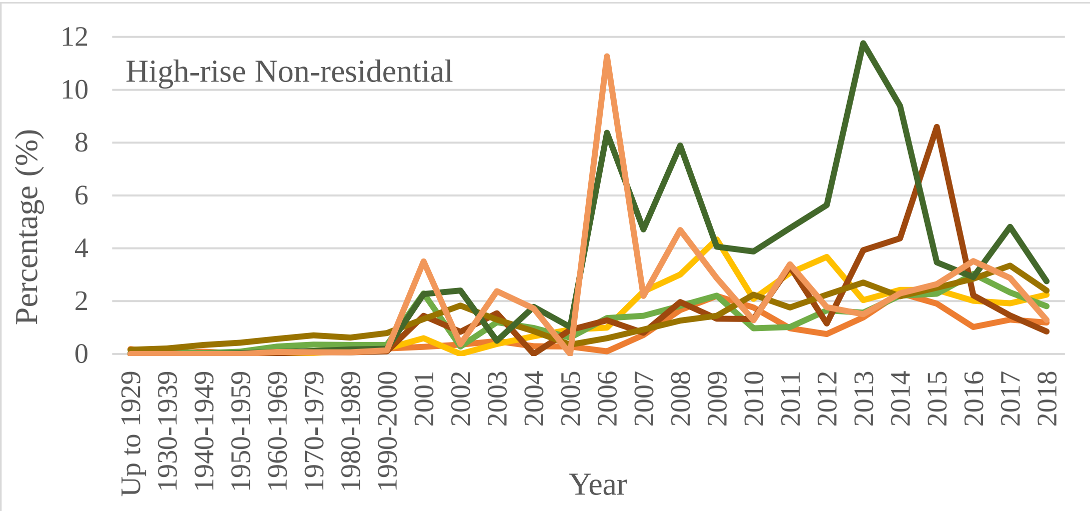
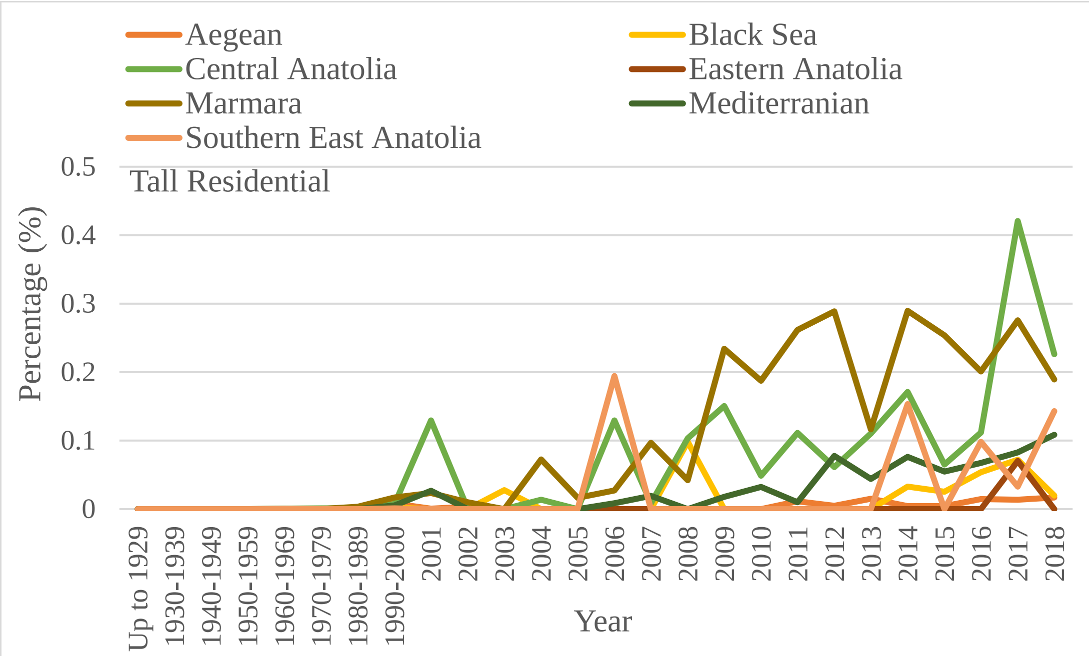


Figure 4.17. Annual variation of high-rise residential and non-residential buildings with respect to Turkish areas

Figure 4.18 represents tall residential and non-residential buildings in Turkish areas. The percentages for residential building are much low in all areas, which means that tall building is not preferred as residential function. On the other hand, for non-residential function the percentages of all areas are more than the residential buildings have. Therefore, tall building is more favored in non-residential purposed ones. Like the high-rise percentages, Southeastern Anatolia becomes prominent for non-residential. On the other hand, the tall non-residential building trend goes upward gradually in only Marmara Area.



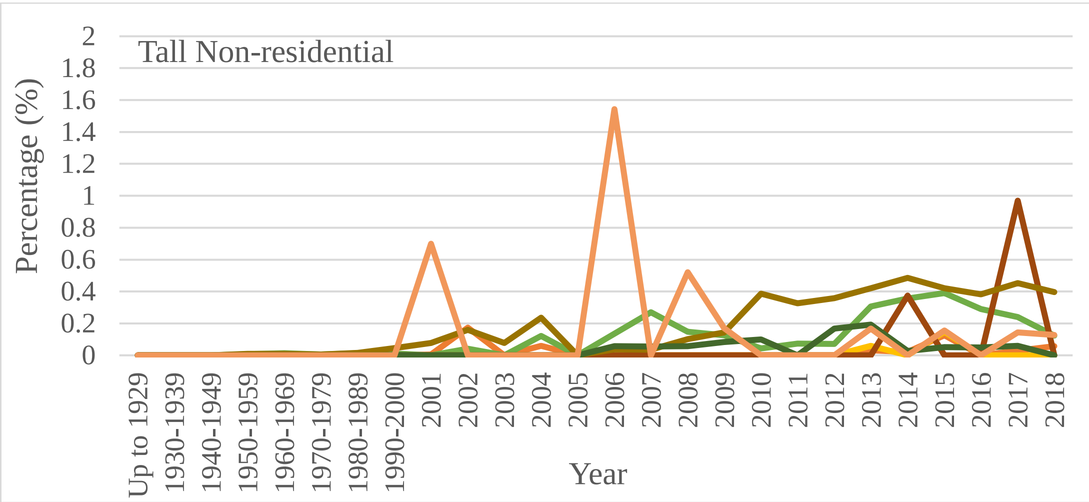


Figure 4.18. Annual variation of tall residential and non-residential buildings with respect to Turkish areas

The percentages of height classes with respect to the structural systems for residential and non-residential buildings are investigated according to Turkish areas in this thesis study. There are slightly differences between their statistics and the statistics of all TBS. Firstly, low-rise residential buildings ratio is higher than mid-rise ones in Aegean, Black Sea, Central Anatolia and Mediterranean area. Moreover, in Marmara and Eastern Anatolia percentages of low-rise residential RC buildings are closer to the proportions of mid-rise RC ones. In addition, the former is less than the later RC residential buildings in Central Anatolia. The related graphs are given in Figure B.7 to B.14.

4.3.3. Number of Stories at Province Level

In this section, total produced buildings are classified according to height classes. The percentages are estimated for each city one by one. Figure 4.19 represents low-rise buildings at province-level on Turkey map. Although, low-rise buildings ratio is around 78.85% in total Turkey, it becomes more than 90% in some cities at province-level observation. The east and southeast edges of the Turkey have high percentages. The reason of that can be their rugged terrain or their low inhabitations. In addition, Muğla has also high ratio because of the existence of summerhouses. Moreover, percentage of low-rise building is around 90% in Yozgat, as being in high ratio group.

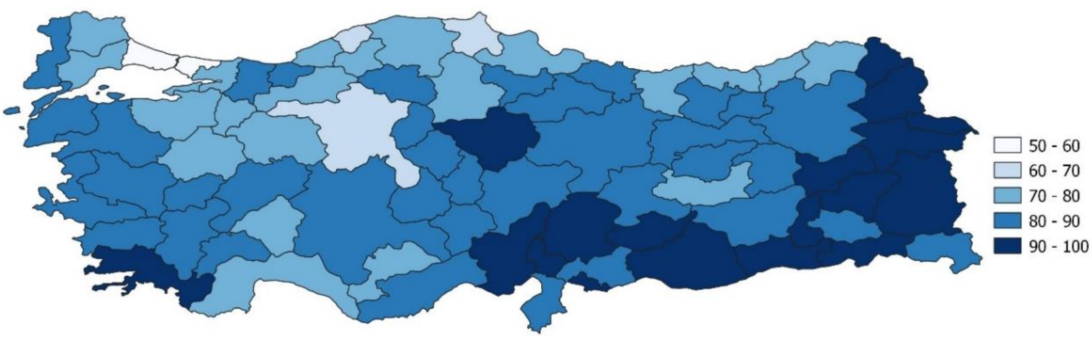


Figure 4.19. Percentage of low-rise buildings at province level

Figure 4.20 depicts percentage distribution of mid-rise buildings at province level. That vary 4.56% to 47.49%; however, only 20.04% of total produced TBS are mid-rise in totality. The cities having highest percentage on Figure 4.19 are now getting the lowest percentage. On the other hand, İstanbul is the only city where more than 40% of buildings are mid-rise.

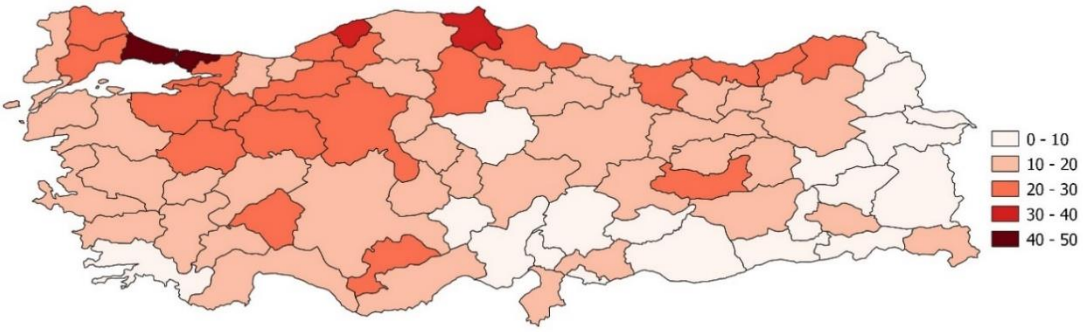


Figure 4.20. Percentage of mid-rise buildings at province level

The percentages for high-rise and tall buildings are less than the percentages for low- and mid-rise buildings. Figure 4.21 shows high-rise buildings percentages at province level. Mersin and Kayseri get more than 2.8% as the dark colored city; though, just 1.1% of the total TBS are high-rise buildings.

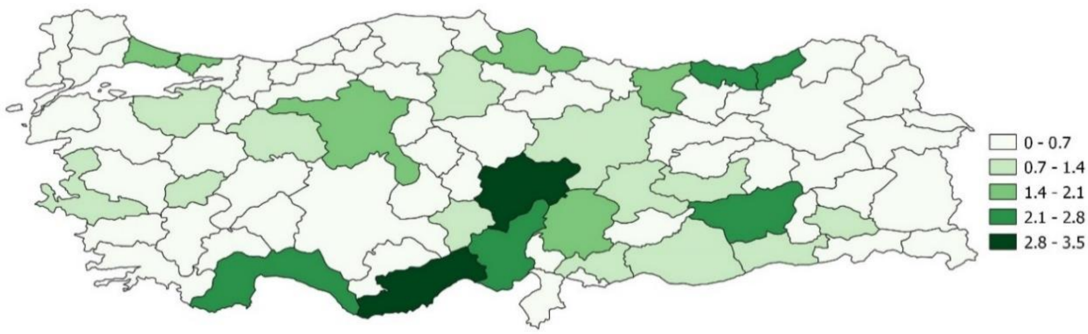


Figure 4.21. Percentage of high-rise buildings at province level

Figure 4.22 demonstrates percentage of tall buildings for each city. Most of the city do not have any tall building. In addition, there are no city in third class, 0.04% to 0.06%. The high percentages belong to the most crowded cities in Turkey. Ankara gets 0.075% and İstanbul takes 0.91% for tall building. That shows the relationship between the population and the building height class.

Figure 4.22. Percentage of tall buildings at province level

4.3.4. Number of Stories in İstanbul

This section is about number of stories in İstanbul in order to provide detail information for estimating risk of casualties caused by expected big İstanbul earthquake. Figure 4.23 represents cumulative variation of number of stories percentages annually with continues lines. In addition, the dashed red line represents cumulative number of building constructed until that year. Differently from the total Turkish stock percentages mentioned before, the percentages of buildings with three stories are almost same with buildings with one and two stories. If the variation of number of stories is investigated in year by year, the percentage of buildings with three stories increases and passes all classes between the years 1990 to 2006. Corresponding graphs has been given in Appendix B in Figure B.15. Furthermore, as one can infer from the Figure 4.23, buildings with four and five stories has higher proportions than their ratios in total TBS. This can be seen notably by rise of mid-rise building class in Figure 4.24.

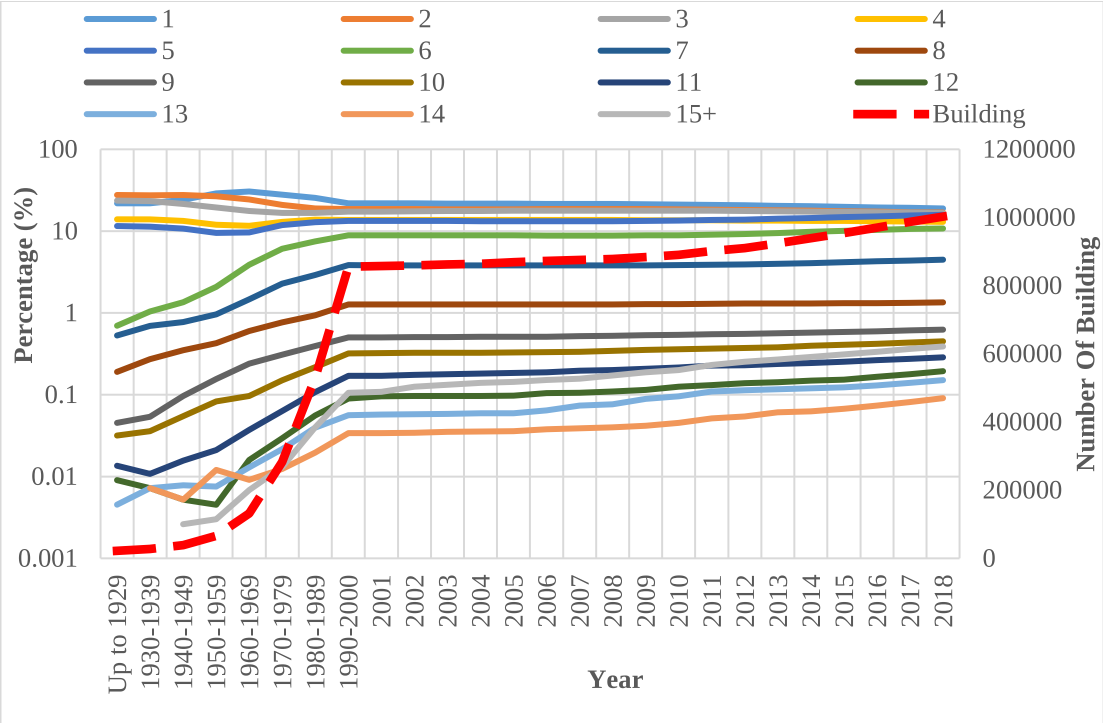


Figure 4.23. *Annual variation of building number of stories percentages and total number of building in İstanbul*

Figure 4.24 shows annual alteration of height classes with continues lines and total number of building with dashed red line. Like the graph of total Turkey height classes, Figure 4.15, percentages of low-rise buildings have inverse relationship between the others.

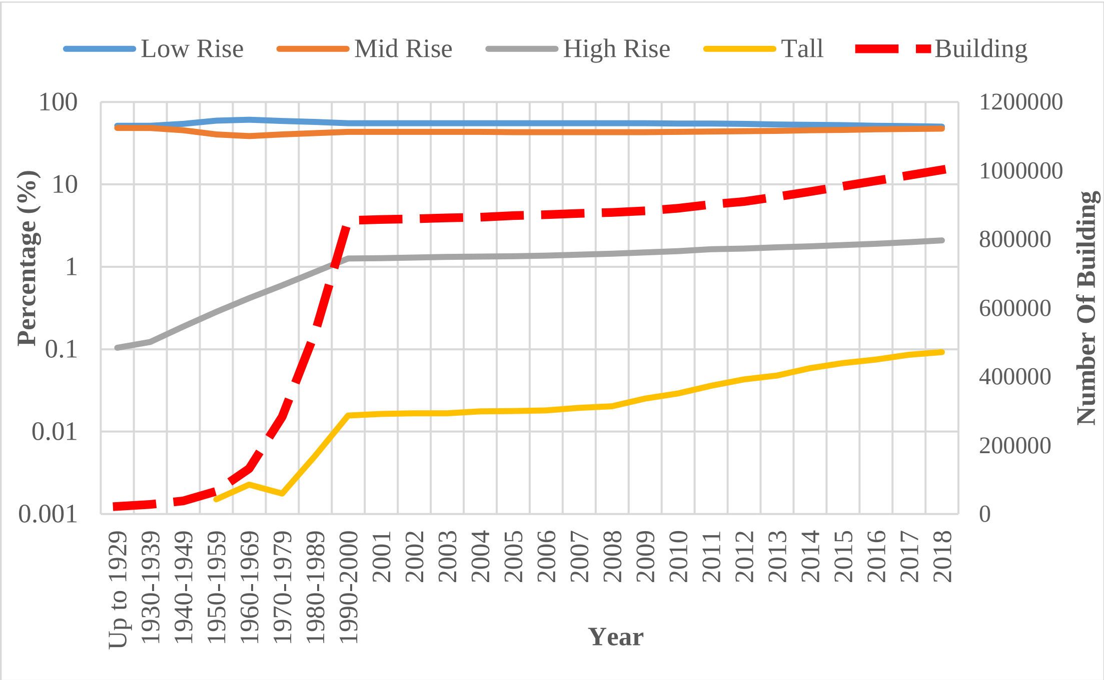


Figure 4.24. Annual variation of building number of stories percentages in İstanbul with respect to function of buildings

When İstanbul building stock height classes are examined at district level, below figures are obtained. The percentages are calculated by total produced number of buildings at each district. As one can infer from Figures 4.25 and 4.26, low-rise and mid-rise percentages are in invert relationship. Furthermore, the districts located at edges, 5 widest districts in İstanbul, have increased rate for low-rise buildings as an effect of rural environment. These are Silivri, Çatalca, Arnavutköy, Beykoz and Şile.

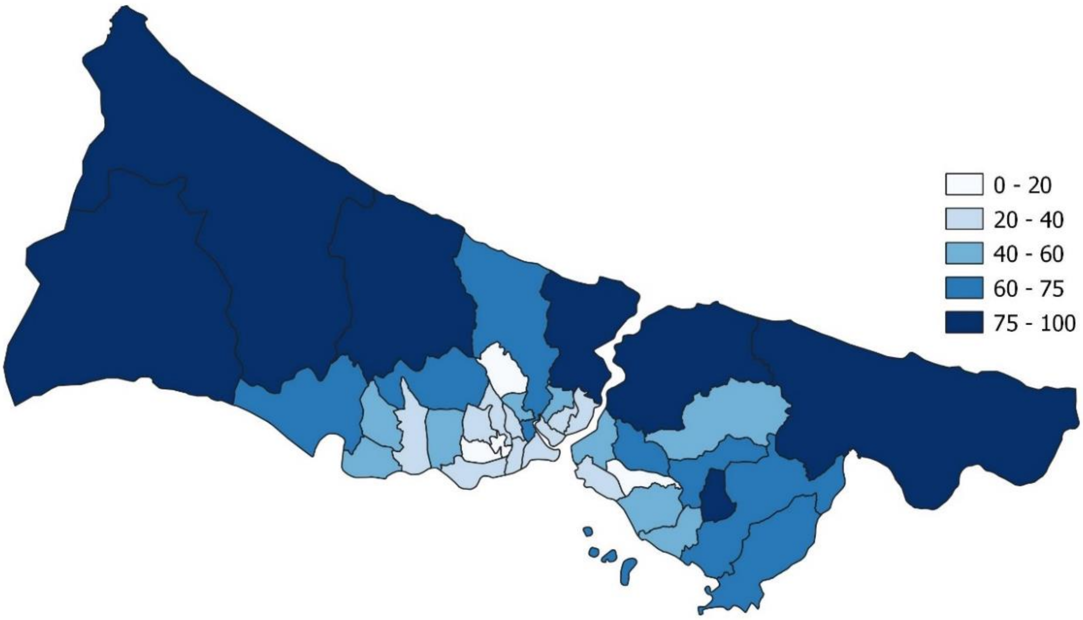


Figure 4.25. Percentages of low-rise buildings in İstanbul at district level

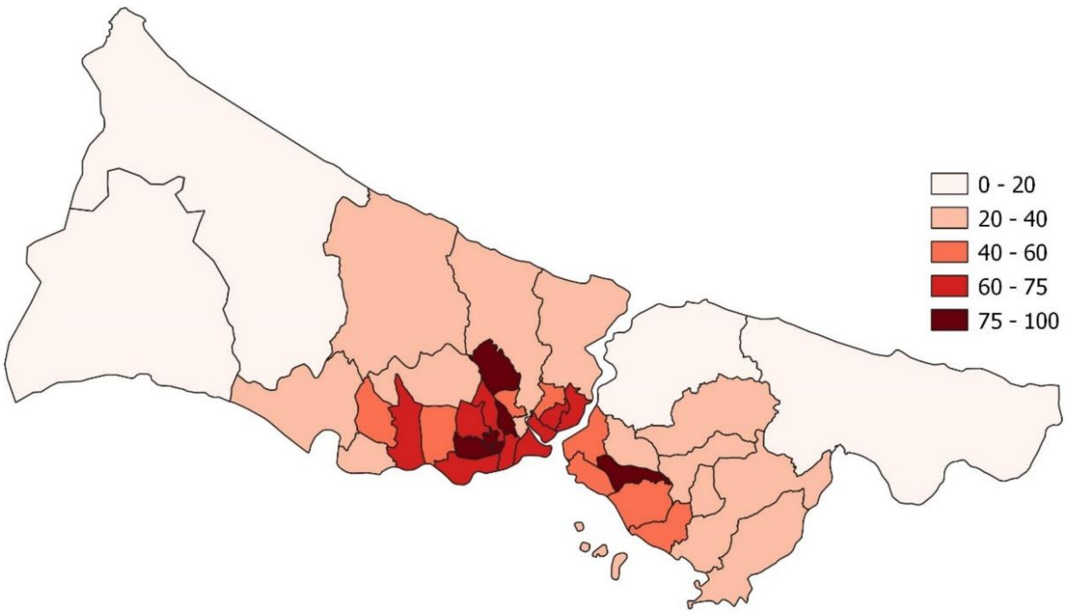


Figure 4.26. Percentages of mid-rise buildings in İstanbul at district level

Figure 4.27 depicts percentages of high-rise buildings in İstanbul at district-level with various rates. Başakşehir, Beylikdüzü and Kadıköy as the most popular districts in İstanbul dominate the high-rise building statistics. Another point should be mentioned is that there is not any district in the third class, up %6 to %9.

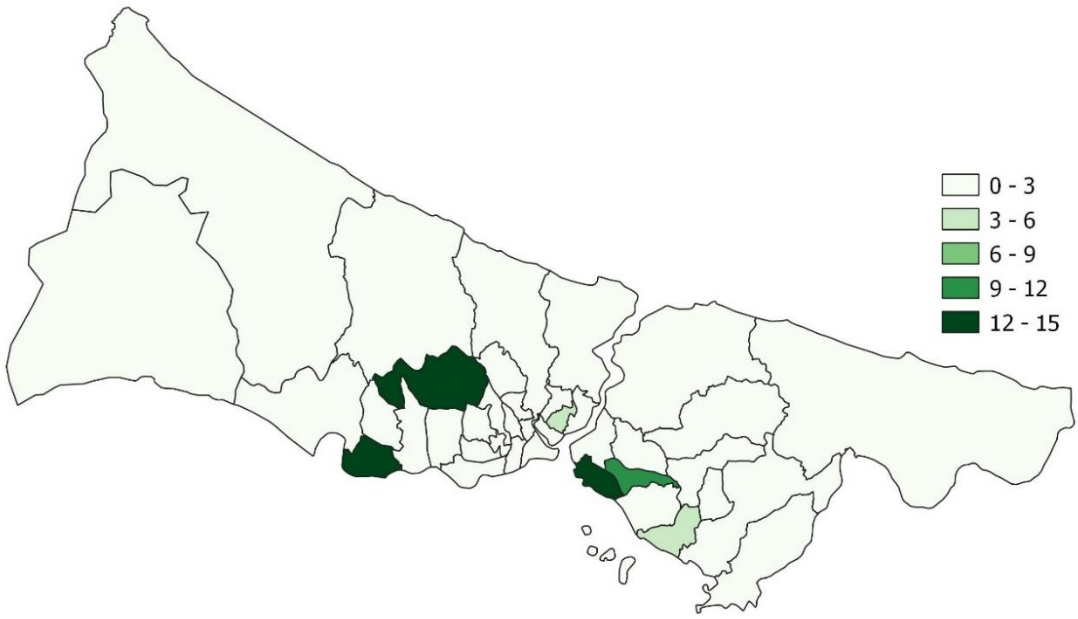


Figure 4.27. Percentages of high-rise buildings in İstanbul at district level

Figure 4.28 represents pattern of tall buildings in İstanbul with ratios, whose lejant differs from above cited figures. One can observe that percentages of all districts are bigger than zero at aforementioned height class figures, but there is not any tall buildings located in ten counties. On the other hand, in only one district, Ataşehir, 2.32% of buildings are tall as a reason of new constructions with more than or equal to 20 stories.

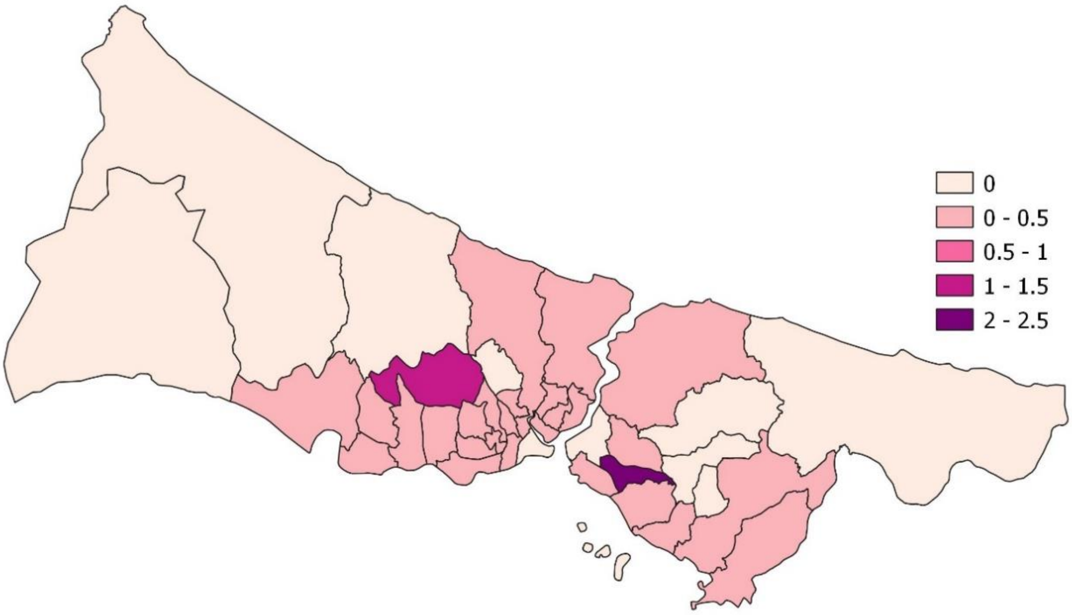


Figure 4.28. Percentages of tall buildings in İstanbul at district level

Figure 4.29 represents the variation of height classes with respect to structural system for İstanbul building stock. The ratios of low-rise and mid-rise masonry buildings are almost same. The reason of that can be the classification of wood frame buildings with three stories as mid-rise. They are a common building type in İstanbul like the wood frame buildings with one or two stories. Furthermore, mid-rise RC buildings are more than the low-rise RC buildings, as a difference from total TBS statistics. On the other hand, the percentages of mid-rise is more than low-rise buildings for composite and RC structural system. Especially, the difference between the mid-rise composite and low-rise composite is much more than the other. In another words, one can infer from the graph that composite mid-rise buildings are more common than composite low-rise buildings.

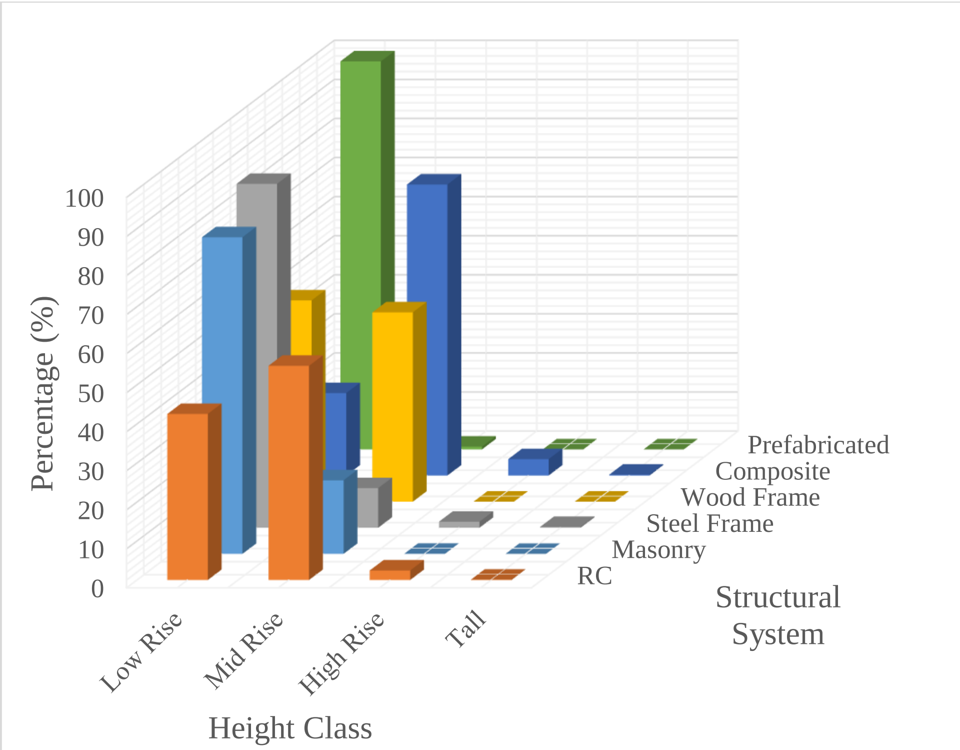


Figure 4.29. Percentage of low, mid, high and very-high-rise buildings with respect to structural system in İstanbul

When percentage of height classes of İstanbul building stock with respect to structural systems are separated according to function of buildings, some differentiations can be observed. The percentages of low-rise non-residential buildings with composite and RC structural system pass the mid-rises. The corresponding graphs has been given in Appendix B in Figure B.16.

4.4. Material of Infill Wall

This study also provides material of infill wall statistics by harmonizing data taken from TUIK and investigated according to study methods. These material of infill walls are categorized by TUIK as brick, hollow concrete block (HCB), wood, concrete block

(CB), calcium silicate brick (CSB), stone, adobe, light panel (LP), steel plate (SP) and other.

4.4.1. Material of Infill Wall in Turkey

Figure 4.30 depicts variation of material of infill wall for Turkish building stock annually. One can infer that brick has been the most used material for infill wall, whose percentage is around 65% in total TBS. There is no any data for infill wall material of buildings constructed in 2001, as mentioned in methodology chapter. After 2001, HCB material is the secondly preferred material for infill wall; however, the differentiation between the percentages of brick and HCB is very huge. This observation fortifies that brick is the common material for building construction in Turkey.

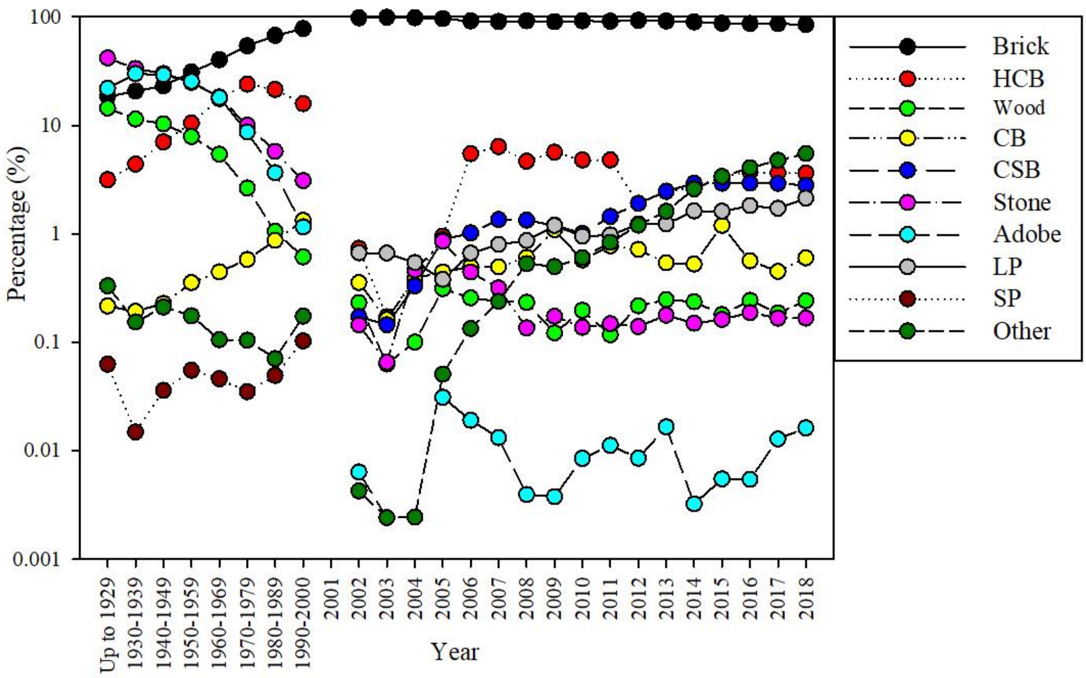


Figure 4.30. Annual variation of material of infill wall in Turkey

In this study, annual variation of infill wall material has also investigated with respect to function of buildings, given in Appendix B Figure B.17. Light panel become the second material for non-residential buildings nowadays, whose percentage is around 11%; though in cumulative the second infill wall material is HCB for both two type of function.

One point should not be forgotten that infill wall material is related to structural system type. Figure 4.31 represents most common building types in Turkey. The RC frame building with brick infill wall is demonstrated in Figure a; whereas RC frame building with HCB infill wall is in Figure b. In addition, Figure c presents the building constructed with wood for structural system and infill wall material.

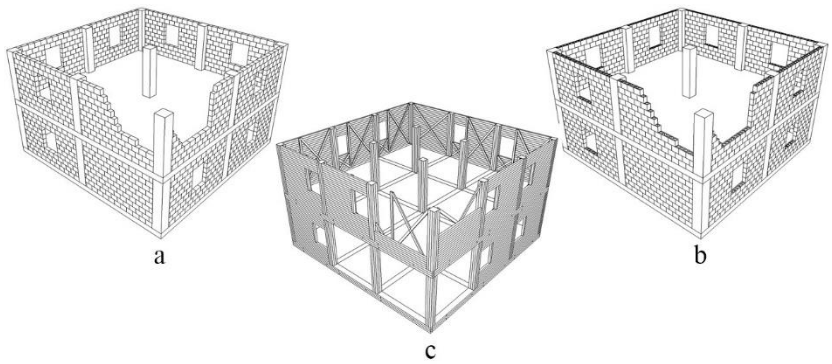


Figure 4.31. Sketches about common structural system and infill wall material in Turkey

The relationship between the infill material and structural system for Turkish building stock is depicted in Figure 4.32 with respect to the function of buildings. The percentage of each has been normalized with the total buildings with same structural system to calculate percentages of infill wall material because of the undulated number of building per each structural system. The results show that brick is the primarily material for infill wall for all structural systems except wood frame. The reason of that can be that brick, stone and HCB serve as load bearing materials, as structural system elements, in masonry buildings. Considering the structural system section, as most the familiar structural system, RC structure is examined in four system as RC Frame (RCF.), RC Dual (RCD), RC Shear wall (RCW) and RC Unknown (RCU). All of the RC structures has been constructed with brick for infill wall material; however, the second most frequent material vary from HCB, CB and CSB with respect to type of RC and building function. On the other hand, percentage of infill wall material differs more for composite according to function of building. Composite residential buildings panels have 70.55% for brick, 12.28% for HCB and 9.11% for LP; although, composite non-residential buildings become 47.99% for brick, 23.53% for HCB and 16.81% for LP respectively. As one can obviously infer from the figure, steel plate material is only favored for buildings with steel frame structural system. At that steel frame structures, the ratios of infill wall material type are 31.64% for brick, 29.50% for LP and 20.70 for SP in totality. In contrary, for residential and non-residential buildings, these ratios become 21.63% and 33.26% for brick, 48.27% and 26.47% for LP and 15.80% and 21.49% for steel plate.

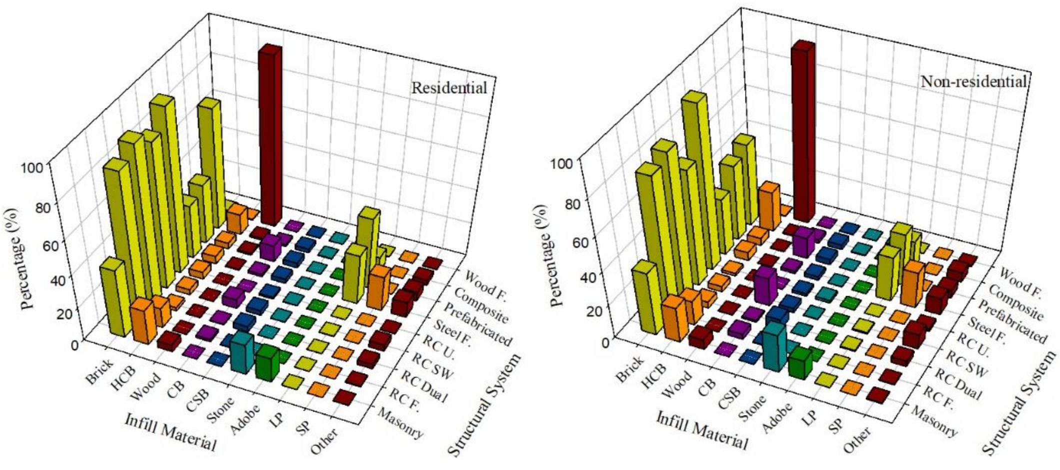


Figure 4.32. Percentage of material of infill walls at residential and non-residential buildings with respect to structural system

Apart from the structural system, material of infill wall is analyzed with height classes with respect to building function in this study. The trends are almost identical. In other words, the results do not change with the height classes. The related graph can be seen in Appendix B Figure B.18.

4.4.2. Material of Infill Wall at Province Level

The variation about the percentage of infill wall material according to Turkish areas are mentioned previously. In order to observe this contrast, materials varied from area to area are visualized on Turkey map at province level. The percentages are defined by the total number of building in each city one by one due to the non-equal number of building in each city. As one can infer from Figures 4.33 and 4.34 most costal town in Aegean, Marmara and Black Sea areas use brick; however, buildings in Van and Gaziantep are constructed with HCB with respectively 78.45% and 78.43%. Considering the ratio of brick (65%) and HCB (15.81%) in total Turkish building stock, these percentages are distinctive.

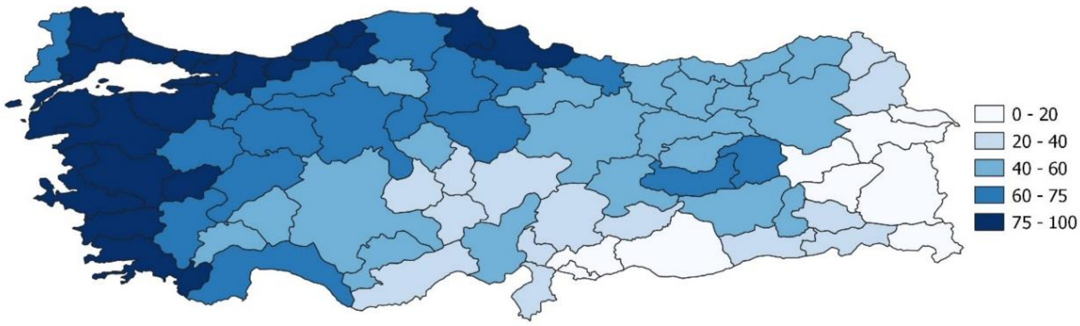


Figure 4.33. Percentage of brick for infill walls in Turkey at province level

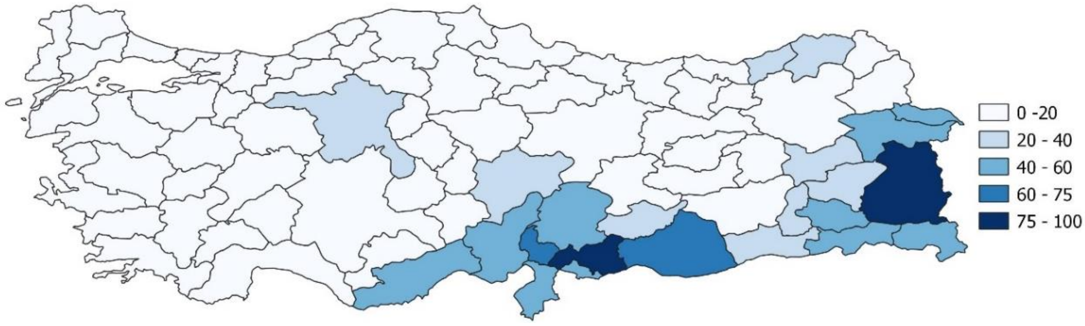


Figure 4.34. Percentage of hollow concrete block (HCB) for infill walls in Turkey at province level

When wood, which has 2.33% in total TBS, is investigated for infill wall in each city, one can deduce that use of wood is very rare. In around 75% of the cities, there is less or equal to 4% building preferred with wood. Besides that, there is only one city, Bolu, where 17.36% building use wood as infill wall material. The related graph has been given in Figure 4.35.

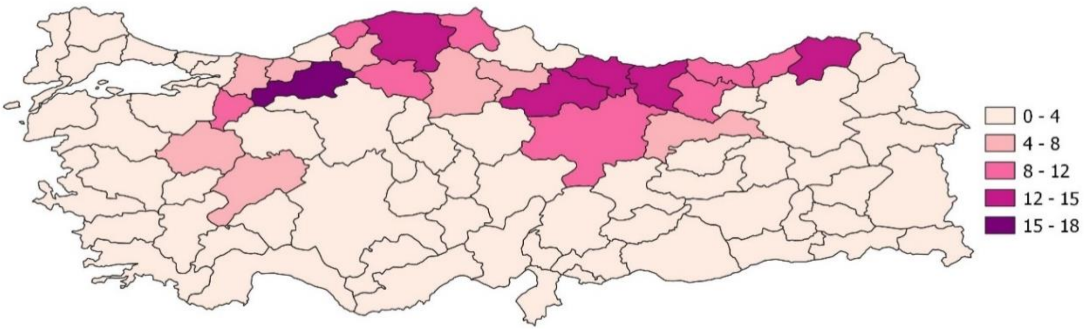


Figure 4.35. Percentage of wood for infill walls in Turkey at province level

CSB, 0.31% of total TBS, is also investigated at province-level in Figure 4.36. Although the contrasts according to Turkish areas appear much varied, the percentages for all cities are identified between 0 to 3% whose differentiation is very little. Furthermore, as seen in figure 4.35, Bolu has highest proportion for CSB as 2.99%.

Figure 4.36. Percentage of calcium silicate brick (CSB) for infill walls in Turkey at province level

In total TBS 8.36% of the building infill wall is stone. Figure 4.37 shows percentage of stone at province level in Turkey. One point should be noted there that stone can serve as load bearing material in masonry and wood frame buildings. Ardahan that is a mountain region has the highest ratio as 62.73%. The reason of that may be the common structural system type in Ardahan, which is masonry.

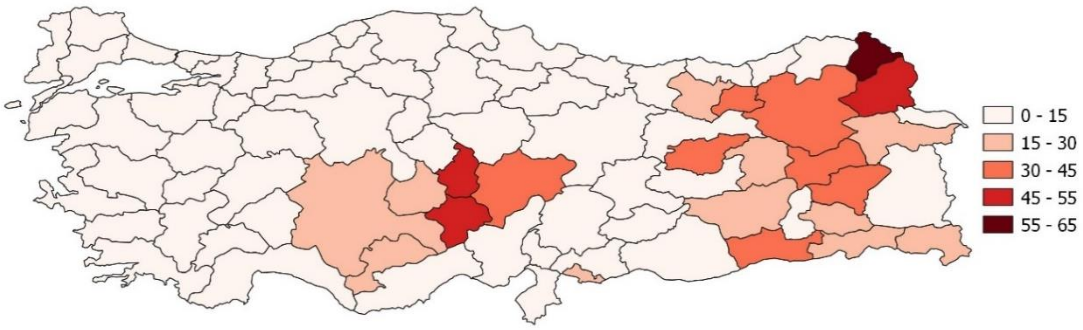


Figure 4.37. Percentage of stone for infill walls in Turkey at province level

Adobe, mainly material of structural system, is conventional material for infill wall in Turkey, whose ratio is 6.71% in total stock. Figure 4.38 depicts percentages of adobe for infill wall material at province-level in Turkey. When examining adobe in city scale, 30 cities have buildings with adobe for infill wall over that ratio. The highest ratio is belong to Malatya with 35.03% where the proportion of masonry building is 69.75%. This observation fortifies that traditional infill wall material is still used in Turkey.

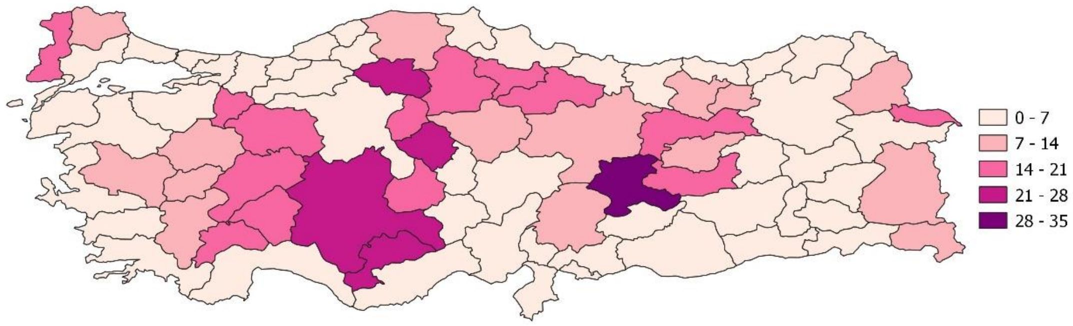


Figure 4.38. Percentage of adobe for infill walls in Turkey at province level

4.4.3. Material of Infill Wall in İstanbul

This section is about material of infill wall in İstanbul. Figure 4.39 represents annual variation of infill wall material percentages in İstanbul. Nowadays brick is the primarily used infill wall material with 96.22%. The second most preferred material is CSB with 2.28%. The percentage of others vary from 0.60% to 0% . This observation fortifies the recent trend for the infill wall material.

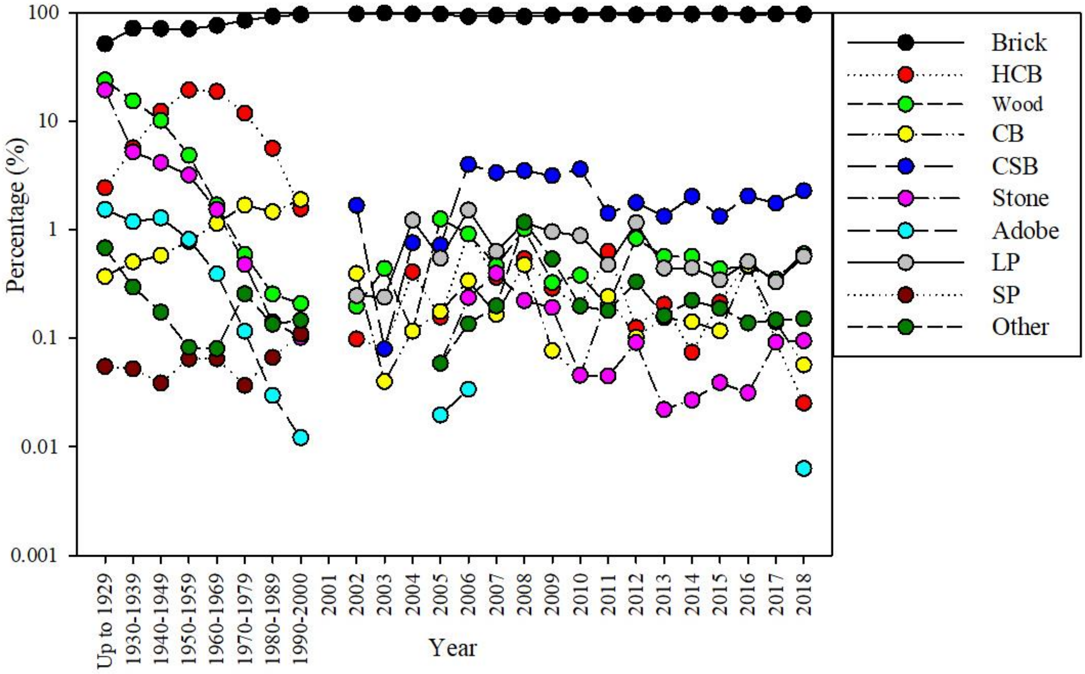


Figure 4.39. Annual variation of material of infill wall percentage in İstanbul

If the alteration of infill wall material with annual percentages for residential and non-residential buildings is investigated, the highest percentage is still belong to brick for both building using types, which is in total 90.74% for residential and 84.28% for non-residential buildings. For residential buildings, HCB is the secondly favored material with having 5.90% in totality. The third one is wood with 1.24% for total İstanbul building stock. On the other part, for non-residential buildings the second most widespread infill wall material is HCB (3.97%), too. Unlike to residential buildings, the third most used material is CB for non-residential buildings. On the other hand, nowadays after brick material, CSB is the most current preferred material with 2.05% for residential; however the second one becomes LP with 6.79% for non-residential purposed buildings. For further information about the annual variation of infill wall material percentages in İstanbul, Figure B.20 is available in Appendix B.

Figure 4.40 shows material of infill walls with respect to structural systems for residential and non-residential buildings in İstanbul. Except from three types of structural system, mentioned later, brick is the primarily material within over 50%. This exception exists for wood frame, prefabricated and steel frame structural systems. Similar to Turkish total statistics, wood infill wall is most preferred one for wood frame structures in both two types of building function. Prefabricated building are mostly with light panel; in addition, steel plate is most familiar for steel frame building for residential and non-residential purposed usage. In residential buildings, HCB bar is the second highest for masonry buildings with 27%; however, in non-residential buildings this ratio becomes the third with 12.73% because stone has 18.23%. The reason can be that stone infill wall material, as mentioned before, serves as load bearing element. On the other hand, as seen in figure, other differences between the graphs are usually about the percentages of CB, CSB and other materials but these variations are so little.

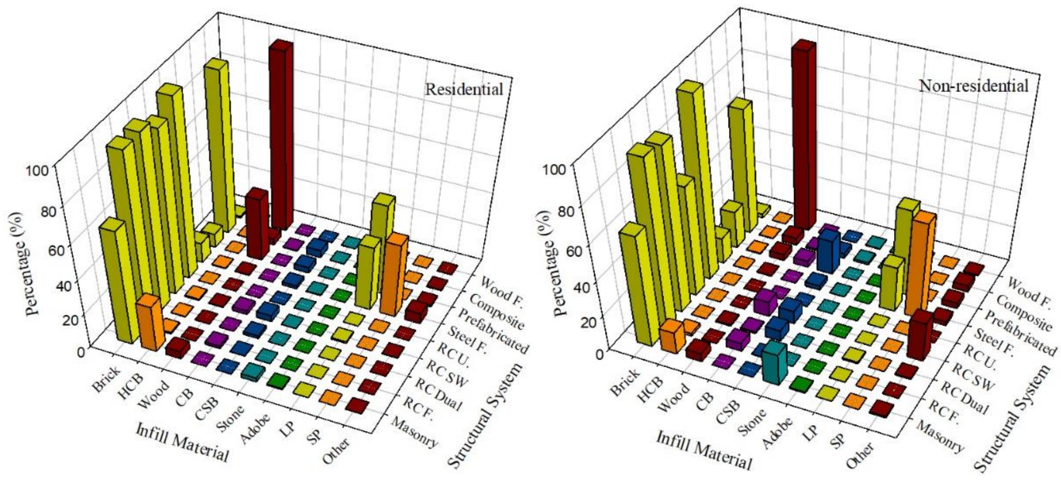


Figure 4.40. Percentage of material of infill walls at residential and non-residential buildings with respect to structural system in İstanbul

If the material of infill wall is examined according to height classes, Figure 4.41 is obtained. From the graphs, one can observe that brick is used primarily as expected, but its ratios are less in non-residential buildings. That means, in residential building, brick has 85.09% for low-rise, 96.33% for mid-rise, 92.77% for high-rise and 82.82% for tall buildings; however it becomes 79.45% for low-rise, 91.88% for mid-rise, 88.34% for high-rise and 65.70% for tall non-residential buildings. Other percentages over 10% in residential buildings are HCB with 11.17% for low-rise and CSB with 11.89% for tall buildings. The others are less than or equal to 3%. In non-residential building, CSB material is used as 21.51% for tall buildings. Other most preferred materials, whose percentages are more than 3%, are HCB with 6.04% and stone with 5.29% for low-rise, CB with 7.09% for high-rise and with 6.98 for tall buildings.

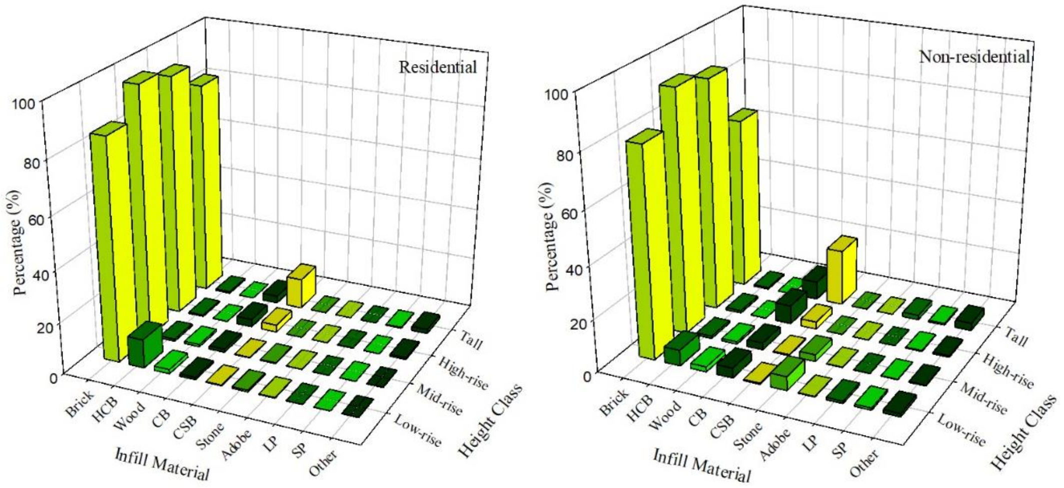


Figure 4.41. Percentage of material of infill walls at residential and non-residential buildings with respect to height classes in İstanbul

4.5. Number of Dwelling Unit

Number of dwelling unit is another parameter scrutinized in this study. In this study, as one already know, buildings are researched in two function of building: residential and non-residential. At the same time, the numbers of autonomous unit, flat, in the buildings is also taken from TUIK.

4.5.1. Number of Dwelling Unit in Turkey

Figure 4.42 depicts annual cumulative variation of the ratio of number of dwelling unit to number of residential building. The ratio of each year has been defined with total dwelling unit to total residential building. Up to 1929, this ratio has been only 1.39 unit/building that means most of the residential building has one unit; however, the trend has gone up. Then today this ratio becomes 3.05 unit/building. That shows the effect of urbanization and/or use of multi-dwelling buildings, which are mostly two or more stories high.

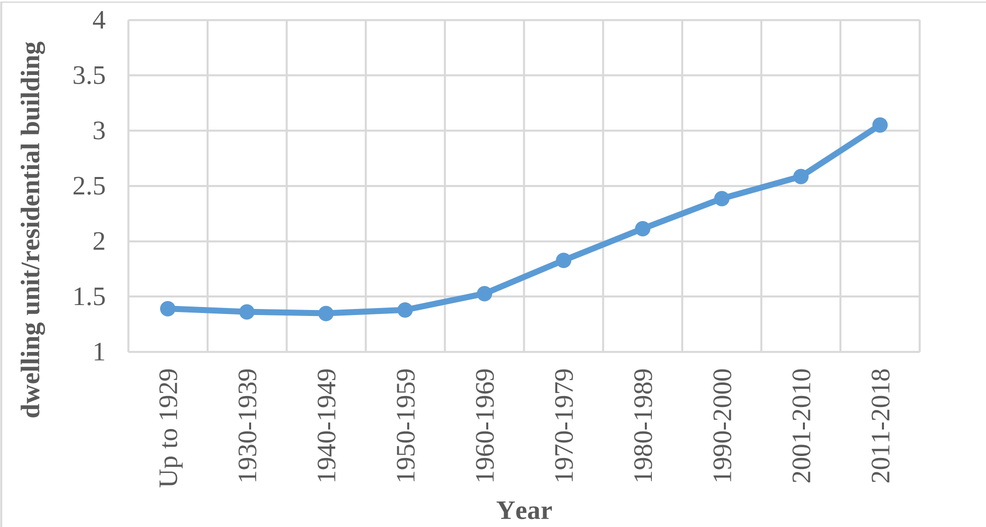


Figure 4.42. Annual variation of the ratio of total dwelling unit to total residential building

Figure 4.43 demonstrates dwelling unit per number of residential building, 3.05 for total building stock in Turkey, with respect to city administration. The mean value becomes 2.7 for Turkey. Furthermore, as expected before, the ratio is higher in big city than other, but the differentiation is just 0.3.

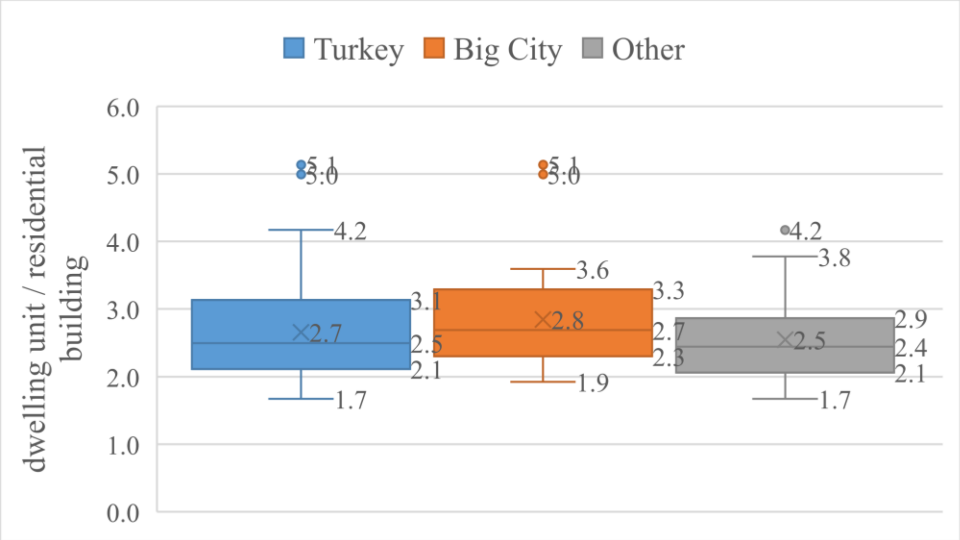


Figure 4.43. Ratio of dwelling unit per number of residential building with respect to city administrative

Table 4.3 shows percentage of dwelling unit to total number of residential building. Buildings in Turkey have 2.7 dwelling units in average; however, as one can infer from table, that ratios are higher in Marmara and Central Anatolia respectively, where İstanbul and Ankara, most crowded cities in Turkey, are located.

Table 4.4. *Variation of percentage of number of dwelling unit and ratio of total number of dwelling unit to total number of residential building in Turkish Areas*

Area	Total Number of Dwelling Unit / Total Number of Residential Building
Aegean	2.45
Black Sea	2.94
Central Anatolia	3.29
Eastern Anatolia	2.34
Marmara	3.98
Mediterranean	2.60
Southeastern Anatolia	2.42
Turkey	2.70

The significant ratios of number of dwelling unit per residential building in İstanbul and Ankara can be seen in Figure 4.44, which shows that proportion at province-level. Except from these cities, Yalova with 4.17 unit/building, Bartın with 3.76 unit/building, Sinop with 3.73 unit/building, Samsun with 3.6 unit/building and Karabük with 3.56 unit/building become in the third lejant.

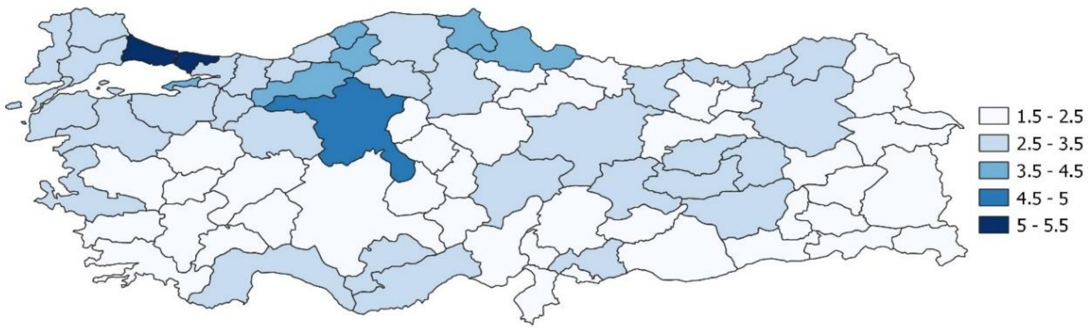


Figure 4.44. Ratio of dwelling unit per number of residential building with respect to city administrative

4.5.2. Number of Dwelling Unit in İstanbul

In this section, dwelling unit in İstanbul is observed privately. Figure 4.45 depicts annual alteration of the ratio of total dwelling unit to total residential building. Up to 1929, this ratio has been only 2.34 unit/building; however, the trend has gone up sharply during 1950 to 2000. After that time, the trend slightly increases except 2009, in which the rate picked up to 5.73. As a result, today this ratio become 5.15; though total Turkish building stock ratio, as mentioned before, is only 3.05 unit/building. That points crowdedness of İstanbul.

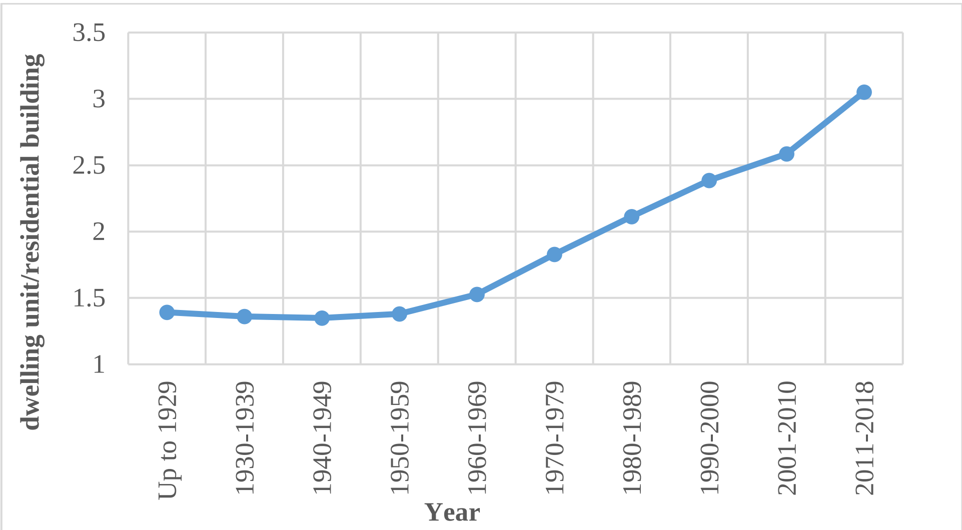


Figure 4.45. Annual variation of the ratio of total dwelling unit to total residential building

Figure 4.46 represents the variation of dwelling unit per number of residential building at province-level in İstanbul. This figure fortifies that residential buildings crowded with units are located around the city center. That dominates the significance of city center for dwelling unit.

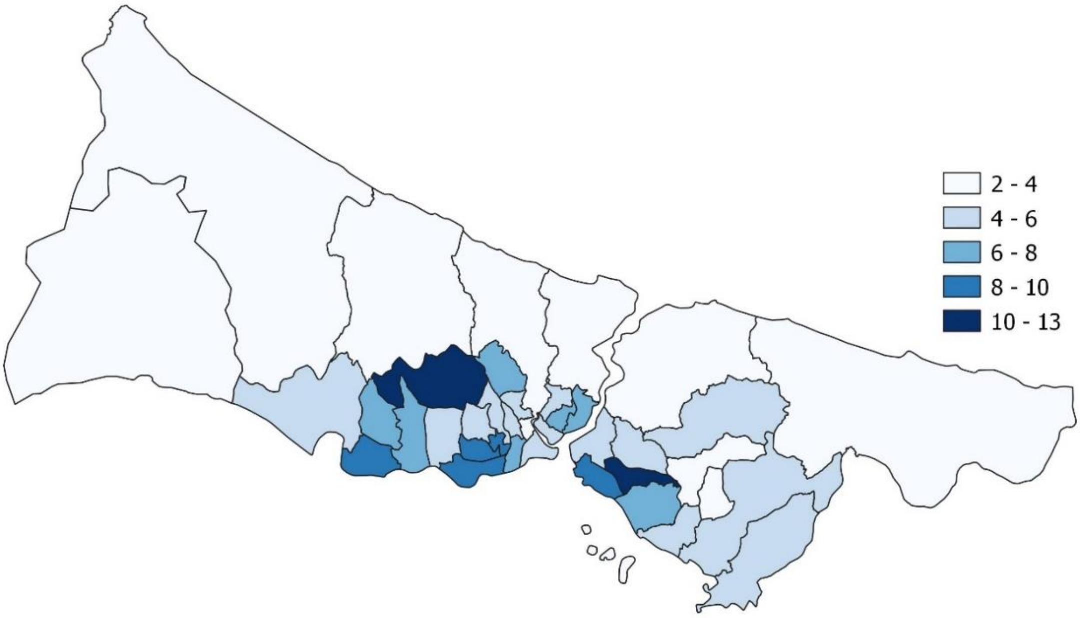


Figure 4.46. Variation of dwelling unit per number of residential building at district level in İstanbul

4.6. Total Floor Area

Total floor area is the last parameter investigated in this study.

4.6.1. Total Floor Area in Turkey

Figure 4.47 represents annual variation of total floor area (m^2) per total building for both two types of building function. Total floor area has been normalized for each year with total building number for each building functions. Although, the difference between the ratios for residential and non-residential buildings has become higher; the relationship between them, the ratio for non-residential is nearly double of the rate for residential buildings has been almost same.

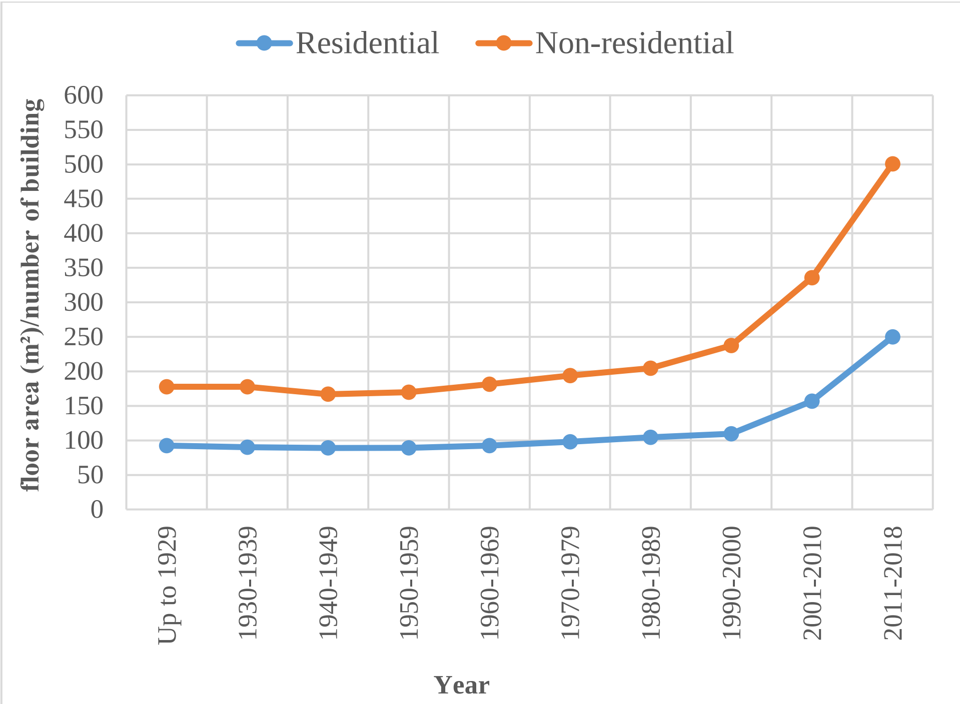


Figure 4.47. Annual variation of total floor area (m²) per number of building with respect to function of building

In Turkey total ratios are 249.11 m² for residential and 496.54 m² for non-residential buildings; however, those values for big city and other are seen in Figure 4.48. As one can infer, mean value of big cities is higher and this value of other cities is less than the mean value of Turkey. Moreover, the difference is higher in non-residential used buildings.

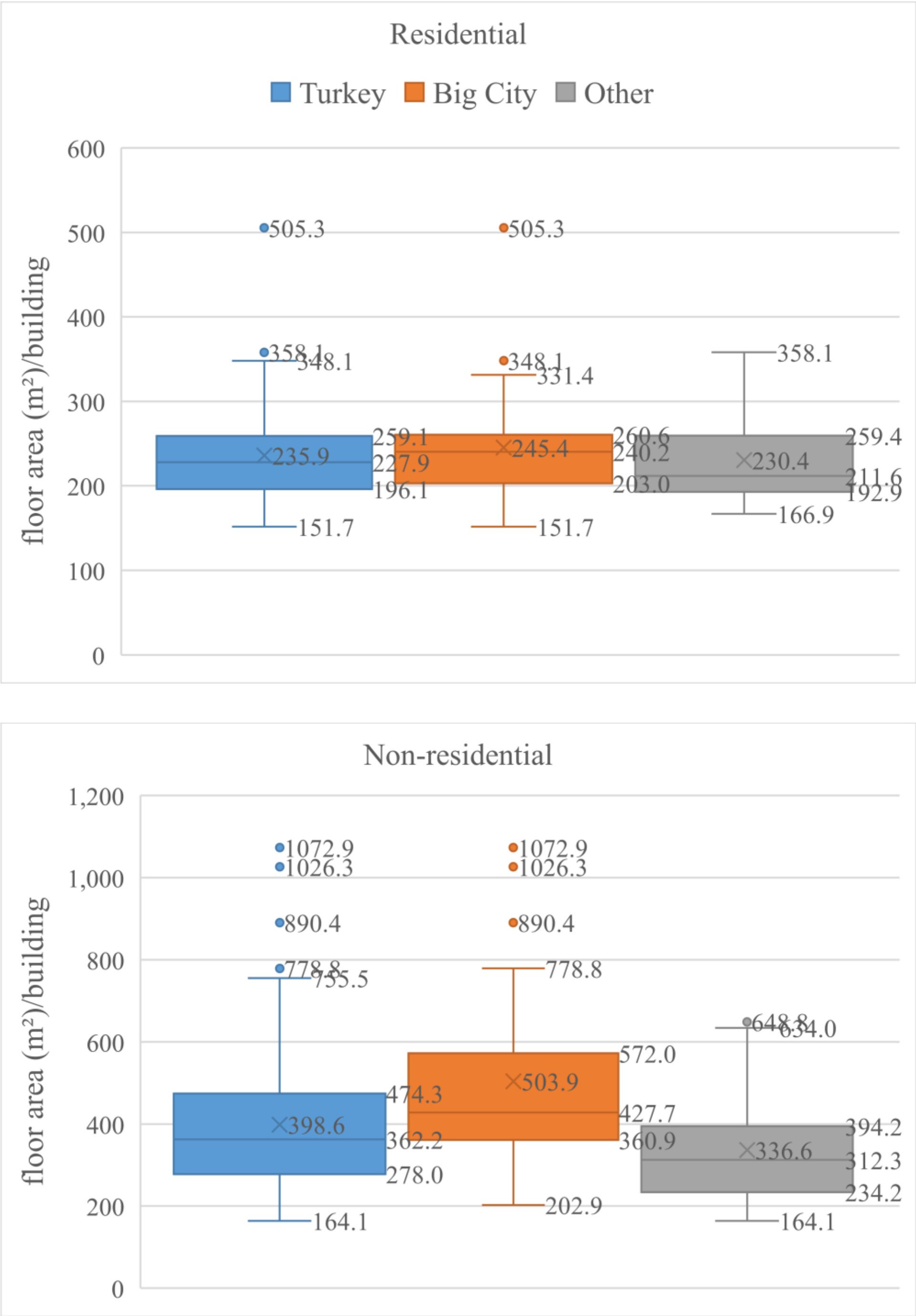
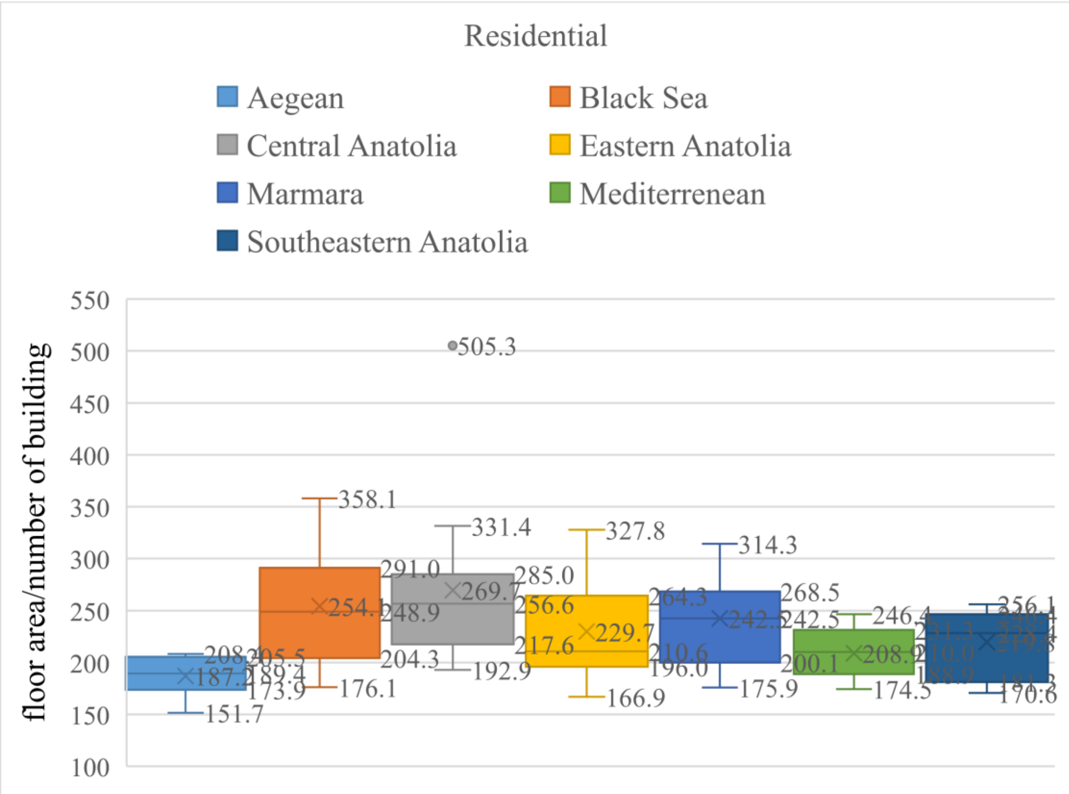


Figure 4.48. Ratio of total floor area (m²) to number of building with respect to city administrative for residential and non-residential buildings

Table 4.5 and Figure 4.49 represent ratio of total floor area (m²) to number of building for residential and non-residential buildings. Table is drawn according to total stock of each area; although, figure is provided according to total stock of each city located in that area. The difference between the table and graphs is more than 20m² in Central Anatolia and Marmara for both building function, and in Mediterranean and Southeastern areas for only non-residential building. Moreover, one can also release that average square meter of dwelling unit area in Central Anatolia is the highest dwelling units in Turkey. In addition, the widest non-residential autonomous unit locates in Marmara area. That shows the requirement of wide place for each area.

Table 4.5. *Various ratios of total floor area (m²) to total number of building for residential and non-residential purposed buildings in Turkish Areas*

Area	Residential	Non-residential
Aegean	188.9 m²	431.1 m²
Black Sea	247.2 m²	330.9 m²
Central Anatolia	332.5 m²	472.7 m²
Eastern Anatolia	234.4 m²	278.1 m²
Marmara	265.3 m²	796.9 m²
Mediterranean	216.7 m²	467.2 m²
Southeastern Anatolia	230.3 m²	432.5 m²



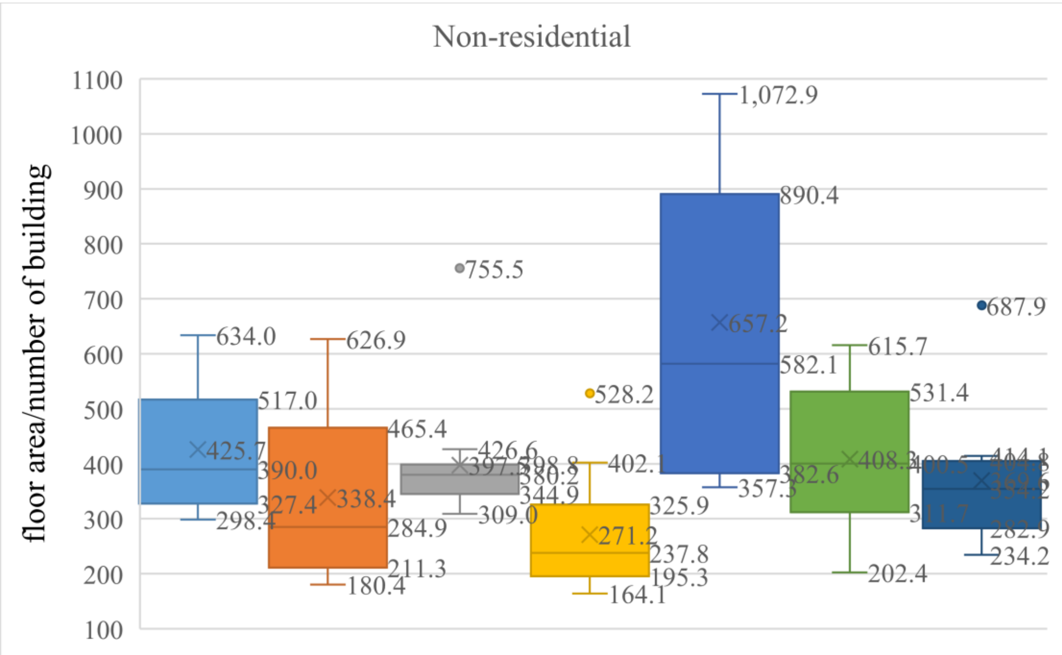


Figure 4.49. Ratio of total floor area (m²) to number of building with respect to city administrative for residential and non-residential buildings in Turkish areas

At province level, the ratio of total floor area (m²) to number of building for residential and non-residential building is seen in Figure 4.50. In residential used building, Ankara has the ratio with 505.33 m², which is the biggest square meter. That causes the widest floor area belonging to Central Anatolia. The second one is in Düzce with 358.13 m². On the other hand, the most enlarged non-residential unit is located in Kocaeli with 1072.86 m². İstanbul has 1026.31 m² as the second city. These cities supply the Marmara area having the widest non-residential unit.

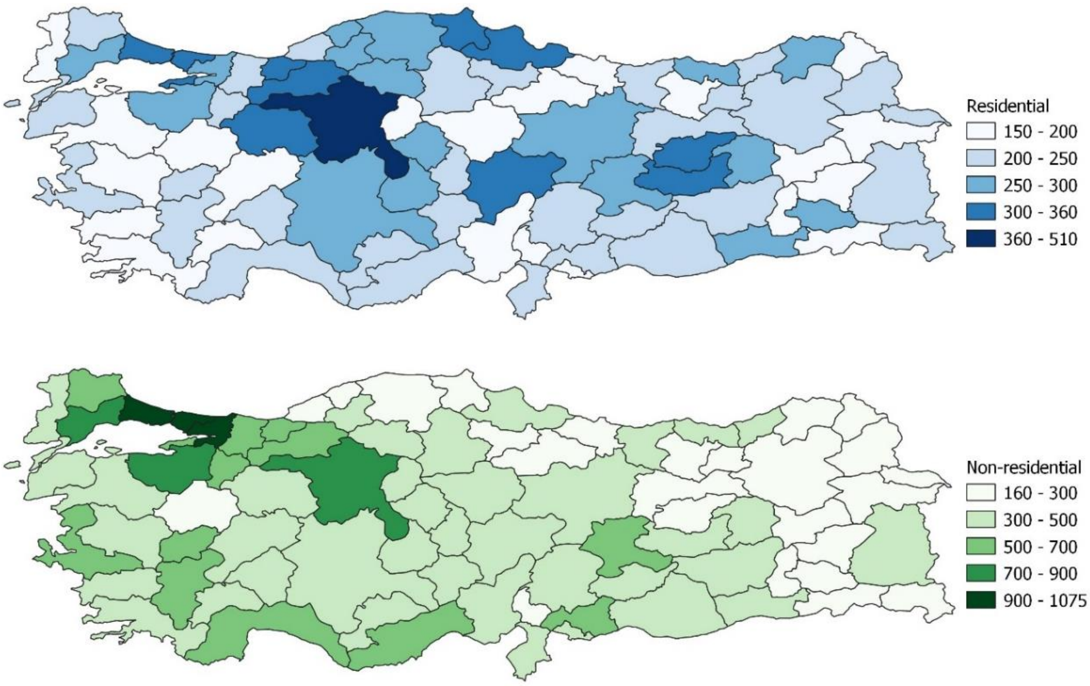


Figure 4.50. Ratio of total floor area (m²) to number of building at province level for residential and non-residential buildings in Turkey

4.6.2. Total Floor Area in İstanbul

In İstanbul, total floor areas for residential and non-residential buildings have highest values in comparison with other cities. Figure 4.51 presents annual variation of total floor area per number of building for both two types of building function. For buildings constructed before 1929, total floor areas of non-residential and residential buildings are 277.77m² and 79.66m² in average, respectively. For the last 90 years, these values have been risen to 1040.50 m² for non-residential buildings and 303.11 m² for residential buildings in average.

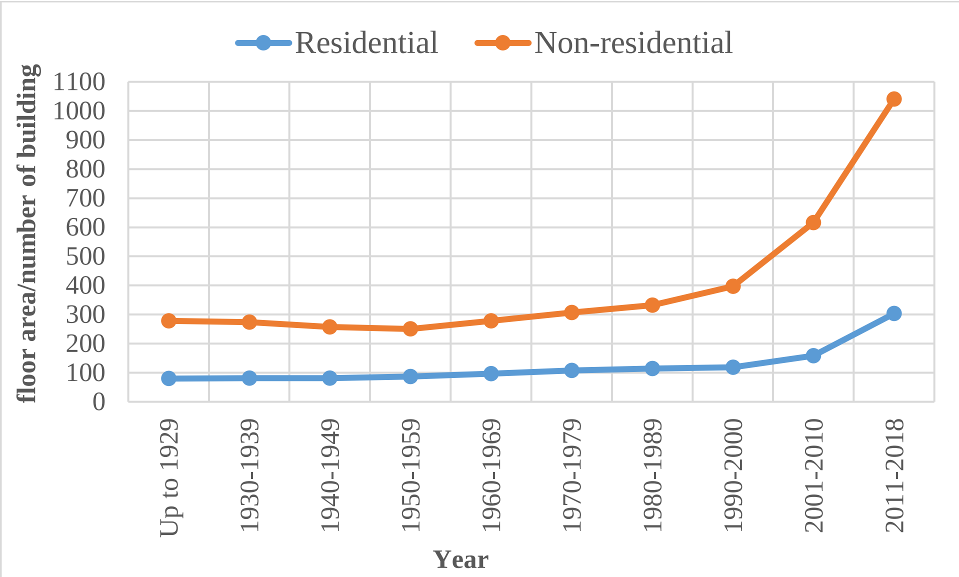


Figure 4.51. Annual variation of total floor area (m²) per number of building with respect to function of building in İstanbul

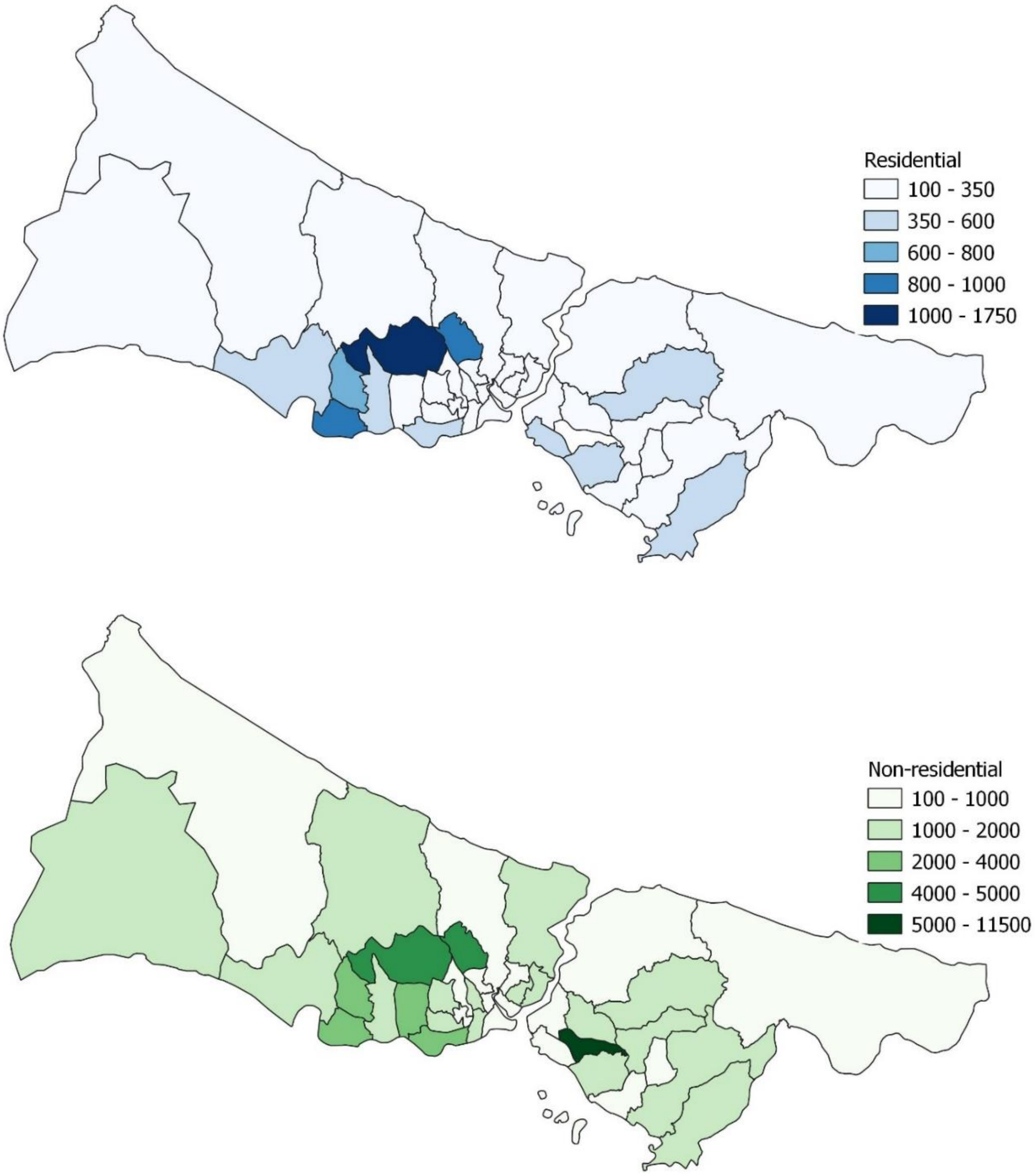


Figure 4.52. Ratio of total floor area (m²) to number of building at district level for residential and non-residential buildings in İstanbul

Ratio of total floor area (m²) to number of building for residential and non-residential purposed buildings in İstanbul is viewed at district level in Figure 4.52. As one can firstly observe that total area per building is larger for non-residential than residential buildings. Surprisingly, Ataşehir, having highest proportion of dwelling unit per number of residential building as noted before, has also largest rate of floor area to number of building for both two uses of building with 1730.02 m^2 at above and 11338.15 m^2 at below map. In addition, the second for rate of dwelling unit to number of residential building, Başakşehir takes again the second floor with 1949.96 m^2 for residential and 4339.56 m^2 for non-residential buildings. Next, the third districts is Sultangazi with 897.50 m^2 on the first and with 4270.61 m^2 on the second map. Another point that should be noted that, there is not any average floor area with 3000 m^2 to 4000 m^2 for non-residential purposed usage. As a result, mean floor area value is big around the city center. This observation fortifies the observed huge ratio of dwelling unit to number of residential building statistics.

CHAPTER 5

SUMMARY AND CONCLUSIONS

This study is a statistical study for harmonization of up-to-date TBS. For consistent and harmonized TBS portfolio database, the material and methodology of this study is summarized in the first section. Then, the conclusions of the analysis are explained in the second section. The limitations of the study and the propositions for further studies presented in this chapter respectively at the end.

5.1. Summary of the Study

The aim of this study is to provide up-to-date harmonized building database for Turkish building stock. This study uses 2000 Building Census and The Building Permit Statistics taken from Turkish Statistical Institute (TUIK) as primary source of information about Turkish building stock. Building Permit Statistics can be also reachable on TUIK website (https://biruni.tuik.gov.tr/yapiizin/giris.zul). The significance of this study is its widespread building stock database. That combines 2000 BUC and BOP database for providing harmonized and consistent Turkish building stock portfolio.

To perform this study, building attributes in these sources have been examined several times to harmonize the taken building database. These attributes are the location, the year of completion, the function of building, the structural system, the number of story, the material of infill wall, the number of dwelling unit and total floor area. The location of building is investigated at region-, province- and only for İstanbul district-level. The year of completion includes:

- the buildings constructed before 1930 as up to 1929,

- the buildings constructed between 1930 and 2000 that are classified as 1930-1939, 1940-1949, 1950-1959, 1960-1969, 1970-1979, 1980-1989 and 1990-2000
- buildings constructed between 2001 and 2018 that are mentioned individually.

The classes of the year are obtained by the database taken from TUIK. As the other attribute, the function of building is categorized as the occupancy type, residential and non-residential. If at least half of the building is used for residential purposes, that is classified as residential building.

In previous studies, most of the study is about only masonry (Demirel et al., 2013) and/or RC (Bal et al., 2007); however this study examines structural system of the building stock with 9 categories that are masonry, RCD, RCF, RCW, RCU, steel frame, composite, prefabricated and wood frame. For the harmonization of structural system information taken from 2000 BUC and BOP database, a questionnaire, whose respondents were selected with respect to their research areas, has been arranged for consistent structural system classification. As other differentiation from the previous studies, this study investigates number of stories one by one up to 15 because the ratio of building with 15 and more stories are very few in totality. Moreover, the number of stories are classified with respect to height classes, which are low-, mid-, high-rise and tall. The classes are decided by critical review of literature and speech between the author and the advisor. As a result, the attributes and classifications have been researched in this study in order to develop a clear, consistent, harmonized up-to-date database of Turkish building stock.

In order to achieve the goal of this study, building characteristics that are the location, the year of completion, the function of building, the structural system, the number of story, the material of infill wall, the number of dwelling unit and total floor area have been investigated with harmonized categorizes . Their statistics and correlation, which are believed to provide extensive information on characteristics of Turkish building portfolio, have been demonstrated with figures, tables and maps, drawn by QGIS, in detail.

5.2. Conclusion of the Study

In this study, information about 9,394,841 buildings in total have been gathered together. Based on the analysis and statistics related to the research parameters, following conclusions can be drawn with respect to the research parameters:

- The first parameter is function of building, which is categorized as residential and non-residential. The percentage of residential building is 85.97%, whereas non-residential is only 14.03%. The residential building ratios have been investigated according to city administration, big city and other, as well as according to regions of Turkey. The results with respect to city administration are similar to the statistics of whole Turkey, whereas variations are observed at area-scale researches. Moreover, the results demonstrate that non-residential buildings percentage is inversely proportional to number of population.
- Secondly, structural system statistics of Turkish building stock show that the most common system is RC structural system. This study divides RC buildings into four groups as RC frame, RC dual, RC shear wall and RC unknown. The second common structural system is masonry. If the structural system of Turkish buildings is examined with respect to function of building, RC residential buildings in big cities take highest percentage in comparison with the total stock of Turkey and stock of other cities. Furthermore, masonry buildings in metropolitans get smaller ratios. Region based analyses show that Central Anatolia and South Anatolia have smaller residential RC building ratios, but higher ratios of residential masonry buildings is observed in these regions. When this parameter is investigated at province-scale, one can infer that cities near coastlines have more residential RC buildings; whereas masonry buildings for residential usage get more percentage in inner zones of Turkey.

- Thirdly, the results of the statistics about number of stories reveal that low-rise buildings are still the prevalent structure type. That situation cannot be altered with respect to function of building and structural system. Moreover, each structural system in TBS has highest percentage at low-rise building type. Considering Turkish areas one by one, in Marmara and Southeastern Anatolia Areas, low-rise composite buildings has smaller ratio than mid-rise ones. On the other hand, by the help of province-level statistics, one can observe that cities in edge of southeastern and eastern area have preferred low-rise buildingSs, but İstanbul has the highest percentage for mid-rise and tall buildings.
- Another significant parameter is material of infill walls. The statistics highlight the dominance of brick material for all types of structural systems including masonry. The only exception is wood frame where the most preferred infill wall material is wood. The reason can be that the wood infill walls are used as structural element in wood frame buildings. On the other hand, brick is observed as the primarily infill wall material on all height classes including tall buildings where CSB is used as the second most common infill wall material.
- Number of dwelling unit is another parameter investigated in this study. This parameter is important particular for social risks studies. The ratio of dwelling unit to number of residential building has an increasing trend. The statistics for whole Turkey are fairly similar with statistics for city administration, big city and other. Nevertheless, with respect to region-level or province-level researches, some notable differentiations occur on average number of dwelling per building.
- Total floor area is the last parameter investigated in this study. Unsurprisingly, the rate of total floor area to total number of building for non-residential buildings is much higher than for residential buildings. In residential used building, Ankara gets the biggest ratio with 505.33 m².

Being the most crowded city in Turkey, nearly 1/5 population of Turkey, the building stock in İstanbul is investigated privately in totality and at district-level. The aim of that is to identify the characteristics of İstanbul building stock in detail because its building stock portfolio can affect most of the people in Turkey. If the building stock in İstanbul is similar with TBS, the researches applied in İstanbul can be used for whole country as well. The results of İstanbul are summarized as follows:

- In İstanbul, the building stock is 89.68% residential and 10.32% non-residential. In district-scale, Sultangazi with 97.6% residential buildings and Fatih with 29.85% non-residential buildings are categorized as the primarily districts with hugest percentage in the examination.
- One can infer from the structural system of buildings in İstanbul investigation that RC and masonry systems are the two most common structural systems in İstanbul, respectively similar to the whole Turkey.
- If the dwelling unit statistics of İstanbul is investigated, the ratio of dwelling unit to number of residential unit is higher than the rate of whole Turkey. The reason can be the increasing inhabitants' population in İstanbul.
- In terms of floor area, 1026.31m² is the average of non-residential buildings whereas the average total floor area is 303.11m² in residential buildings.

These results highlight that the most common feature of building stock in İstanbul are very similar to the most common feature of TBS; however, the percentages of them are different. The reason of that variation may be the crowded population of İstanbul. For instance, the residential building percentage of İstanbul is more than that ratio of TBS. In addition, the ratio of low-rise building in İstanbul is less than its ratio of TBS in totality. In fact, as mentioned before, the percentage of mid-rise building in İstanbul is higher than the percentage of that in Turkey. These results can be caused by the effects of being a crowded city. Therefore, the building stock in İstanbul cannot be similar to TBS.

As a conclusion of this study, these results and statistical data are critical for representing the TBS portfolio with respect to the available building characteristics. These results can be used a reference driving information on building stock not only for Turkey in totality but also with respect to Turkish regions or cities.

5.3. Limitations of the Study

The database materials in this study are 2000 Building Census and The Building Permit Statistics taken from TUIK. In 2007, the construction permit was become an obligation. It was transferred as hard copy by some Turkish municipalities and by electronic data flow by other municipalities. The hard copy and electronic permits are archived by TUIK. During the process of data in TUIK, some important structural system detail and district information is omitted. Since 2012, all Turkish municipalities has begun to use electronic data system. This thesis study uses processed data for the years 2001 to 2012 and raw data between the years 2013 and 2018 in order to overcome some potential inconsistencies resulted from the lack of electronic and online electronic data flow.

In this study, building permit statistics are from 2001 to 2018, because building stock database about 2019 has not been finished to publish by TUIK, yet. In addition, TUIK can update the data of last 3 years, if necessary. That means that database about the years from 2016 to 2018 might be subject to change by institute.

In Turkey, probably 15 million buildings are located according to common knowledge, TUIK database includes nearly 9 million. Therefore, TUIK database demonstrates approximately 2/3 of total TBS. The squatter houses in large cities and buildings without permits in sub-districts and villages are not included in TUIK database. These buildings are excluded from TUIK database (TUİK, 2011).

Burned and demolished building forms, which have been obliged since 2007 or corresponding data archived by Ministry of Interior cannot be obtained since regarding information not publicized yet. Thus, the number of buildings in provided database by this study is slightly larger than the actual because of the demolished buildings after urban renewal actions in Turkey since 2012.

5.4. Propositions for Further Studies

In this study, only İstanbul is researched at district-level. The future works can include building stock information of other earthquake prone cities at district-level. Moreover, the building stock features may be examined with any detailed location information.

Data of burned and demolished buildings can be included in the database obtained in this study to further increase the accuracy of building stock information.

As mentioned before, the category of RC combines RCD, RCF and RCW. In the previous studies, they are examined with in same class as RC (Bal et al., 2007) or only RCF system is researched (Akhundi et al., 2015). Because their seismic safety can be different from each, they may be investigated in detail separately in future studies.

This study represents the TBS attributes at region-, province- and (only for İstanbul) district-level; furthermore, their correlations are demonstrated in figures and tables. By the help of these figures and tables, one can infer from this study the ratios of attributes from each Turkish area and each city. This information can be used for earthquake loss estimation studies during the modelling of the researched area, such as with DBELA method, or calculating of vulnerability to determine physical and social risks. To conclude, this study harmonizes up-to-date TBS with potentially current and consistent categorization systems to determine useful database. That can be used for future earthquake loss and damage estimations and vulnerability studies.

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APPENDICES

A. Questionnaire

Türkiye Bina Stoku

Bu araştırma, ODTÜ Yapı Bilimleri Programı yüksek lisans öğrencisi Gizemnur Talas Soylu tarafından Mimarlık Bölümü öğretim üyelerinden Dr. Öğr. Üyesi Bekir Özer Ay'ın danışmanlığında yürütülen tez çalışmaları kapsamında yapılan bir anket çalışmasıdır. Bu form sizi araştırma koşulları hakkında bilgilendirmek için hazırlanmıştır.

Çalışmanın Amacı Nedir?

Araştırmanın amacı, Türkiye İstatistik Kurumu'ndan (TÜİK) elde edilen ve farklı sınıflandırma yaklaşımları ile oluşturulmuş Türkiye'deki bina tipi yapıların taşıyıcı sistemlerine ilişkin verileri katılımcıların bilgi ve mesleki deneyiminden yararlanılarak uyumlu hale getirmek ve kabul edilebilir ortak bir sınıflandırmanın yapılmasına yönelik bilgi toplamaktır.

Bize Nasıl Yardımcı Olmanızı İsteyeceğiz?

Araştırmaya katılmayı kabul ederseniz, sizden beklenen, ankette taşıyıcı sistem, dolgu malzemesi ve taşıyıcı sistem detayları verilen her bir bina grubu için araştırmayı yürüten Gizemnur Talas Soylu tarafından TÜİK'in güncel sınıflandırma sistemi ile uyumlu olacak şekilde hazırlanmış taşıyıcı sistem kategorileri içerisinden en uygun olanını seçmenizdir. Bu çalışmaya katılım ortalama olarak 10 dakika sürmektedir.

Sizden Topladığımız Bilgileri Nasıl Kullanacağız?

Araştırmaya katılımınız tamamen gönüllülük temelinde olmalıdır. Ankette, sizden kimlik veya kurum belirleyici hiçbir bilgi istenmemektedir. Cevaplarınız tamamıyla gizli tutulacak, sadece araştırmacılar tarafından değerlendirilecektir. Katılımcılardan elde edilecek bilgiler toplu halde değerlendirilecek ve bilimsel araştırma ve yayımlarda kullanılacaktır. Sağladığınız veriler gönüllü katılım formlarında toplanan kimlik bilgileri ile eşleştirilmeyecektir.

Katılımınızla ilgili bilmeniz gerekenler:

Anket, genel olarak kişisel rahatsızlık verecek sorular içermemektedir. Ancak, katılım sırasında sorulardan ya da herhangi başka bir nedenden ötürü kendinizi rahatsız hissederseniz cevaplama işini yarıda bırakıp çıkmakta serbestsiniz. Böyle bir durumda anketi uygulayan kişiye, anketi tamamlamadığınızı söylemek yeterli olacaktır.

Araştırmayla ilgili daha fazla bilgi almak isterseniz:

Anket sonunda, bu çalışmayla ilgili sorularınız cevaplanacaktır. Bu çalışmaya katıldığınız için şimdiden teşekkür ederiz. Çalışma hakkında daha fazla bilgi almak için Yapı Bilimleri Programı yüksek lisans öğrencisi Gizemnur Talas Soylu (E-posta: e164877@metu.edu.tr) ya da tez danışmanı Mimarlık Bölümü öğretim üyelerinden Dr. Öğr. Üyesi Bekir Özer Ay (E-posta: ozer@metu.edu.tr) ile iletişim kurabilirsiniz.

Anketi Doldururken:

Ankette, Türkiye İstatistik Kurumu (TÜİK) verilerine göre oluşturulmuş ve “Taşıyıcı Sistem”, “Dolgu Malzemesi” ve “Taşıyıcı Sistem Detayı” belirtilen her bir bina grubu için seçenekler arasında verilen taşıyıcı sistem sınıfları arasından en uygun olanını işaretleyiniz. Taşıyıcı sistem seçenekleri, TÜİK’in, Avrupa Birliği uyum çalışmaları çerçevesinde inşaat tipleri sınıflamasına göre oluşturduğu [1] güncel taşıyıcı sistem kategorileri dikkate alınarak hazırlanmıştır.

Aşağıda TÜİK'in taşıyıcı sistem ve duvar malzemesi sınıflarına ilişkin açıklamaları bulunmaktadır:

Taşıyıcı sistem:

Yığma veya Yığma (Kagir): Bina ağırlığını duvarlar yoluyla temele yükleten inşaat tarzıdır.

İskelet veya İskelet (Karkas): Bina kütlesini taşıyacak ve temele iletecek nitelikte çelik, betonarme ve ahşap bir iskelet meydana getirilerek duvar malzemesinin bu iskelet arasına yerleştirilmesi yoluyla yapılan inşaat tarzıdır.

i. Çelik

ii. Ahşap

iii. Betonarme

iv. Yerinde dökme

v. Diğer

Tünel kalıp sistemi: Yapılarda betonarme taşıyıcı duvarlarının (perde duvarlar) ve döşemelerin birlikte ve tek işlemde, yerinde dökümünü sağlayan bir inşaat tarzıdır. Bu sistem ile inşa edilen yapılarda, yapı yükleri iskelet sistemindeki gibi kolon ve kirişlerin yerine, betonarme taşıyıcı duvarlar (perde duvarlar) tarafından taşınmaktadır.

Kompozit: İki veya daha fazla malzemenin birleştirilmesi ile bileşenlerin daha farklı özellikler sağladığı bileşkelere kompozit denir.

Prefabrik: Standartlaştırılmış elemanlar ya da önceden üretilerek belirli bir plana göre birleştirilmiş bileşenler yardımı ile inşaat yapmayı sağlayan inşaat tarzıdır.

Büyük ölçüde önceden fabrikada imal edilmiş olan hazır bina elemanlarının (duvarlar, taşıyıcı kolon ve kirişler vb.), binanın inşa edileceği yerde montajının yapılmasıdır.

Diğer: Yukarıda açıklanan taşıyıcı sistemlerden farklı bir tarzda yapılan inşaat tarzıdır.

Duvar Malzemesi:

Çelik Levha: Duvar malzemesi olarak çelik levha kullanılması sonucu elde edilen inşaat tarzıdır. Çelik iskelet sisteminde kullanılır.

Beton Blok: Duvar malzemesi olarak dökme beton veya fabrika imali prefabrik beton blok kullanılması sonucu elde edilen inşaat tarzıdır.

Briket: Duvar malzemesi olarak briket kullanılması sonucu elde edilen inşaat tarzıdır.

Tuğla: Duvar malzemesi olarak tuğla kullanılması sonucu elde edilen inşaat tarzıdır.

Ahşap: Duvar malzemesi olarak ahşap kullanılması sonucu elde edilen inşaat tarzıdır.

Taş: Duvar malzemesi olarak taş kullanılması sonucu elde edilen inşaat tarzıdır.

Kerpiç: Duvar malzemesi olarak kerpiç kullanılması sonucu elde edilen inşaat tarzıdır.

* Gaz Beton, Hafif Panel, Bilinmeyen, Diğer: TÜİK tanımı bulunmamaktadır.

TÜİK verisinde dolgu malzemesi türünün ya da taşıyıcı sistem detay bilgisinin bulunmadığı durumlar NA ile belirtilmiştir.

[1] Türkiye İstatistik Kurumu, (2011), “Yapı İzin İstatistikleri 2010”, Ankara, Türkiye

Aşağıda "taşıyıcı sistem", "dolgu malzemesi" ve "taşıyıcı sistem detayları" TUİK'in tanımladığı şekilde verilen her bir bina grubu için en uygun taşıyıcı sistemi seçiniz.

1.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Ahşap (Wood)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Ahşap (Wood)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA; Diğer; İskelet (Karkas); İskelet (Karkas) --> Ahşap (NA; NA; Other; Skeleton (Frame); Skeleton (Frame) --> Wood Frame)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

2.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Ahşap (Wood)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Briket; Diğer; Gaz beton; Hafif panel; Kerpiç; Tuğla (HCB; Other; CSB; LP; Adobe; Brick)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA; İskelet (Karkas) --> Ahşap (NA; Skeleton (Frame) --> Wood Frame)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabricated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

3.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Betonarme; Betonarme-diğer (RC; RC-Other)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Beton blok (CB)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA; İskelet (Karkas); İskelet (Karkas) --> Betonarme (NA; Skeleton (Frame); Skeleton (Frame) --> RC)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabricated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

4.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Betonarme; Betonarme-diğer (RC; RC-Other)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	NA; Briket; Diğer; Gaz beton; Hafif panel; Tuğla (NA; HCB; Other; CSB; LP; Brick)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA; İskelet (Karkas); İskelet (Karkas) --> Betonarme (NA; Skeleton (Frame); Skeleton (Frame) --> RC)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

5.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Betonarme; Betonarme-diğer (RC; RC-Other)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Taş (Stone)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA; İskelet (Karkas); İskelet (Karkas) --> Betonarme (NA; Skeleton (Frame); Skeleton (Frame) --> RC)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

6.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Betonarme; Betonarme-diğer (RC; RC-Other)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Ahşap (Wood)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA; İskelet (Karkas) (NA; Skeleton (Frame)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

7.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Betonarme (RC)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	NA; Briket; Diğer; Gaz beton; Hafif panel; Tuğla (NA; HCB; Other; CSB; LP; Brick)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	İskelet (Karkas) --> Betonarme --> Çerçeveli + Perdeli Sistem (Skeleton (Frame) --> RC --> Dual)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

8.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Betonarme (RC)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	NA; Briket; Diğer; Gaz beton; Hafif panel; Tuğla (NA; HCB; Other; CSB; LP; Brick)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	İskelet (Karkas) --> Betonarme --> Çerçeveli Sistem (Skeleton (Frame) --> RC --> Frame)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

9.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Betonarme (RC)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Beton blok (CB)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	İskelet (Karkas) --> Betonarme --> Çerçeveli Sistem (Skeleton (Frame) --> RC --> Frame)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

10.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Betonarme (RC)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	NA; Briket; Diğer; Gaz beton; Tuğla (NA; HCB; Other; CSB; Brick)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	İskelet (Karkas) --> Betonarme --> Perdeli Sistem (Skeleton (Frame) --> RC --> Shear Wall)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

11.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Betonarme (RC)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Beton blok (CB)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	İskelet (Karkas) --> Betonarme --> Perdeli Sistem (Skeleton (Frame) --> RC --> Shear Wall)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

12.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Çelik (Steel Frame)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Ahşap (Wood)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA; İskelet (Karkas) --> Çelik (NA; Skeleton (Frame) --> Steel Frame)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

13.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Çelik (Steel Frame)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Briket; Diğer; Gaz beton; Hafif panel; Tuğla (HCB; Other; CSB; LP; Brick)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA; Diğer; İskelet (Karkas) --> Çelik (NA; Other; Skeleton (Frame) --> Steel Frame)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

14.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Çelik (Steel Frame)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Beton blok (CB)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	İskelet (Karkas) --> Çelik (Skeleton (Frame) --> Steel Frame)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

15.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Diğer (Other)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	NA; Briket; Diğer; Gaz beton; Hafif panel; Tuğla (NA; HCB; Other; CSB; LP; Brick)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA; Diğer (NA; Other)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

16.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Diğer (Other)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Beton blok (CB)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA; Diğer (NA; Other)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

17.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	İskelet; İskelet (karkas) (Skeleton; Skeleton (Frame))
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Briket; Gaz beton; Hafif panel; Tuğla (HCB; CSB; LP; Brick)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA (NA)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

18.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	İskelet; İskelet (karkas) (Skeleton; Skeleton (Frame))
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Kerpiç (Adobe)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA (NA)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

19.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	İskelet; İskelet (karkas) (Skeleton; Skeleton (Frame))
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Beton blok (CB)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA (NA)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

20.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	İskelet; İskelet (karkas) (Skeleton; Skeleton (Frame))
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Taş (Stone)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA (NA)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

21.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	İskelet; İskelet (karkas) (Skeleton; Skeleton (Frame))
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Ahşap (Wood)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA (NA)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

22.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	İskelet; İskelet (karkas) (Skeleton; Skeleton (Frame))
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Diğer (Other)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA (NA)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

23.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	İskelet (Skeleton)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Çelik levha (SP)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA (NA)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

24.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Kompozit (Composite)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Briket; Diğer; Gaz beton; Hafif panel; Tuğla (HCB; Other; CSB; LP; Brick)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA; Karma (NA; Composite)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

25.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Kompozit (Composite)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Ahşap (Wood)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA; Karma (NA; Composite)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

26.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Kompozit (Composite)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Beton blok (CB)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA; Karma (NA; Composite)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

27.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Prefabrik (Prefabricated)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	NA; Briket; Diğer; Gaz beton; Hafif panel; Tuğla (NA; HCB; Other; CSB; LP; Brick)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA; Diğer; İskelet (Karkas); Prefabrik (NA; Other; Skeleton (Frame); Prefabricated)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

28.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Prefabrik (Prefabricated)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Ahşap (Wood)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA; Prefabrik (NA; Prefabricated)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

29.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Prefabrik (Prefabricated)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Beton blok (CB)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA; Prefabrik (NA; Prefabricated)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

30.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Prefabrik (Prefabricated)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	NA; Briket; Diğer; Hafif panel; Tuğla (NA; HCB; Other; LP; Brick)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	Yarı prefabrik (Half Prefabricated)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

31.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Tünel kalıp (Tunnel Frame)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Beton blok; Briket; Gaz beton; Hafif panel; Tuğla (CB; HCB; CSB; LP; Brick)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA (NA)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

32.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Yerinde dökme (Cast-in-Place)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	NA; Briket; Diğer; Hafif panel; Tuğla (NA; HCB; Other; LP; Brick)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA; Diğer; İskelet (Karkas); İskelet (Karkas) --> Betonarme (NA; Other; Skeleton (Frame); Skeleton (Frame) --> RC)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

33.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Yerinde dökme (Cast-in-Place)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Taş (Stone)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	Diğer; İskelet (Karkas); İskelet (Karkas) --> Betonarme (Other; Skeleton (Frame); Skeleton (Frame) --> RC)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

34.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Yerinde dökme (Cast-in-Place)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Beton blok (CB)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA; Diğer; İskelet (Karkas); İskelet (Karkas) --> Betonarme (NA; Other; Skeleton (Frame); Skeleton (Frame) --> RC)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

35.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Yerinde dökme (Cast-in-Place)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Briket; Diğer; Gaz beton; Tuğla (HCB; Other; CSB; Brick)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	İskelet (Karkas) --> Betonarme --> Çerçeveli + Perdeli Sistem (Skeleton (Frame) --> RC --> Dual)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

36.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Yerinde dökme (Cast-in-Place)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Beton blok (CB)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	İskelet (Karkas) --> Betonarme --> Çerçeveli + Perdeli Sistem (Skeleton (Frame) --> RC --> Dual)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

37.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Yerinde dökme (Cast-in-Place)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Briket; Diğer; Gaz beton; Tuğla (HCB; Other; CSB; Brick)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	İskelet (Karkas) --> Betonarme --> Çerçeveli Sistem (Skeleton (Frame) --> RC --> Frame)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

38.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Yerinde dökme (Cast-in-Place)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Beton blok (CB)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	İskelet (Karkas) --> Betonarme --> Çerçeveli Sistem (Skeleton (Frame) --> RC --> Frame)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

39.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Yerinde dökme (Cast-in-Place)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Taş (Stone)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	İskelet (Karkas) --> Betonarme --> Çerçeveli Sistem (Skeleton (Frame) --> RC --> Frame)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

40.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Yerinde dökme (Cast-in-Place)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Beton blok; Briket; Diğer; Gaz beton; Tuğla (CB; HCB; Other; CSB; Brick)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	İskelet (Karkas) --> Betonarme --> Perdeli Sistem (Skeleton (Frame) --> RC --> Shear Wall)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

41.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Yerinde dökme (Cast-in-Place)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Briket; Diğer; Gaz beton; ;Hafif panel; Tuğla (HCB; Other; CSB; ;LP; Brick)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	Prefabrik (Prefabricated)

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

42.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Yerinde dökme (Cast-in-Place)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Briket; Diğer; Gaz beton; Tuğla (HCB; Other; CSB; Brick)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	Yığma (Kagir) (Masonry(Stone))

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

43.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Yığma (Masonry)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Briket; Diğer; Gaz beton; Hafif panel; Kerpiç; Taş; Tuğla (HCB; Other; CSB; LP; Adobe; Stone; Brick)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA; Diğer; Yığma (Kagir) (NA; Other; Masonry (Stone))

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

44.

TAŞIYICI SİSTEM (STRUCTURAL SYSTEM)	Yığma (Masonry)
DOLGU MALZEMESİ (MATERIAL OF INFILL WALL)	Ahşap (Stone)
TAŞIYICI SİSTEM DETAY (STRUCTURAL SYSTEM DETAIL)	NA; Yığma (Kagir) (NA; Masonry (Stone))

Her satırda yalnızca bir şıkkı işaretleyin. (Select only one choice.)

	Yığma (Masonry)	Betonarme Çerçeve (RCF)	Betonarme Çerçeve + Perde (RCD)	Betonarme Perde - Tünel Kalıp (RCW)	Betonarme Bilinmeyen (RCU)	Çelik (Steel Frame)	Prefabrik (Prefabri-cated)	Kompozit (Composite)	Ahşap (Wood Frame)
Uygun Taşıyıcı Sistem (Proper Structural system)	☐	☐	☐	☐	☐	☐	☐	☐	☐

B. Figures For Further Information in Detail

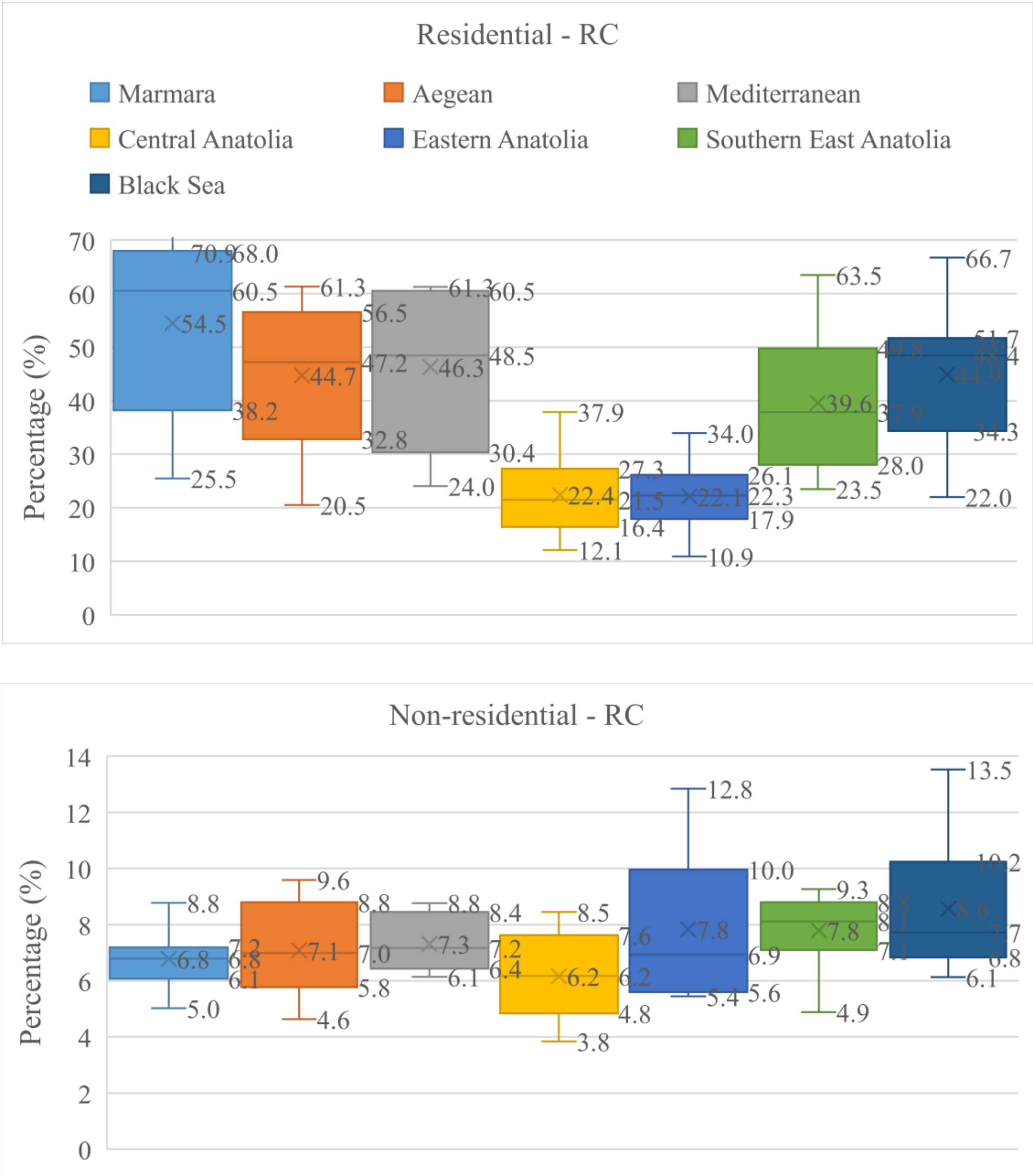
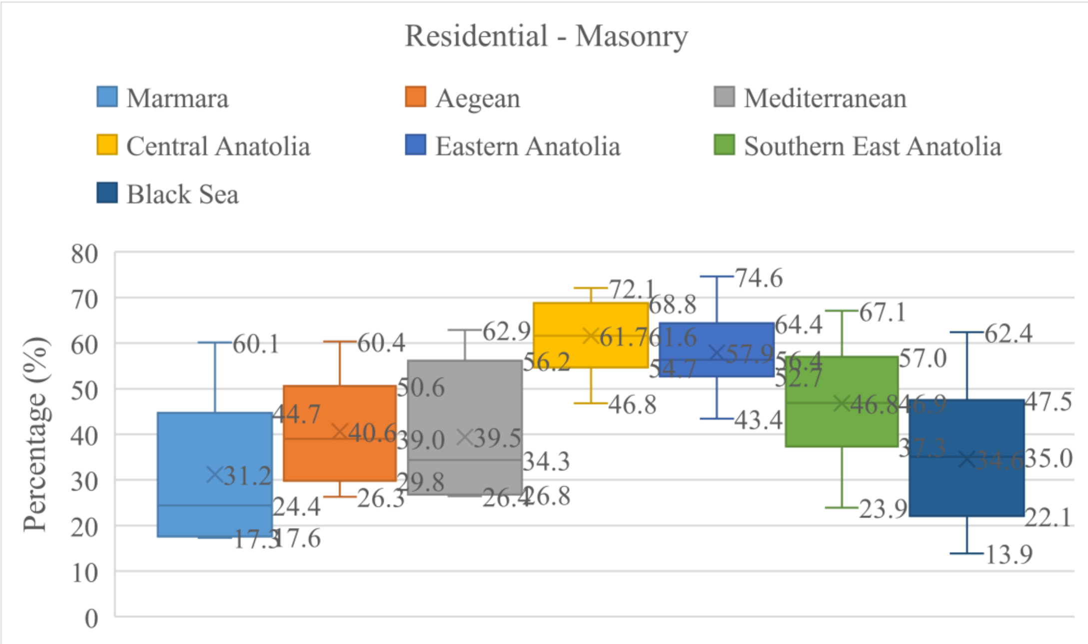


Figure B.1. The percentage of RCF structural system for residential and non-residential buildings with respect to Turkish regions



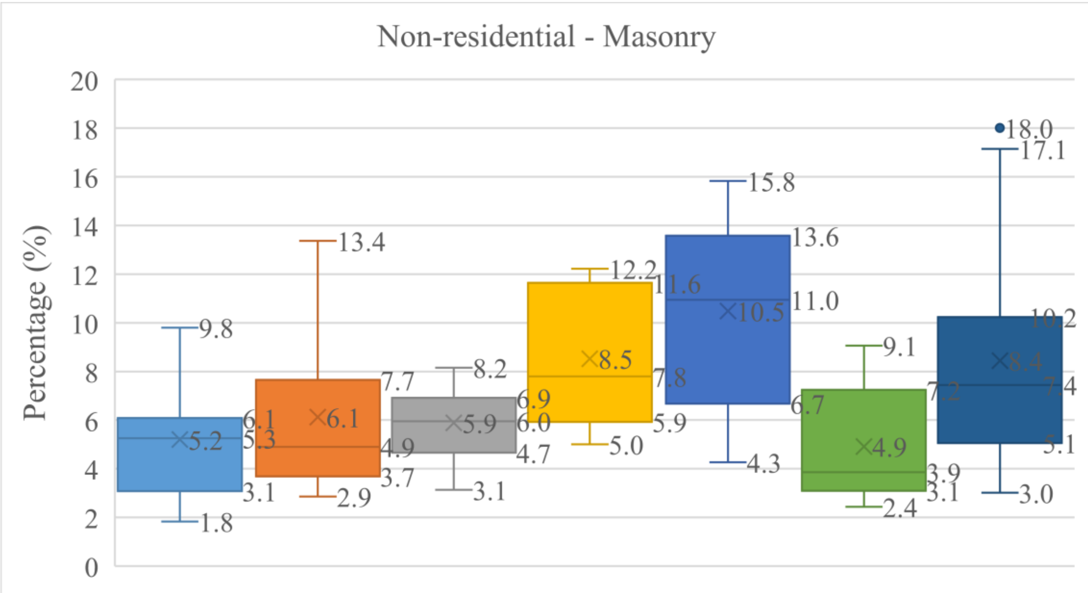
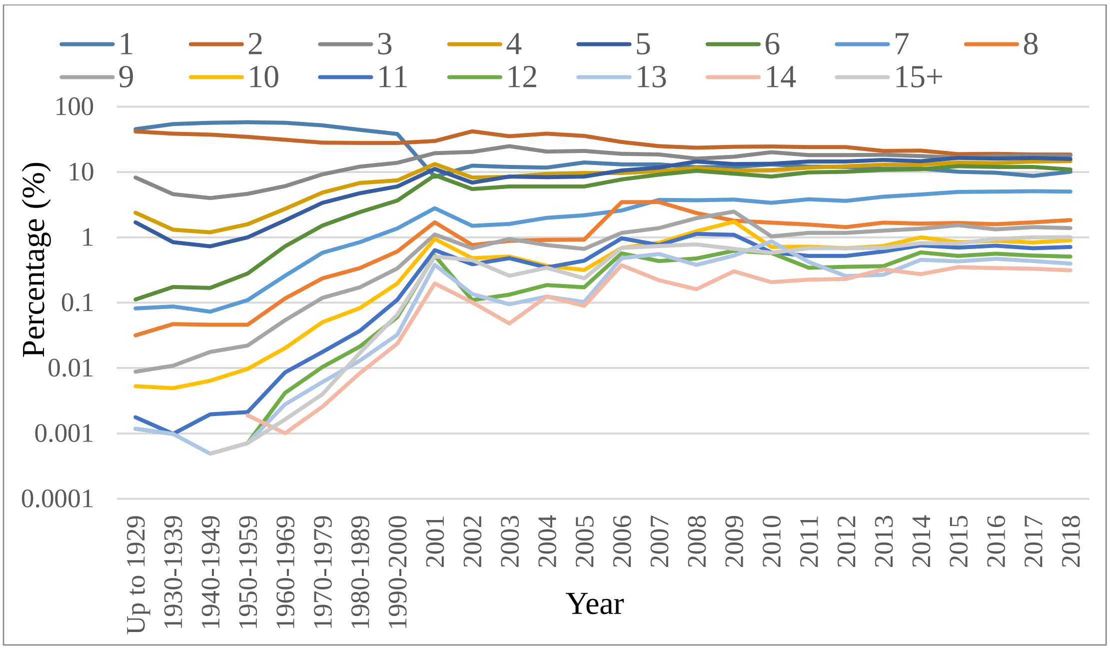


Figure B.2. The percentage of masonry structural system for residential and non-residential buildings with respect to Turkish regions



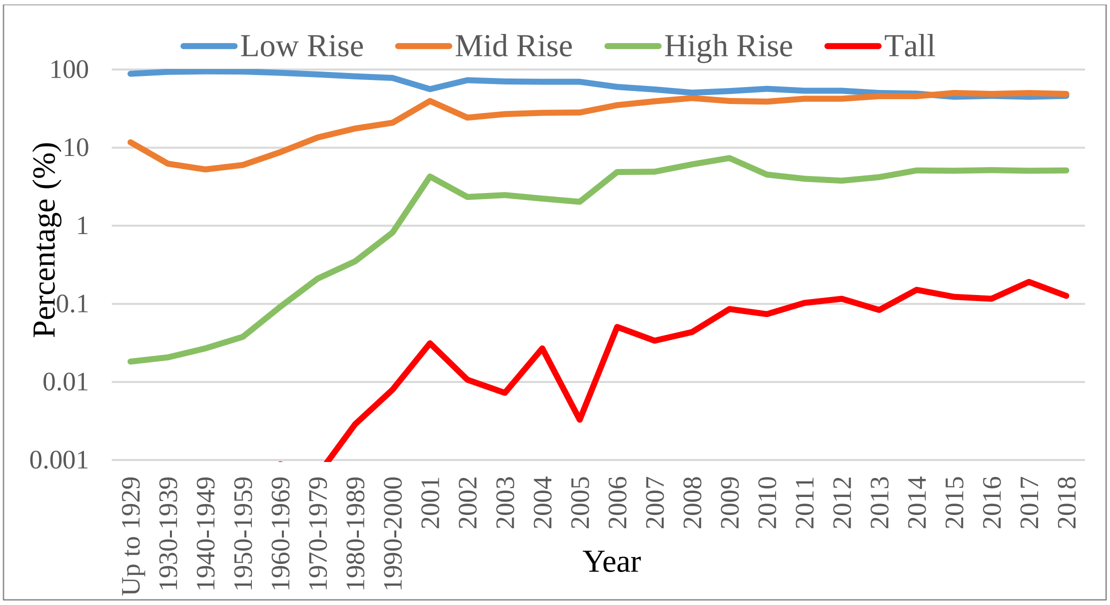
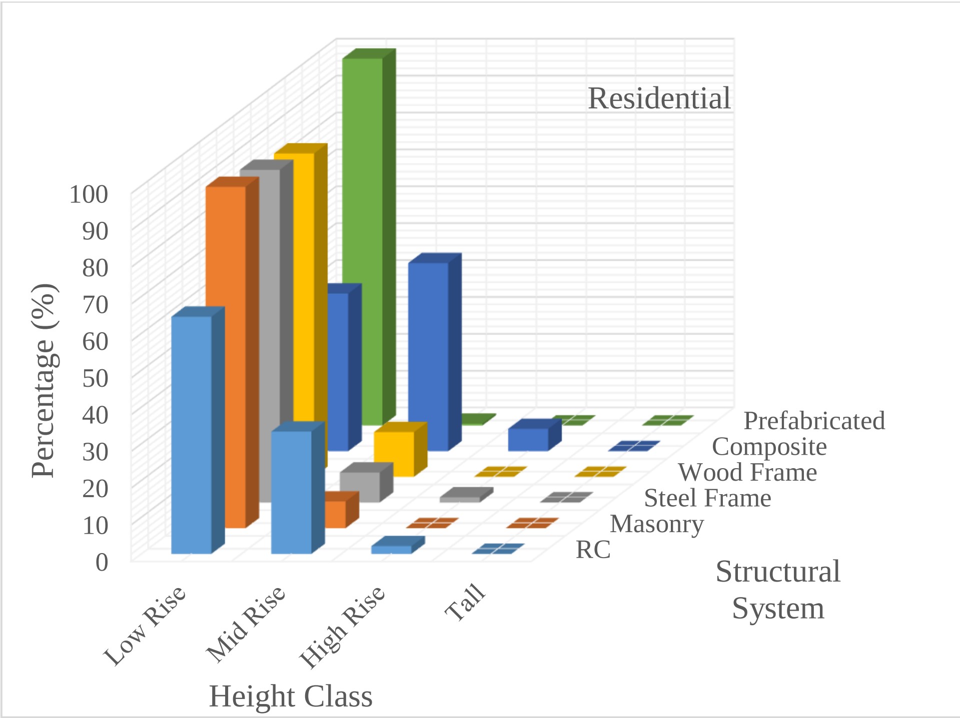


Figure B.3. Annual variation of Turkish building number of stories percentages



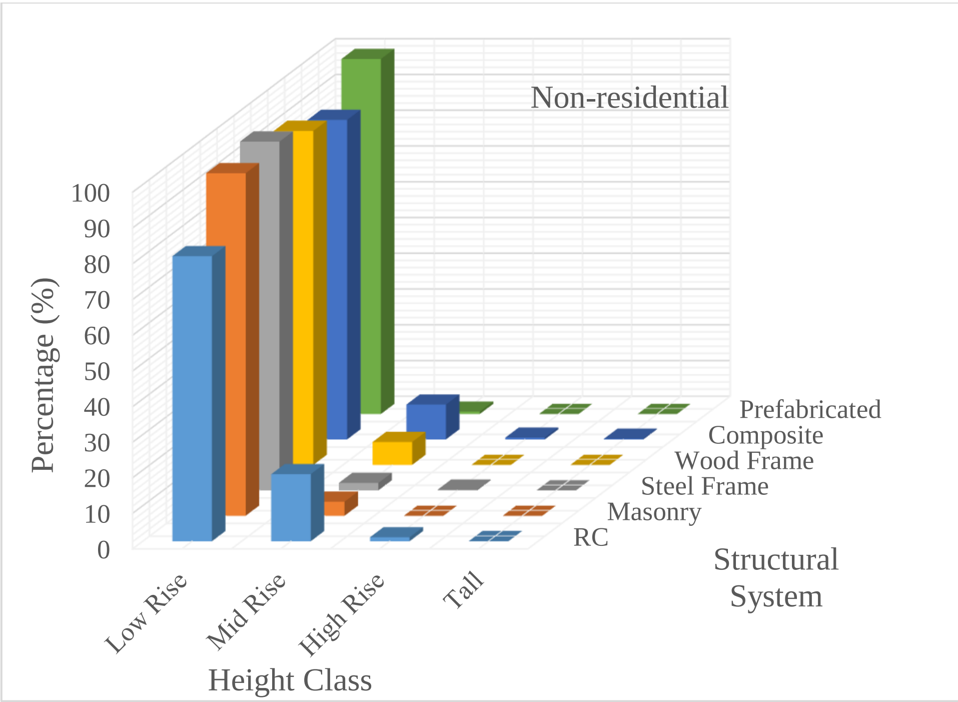


Figure B.4. Variation of low, mid, high-rise and tall buildings in Turkey with respect to the structural system for residential and non-residential buildings

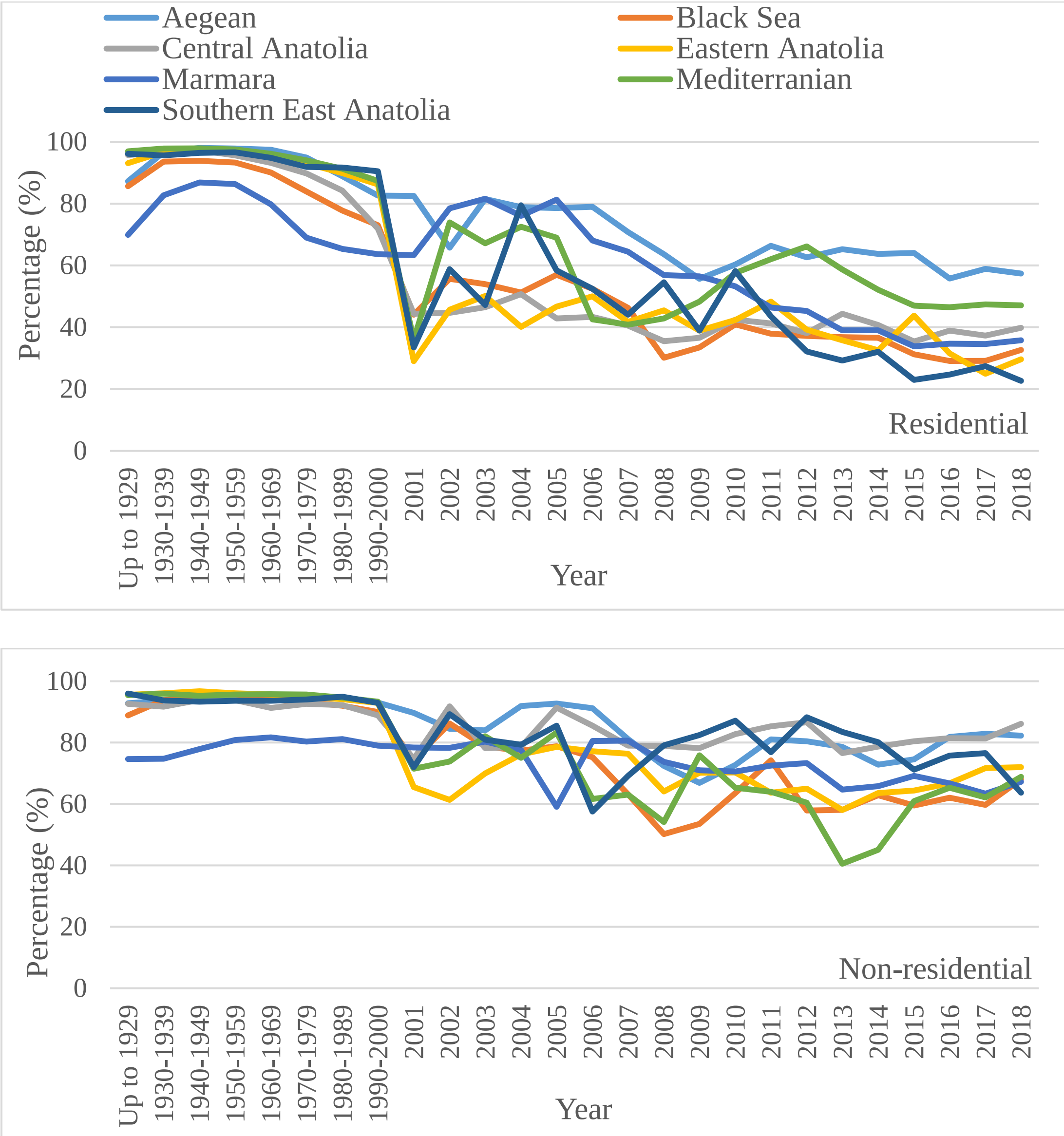
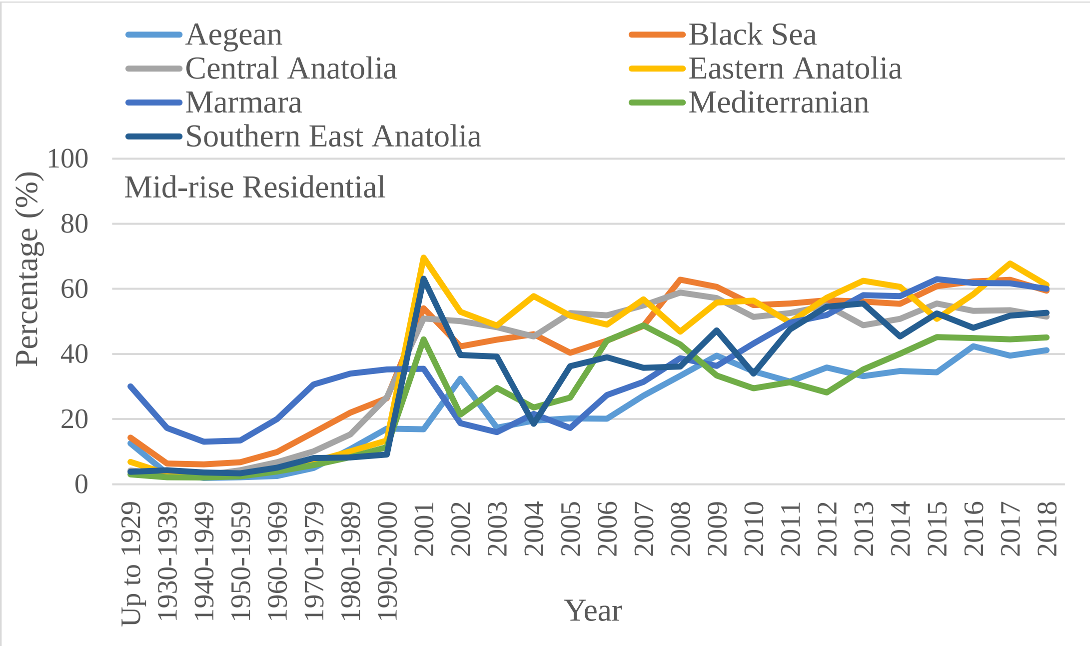


Figure B.5. Annual variation of low-rise residential and non-residential buildings with respect to Turkish areas



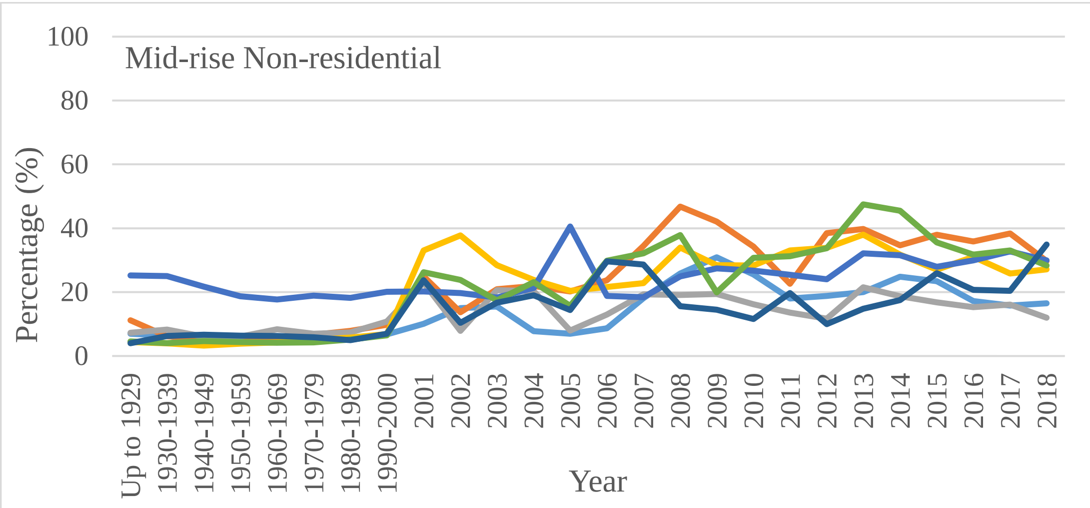
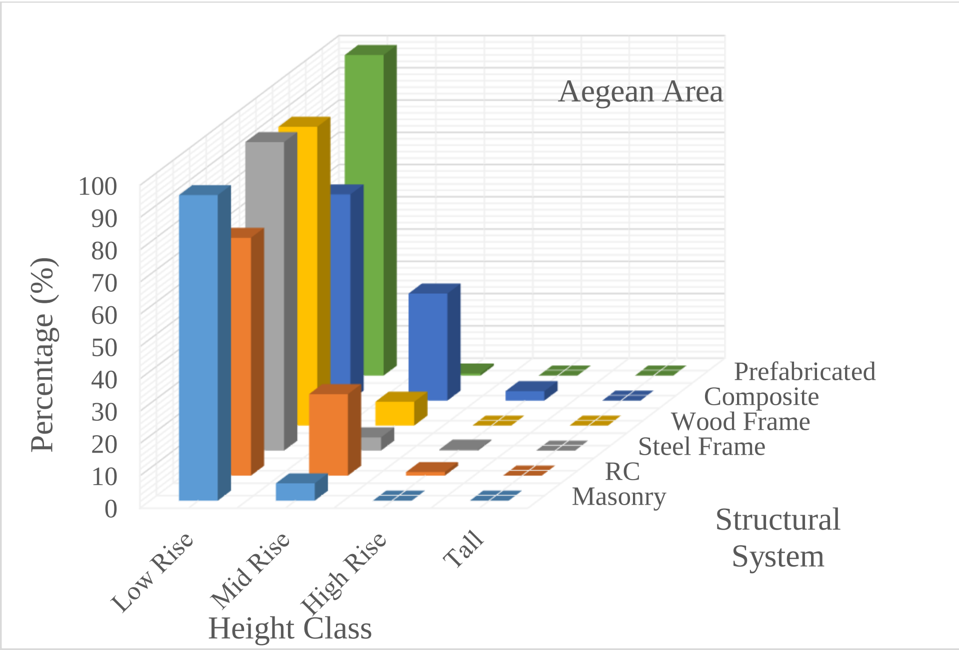


Figure B.6. Annual variation of mid-rise residential and non-residential buildings with respect to Turkish areas



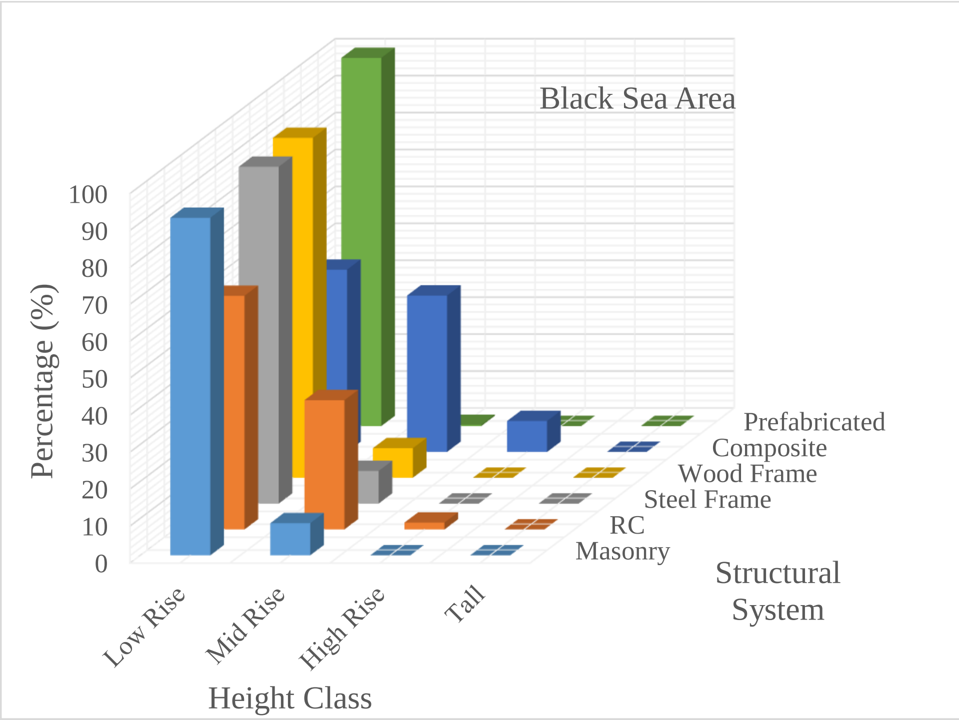
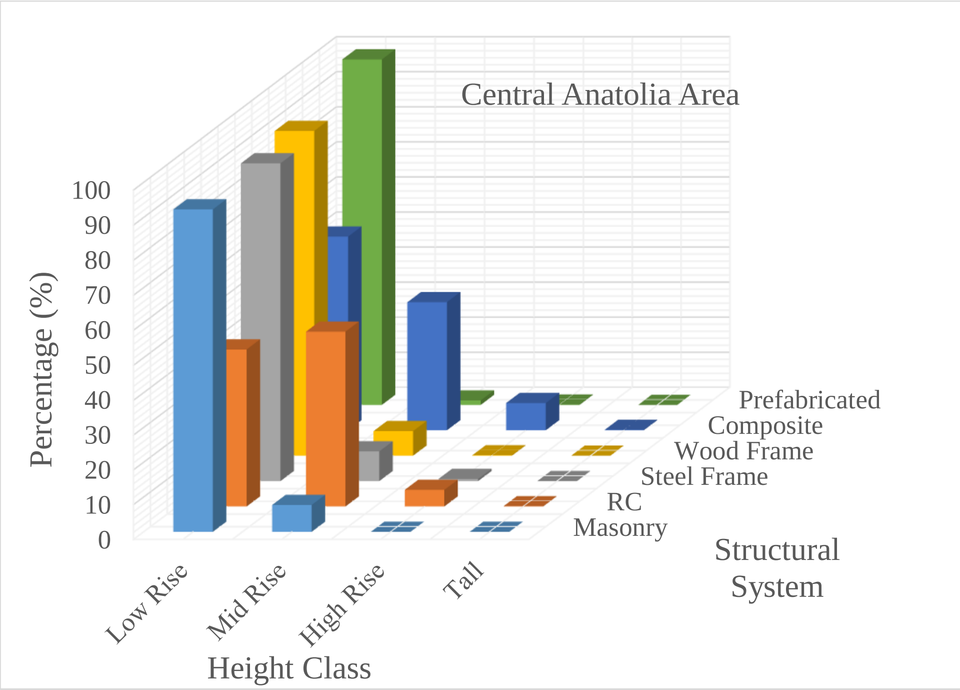


Figure B.7. Percentage of low, mid, high-rise and tall residential buildings with respect to structural system in Aegean and Black Sea Areas



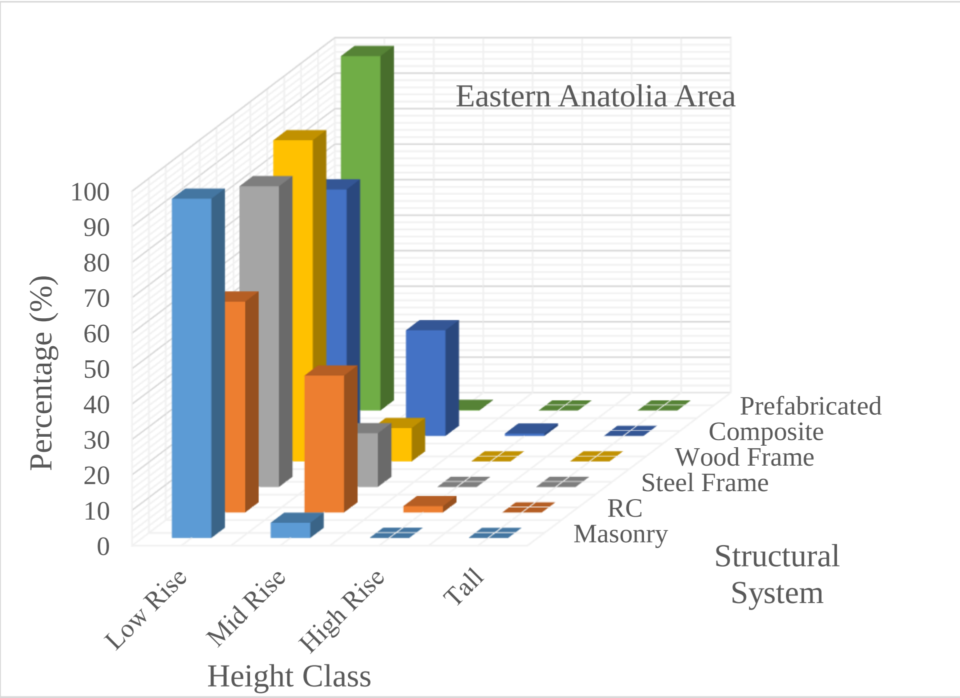


Figure B.8. Percentage of low, mid, high-rise and tall residential buildings with respect to structural system in Central and Eastern Anatolia Areas

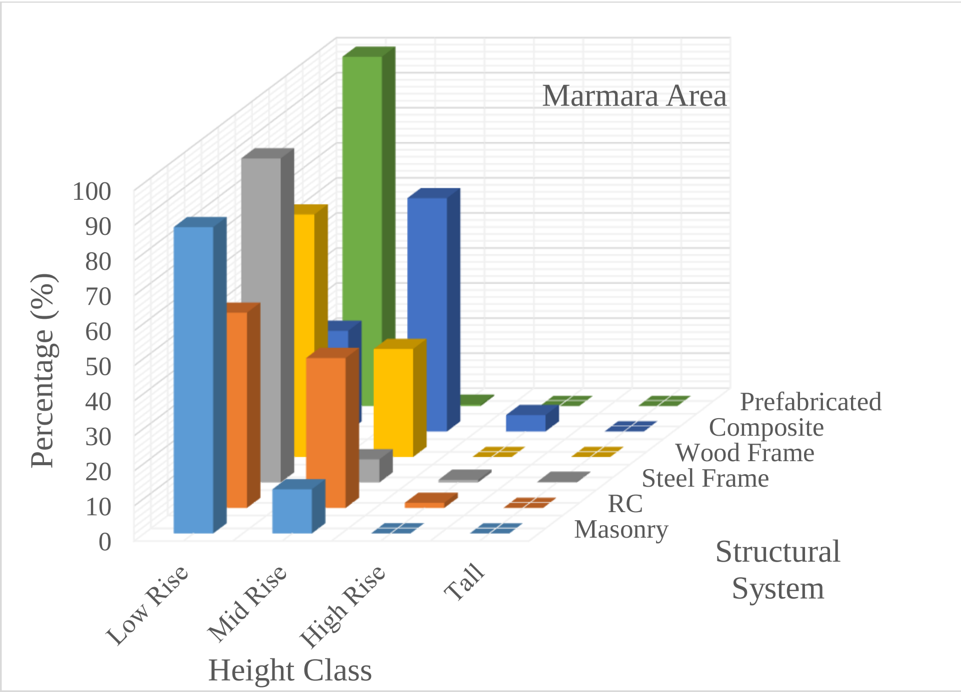
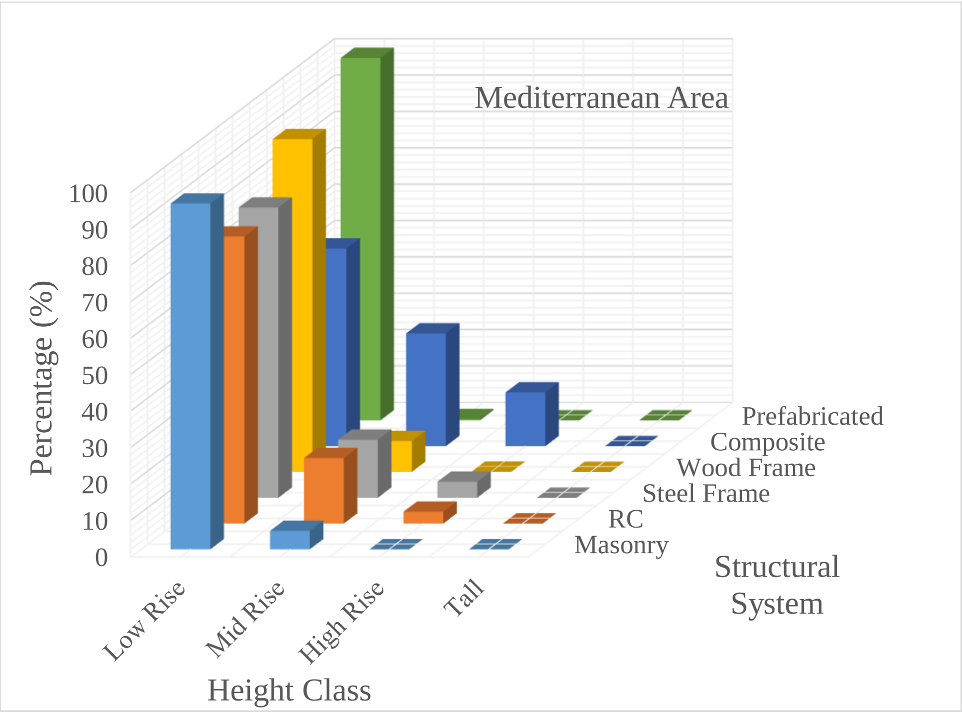


Figure B.9. Percentage of low, mid, high-rise and tall residential buildings with respect to structural system in Eastern Anatolia and Marmara Areas



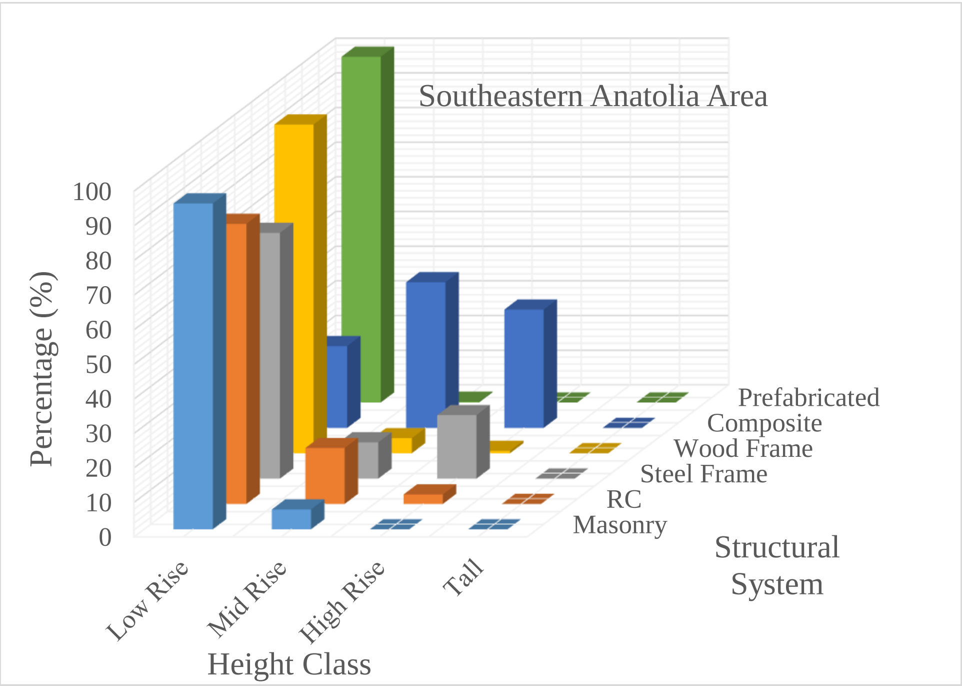


Figure B.10. Percentage of low, mid, high-rise and tall residential buildings with respect to structural system in Mediterranean and Southeastern Anatolia Areas

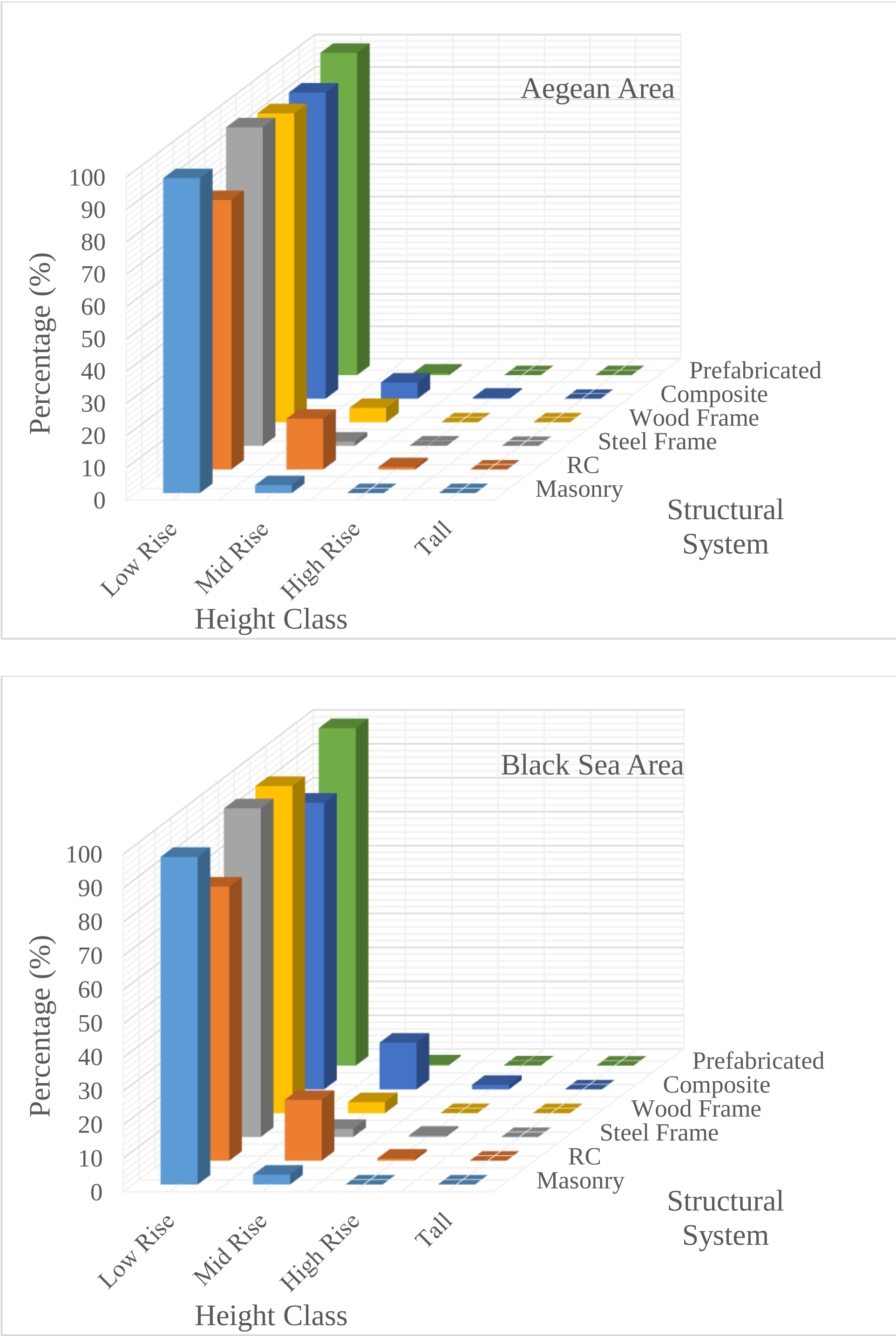
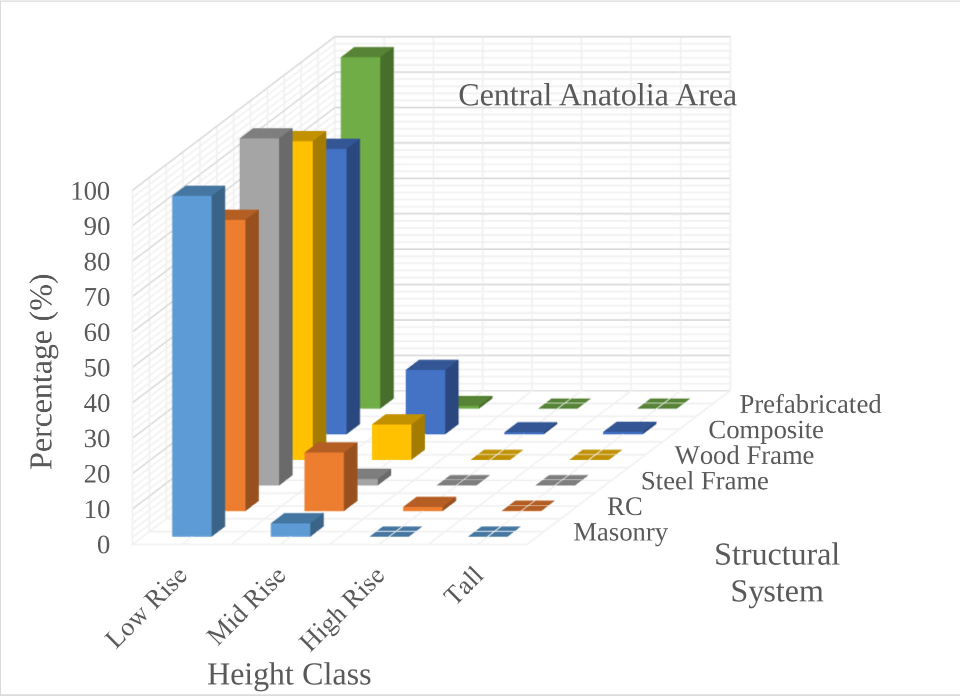


Figure B.11. Percentage of low, mid, high-rise and tall non-residential buildings with respect to structural system in Aegean and Black Sea Areas



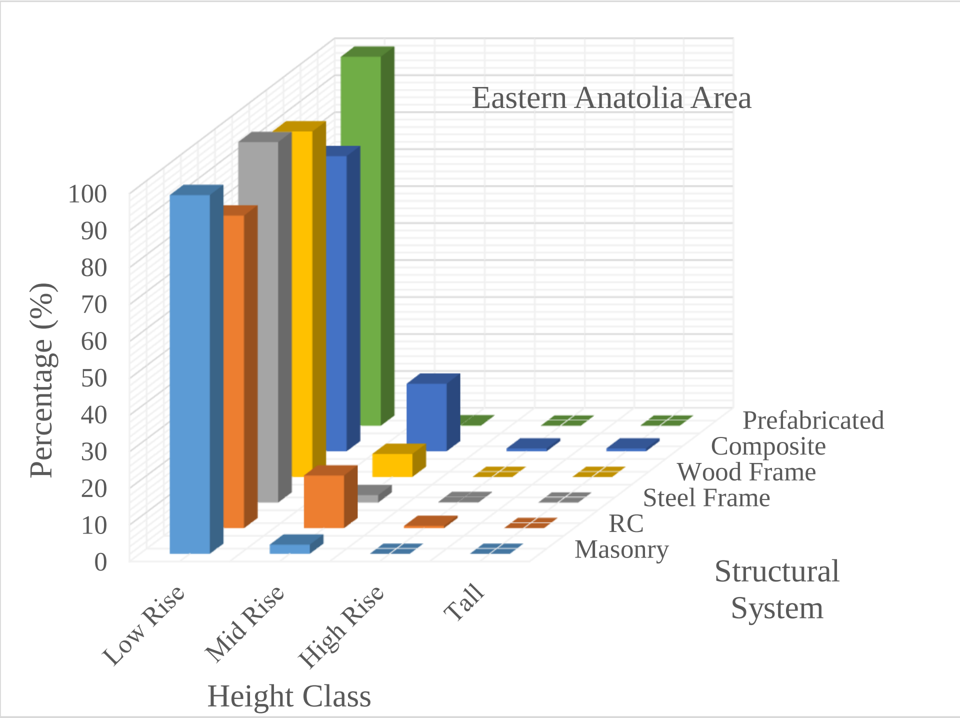
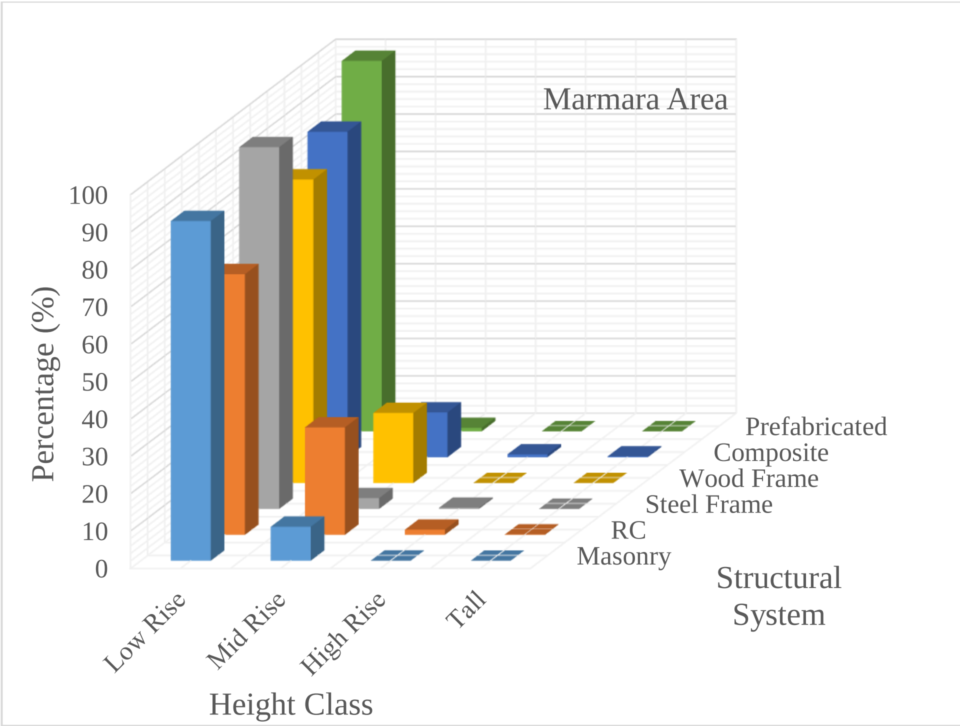


Figure B.12. Percentage of low, mid, high-rise and tall non-residential buildings with respect to structural system in Central and Eastern Anatolia Areas



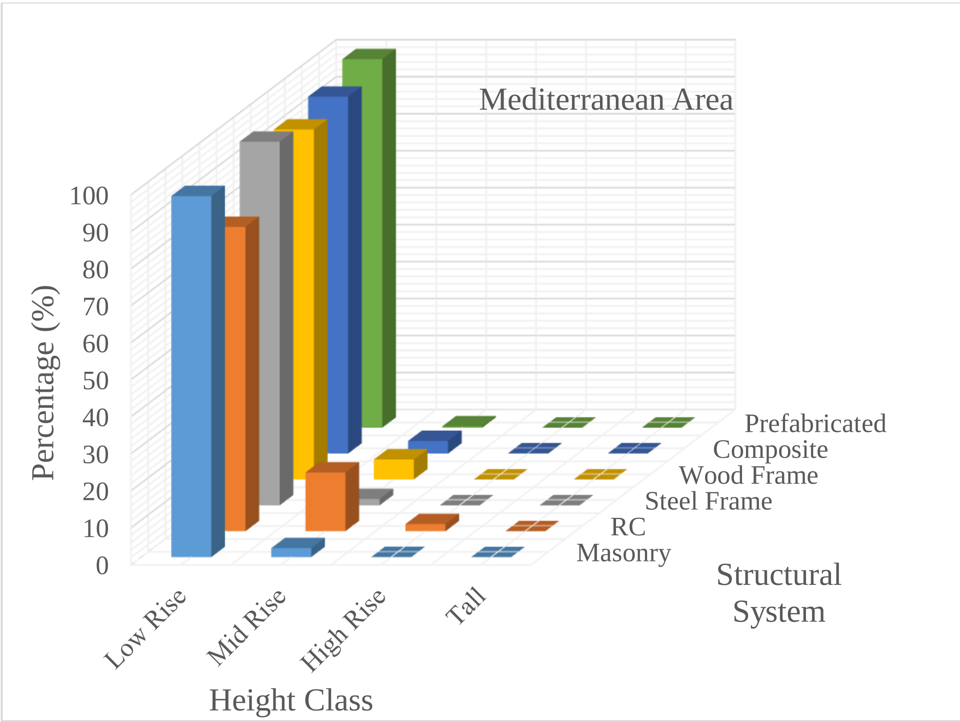


Figure B.13. Percentage of low, mid, high-rise and tall non-residential buildings with respect to structural system in Marmara and Mediterranean Areas

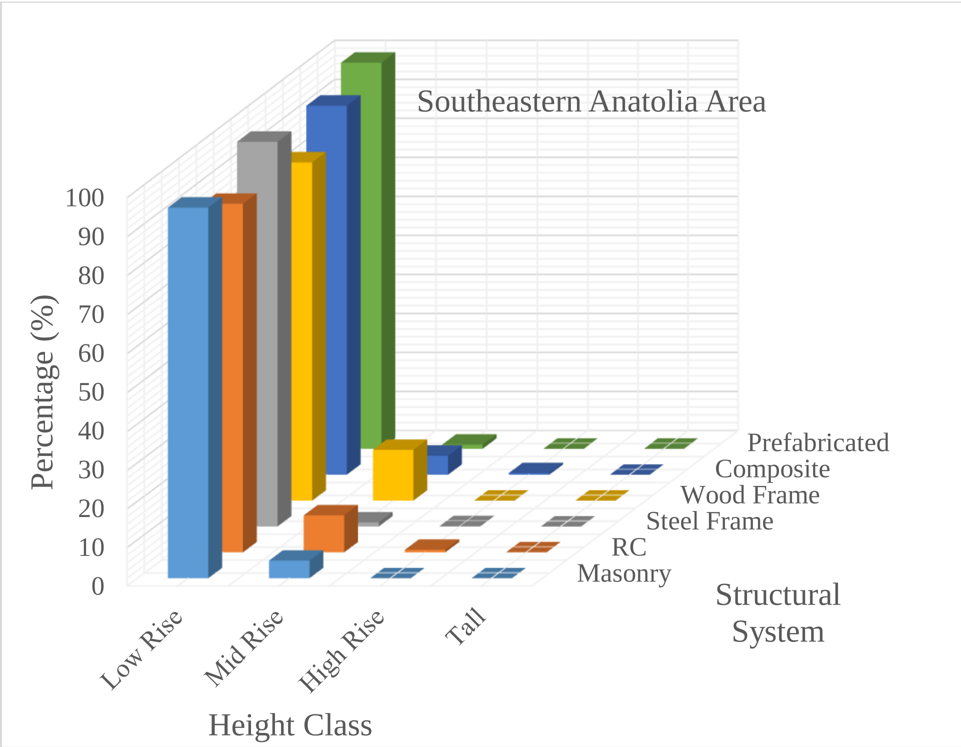
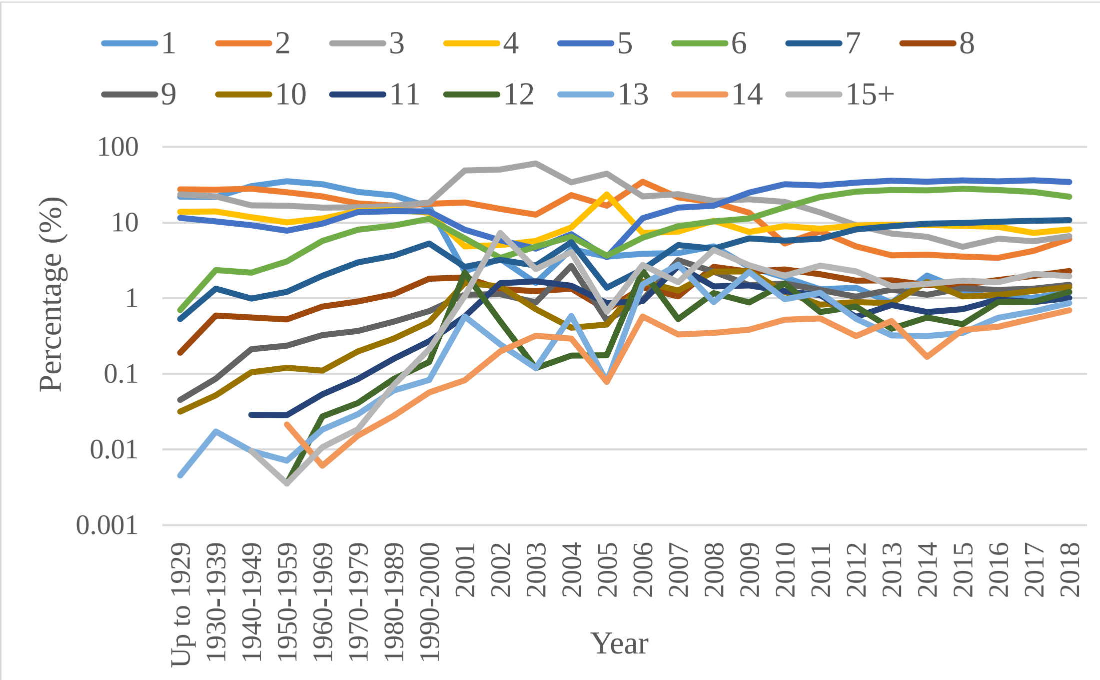


Figure B.14. Percentage of low, mid, high-rise and tall non-residential buildings with respect to structural system in Southeastern Anatolia Area



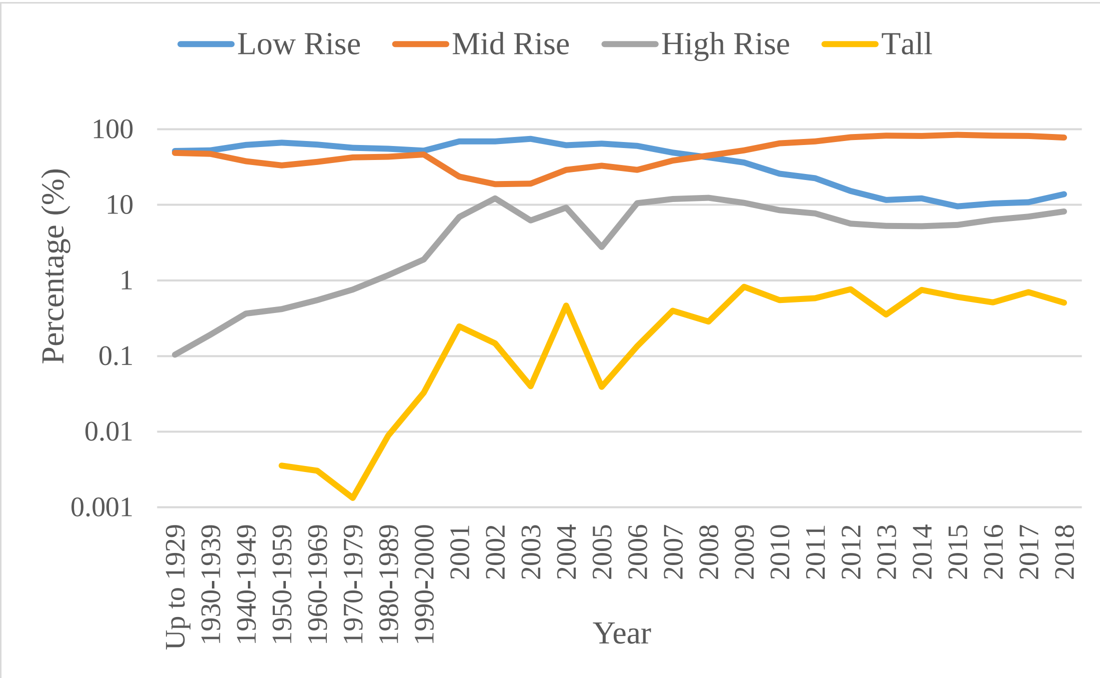
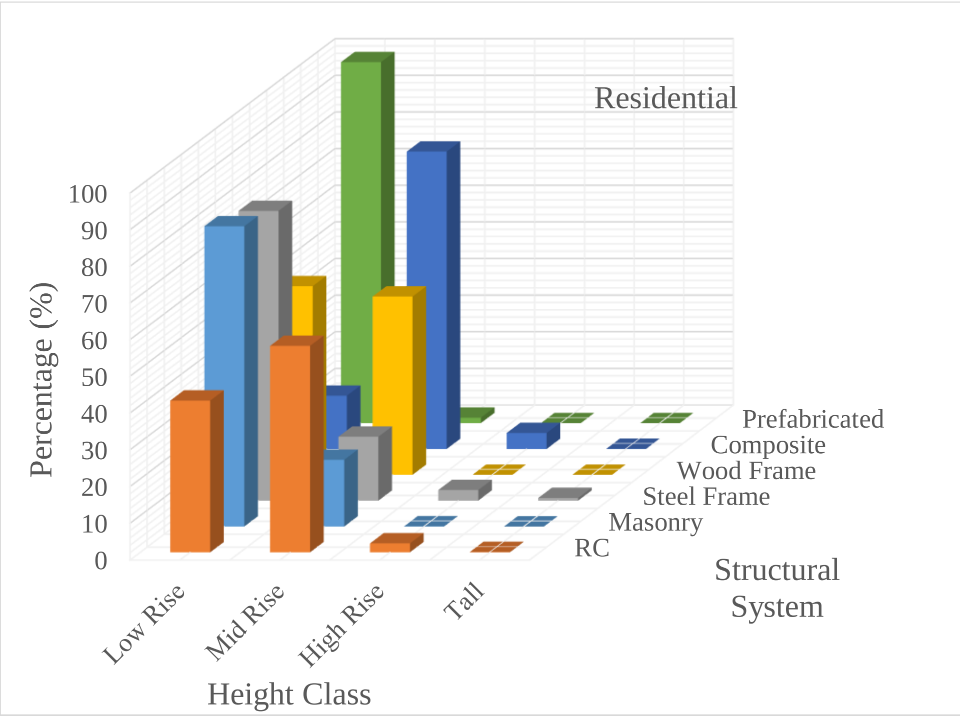


Figure B.15. Annual variation of building number of stories percentages in İstanbul



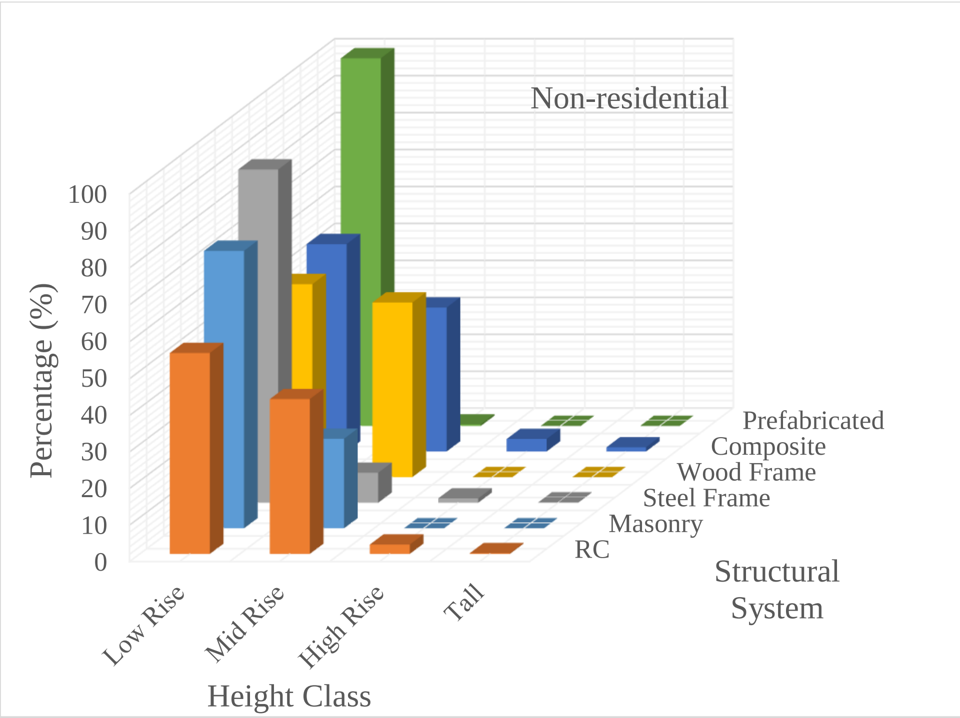


Figure B.16. Percentage of low, mid, high and very-high-rise residential and non-residential buildings with respect to structural system in İstanbul

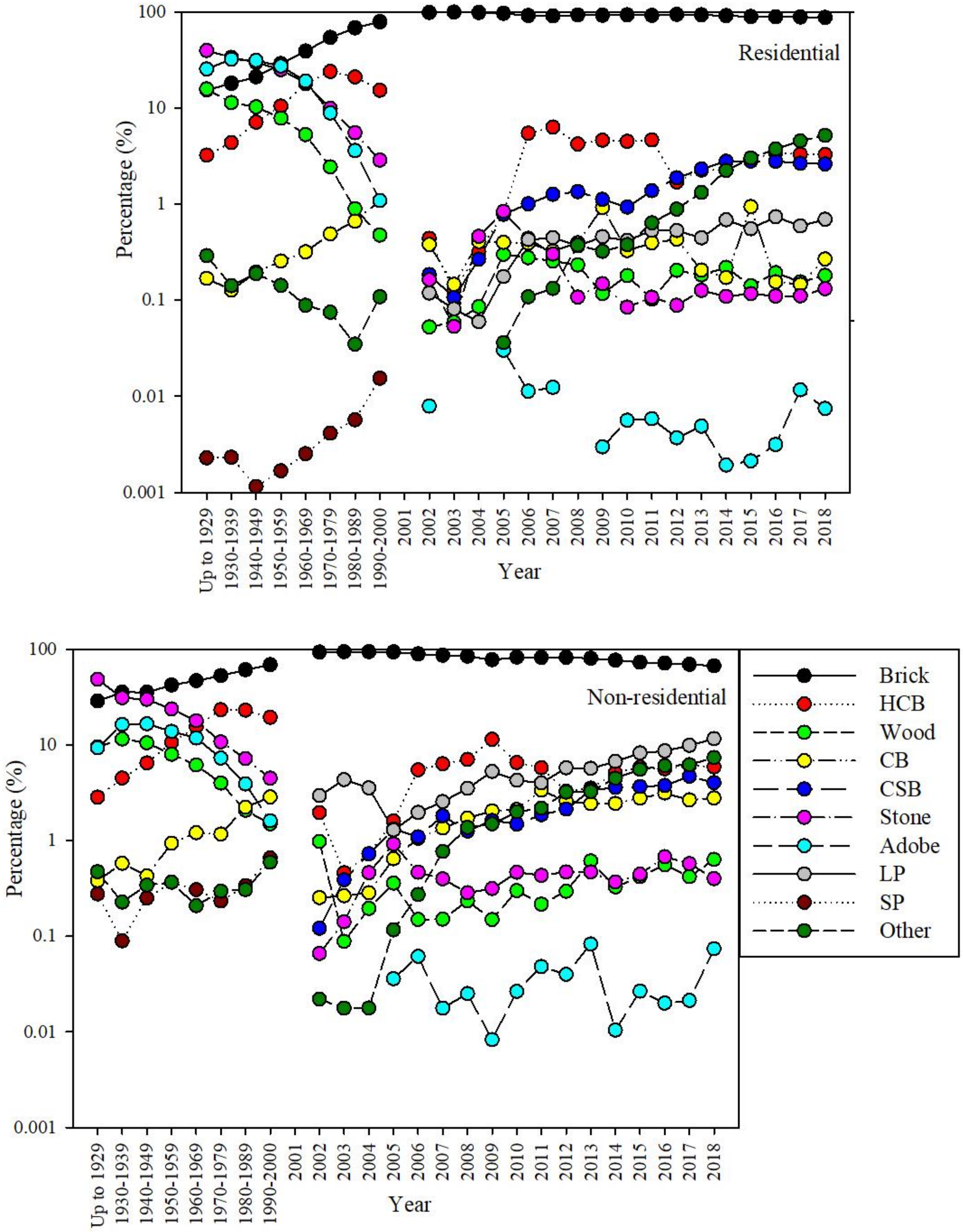


Figure B.17. Annual variation of material of infill wall in Turkey with respect to the use of building

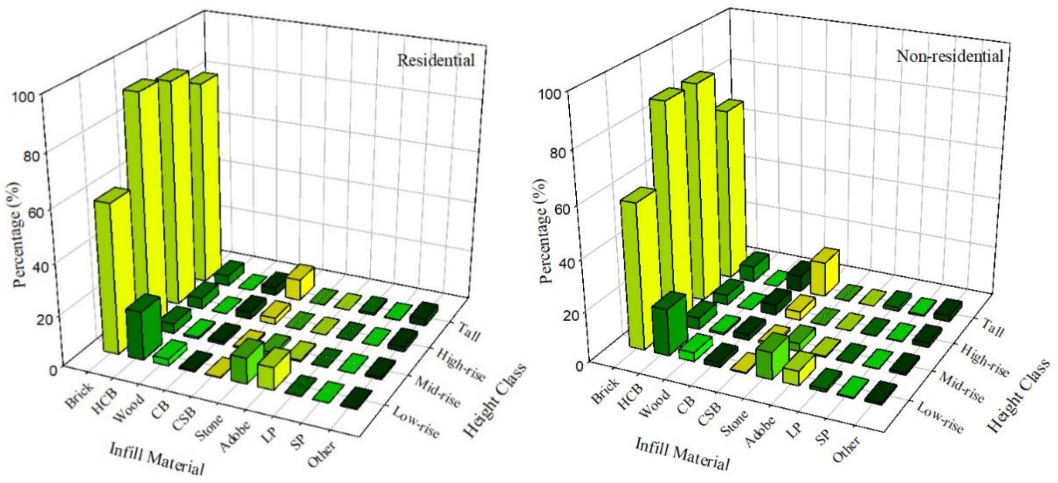


Figure B.18. Percentage of material of infill walls at residential and non-residential buildings with respect to height classes

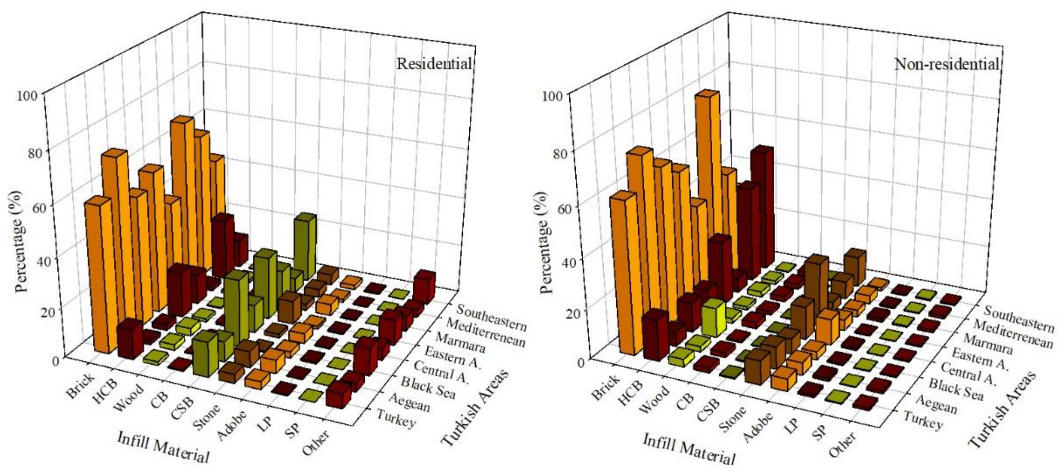


Figure B.19. Percentage of material of infill walls at residential and non-residential buildings with respect to Turkish areas

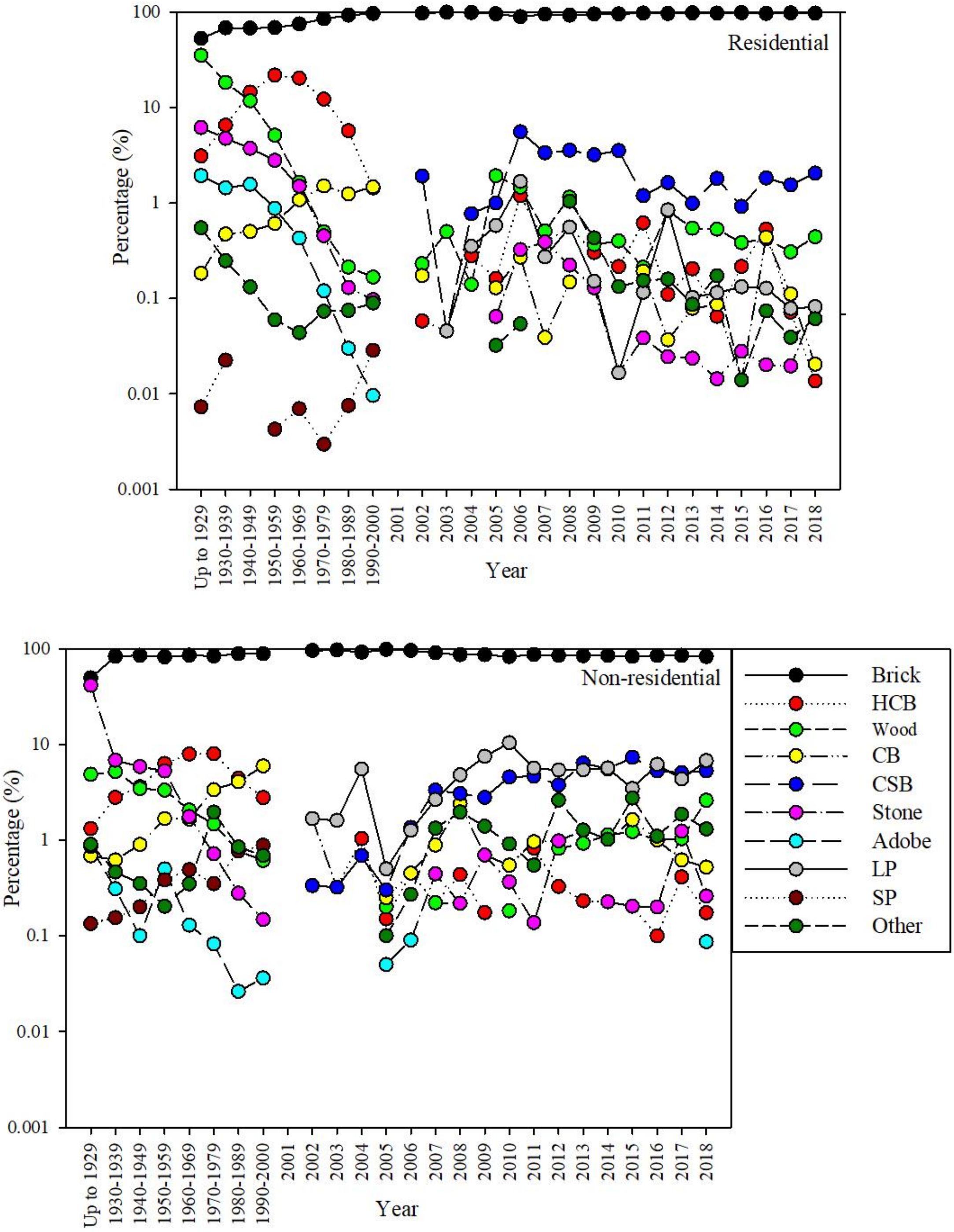


Figure B.20. Annual variation of material of infill wall percentage with respect to the use of building in İstanbul