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Amaç ve Kapsam

Muş Alparslan Üniversitesi Mühendislik-Mimarlık Fakültesi dergisi, temel mühendislik bilimleri alanında, mühendisliğin güncel araştırma konularına odaklı hem deneysel hem de kuramsal çalışmaların yayınına öncelik tanır. Disiplinler arası çalışmaları ve teknolojileri içeren akademik yayınları teşvik eder. İlgili bilimlerin ve bireylerin ulusal ve uluslararası gelişimlerine katkıda bulunmayı, bu alanlarla ilgili kaynakları geliştirmeyi amaçlar. Derginin dili Türkçe ve İngilizcedir.

Mühendislik biliminin temeline ait kuramsal çalışmalara, teknolojik gelişmelere ve mühendislik odaklı disiplinler arası çalışmalara kapsamı dahilinde yer veren dergimiz; kuramsal, deneysel, araştırma ve derleme türünde içeriklerle yılda iki kez (Aralık, Haziran) yayımlanmakta, güncel akademik literatürü araştırmacılara ve kamuoyuna aktarmayı hedeflemektedir.

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Aims and Scope

Muş Alparslan University Faculty of Engineering and Architecture journal gives priority to the publication of both experimental and theoretical studies in the field of basic engineering sciences, focusing on current research topics in engineering. It encourages academic publications involving interdisciplinary studies and technologies. It aims to contribute to the national and international development of related sciences and individuals, and to develop resources related to these fields. The languages of the journal are Turkish and English.

Our journal, which includes theoretical studies on the foundation of engineering science, technological developments and interdisciplinary studies focused on engineering; It is published twice a year (December, June) with theoretical, experimental, research and compilation content, and aims to convey the current academic literature to researchers and the public.

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Yayın Etiği ve Sorumluklar

Dergimizin yayın süreci, sürece dahil olan herkes için (yazarlar, hakemler, editörler) akademik etik ilkelerine ve standartlara uymayı şart koşmaktadır. Bu kapsamda sürece dahil olan tüm akademisyenlerin aşağıdaki sorumlulukları kabul ettiği varsayılmaktadır. Bu kapsamda ifade edilen sorumluluklar belirlenirken açık erişim kurallarını düzenleyen Committee on Publication Ethics (COPE) tarafından belirtilen kurallar ve sorumluluklar kullanılmıştır.

Yazarların Etik Sorumlulukları

Yazar(lar), tüm akademik çalışmalarında özgün olmalıdır. Yaptıkları çalışmalarda diğer akademik çalışmalardan yararlanmaları durumunda eksiksiz bir şekilde kaynak gösterimi ve/veya alıntı yapmaları gerekmektedir. Çalışmaya katkı sunmayan kişiler yazar olarak çalışmaya dahil edilmemelidir. Araştırmacılar, çalışmalarını aynı anda birden fazla yayın organına gönderemezler. Her bir gönderim süreci, önceki başvurunun sonuçlanmasına müteakip yapılmalıdır. Başka bir mecrada yayımlanmış bir çalışma dergimize gönderilmemelidir. Gönderilen çalışmaların, çıkar çatışması teşkil edecek içerikler, durumlar ve ilişkiler barındırması durumunda bilgilendirme yapılmalıdır. Yazarlar, talep edilmesi durumunda çalışmaya ait ham verileri ve deney bilgilerini yayın kurulu ve bilim kuruluna sunmaya hazır olmalıdır. Değerlendirme süreci başlatılmış bir çalışma için, yazar ekleme, sırasını değiştirme veya yazar çıkarma gibi teklifler mümkün değildir. Yazar(lar) çalışmalarında kullandıkları verilerin (varsa) etik haklarına, kullanım haklarına, araştırma/analiz/deney gibi işlemler için gerekli izinlere sahip olduğuna dair belgelere sahip olmalıdırlar. Yazar(lar) değerlendirme sürecine alınmış, erken görünüm aşamasına geçmiş veya yayımlanmış çalışmalarında bir hata fark etmeleri durumunda, dergi editörünü veya dergi yayıncısını bilgilendirmeli, düzeltme veya geri çekme işlemlerinde işbirliği yapmalıdır.

Editörlerin Etik Görev ve Sorumlulukları

Dergipark sayfasında açıkça belirtilmiş açık erişim kurallar bütünlüğünü sağlayan COPE tarafından ifade edildiği üzere; derginin gelişimine devamlılık kazandırma, dergide yayımlanan akademik çalışmaların kalitesini arttırmaya yönelik aşamaları titizlikle yürütme, okuyucuların ve yazarların ihtiyaçlarına yönelik çalışmalar yapma, düzeltme veya açıklama gerektiren hususlarda açık ve şeffaf iletişim kurma, fikri mülkiyet haklarından ve akademik etik kurallarından taviz vermemek koşuluyla tüm iş süreçlerini devam ettirme gibi işler, editörün başlıca etik görev ve sorumluluklarıdır.

Hakemlerin Etik Sorumlulukları

Bir hakem, kendi uzmanlık alanına ait akademik çalışmaları değerlendirmeye almalıdır. Yaptığı değerlendirmelerde tarafsız ve gizli olmalıdır. Bu ilkeler kapsamında yaptığı çalışmaların değerlendirme sonuçlarını süreç sonunda kamu ile paylaşmamalı ve imha etmelidir. Değerlendirmesi neticesinde bir çıkar çatışması tespit etmesi durumunda ilgili editör bilgilendirilmeli ve çalışmayı inceleme süreci reddedilmelidir. Yapılan hakemlik değerlendirmesinin sonucunu yapıcı ve kibar bir üslup ile iletmeli, düşmanlık, iftira veya hakaret içeren negatif ve kişisel iletişim üslubu kullanılmamalıdır. Hakemliği kabul edilen çalışmaları taahhüt edilen süre içerisinde ve belirtilen akademik etik kuralları çerçevesinde değerlendirmeli ve sonucu iletmelidir.

Yayıncının Etik Sorumlulukları

Dergimiz sürece dahil ettiği tüm çalışmalar için editörleri sorumlu kılmaktadır. Dergide yapılan çalışmalardan politik veya ekonomik kazançlar elde edilmemesi için gereken tedbir çalışmalarını editör yürütmektedir. Dergimiz editör kararları oluşturulmasında bağımsızlığı taahhüt eder. Dergimiz, kabul ettiği tüm çalışmaların fikri mülkiyet ve telif haklarını koruduğunu taahhüt eder. Editörlerin süreçle ilgili akademik suiistimaller ve intihalle ilgili konularda ilgili önlemleri alma sorumluluğu yine dergimizin taahhüdü altındadır.

Yazarlar ile İlişkiler

Editörler, yazarların gönderdiği makalelerde çalışmanın özgünlüğü, anlatımın açıklığı ve derginin amaç-kapsamına uygunluğu noktasında değerlendirme yaparak olumlu veya olumsuz karar vermektedir. Bu kapsamda ciddi bir problem teşkil etmeyen tüm çalışmalar değerlendirme sürecine alınır. Editörler, hakem önerilerini dikkate almalıdır. Editörler, çalışmalarla ilgili önceki editörler tarafından verilen kararları, etik ve kapsam noktasında büyük bir problem tespit edilmemesi halinde değiştirmemelidir.

Hakemler ile İlişkiler

Kör Hakemlik ve Değerlendirme Süreci politikaları, editör tarafından titizlikle yürütülmelidir. Hakemler, ilgili yayının uzmanlık sahasına göre seçilmelidir. Yayınla ve süreçle ilgili tüm bilgiler hakemlerle açık bir şekilde paylaşılmalıdır. Yazar-hakem arası çıkar çatışması olup olmadığı yönündeki tespit editörün sorumluluğundadır. Değerlendirme sürecinin başlamasıyla birlikte hakemlerin kimlikleri gizli tutulmalıdır. Editörler, hakemleri tarafsızlık, bilimsellik ve nesnellik hususlarında teşvik etmelidir. Hakem havuzlarının geniş tutulmasına dikkat edilmelidir. Hakemlerin değerlendirme sürecine yönelik performanslarını arttırmak için uygulamalar ve politikalar güdülmelidir. Bilimsellikten ve akademik etik kurallarından uzak süreçler engellenmelidir.

Okuyucu ile İlişkiler

Editör, derginin hitap ettiği okuyucu kitlesinin ihtiyaç duyduğu beklentileri karşılamaya yönelik kararlar vermelidir. Yayınlanacak çalışmaların akademinin her türlü kademesine (okuyucu, araştırmacı) ve literatüre katkı sağlayacak özgün çalışmalar olmasına dikkat etmelidir. Okuyuculardan ve akademik camiadan gelecek geri bildirimleri dikkate almalı ve açıklayıcı geri bildirimlerde bulunmalıdır.

Yayın Kurulu ile İlişkiler

Editör, yayın kurulunda bulunan üyelerin, ilgili politika ve yönergelere uyumlu şekilde çalışması adına sorumludur. Bu politikalar kapsamında ilgili üyeler bilgilendirilmeli ve gelişmelerden haberdar edilmelidir. Yeni üyelere gerekli eğitim ve bilgilendirme sağlanmalıdır.

Dergi Sahibi ve Yayıncı ile İlişkiler

Akademik etik kuralları çerçevesinde, editör ile yayıncı bağımsızlık sözleşmesi imzalamaktadır. Yani editörler alacakları kararlarda yayıncı ve dergi sahibinden bağımsızdır.

Kişisel Verilerin Korunması

Dergi editörü, dergide yayımlanan çalışmalarda bulunan tüm bilgilerin, deneklerin ve görsellerin korunmasını sağlamakla sorumludur. Çalışmada eğer varsa denek olarak kullanılan bireylerin izinleri belgelendirilmediği sürece çalışmayı reddetmelidir. Ayrıca dergi editörü, yayın sürecinde bulunan herkesin (yazar, hakem ve okuyucu) bireysel verilerini korumakla sorumludur.

Etik Kurul, İnsan ve Hayvan Hakları

Editör, çalışma kapsamında genel anlamda insan ve hayvan haklarının korunmasını sağlamalıdır. Çalışma deneylerinde kullanılan verilere ve deneklere ve araştırmalara ilişkin gerekli izinlerin ve etik kurul raporlarının kontrolünü yapmakla mesuldür.

Olası Suiistimal ve Görevi Kötüye Kullanmaya Karşı Önlem

Suiistimal ve görevi kötüye kullanma hallerine karşı tedbir almak editörün görevidir. Bu konuyla ilgili şikayetlerin tespit edilmesi ve değerlendirilmesi noktasında titiz bir çalışma yürüten editör, ilgili bulguları paylaşmalı ve akademik etik ortamının devam etmesini sağlamalıdır.

Fikri Mülkiyet Haklarının Korunması

Dergi editörü, tüm çalışmaların fikri mülkiyet haklarını korumakla ve akademik etik ihlallerinde ve diğer olumsuzluklarda derginin, yazarların, hakemlerin haklarını savunmakla yükümlüdür. Ayrıca dergi editörü dergide yayımlanan çalışmaların intihal sonucu başka bir akademik çalışmanın fikri mülkiyetini ihlal edip etmediği yönündeki teyidi yapmalı ve gerekli önlemi almalıdır. Bu tedbirlerin başında değerlendirme sürecinde yazardan çalışmasıyla birlikte makalenin intihal raporu da talep edilmektedir.

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Editorial Ethics and Responsibilities

Publication Ethics and Responsibilities The publication process of our journal requires everyone involved (authors, referees, editors) to comply with academic ethical principles and standards. In this context, it is assumed that all academicians involved in the process accept the following responsibilities. While determining the responsibilities expressed in this context, the rules and responsibilities specified by the Committee on Publication Ethics (COPE), which regulates open access rules, were used.

Ethical Responsibilities of Authors

The author(s) must be original in all their academic works. If they benefit from other academic studies in their studies, they are required to give full reference and/or citation. Persons who do not contribute to the study should not be included as authors. Researchers cannot submit their work to more than one publication at the same time. Each submission process must be made following the conclusion of the previous application. A study published in another medium should not be sent to our journal. In case the submitted works contain content, situations and relationships that will constitute a conflict of interest, information should be provided. Authors should be ready to present the raw data and experimental information of the study to the editorial board and scientific committee, if requested. It is not possible to add an author, change the order or remove an author for a work whose evaluation process has been started. Author(s) should have documents showing that the data they use in their studies (if any) have ethical rights, usage rights, and necessary permissions for research/analysis/experiment. Author(s) should inform the journal editor or journal publisher and cooperate in correction or retraction if they notice an error in their review, early view stage or published work.

Ethical Duties and Responsibilities of Editors

As stated by COPE, which ensures the integrity of open access rules clearly stated on the Dergipark page; To ensure continuity in the development of the journal, to carry out the steps to increase the quality of academic studies published in the journal, to work towards the needs of readers and authors, to communicate openly and transparently in matters that require correction or explanation, to continue all business processes without compromising intellectual property rights and academic ethical rules. are the main ethical duties and responsibilities of the editor.

Ethical Responsibilities of Referees

A referee should evaluate academic studies in his field of expertise. It should be impartial and confidential in its evaluations. Within the scope of these principles, the evaluation results of the studies should not be shared with the public at the end of the process and should be destroyed. If a conflict of interest is detected as a result of its evaluation, the relevant editor should be informed and the review process of the study should be rejected. The result of the refereeing evaluation should be conveyed in a constructive and polite manner, and negative and personal communication style containing hostility, slander or insult should not be used. He/she should evaluate the studies accepted as referees within the promised time and within the framework of the specified academic ethical rules and communicate the result.

Ethical Responsibilities of Publisher

Our journal makes the editors responsible for all the works included in the process. The editor carries out the necessary measures to prevent political or economic gains from the work done in the journal. Our journal is committed to independence in the creation of editorial decisions. Our journal undertakes to protect the intellectual property and copyrights of all accepted works. The responsibility of the editors to take the necessary precautions regarding academic misconduct and plagiarism related to the process is also under the commitment of our journal.

Relations with Authors

In the articles sent by the authors, the editors make a positive or negative decision by evaluating the originality of the study, the clarity of the narrative, and the suitability of the journal's purpose-scope. In this context, all studies that do not pose a serious problem are included in the evaluation process. Editors should consider referee suggestions. Editors should not change the decisions made by previous editors about the studies unless a major problem in terms of ethics and scope is detected.

Relations with Referees

Blind Review and Review Process policies should be meticulously followed by the editor. Reviewers should be selected according to the field of expertise of the relevant publication. All information about the publication and the process should be shared openly with the referees. It is the editor's responsibility to determine whether there is a conflict of interest between the author and the referee. With the start of the evaluation process, the identities of the referees should be kept confidential. Editors should encourage referees for impartiality, scientificity and objectivity. Care should be taken to keep the referee pools wide. Practices and policies should be pursued to increase the performance of referees in the evaluation process. Processes that are far from being scientific and academic ethical rules should be prevented.

Relations with the Readers

The editor must make decisions to meet the expectations of the audience the magazine addresses. Care should be taken that the studies to be published are original studies that will contribute to all levels of the academy (readers, researchers) and the literature. It should take into account the feedback from the readers and the academic community and provide explanatory feedback.

Relations with the Editorial Board

The editor is responsible for the members of the editorial board to work in compliance with the relevant policies and guidelines. Within the scope of these policies, the relevant members should be informed and informed about the developments. New members should be provided with the necessary training and information. Relations with Journal Owner and Publisher Within the framework of academic ethical rules, the editor and the publisher sign an independence agreement. In other words, editors are independent of the publisher and journal owner in their decisions.

Relations with Owner of Journal and the Publisher

Within the framework of academic ethical rules, the editor and the publisher sign an independence agreement. In other words, editors are independent of the publisher and journal owner in their decisions.

Protection of Personal Data

The journal editor is responsible for ensuring that all information, subjects and images found in the studies published in the journal are protected. Individuals used as subjects in the study, if any, should refuse to work unless their consent is documented. In addition, the journal editor is responsible for protecting the individual data of everyone involved in the publication process (author, referee and reader).

Ethics Committee, Human and Animal Rights

The editor should ensure the protection of human and animal rights in general within the scope of the work. It is responsible for controlling the necessary permissions and ethics committee reports regarding the data and subjects used in the study experiments and research.

Precaution against Potential Abuse and Abuse

It is the editor's duty to take precautions against abuse and misconduct. The editor, who carries out a meticulous work in detecting and evaluating complaints about this subject, should share the relevant findings and ensure the continuation of the academic ethical environment.

Protection of Intellectual Property Rights

The editor of the journal is responsible for protecting the intellectual property rights of all studies and defending the rights of the journal, authors and referees in case of violations of academic ethics and other negativities. In addition, the journal editor should confirm whether the studies published in the journal violate the intellectual property of another academic work as a result of plagiarism and take the necessary action. At the beginning of these measures, the plagiarism report of the article is requested from the author along with his/her work during the evaluation process.

NOTE: If you encounter a situation that does not comply with academic ethics in our journal, please contact us immediately via muhmimdergi@alparslan.edu.tr .

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Araştırma Makalesi/Research Article

Nutritional Problems and Interventions Occurring in Earthquake

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Abstract

Earthquakes are among the natural disasters that occur frequently in many countries. Natural disasters have a negative impact on people's physical and mental health. As with other disasters, the first priority for earthquakes is nutrition. It is critical that clean water and safe food are delivered to earthquake victims as soon as possible after the earthquake. At the same time, people's energy, protein, and vitamin needs should be met with the food that is delivered. Infants, pregnant women, and the elderly are among the priority groups for post-earthquake food supply. It is also of great importance that there are people belonging to special nutrition groups among the earthquake victims. Experts must participate in meeting water and food needs to avoid various problems. Prepared contingency plans should address nutritional needs more comprehensively by considering priority and special groups, and nutritional interventions should be identified in advance. In this study, the nutritional problems that occurred after the earthquakes in the world and in our country were identified and nutritional intervention studies were examined.

Keywords: Earthquake, Nutritional Needs, Health, Safe Food

Depremlerde Ortaya Çıkan Beslenme Sorunları ve Müdahaleleri

Özet

Deprem, Dünya'nın birçok ülkesinde sıklıkla karşılaşılan doğal afetlerden biridir. Doğal afetler insanların fiziksel ve ruhsal sağlığını olumsuz bir şekilde etkilemektedir. Yaşanan diğer afetlerde olduğu gibi depremde de beslenme ihtiyacı ilk sırada yer almaktadır. Depremin ardından depremzedelere kısa bir süre içerisinde temiz su ve güvenli gıdanın ulaşması hayati önem taşımaktadır. Aynı zamanda ulaştırılan gıda ile bireylerin enerji, protein ve vitamin ihtiyacı da karşılanıyor olmalıdır. Bebekler, hamileler ve yaşlılar deprem sonrasında gıda desteğinin sağlanmasında öncelikli grupta yer almaktadırlar. Ayrıca depremzedeler arasında özel beslenme gruplarında bulunan bireylerin olması da büyük bir önem arz etmektedir. Su ve gıda ihtiyacının giderilmesinde konunun uzmanlarının görev alması yaşanacak çeşitli problemlerin önlenmesi açısından oldukça önemlidir. Hazırlanan acil durum eylem planlarında beslenme ihtiyacının öncelikli ve özel gruplar düşünülerek daha kapsamlı bir şekilde ele alınması ve beslenme müdahalelerinin önceden belirlenmesi gerekmektedir. Bu çalışmada dünyada ve ülkemizde yaşanan depremler sonrasında ortaya çıkan beslenme sorunları ortaya konulmuş ve beslenme müdahalesi konusunda yapılan çalışmalar incelenmiştir.

Anahtar kelimeler: Deprem, Beslenme İhtiyacı, Sağlık, Güvenli Gıda

1. INTRODUCTION

Natural disasters, which cause deaths, injuries, destruction of habitats and failure to meet basic needs such as food and water, have a significant impact on human life. Particularly, sudden events such as earthquakes, fires, avalanches, floods, etc., disrupt people's normal routines and daily activities. According to statistical studies, earthquakes rank first among natural disasters in terms of their impact and risks [1]. Damage to food resources and food systems after natural disasters and the negative consequences of these damages on people's livelihoods are a significant threat to food security. The consequences of natural disasters can last for a long time. The impairment of infrastructure affecting people's livelihoods, including livestock, agricultural activities, lands, and transportation routes, weakens food security [2].

Individuals are directly injured or lose their lives as a result of natural disasters. Moreover, survivors facing challenges such as severe stress, lack of sleep, difficulties in accessing medical assistance and medication, and malnutrition are at risk of diseases such as hypertension and diabetes. Hence, there is a tendency for fatal or non-fatal cardiovascular diseases to emerge after disasters [3].

The emergence of nutrition-related issues after disasters is influenced not only by short-term food shortages, but also by imbalanced and inadequate nutrition in the long run. Efforts are made to supply the food and water needs through various relief organizations reaching the affected areas. However, the establishment of temporary shelters post-disaster may not always ensure adequate and balanced nutrition, particularly affecting children, the elderly, pregnant women, and individuals in special dietary groups [4,5]. The composition of meals in emergency shelters indicates malnutrition, with excess carbohydrates and low levels of protein, fibre, vitamins and minerals. Improving the quality of meals in temporary shelters has been shown to reduce the incidence of diseases and disaster-related deaths [6]. Studies reveal both positive and negative relationships between nutrition and cardiovascular diseases [7,8]. After the disaster, problems related to nutrition must be solved quickly and arrangements such as food storage for special diets must be made in advance.

2. NUTRITION-RELATED HEALTH PROBLEMS OCCURRING AFTER the EARTHQUAKE

Following devastating earthquakes that have occurred in many countries around the world and at different times, it can be challenging for individuals who have survived the rubble and lost their homes to access food. Additionally, this situation leads to deficiencies in food hygiene and directly causes health problems. After the 2010 earthquake in Haiti, one of the poorest countries in the world, numerous health problems such as cholera, malnutrition, poisoning, anxiety, and depression emerged [9]. Consuming ready-made foods with high energy value can be beneficial in preventing malnutrition [10].

After an earthquake, the storage conditions of food become more challenging, leading to an increase in food poisoning cases. Necessary precautions should be taken in the storage of perishable foods such as milk and dairy products. Consumption of spoilt and contaminated foods can lead to serious health problems. This situation results in a high number of food poisoning cases being admitted to hospitals [11]. Canned foods, especially those preferred immediately after disasters, should be constantly monitored. Canned foods whose packaging integrity is compromised, opened or damaged should never be used. Foods that require a cold chain must be maintained at specific temperatures during transportation and storage. To avoid cross-contamination, great attention should be paid to the hygiene of equipment and personnel. Cleaning procedures should be planned in detail. In this way, food safety can be ensured [12].

The contamination of water sources after an earthquake can lead to the spread of diarrheal diseases. This situation poses a serious public health issue, particularly in areas with inadequate hygiene conditions. Research indicates an increase in the frequency of diarrheal diseases after an earthquake, which can lead to potentially fatal situations [13]. In Nepal, following the 7.8 magnitude earthquake in 2015, damage to the water supply systems made it difficult to access clean drinking water, leading to an increase in malnutrition rates among children [14].

After natural disasters, children become more vulnerable to infectious diseases due to various factors. Factors such as infrastructure damage, changes in environmental conditions, contamination of water and food sources, difficulty in accessing clean water and food, inadequate waste control, disruption or restriction of access to health services, negatively impact the immune system of children. The risk of diseases that can be prevented by vaccination, particularly, increases. Children may have to live in crowded living conditions for extended periods, and inadequate personal hygiene also increases the risk of spreading infectious diseases. Additionally, factors such as lack of information after a disaster, inadequate animal and vector control, delayed burial procedures, and unhealthy preservation of bodies also contribute to the increase in infectious diseases. The disruption of established systems after a disaster, loss of the living environment, and hindrance of healthy development lead to children becoming more fragile and hopeless individuals in the future [15].

The extreme shock removed during natural disasters such as earthquakes adversely affects the growth and development of children. A study reported that children affected by the earthquake in India in 2001 were 5-9 cm shorter than their peers who were not affected by the earthquake [14]. Another study, which observed the nutritional status of children living in temporary shelters after the earthquake for 2 years, demonstrated the necessity of providing nutritional support as well as psychosocial support to ensure normal growth of children and to mitigate the long-term effects of the earthquake, in addition to providing psychosocial support [16]. Bhadra (2015) advocates the use of school-community-based strategies for the protection of children [17].

After the Wenchuan (China) earthquake in 2008, a study found that women in the earthquake-affected areas increased their consumption of ready-to-eat foods, stockpiled food, and experienced nutritional disorders. In a study conducted two years after the earthquake, it was found that the number of breastfed children decreased and 90% of children did not receive nutritional supplements despite being malnourished. The rate of anemia among children affected by the earthquake increased from 36.5% immediately after the earthquake to 67.5% after two years [18].

Following the earthquake in Japan in 2011, which caused a tsunami and a nuclear disaster with a magnitude of 9.0, it was found that the levels of sodium and vitamin deficiencies increased among individuals in temporary shelters [19]. Other studies conducted after the Japan earthquake reported a significant increase in the frequency of cardiovascular diseases in the past three years compared to other disaster areas [20,21].

3. NUTRITION IN EARTHQUAKE EMERGENCY PLANS

According to the Turkish Disaster Response Plan, which systematically plans intervention at national and local levels, the responsibility for nutrition services in disasters is assigned to the Türk Kızılay. The Ministry of Environment, Urbanization and Climate Change, the Ministry of Health, the Ministry of Agriculture and Forestry, and the Ministry of Interior provide support to the Türk Kızılay at the national level for nutrition services. The local organizations of these institutions, civil society organizations, the private sector, and municipalities are the units with which the Türk Kızılay collaborates at the local level [22].

The nutrition plan for disasters is designed according to the first 72 hours following the disaster, also known as the golden hours, and the period after 72 hours. Nutrition activities carried out in the 0-72 hour period in the disaster area are considered early-phase nutrition services [23]. It is important to provide easily accessible, non-perishable, easy-to-consume, and durable foods during the golden hours (0-72 hours). During this time, emergency nutrition kits are distributed to individuals, consisting of 1 packet of 0.25 ml water, 1 sweet biscuit, and 1 packet of 200 ml fruit juice. The aim of nutrition services in disasters is to provide foods with high nutritional value and energy to individuals. Nutrition services, initially carried out using serving vehicles, are continued with mobile ovens, mobile kitchens, and kitchen kits depending on the scale of the incident [24].

Nutrition services conducted after the golden hours encompass long-term nutrition services. Following early-phase nutrition services, distribution of hot meal sets and dry foods to disaster-affected families should be planned. Under long-term nutrition services, a food package should be prepared to meet the average 7-day nutritional needs of a family of 5 [25].

4. NUTRITIONAL PROBLEMS AND INTERVENTIONS AFTER THE EARTHQUAKE

Interventions after disasters are categorized as acute, mid-term, and long-term. In the acute period, meeting the basic needs of the disaster victims such as nutrition, shelter, reaching their relatives, accessing medical treatment if necessary, and ensuring their safety and well-being is considered one of the most important and prioritized psychosocial interventions. The interventions conducted immediately after the disaster belong to the acute period. Mid-term and long-term psychosocial services include psycho-education and empowerment programs, while long-term interventions involve specialized mental health professionals focusing on the individual and the event. The acute period is the period when the basic and safety needs are attempted to be met immediately after the disaster (between 1-3 weeks). In the acute period, besides meeting the basic needs (nutrition, shelter, etc.) of individuals exposed to traumatic events, the aim is to instill a sense of safety and hope. The importance of support in the acute period is highlighted during this period when these feelings are intensely experienced. The goal in this period is to provide appropriate, flexible, and basic assistance considering the symptoms. During acute period, it is possible to observe the difficulties of individuals affected by the disaster by carefully observing the environment and determine an appropriate intervention method based on these observations [26].

The Ministry of Interior Disaster and Emergency Management Presidency (AFAD) has published the Turkish Disaster Response Plan (TAMP), which explains the national and local level intervention system. TAMP has stated that effective intervention management consists of three stages: preparation, intervention, and pre-recovery. The intervention levels are divided into four groups based on the degree of impact. The levels, named S1-S4, determine the impact and specify the groups that will provide support based on the type and scale of the event. AFAD manages the entire process [10]. Within the scope of TAMP, nutrition services have been determined considering individuals with special nutritional needs such as infants, children, pregnant women, patients, etc., based on ensuring the adequate food intake level of earthquake victims. During the early hours of disasters, the Provincial and District Disaster and Emergency Management Centers are responsible for meeting the early and long-term nutritional needs [23].

Turkey, home to some of the world's most important fault lines, is experiencing severe earthquakes. Encountering nutrition problems during earthquakes has highlighted the need to create emergency action plans. Especially after the Marmara earthquake on August 17, 1999, studies have gained momentum. Following the earthquake in Van on 23 October 2011, Türk Kızılay and various organisations established 13 tent cities to meet the food and shelter needs of the people and provided social service support after the earthquake response process, which proved to be an improvement compared to the Marmara earthquake [10].

Various interventions have been made to address nutrition problems that arise after earthquakes in many parts of the world. 'Child Nutrition Week', which was activated after the 7.8 magnitude earthquake in Nepal, created an effective platform by delivering basic nutrition services packages to children and mothers in the earthquake-affected areas. Positive progress has been recorded between measurements made between two periods as a result of the measures and incentives taken. Pregnant women's iron and folic acid needs have been met with many nutritional supplements [10].

After the Great Japan Earthquake in 2011, researchers observed that earthquake survivors changed their dietary habits by consuming unhealthy, high-salt foods. Therefore, the Japanese government aimed to change and socialize these habits by creating cooking classes for earthquake survivors with the slogan "Eat Well, Live Well." It has been shown that these classes have improved the mental and physical health of the survivors [27].

During the 2017 Iran Earthquake, various nutrition interventions were implemented within the first 10 days, including rapid assessment of the nutrition status of children and breastfeeding mothers, providing specific nutrition support for diabetic and hypertensive patients, and supplying vitamin A, vitamin D, calcium, iron supplements, and multivitamins for children under 2 years of age. There was a serious shortage of nutrition experts in the region following the earthquake [28].

After the earthquake in Northern Pakistan in 2005, food supplementation was provided to prevent acute malnutrition in children under 5 years of age [29].

In a study conducted by Yolcu (2020), a comparison was carried out between the earthquakes in Chile (2019) and Elazığ (2020). Differences in disaster risk and crisis management application methods were observed in both earthquakes. It was found that Chile has made significant progress in earthquake preparedness, while Türkiye has been reported to have weaker interventions. Despite all legal regulations, it has been suggested that the societal and institutional approach to earthquake preparedness, intervention after the earthquake, and recovery efforts weaken earthquake culture and its achievements. It has been stated that this situation negatively affects the distribution of the country's economy and the budget allocated to regional investments, as observed in the aftermath of the Elazığ earthquake [30].

In the Kahramanmaraş earthquake that occurred in Türkiye on February 6, 2023, in addition to the inability to reach the region in time, an important problem related to nutrition was the inability to deliver food aid to villages and settlements that were far from the center because the roads were closed. Effective planning of logistical activities plays a crucial role in reaching the needed areas quickly. In addition, it is of great importance to manage the volunteers contributing to food aid on the ground from a single center and to identify the need for food and water by establishing a communication network to accurately and effectively deliver aid to hard-to-reach areas. It has also demonstrated the power of the internet and social media to ensure communication. In this way, it was reported where and what was needed in the earthquake area, and those who wanted to help organized and sent their aid [31].

Following earthquakes, a significant increase in malnutrition and various vitamin and micronutrient deficiencies is observed, especially in women and children. Vitamin content is insufficient, particularly due to excessive grain consumption in many diets. Multivitamin tablet supplements, along with main and side dishes, can play an important role in meeting the vitamin and mineral needs of earthquake victims to achieve optimal health quickly and effectively. Therefore, nutritional supplement programs need to be included in disaster

management plans. However, it is important not to overlook symptoms related to Crush syndrome when developing intervention plans [31].

5. CONCLUSION

The measures taken by states in response to earthquakes play a crucial role in saving many lives. Precautions before and after earthquakes should include considerations for food and nutrition, in addition to shelter and emergency response. The research underscores the importance of taking measures to prevent anemia, malnutrition, growth retardation in children, cardiovascular disease, and gastrointestinal problems resulting from nutritional deficiencies after earthquakes. Particular attention should be paid to people with special health needs before earthquakes, such as diabetics, pregnant women, and children, to mitigate the risks. Sound strategies must be developed to protect against potential disruptions in the food supply chain after earthquakes or other emergencies, and systems should be put in place in advance. To effectively manage earthquakes and similar emergencies, it is important to plan and implement processes such as storing non-perishable, easy-to-prepare food, prioritizing food hygiene and sanitation to prevent contamination of water and food, and coordinating the food supply chain. It is also necessary to determine the nutritional needs of specific groups and to train those responsible for post-earthquake nutrition accordingly. Comprehensive and realistic solutions outlined in emergency plans are of great importance for the well-being of people who survive disasters.

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REFERENCES

1. Khosravi B., XosravinT., Ziapour A., Fattahi E., Chaboksavar F., Yoosefi Lebni J. Challenges and problems facing 2017 kermanshah earthquake survivors: a qualitative study, Community Mental Health Journal, 57 340-348, 2021.
2. Ainehvand S., Raeissi P., Ravaghi H., Maleki M. Natural disasters and challenges toward achieving food security response in Iran, Journal of education and health promotion, 8, 2019.
3. Ohira T., Nakano H., Nagai M., Yumiya Y., Zhang W., Uemura M., Sakai A., Hashimoto S. Changes in cardiovascular risk factors after the Great East Japan Earthquake, Asia Pacific Journal of Public Health, 29 47s-55s, 2017.
4. Etiler N. Afetlerde Sık Karşılaşılan Sorunlar, İstanbul Tıp Kitabevi, 1-15, 2012.
5. Tsuboyama-Kasaoka N., Purba M. B. Nutrition and earthquakes: experience and recommendations. Asia Pacific Journal of Clinical Nutrition, 23 505-513, 2014.
6. Miyagawa N., Tsuboyama-Kasaoka N., Harada M., Nishi N. A review of factors associated with nutritional problems and improvement initiatives after natural disasters, The Japanese Journal of Nutrition and Dietetics, 78 S111-S120, 2020.
7. He F. J., Nowson C. A., Lucas M., MacGregor G. A. Increased consumption of fruit and vegetables is related to a reduced risk of coronary heart disease: meta-analysis of cohort studies, Journal of Human Hypertension, 21 717-728, 2007.
8. Hooper L., Martin N., Jimoh O. F., Kirk C., Foster E., Abdelhamid A. S. Reduction in saturated fat intake for cardiovascular disease, Cochrane Database of Systematic Reviews, 8 CD011737, 2020.
9. Dube A., Moffatt M., Davison C., Bartels S. Health outcomes for children in Haiti since the 2010 earthquake: a systematic review. Prehospital and Disaster Medicine, 33 77-88, 2018.
10. Özcan F. Ö., Duru, Ö. A. Doğal afetlerde gıda ihtiyaç durumunun değerlendirilmesi ve beslenme müdahaleleri: deprem örnekleri açısından incelenmesi. Sağlık Akademisyenleri Dergisi, 8 337-341, 2021.
11. Kirk M. D., Pires S. M., Black R. E., Caipo M., Crump J. A., Devleesschauwer B., Döpfer D., Fazil A., Fischer-Walker C. L., Hald T., Hall A. J., Keddy K. H., Lake R. J., Lanata C. F., Torgerson P. R., Havelaar A. H., Angulo F. J. World Health Organization estimates of the global and regional disease burden of 22 foodborne bacterial, protozoal, and viral diseases, 2010: a data synthesis. Plos Medicine, 12 e1001921, 2015.
12. Aldemir T. Doğal afetler sonrası afetzedelerin beslenmesi: 2023 Kahramanmaraş depremi örneği, Avrasya Sosyal ve Ekonomi Araştırmaları Dergisi, 10 686-701, 2023.
13. Guha-Sapir D., Hoyois P., Wallemacq P., Below R. Annual disaster statistical review 2016. The Numbers and Trends, 1-91, 2017.

14. Shrestha S., Thorne-Lyman A. L., Manohar S., Shrestha B., Neupane S., Rajbhandary R., Shrestha R., Klemm R. D. W., Nonyane B. A. S., Adhikari R. K., Webb P., West K. P. Pre-earthquake national patterns of preschool child undernutrition and household food insecurity in Nepal in 2013 and 2014. Asia Pacific journal of Clinical Nutrition, 27 2018.

15. Karabulut D., Bekler T. Doğal afetlerin çocuklar ve ergenler üzerindeki etkileri, Doğal Afetler ve Çevre Dergisi, 5 368-376, 2019.

16. Dhoubhadel B. G., Raya G. B., Shrestha D., Shrestha R. K., Dhungel Y., Suzuki M., Yasunami M., Smith C., Ariyoshi K., Parry C. M. Changes in nutritional status of children who lived in temporary shelters in Bhaktapur municipality after the 2015 Nepal earthquake. Tropical Medicine and Health, 48 2020.

17. Bhadra S. Psychosocial support for protection of children in disasters, In: Deb S. (eds), Child Safety, Welfare and Well-being, Springer, 453-482, 2022.

18. Hu P., Han L. L., Hou F. G., Xu X. L., Sharma M., Zhao Y. Dietary attitudes and behaviours of women in China after the 2008 Wenchuan earthquake in three seismically different zones. Asia Pacific Journal of Clinical Nutrition, 25 849-857, 2016.

19. Güden R. A., Borlu A. Afetlerde toplum beslenmesi ve hassas gruplara yönelik beslenme planı. Food and Health, 9 61-68, 2023.

20. Aoki T., Fukumoto Y., Yasuda S., Sakata Y., Ito K., Takahashi S. M., Tsuji I., Shimokawa H. The great east japan earthquake disaster and cardiovascular diseases, European Heart Journal, 33 2796-2803, 2012.

21. Omama S., Yoshida Y., Ogasawara K., Ogawa A., Ishibashi Y., Nakamura M., Tanno K., Ohsawa M., Onoda T., Itai K., Sakata K. Influence of the great East Japan earthquake and tsunami 2011 on occurrence of cerebrovascular diseases in Iwate, Japan, Stroke, 44 1518-1524, 2013.

22. AFAD. TAMP Türkiye Afet Müdahale Planı.

23. Türk Kızılayı. Afetlerde Beslenme Akreditasyonu, 2021.

24. Oral İ., Bozbey M. M., Özcan G. G., Özdemir A., Güler A., Coşar A. E., Aslan S., Soylu F., Hatipoğlu Ç. Türk Kızılayı Beslenme Hizmet Modeli. Öztürk İ., Koçak Ç. (Eds.), Türk Kızılayı Beslenme Hizmetleri Klavuzu, Ankara, 29-54, 2017.

25. Doğru S., Ede G. Afet durumlarında besin ve beslenme desteğinin planlaması. Sağlık Bilimlerinde Güncel Yaklaşımlar, 1 25-34, 2020.

26. Aydın M. Deprem özelinde afetleri ve kitlesel travmayı anlamak. Türk Nöroşirürji Dergisi 33 165-169, 2023.

27. Tashiro A., Sakisaka K., Kinoshita Y., Sato K., Hamanaka S., Fukuda Y. Motivation for and effect of cooking class participation: a cross-sectional study following the 2011 Great East Japan Earthquake and Tsunami, International Journal of Environmental Research and Public Health, 17 7869, 2020.

28. Peyravi M., Ahmadi Marzaleh M., Khorram-Manesh A. An overview of the strengths and challenges related to health on the first 10 days after the large earthquake in the west of Iran, 2017. Iranian Journal of Public Health, 48 963-970, 2019.

29. Hossain S. M. M., Maggio D. M., Sullivan K. M. Relationship between food aid and acute malnutrition following an earthquake, Food and Nutrition Bulletin, 30 336-339, 2009.

30. Yolcu M., Bekler T. Deprem kültürü ve farkındalık çalışmaları: Şili ve Elazığ depremlerinin karşılaştırılması, Lapseki Meslek Yüksekokulu Uygulamalı Araştırmalar Dergisi, 1 71-82, 2020.

31. Turgut R., Yenigün A., Mutlu H., Günalan E. Depremzedelerin optimal sağlığı için besinsel takviyelerin önemi. Kahramanmaraş merkezli depremler sonrası için akademik öneriler, 617-624, 2023.

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Araştırma Makalesi/Research Article

Static Analysis and Cost Estimation of Reinforced Concrete Buildings Created Using Different Soil Parameters According to TEC 2007 and TBEC 2018

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Abstract

After every earthquake in our country, there is a significant loss of life and property. The changes in seismic regulations aim to minimize these losses. This study focuses on the differences between the current TBEC 2018 and TEC 2007 seismic codes. Analyzing a five-story reinforced concrete building using the IdeCAD structural analysis computer program, designed according to TEC 2007 and TBEC 2018 seismic regulations, forms the basis of this study. By altering soil and seismic parameters on the designed five-story reinforced concrete building, various analyses were conducted. The results of the analyses, depicted in graphs and tables, illustrate how the cost varies between TBEC 2018 and TEC 2007 seismic regulations based on the derived quantities. Upon examination of the results, it is evident that, overall, TBEC 2018 incurs higher costs, utilizes more reinforcement, and places greater emphasis on soil classes compared to TEC 2007. Furthermore, it is concluded that the new Turkey earthquake hazard mapearthquake hazard map provides more accurate results in determining earthquake zones. TBEC 2018 is observed to be more comprehensive in all aspects and to stand on the safer side.

Keywords: Earthquake Zone, Earthquake-Soil Relationship, Cost Calculation, TBEC 2018, TEC 2007, Soil Classes

Farklı Zemin Parametreleri Kullanılarak Oluşturulan Betonarme Binaların TEC 2007 ve TBEC 2018'e Göre Statik Analizi ve Maliyet Hesaplaması

Özet

Her deprem sonrası ülkemizde birçok can ve mal kaybı meydana gelmektedir. Deprem yönetmeliklerinin değişimi ile bu can ve mal kaybı en aza indirilmeye çalışılmaktadır. Günümüzde kullanılmakta olan TBEC 2018 ile TEC 2007 arasında oluşan farklılıklar bu çalışmada ele alınmıştır. Bu çalışmayla İdeCAD statik analiz bilgisayar programında TEC 2007 ve TBEC 2018 deprem yönetmeliklerine gore hazırlanan beş katlı betonarme bir binada analiz yapılmıştır. Tasarımı yapılan 5 katlı betonarme bina üzerinde zemin ve deprem parametreleri değiştirilerek analizler yapılmıştır. Analiz sonuçlarından çıkan metrajlar doğrultusunda TBEC 2018 ile TEC 2007 deprem yönetmeliklerinde maliyetin ne kadar değiştiği grafik ve tablolarla gösterilmiştir. Sonuçlara bakıldığında genel olarak bütün analizlerde TBEC 2018'de maliyetin daha fazla olduğu, donatının daha fazla kullanıldığı, TBEC 2007'de zemin sınıflarına daha az önem verildiği görülmektedir. Ayrıca deprem bölgelerinin belirlenmesinde yeni Türkiye Deprem Haritasının daha net sonuçlar verdiği kanısına varılmıştır. TBEC 2018'in her açıdan daha kapsamlı olduğu ve daha güvenilir tarafta kaldığı gözlemlenmiştir.

Anahtar Kelimeler: Deprem Bölgesi, Deprem-Zemin İlişkisi, Maliyet Hesabı, TBEC 2018, TEC 2007, Zemin

1. INTRODUCTION

Turkey is a seismically active country where seismic movements are prevalent. Consequently, earthquake-resistant construction practices are implemented, and a set of standards is established. These standards, known as earthquake regulations, aim to ensure that the structural support system effectively transfers all horizontal and vertical loads from the top of the structure to the base soil[1]. To achieve this objective, earthquake regulations are formulated, considering the necessary calculations and rules to guarantee the stability, rigidity, and adequate resistance of the structure[1]. The earthquake regulations are founded on theoretical studies and research conducted since their inception, incorporating insights gained from practical applications of existing structures, as well as findings and discussions on what was done incorrectly or correctly[2]. Since their initial development, earthquake regulations have undergone updates in 1947, 1949, 1953, 1961, 1968, 1975, 1997, 2007, and 2018. These revisions have been made in response to the global and national needs, taking into account the experiences gained, investigations conducted, and the discourse on construction practices. Notably, the Italian Construction Instruction for earthquake-prone areas issued in 1940 has also contributed to shaping these regulations (Table 1).

Table 1. Regulations implemented so far in Turkey

Date	Regulatory Name
1940	Italian Building Instruction for construction in the Zelzele districts
1944	Construction Instruction in Zelzele districts
1949	Turkey's Regulation on the Construction of the Territories of earth Struggling
1953	Regulations on the areas of the earth Strap
1961	Regulations on structures to be carried out in disaster areas
1968	Regulations on structures to be carried out in disaster areas
1975	Regulations on structures to be carried out in disaster areas
1997	Regulations on structures to be carried out in disaster areas
2007	Regulations on structures to be carried out in earthquake areas
2018	Turkey Building earthquake Regulation

In the design of earthquake-resistant structures, from the past to the present, the earthquake and superficial soil parameters of the region, along with certain attributes of the construction model, were considered sufficient [3]. However, the damage to buildings resulting from earthquakes has underscored the necessity for more extensive investigation [4]. Studies indicate that dividing a city into regions based on post-earthquake damage can serve as a valuable guide for reconstruction efforts [4]. Rather than waiting for a new devastating earthquake to occur in construction-exposed areas, it is more rational to apply methods developed by addressing existing data, rather than waiting for damage records to be insufficient and creating strategies as was done previously [3]. Earthquakes passing through floorboards can alter the properties of the ground, causing it to soften and lose strength. Hence, one of the crucial steps in determining earthquake characteristics during the design process for any region involves identifying the soil layers in that area and understanding the properties of the floors under repeated tension [5]. Detailed information about the properties of floorplates can be obtained through field and

laboratory experiments. Recordings from vertical measurement networks impact the characteristics of earthquake movement on the floor surface, influencing the properties of the floor layer. The proximity of earthquake records suggests that ground characteristics may vary, even at close distances, due to the interaction between the earthquake source and geotechnical properties [6]. The changes in regulations in Turkey have prompted various studies. In a study titled "Comparing the Iranian Earthquake Regulation with the Turkish Earthquake Regulation," Iran reviewed the earthquake regulations of both countries (2005 and 2007) and highlighted the differences, ultimately concluding that the Turkish earthquake regulation is more comprehensive [7]. Another study, "Review of a Model Structure Sized and Equipped According to the Earthquake Regulation 1997," compared a design based on the earthquake regulations from 2007 with an older regulation dated 1997. The design included two types of models: a symmetrical frame system and a symmetrical curtain frame system[8]. In the study "Comparing TDY 2007 to Eurocode 8 in Terms of Cost in Concrete Buildings," the two regulations were compared regarding design rules using the Sta4-CAD computer program for a 3- and 5-story concrete model. The analysis considered performance targets, design rules, soil conditions, earthquake impact, and cost comparison based on the results [9]. An investigation into the behavior of a concrete building according to old and current design regulations explored principles and developments in regulations issued in 1961, 1968, 1975, 1997, and 2007 in Turkey. Using SAP2000 computer programs for analysis, the study compared the displacement, floor weights, floor vertical carrier concrete, and equipment metals under different regulations [3]. In the study "Proposal for Strengthening a Building According to the 2007 Regulations of a Concrete Structure Made According to the 1998 Earthquake Regulations," performance analysis was conducted according to the 2007 earthquake regulations, and alternative enhancement proposals were made based on the results obtained from the Sta4CAD static analysis computer programs [10]. "The Design and Analysis of a High-Rise Building According to Two Regulations" focused on performance-based design according to the 2007 Turkish earthquake regulations and the Istanbul High Buildings Earthquake Regulation. Linear and nonlinear analyses were conducted, revealing that the carrier elements, curtains, and columns remained elastic, and nonlinear behavior was limited based on the regulations [11].

One of the most critical factors influencing building design is the evolution of earthquake regulations. In Turkey, a total of 10 different regulations have been utilized to date, undergoing revisions or complete transformations over time. When designing a building, it is essential to determine which regulations are currently in effect, understand the rules they encompass, and apply them to the project. The purpose of this article is to address these impactful considerations in building design, specifically focusing on buildings located in earthquake zones identified in 2007. The study further delves into the soil class and soil bed coefficient aspects in a 5-story concrete building according to the 2018 Turkey Building earthquake regulations. The analysis is conducted using a computer program that incorporates soil safety strain and earthquake zone parameters. Additionally, the study aims to compare the costs based on the results obtained from the analysis.

2. MATERIAL AND METHODS

This article aims to establish a 5-story concrete model to examine the variations in metrics and costs in structures resulting from the latest regulatory changes in our country. The models, designed using the IdeCAD static analysis computer program, will be analyzed according to TEC 2007 and TBEC 2018, enabling a comprehensive comparison of changes in the design and analysis phases between the two regulations. Furthermore, the study will involve altering parameters such as soil class, soil bed coefficient, soil safety carrying force, and earthquake zone according to TEC 2007 and TBEC 2018. The program will conduct analyses, and a comparison of construction metrics will be made.

Cost calculations will be based on current prices, utilizing exposure recipes and unit prices available at 2023 prices issued by the Ministry of Environment and Urbanization. Graphics and tables will be used to present the costs according to changing regulations. The study aims to highlight the potential challenges faced by technical personnel in implementing effective earthquake regulations, emphasizing the importance of proper governance to avoid designs that could endanger human life and negatively impact costs. By focusing on the implementation of the 2018 Turkey Building earthquake regulations, effective from January 1, 2019, the study will determine how costs have evolved and attempt to provide insights for the current application of earthquake regulations.

The 5-story concrete building generated by the IdeCAD program comprises frame systems with columns and beams. The analysis is conducted using TBEC 2018 and TEC 2007, wherein the soil bed coefficient and soil carrying force are chosen based on soil classes (refer to Table 2 and Table 3). When determining the floor bed coefficients, the table prepared by Bowles in 1996 is taken into consideration (see Table 4). In TEC 2007, earthquake classes are categorized as 1, 2, 3, and 4. TBEC 2018, on the other hand, conducts seismic assessments based on earthquake zones, which are 1, 2, 3, and 4, as defined in the legislation predating the Turkey earthquake hazard map. Spectrum values are determined by extracting latitude and longitude values corresponding to earthquake zones in degrees. Soil classes based on the two earthquake methods are presented in Table 5 and Table 6.

Table 2. Soil bed coefficients based on the type of soil

Soil Type	K_s (kN/m3)
Loose sand 4800-16000	
Medium-sized sand 9600-80000	
Hard sand 64000-128000	
Clay medium-sized sand 32000-80000	
Medium-sized sand with silo 24000-48000	
Hairy soils:	
qa<200 kPa	12000-24000
200<qa<800 kPa	24000-48000
qa>800 kPa	>48000

Table 3. Soil handling forces linked to the type of soil

Soil Type	qemin (t/m2)
Solid rock	> 100
Hard gravel/hard gravel and sand	> 60
Medium hard gravel/medium hard gravel and sand	20-60
Hard sand	> 30
Medium hard sand	10-30
Loose sand	< 10

Table 4. Soil groups according to the TEC 2007

Soil Assembly	Floor Group Description
(A)	Solid volcanic rocks and solid metamorphic rocks with hard cement Very hard sand, gravel Hard hair and hair with mattress
(B)	Loose volcanic rocks, such as Tuf and aglomera, sedimentary rocks with discontinuous planes Hard sand Very solid hair and hair with mattresses
(C)	Metamorphic rocks and sedimentary rocks with soft discontinuities planes…. Medium hard sand, gravel Solid hair and hair with mattress
(D)	High level of underground water soft, thick layers of aluvation Loose sand Soft hair, silky hair

Table 5. Local soil classes according to the TEC 2007

Local soil Class	Explanation
Z1	(A) assembly soils H1 ≤ 15 m (B) assembly soils
Z2	H1 > 15 m (B) assembly soils H1 ≤ 15 m (C) assembly soils
Z3	15 m < h1 <50 m (C) assembly soils H1 ≤ 10 m (D) assembly soils
Z4	H1 > 50 m (C) assembly soils H1 > 10 m (D) assembly soils

Table 6. Local soil classes according to the TBEC 2018

Local soil Class	Explanation
ZA	Tough, hard rocks
ZB	Low-split, medium-solid rocks
ZC	Very hard sand, gravel and hard clay or very loose, very cracked weak rocks
ZD	Medium hard - hard sand, gravel or multi-ply clay plates
ZE	Loose sand, gravel or soft-solid clay plates, or a layer of soft clay that is thicker than 3 meters in total

In the study, the three-dimensional representation of the 5-story building is depicted in Figure 1. The analysis of the 5-story reinforced building involves mapping ground classes ZA, ZB, ZC, ZD, and ZE in TBEC 2018, and determining bed coefficients based on soil classes Z1, Z2, Z3, Z4 (refer to Table 2), and soil carrying forces (refer to Table 3) in TEC 2007. The analysis considers concrete quantity, mold quantity, and the overall equipment amount, facilitating a cost comparison. Construction details of the 5-story reinforced concrete building are provided in Table 7.

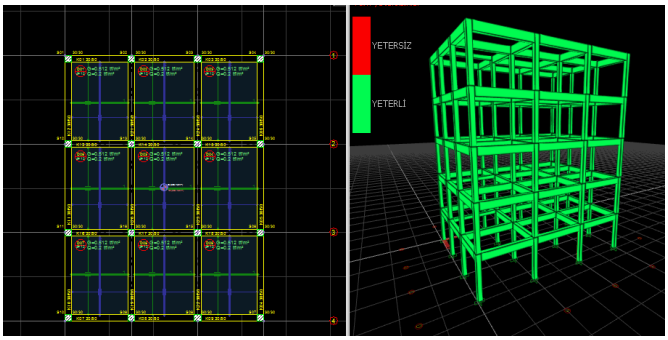

Figure 1. Three-dimensional view of the 5-story reinforced concrete building

Tablo 7. Building features of the 5-storey

Properties	Parameters	Values
Building Properties	Floor height (h)	3 (m)
	Total height (H)	15(m)
	Contruction type	Housing
	Carrier system behavior (R)	8
	Structure importance coefficient (I)	1.0
	Building height class	7
	Earthquake design class (DTS)	1,1a,2,2a
Section Properties	Column dimensions	0,3*0,3m
	Beam dimensions	0,3*0,5m
	Slab thickness	0,12 m
Material Properties	Concrete properties	C30(30 MPa)
	Steel properties	S420(420 MPa)

3. RESULTS AND DISCUSSION

The quantities resulting from the structural analysis of a 5-story reinforced concrete building in the İdeCad program are provided in Figure 2-13.

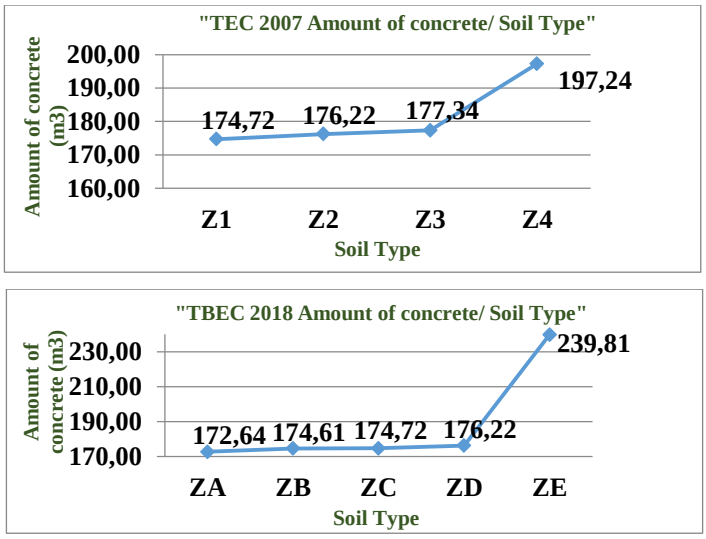

Figure 2. Amount of concrete in the area corresponding to the 1st-degree zone earthquake in TEC 2007

When analyzing the results obtained in the region corresponding to seismic zone 1 according to the TEC 2007, it is observed that as the soil class deteriorates, there is an increase in concrete quantities in both seismic regulations. The most significant difference is observed in the worst soil class.

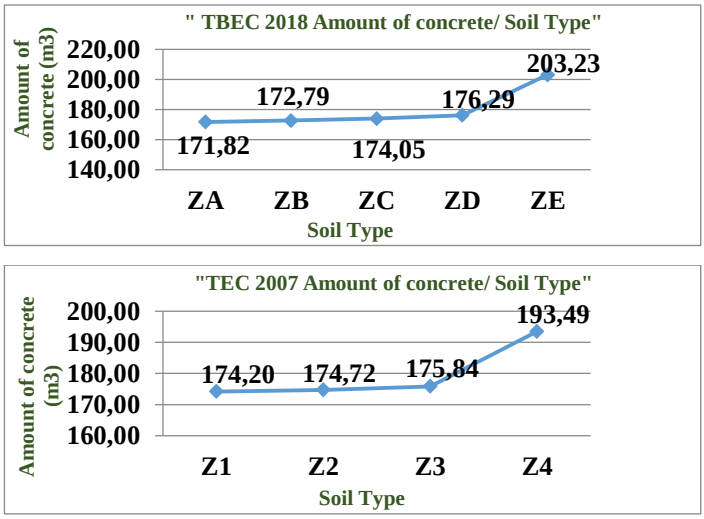

Figure 3. Amount of concrete in the area corresponding to the 2nd-degree earthquake zone in TEC 2007

When analyzing the results obtained in the region corresponding to seismic zone 2 according to the TEC 2007, it is observed that as the soil class deteriorates, there is an increase in concrete quantities in both seismic regulations. The difference between the worst soil classes has decreased compared to the difference in seismic zone 1.

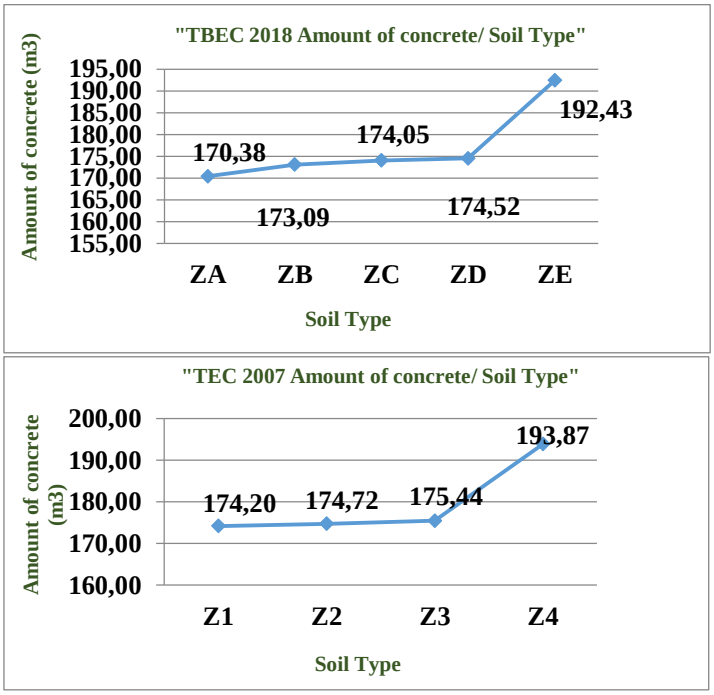

Figure 4. Amount of concrete in the area corresponding to the 3rd-degree earthquake zone in TEC 2007

When analyzing the results obtained in the region corresponding to seismic zone 3 according to the TEC 2007, it is observed that as the soil class deteriorates, there is an increase in concrete quantities in both seismic regulations. However, this increase is not as significant as in seismic zones 1 and 2. When looking at the worst soil classes, almost the same results have been obtained.

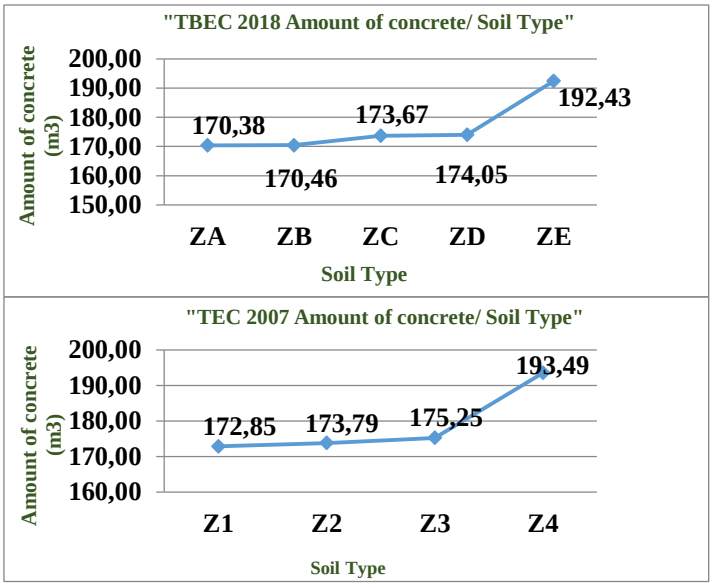

Figure 5. Amount of concrete in the area corresponding to the 4th-degree earthquake zone in TEC 2007

When analyzing the results obtained in the region corresponding to seismic zone 4 according to the TEC 2007, similar outcomes to seismic zone 3 are observed. Comparable results have been obtained in both seismic regulations for areas falling under seismic zones 3 and 4.

The total reinforcement quantity varying according to seismic zones is provided in Figures 6-9.

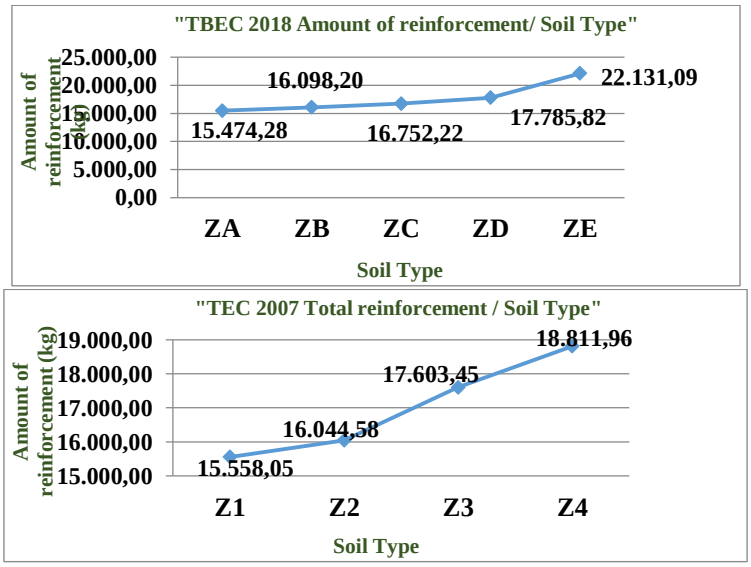

Figure 6. The total reinforcement quantity in the area corresponding to seismic zone 1 according to TEC 2007

As a result of analyses conducted in the region corresponding to seismic zone 1 according to TEC 2007, the total reinforcement quantity has increased as the soil class deteriorates in both seismic regulations. The most significant difference occurred when the soil class was at its worst.

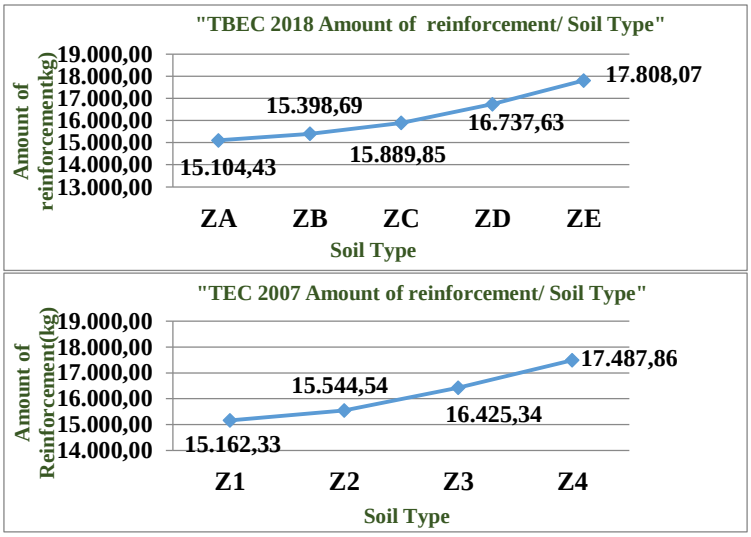

Figure 7. The total reinforcement quantity in the area corresponding to seismic zone 2 according to TEC 2007

As a result of analyses conducted in the region corresponding to seismic zone 2 according to TEC 2007, the total reinforcement quantity has increased as the soil class deteriorates in both seismic regulations. The increase in reinforcement quantity with changing soils is less pronounced compared to seismic zone 1.

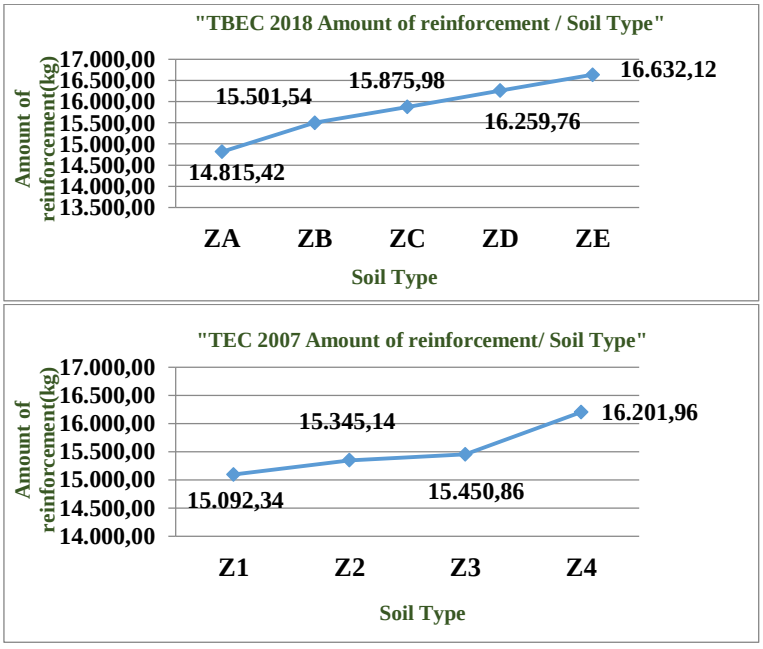

Figure 8. The total reinforcement quantity in the area corresponding to seismic zone 3 according to TEC 2007

As a result of analyses conducted in the region corresponding to seismic zone 3 according to TEC 2007, the total reinforcement quantity has increased as the soil class deteriorates in both seismic regulations. When examining the reinforcement quantity in the best soil classes, it is observed that TEC 2007 uses more reinforcement. However, when looking at the worst soil class, TBEC 2018 utilizes more reinforcement, indicating a greater increase in both concrete and reinforcement quantities with the deterioration of the soil class.

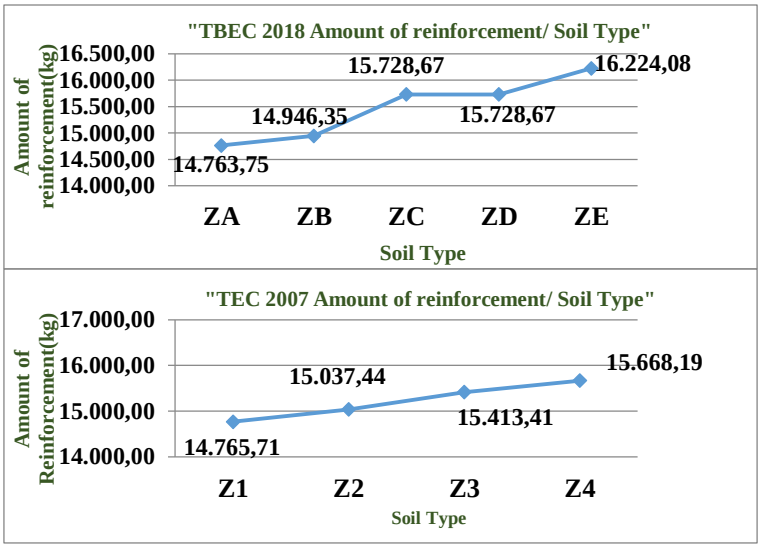

Figure 9. The total reinforcement quantity in the area corresponding to seismic zone 4 according to TEC 2007

As a result of analyses conducted in the region corresponding to seismic zone 4 according to TEC 2007, the total reinforcement quantity has increased as the soil class deteriorates in both seismic regulations. When examining the reinforcement quantity in the best soil classes, similar results are obtained, while looking at the worst soil classes, it is observed that TBEC 2018 uses more reinforcement.

The amount of molding that varies according to earthquake zones is given in Figure 10-13.

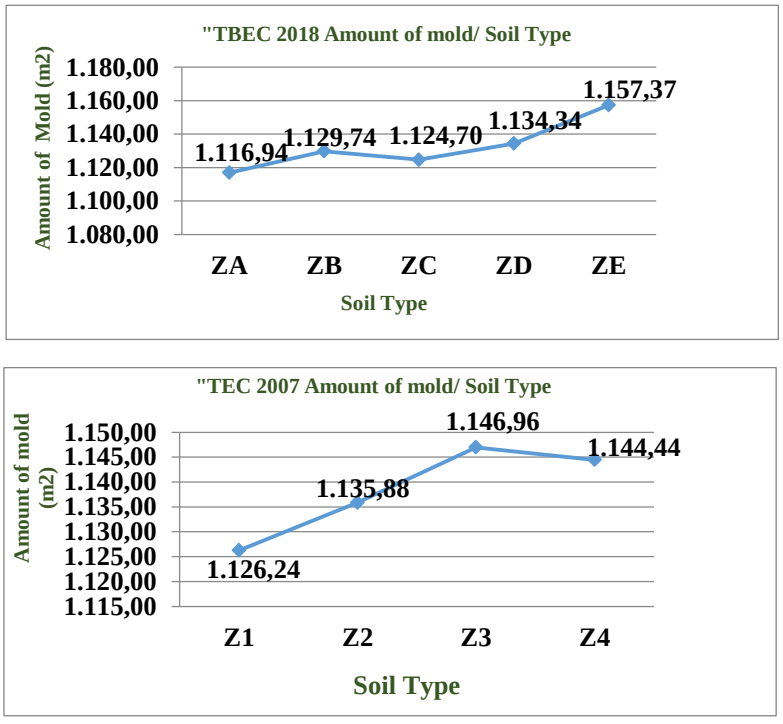

Figure 10. The mold quantity in the area corresponding to seismic zone 1 according to TEC 2007

As a result of analyses conducted in the region corresponding to seismic zone 1 according to TEC 2007, no significant increase has been observed in the total formwork quantity as the soil class deteriorates in both seismic regulations.

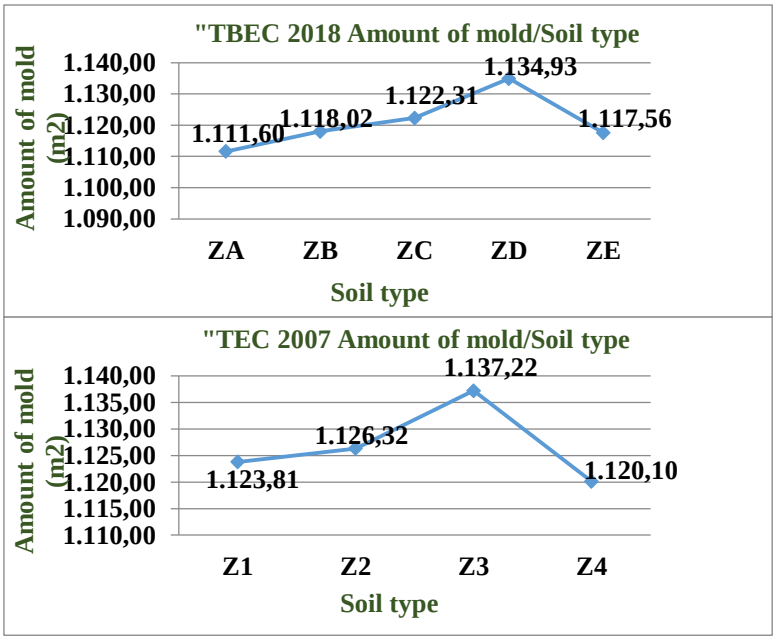

Figure 11. The mold quantity in the area corresponding to seismic zone 2 according to TEC 2007

As a result of analyses conducted in the region corresponding to seismic zone 2 according to TEC 2007, the highest formwork quantity in both seismic regulations has been observed in the soil class just preceding the worst soil class. Overall, there is a slight increase in formwork quantities for both regulations.

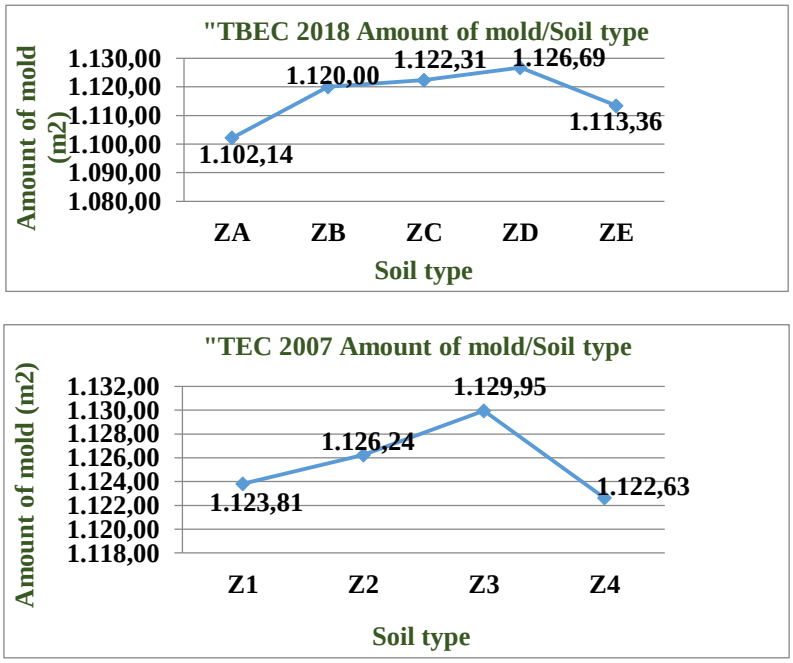

Figure 12. The mold quantity in the area corresponding to seismic zone 3 according to TEC 2007

As a result of analyses conducted in the region corresponding to seismic zone 2 according to TEC 2007, the highest formwork quantity in both seismic regulations has been observed in the soil class just preceding the worst soil class. Overall, there is a slight increase in formwork quantities for both regulations.

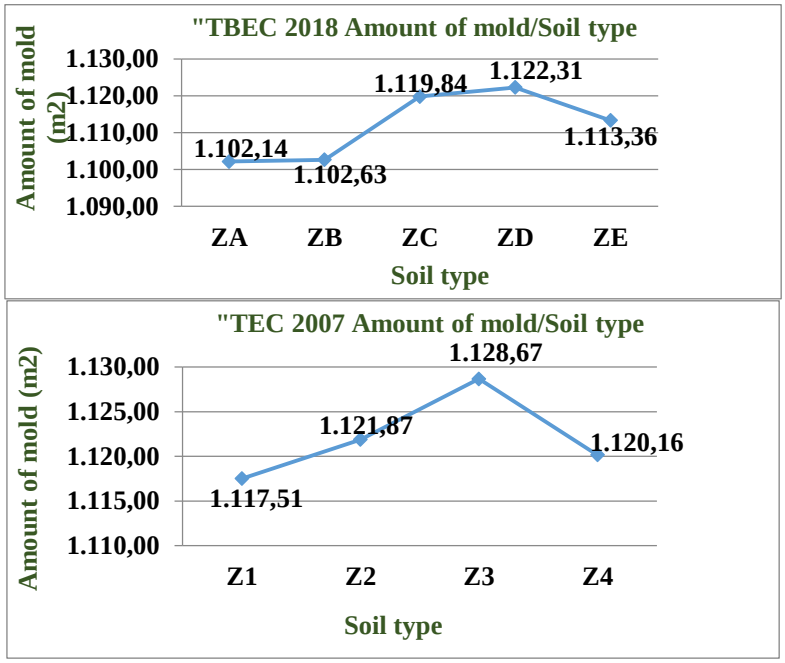

Figure 13. The mold quantity in the area corresponding to seismic zone 4 according to TEC 2007

As a result of analyses conducted in the region corresponding to seismic zone 4 according to TEC 2007, the highest formwork quantity in both seismic regulations has been observed in the soil class just preceding the worst soil class. Overall, there is a slight increase in formwork quantities for both regulations. Similar results were obtained for seismic zone 3.

The quantities of concrete, reinforcement and mold determined in TBEC 2018 and TEC 2007 are determined by the prices of the Ministry of Environment and Urbanization in 2023 and are calculated in Tables 8,and 9.

Table 8. Total equipment costs according to TBEC 2018

Earthquake Zones	**TBEC 2018 Soil Classes**				
	ZA	ZB	ZC	ZD	ZE
1	□1.154.561,91	□1.179.313,44	□1.194.376,26	□1.227.606,86	□1.461.806,76
2	□1.141.409,28	□1.153.309,31	□1.169.953,25	□1.200.893,28	□1.269.310,28
3	□1.127.590,13	□1.157.293,36	□1.169.594,99	□1.182.101,28	□1.218.460,26
4	□1.126.255,49	□1.127.436,26	□1.164.123,82	□1.165.789,97	□1.207.566,11

Table 9. Total equipment costs according to TEC 2007

Earthquake Zones	**TEC 2007 Soil Classes**			
	Z1	Z2	Z3	Z4
1	□1.164.149,74	□1.183.249,52	□1.229.953,04	□1.295.426,68
2	□1.047.510,08	□1.059.000,93	□1.087.445,56	□1.128.702,95
3	□1.150.222,24	□1.158.650,28	□1.164.148,12	□1.213.272,42
4	□1.136.860,82	□1.147.297,85	□1.162.329,63	□1.197.818,99

When the total cost is examined, the cost increases as the soil class deteriorates for both regulations in each earthquake zone. The most pronounced increases are observed in the 1st-degree earthquake zone. There is not a significant cost increase for the 4th-degree earthquake zone. Considering both regulations, the highest cost occurs in TBEC 2018 for the Z4 soil class in the 1st-degree earthquake zone.

4. CONCLUSION

This study has been tried to create a prediction in the implementation of the TBEC 2018, and the differences between the TBEC 2018 and TEC 2007 have been established. In TBEC 2018, it is observed that the costs of concrete, reinforcement, and formwork are higher for the 1st-degree earthquake zone. As we move to the 4th-degree earthquake zone, similar costs emerge in both TBEC 2018 and TEC 2007. In response to the earthquakes experienced in our country, TBEC 2018 has deemed it appropriate to construct more robust residential structures by increasing the quantity of concrete and reinforcement, thereby staying on the safer side. This study has been used to determine what changes are made to the cost of building, along with changing regulations. This study has revealed the significant impact of soil class, emphasizing the necessity for careful preparation of soil investigation reports. In future studies, variations in the number of coats such as 7, 11, etc., can be explored. Additionally, besides altering the soil class, changes in concrete types can be considered. The structural frame can be repositioned outside the system and analyzed by adopting a riveted system. This approach applies not only to regular buildings but also to irregular structures, including basement buildings.

REFERENCES

1. Öztürk, M.T., 2009. Eski Deprem Yönetmeliklerine Göre Boyutlandırılan Betonarme Binaların Güncel Yönetmeliğine Göre Deprem Performansının Belirlenmesi (Yüksek lisans tezi). İstanbul Teknik Üniversitesi, Fen Bilimleri Enstitüsü, İstanbul.
2. Yanık, A., 2008. Mevcut Deprem Yönetmeliği ile Yürürlükten Kaldırılan Deprem Yönetmeliğinin Karşılaştırılması (yüksek lisans tezi). Karadeniz Teknik Üniversitesi, Fen Bilimleri Enstitüsü, Trabzon.
3. Üstün, M., 2013. Betonarme Bir Binanın Davranışının Eski ve Güncel Tasarım Yönetmeliklerine Göre İncelenmesi (yüksek lisans tezi). İstanbul Teknik Üniversitesi, Fen Bilimleri Enstitüsü, İstanbul.
4. Ansal A. M., Iyisan R., Ozkan, M., 1997. A Preliminary Microzonation Study for the Town of Dinar, Editor: Seco P., Seismic Behaviour of Ground and Geotechnical Structures, 4th ed., Taylor& Francis Publisher, Rotterdam.
5. Düzgün, O.A., 2007. Topoğrafik Yapının Zemin Yapı Sistemlerinin Dinamik Davranışı Üzerindeki Etkileşimi (doktora tezi). Atatürk Üniversitesi, Fen Bilimleri Enstitüsü, Erzurum.
6. Garip, Z.Ş., 2005. Deprem Etkisindeki Betonarme Yapılarda Yapı Zemin (yüksek lisans tezi). Sakarya Üniversitesi, Fen Bilimleri Enstitüsü,Sakarya.
7. Mokorrami, A., 2009. İran Deprem Yönetmeliğinin Türk Deprem Yönetmeliği ile Karşılaştırılması (yüksek lisans tezi). İstanbul Teknik Üniversitesi, Fen Bilimleri Enstitüsü, İstanbul.
8. Türk, A., 2009. 1997 Deprem Yönetmeliğine Göre Boyutlandırılmış ve Donatılmış Model Bir Yapının 2007 Deprem Yönetmeliğine Göre İrdelenmesi (yüksek lisans tezi). Sakarya Üniversitesi, Fen Bilimleri Enstitüsü, Sakarya.
9. Aydemir, Z., 2011. TDY 2007 ile Eurocode 8'in Betonarme Binalarda Maliyet Açısından Karşılaştırılması (yüksek lisans tezi). Sakarya Üniversitesi, Fen Bilimleri Enstitüsü, Sakarya.
10. Köse, O., 2014. 1998 Deprem Yönetmeliğine Göre Yapılmış Mevcut Betonarme Bir Binanın 2007 Yönetmeliğine Göre Güçlendirme Önerisi (yüksek lisans tezi). Fırat Üniversitesi, Fen Bilimleri Enstitüsü, Elazığ.
11. Çınar, E.D., 2015. 2007 Türk Deprem Yönetmeliği ve İstanbul Yüksek Binalar Deprem Yönetmeliğine Göre Yüksek Bir Binanın Tasarımı (yüksek lisans tezi). İstanbul Teknik Üniversitesi, Fen Bilimleri Enstitüsü, İstanbul.

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Araştırma Makalesi/Research Article

Gayrimenkul Piyasasında Regresyon Yöntemleri ile Veri Madenciliği

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Geliş tarihi:13.09.2023 Kabul tarihi:18.12.2023

Özet

Gelişen ve küreselleşen dünyamızda insanoğlu yerleşim ve yerleşke üzerindeki tecrübesini her geçen gün farklı metot ve modellerle geliştirmektedir. Asıl amaç ev yapmayla beraber evin düşük maliyet ve kaliteli malzeme kullanılarak daha iyi yapılmasıdır. Lakin günümüz Türkiye'sinde mühendis ve müteahhitlerin çoğu malzeme noktasında zafiyet gösterirler. Yani yapı inşasında kalitesiz veya eksik malzeme kullanarak yapıyı maliyetin altında yaparlar ve satış noktasında değerinin çok fazla üstünde satmaya çalışırlar. Bu durum emlak piyasasında çok ciddi dengesizliklere davetiye çıkarmaktadır. Konut fiyatlarını belirlemek ciddi bir emek ister. Konut fiyatlarının tespiti için birden fazla istatistik ve kara kutu yöntemler mevcuttur. Bu çalışmada Lineer Regresyon, YSA, Gradient Boosting (Gradyen Arttırıcı Regresyon), Karar Ağaçları yöntemleri kullanılmıştır. Amaç metre kare fiyatı olarak en yakın sonucu bulmaya çalışmaktır. Yapılan istatiksel çalışma ve karşılaştırma sonucunda ortalama mutlak hata değerleri küçükten büyüğe doğru Karar ağaçları 5.27, Lineer Regresyon 6.06, YSA 13.52 ve Gradient Boosting 14.84 olarak bulunmuştur. Dolayısıyla konut maliyet analizlerinde daha az hata payı için Karar ağaçları yöntemini kullanılabilir.

Anahtar Kelimeler: Regresyon Yöntemleri, Veri Madenciliği, Emlak, Fiyat Analizi

Data Mining with Regression Methods in the Real Estate Market

Abstract

In our developing and globalizing world, human beings are improving their experience of settlements with different methods and models. The main purpose of building a house is to make it better by using low-cost and quality materials. However, in today's Turkey, most engineers and vendors tend to use low-quality materials to maximize their profit. However, they try to sell it much higher than its value. This attitude has been creating serious imbalances in the real estate market. There are several statistics and black box methods to estimate real estate prices. Among them, Linear Regression, ANN, Gradient Boosting and Decision Trees were utilized in this study. The main objective is finding the closest result for the price of a real estate in terms of its square meter. In the statistical study and comparison, the average result absolute error values were changed from smallest to largest as Decision trees 5.27, Linear Regression 6.06, ANN 13.52 and Gradient Boosting 14.84. Therefore, the Decision Trees can be used for less margin of error in construction cost analyses.

Keywords: Regression Methods, Data Mining, Real Estate, Price Analysis

1. GİRİŞ

Geçmiş tarihlerden beri insanlar sürekli olarak barınma ihtiyacı hissetmişlerdir. İlk çağlarda evlerin amacı günümüzdeki gibi konfor amaçlı değil hayatta kalma çabası gütmekteydi. İlk yerleşim yerlerinde höyüklerdeki yapılarda yaşamını sürdüren insanlar sonrasında daha karmaşık yapıları yapmaya başlamışlardır. Bunun yanında özellikle mağara yaşamı insanlar için o dönemde son derece koruyucu ve kurtarıcı olmuştur. Mağaraların yüksek olması yırtıcı hayvanların ulaşımı yönünden oldukça zordu. Zamanla barınma ihtiyacı gelişen teknoloji ve artan nüfusla beraber büyümüştür. Bundan dolayı yapılaşma için gerekli yerin ve kullanılacak malzemelerin araştırılması ve elde edilmesi sonucunda binalar yükselmeye başlamıştır. Binalarla beraber satış sektörünü yönetecek emlakçılar bu piyasada görev almaya başlamıştır. Konut sektörü önemli ölçüde yerli sermayeye bel bağlaması, istihdam hacminin büyüklüğü yönünden oldukça önemlidir. Ayrıca yüksek katma değer üretmesi, başlangıçta imalat olmak üzere farklı sektörlerle sıkı bir girdi-çıktı ilişkisi içinde olması sebebiyle lider ve lokomotif bir sektördür [1].

Şüphesiz ki konut ve emlak piyasası birbirinden ayrılmaz iki önemli sektördür. Bazen konut sektörü hızlı olurken emlak piyasası cansız, bazen ise tam tersine konut sektörü yavaş olurken emlak piyasası çok aktif ve canlı olabilmektedir. Taşınmaz mallardaki satış oranlarının artmasının en önemli nedenlerinden biri faiz oranlarındaki azalıştır. Sonrasında farklı firmalar tarafından fazla miktarda yapılan konutların elde kalarak şişmesi sonucu düşük fiyata satılması bir ikinci nedendir. İnşaat kalemlerinin analiz ve maliyetleri çok hassas ve çok sağlam fizibilite isteyen bir işlemdir. Yapılacak en ufak bir hata maliyet noktasında firma sahibini zora sokacak ve zincirleme bir maliyet kazasına sebebiyet verecektir. O yüzden deneyim ve feraset bu sektörde çok önemli iki unsurdur. Ülkemizde maalesef yatırım aracı olarak konut piyasası en başı çekmektedir. Bu yüzden yatırımcı ilk olarak yatırımını direk olarak gayrimenkul üzerine yapmaktadır. Özellikle bir ev almak için karar verirken o evin kuzey, güney, batı, doğu gibi cephesel yönlerine, yaşına, kullanılan malzemeye, kör cephesine, merkeze olan mesafe ve konumuna, kaçıncı katta olduğuna, elektrik ve su durumuna, o semtte oturan insanların komşuluk ilişkilerine vb. birden fazla etken temel alınır. Karar verme süreci için birden fazla yöntem bulunmaktadır. Özellikle veri madenciliği bu noktadaki açığı kapatmak için son zamanlarda oldukça tercih edilmektedir. Bu analiz yöntemi, çok geniş hacimli verilerin yapısındaki ilişkileri araştırarak aralarındaki bağlantıyı tespit etmeye yardımcı olan ve veri tabanı sistemleri bünyesinde gizli kalmış bilgilerin çekilmesini sağlayan veri analizi yöntemidir [2]. Veri madenciliğinde genel olarak tercih edilen yöntem ise karar ağaçlarıdır. Bu yöntem kolay uygulanabilmesi ve anlaşılabilir sonuçlar vermesi nedeniyle yaygın olarak kullanılan veri madenciliği yöntemlerindendir [3]. Ayrıca yöntem karar alıcıya karar alma aşamasında hangi unsurların göz önünde bulundurulmasını ve her bir unsurun kararın farklı çıktıları ile birlikte geçmişte nasıl bağlantılı olduğunun tespit edilmesi hususlarında yardımcı olur [4]. Bu çalışmada birden fazla yöntem (Lineer Regresyon, YSA, Gradyen Arttırıcı Regresyon, Karar Ağaçları) konut fiyatlarının tahmin etmede kullanılmıştır. Bu modeller arasında karar ağaçları birim m^2 fiyat hesaplarında ortalama mutlak hata olarak en anlamlı sonucu vermiştir. Günümüzde kullanılan model ve teknikler kesin sonuç vermekten ziyade minimum hataya yaklaşma eğilimindedirler. Ayrıca bu modeller olayın fiziksel yönlerini hesaba katmazlar. Çalışmanın bir nebzede olsa emlak ve inşaat sektörüne fayda ve yarar sağlayacağı beklenmektedir.

1.1. Çalışma ve Modellerle İlgili Mevcut Literatür

Emlak üzerine bilim insanları sayısız çalışmaya imza atmışlardır. Lakin bu piyasa sürekli gelişen, değişen ve kendini yenileyen bir sektördür. Tarihi yapılar ve sanat eserleri hariç kendini yenilemeyen ve yaptığı projelerde sürekli tip proje kullanan firma ya da devletler bu sektörde çok fazla ilerleme imkânı bulamazlar. Küresel ölçekte bu varlık piyasası üzerindeki krizler 1980, 1998, 2001, 2008, 2016 ve 2018 yılları arasında ciddi anlamda bir kırılganlık göstermiştir [5].

Dan (2013) Mortgage sisteminin Amerika'da genel olarak kredi kanalıyla talep edilmesi nedeniyle konut fiyatlarındaki esnemenin Avrupa bölgesine göre daha kolay olduğunu belirtmiştir [6]. Ivanov ve Lavrinovic 2003-2006 yılları arasında artış gösteren ihracat gelirlerinin anamal miktarında artma meydana getireceğini ve kredi büyümesine neden olacağını vurgulamışlardır. Kredi ve parasal büyüme gayrimenkul talebini artıracak ve bu durumda emlak piyasası canlanacaktır [7]. Chen (2001) çoklu VAR modelini kullanarak Tayvan' da 1973-1992 yıl aralığında gayrimenkul fiyatları ve hisse senedi arasındaki ilişkiyi açıklamıştır. Bu çalışma sonucuna binaen konut fiyatları ve hisse senedi arasında çok güçlü bir bağın olduğunu belirtmiştir [8].

Guiliodori (2005) 9 Avrupa ülkesi üzerinde VAR modelini kullanarak ayrı ayrı tahminlerde bulunmuş ve ev fiyatlarındaki faize bağlı değişimlerin özel tüketim giderleri üzerine etkisini incelemiştir. Yaptığı çalışma sonucunda ev ve ipotek piyasalarının daha yükselen ve rekabetçi dönemlerinde faiz etkilerinin tüketici giderleri üzerindeki baskısını artırabileceğini belirtmiştir [9]. Taşkın ve ark. (2005) da karar ağaçları yöntemini kullanarak satış hacmi analizini gerçekleştirmişlerdir. Çalışmaya göre işletmenin belli bir zaman diliminde yaptığı satışlar müşterilerin satın alma davranış özelliklerine göre analiz edilmiştir. Yapılan analiz neticesinde müşteriler harcama tutarına göre belli sınıflara ayrılmıştır [10]. Tuna ve ark. (2015) çoklu regresyon analizi ile Ankara Belediyesi sınırları içerisinde yer alan ilçelerde (Çankaya, Akyurt, Gölbaşı, Yenimahalle, Altındağ, Sincan, Etimesgut, Keçiören, Mamak) satışa sunulan konutlara ait verileri kullanarak fiyat tahmini yapmışlardır [11].

Yılmazel ve ark. (2018) yapay sinir ağları yöntemiyle Eskişehir ilindeki konutların fiyatlarını belirlemişlerdir. Konut fiyatlarında etkili olabilecek değişkenlerden oda sayısı, banyo sayısı, konutların büyüklüğü, birinci katta olup olmadığı, evin yer aldığı binadaki toplam kat sayısı, merkezi ısıtma sisteminin olup olmadığı, asansörün, otoparkın, fiber internet bağlantısının ve ankastre mutfağın olup olmadığı gibi farklı fiziksel nitelikleri, bulunduğu mahalle ve tramvaya mesafesi parametreleri girdi olarak kullanılmıştır. Çalışmasında yapay sinir ağları yönteminin ev fiyatlarının tahmin edilmesinde uygun bir araç olarak kullanılabilirliğini belirtmişlerdir [12].

Rossini (1997) hem çoklu regresyon analizini hem de yapay sinir ağlarını konut fiyatlarının tahmininde kullanmıştır. Satışı yapılan konutlarda kullanılan değişkenler; bölge, satış zamanı, arsa alanı, satış fiyatı, mahalle, iyileştirme, eşdeğer inşaat alanı, oda sayısı, çatı tipi, durum, duvar tipi, bina inşaatı ve bina tipi tarihidir. Kullanılan 334 adet veri setinin 223 tanesi eğitim, 111 tanesi ise test için kullanılmıştır. Sonuçta çoklu regresyon analizi %89 doğruluk ve %90 ortalama uyum oranına yaklaşırken, yapay sinir ağları ise %81 doğruluk ve %78 ortalama uyum oranında kalmıştır [13]. Zurada ve ark. (2011) konut fiyat analizlerinde yapay sinir ağları ve bulanık mantık yöntemlerini kullanmışlardır. Hesaplamaya kattıkları değişkenler; banyo adedi, garaj büyüklüğü, ev alanı, şömine, ısıtma sistemi, garaj tipi ve inşaat tipidir. Sonuç olarak yapay sinir ağları ve bulanık mantık

yeterli sayıda veri ve doğru analiz yapılması şartıyla kullanılabilir yöntemler olup, konunun üzerinde durulması gerektiğini belirtmişlerdir [14].

Lu ve ark. (2017) Gradient Boosting ve Lasso yöntemleri ile hibritlenen bir modelle en verimli sonucu bulmuşlardır. Modelde %35 Gradient Boosting ve %65 Lasso kombinasyonu kullanılmıştır [15]. Bilik ve ark. (2019)'da ev halkının konut sahibi olma isteklerini etkileyen sebepler çerçevesinde (hane büyüklüğü, kır-kent yerleşim biçimi, hane geliri, üniversite mezuniyeti, hane reisinin çalışma şekli, medeni durumu ve cinsiyeti) iki farklı yöntemi yani SVR (Destek Vektör Makineleri) ile geleneksel lojistik regresyon yaklaşımının tahmin güçlerini kıyaslamışlardır. Buna göre hane halkının toplam gelirinin ev sahibi olma isteği için en önemli etmen olduğunu vurgulamışlardır. Çalışmaya göre SVR yönteminin konuta sahip olma ve olmama yönünde en iyi olasılıklarda sonuçlar verdiğini belirtmişlerdir [16].

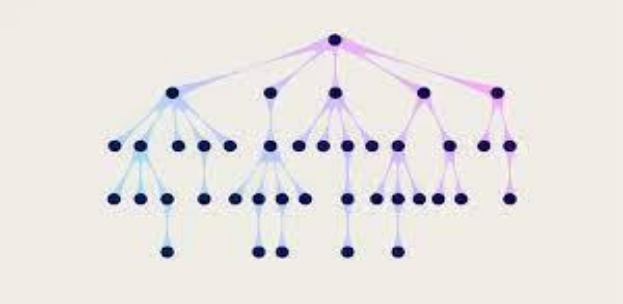
Bu çalışmada konut fiyat analizi ve tahmini için makine öğrenme metotları kullanılmıştır. Genel olarak baktığımızda bu dört modelin konut fiyatlarını tahmin etmede özelikle yaygın olarak kullanıldığını söyleyebiliriz. O yüzden modeller bu çalışmada kullanılmıştır. Dolayısıyla çalışmanın amacı bu modeller arasında en iyi konut tahminini veren fiyatı belirlemektir. Regresyon modellerini kullanmamızın asıl nedeni ortalama mutlak hatayı bulmak içindir. Çalışmada modeller için sınıflandırma yapılmamıştır.

2. REGRESYON MODELLERİ

Regresyon iki değişken arasındaki ilişkiyi belirlemeye yarayan, bağımlı değişkenin bağımsız değişkenden ne oranda etkilendiğini hesaplayan istatistiksel bir yöntemdir. Çalışmada verilerin % 67'si eğitim için geriye kalan %33'si ise test verisi olarak kullanılmıştır. Konut fiyatı için kullanılan değişkenler sırası ile evin yaşı, evin kullanım tarihi, toplu taşımaya olan uzaklık, eve yakın mağaza sayısı, enlem ve boylamdır. Birçok regresyon yöntemi olmakla beraber bu çalışmada dört adet yöntem kullanılması yeterli görülmüştür. Modellerin hata metrikleri kendi aralarında değerlendirilmiştir. Bu yöntemleri kısaca açıklamakta fayda vardır.

2.1. Karar Ağaçları

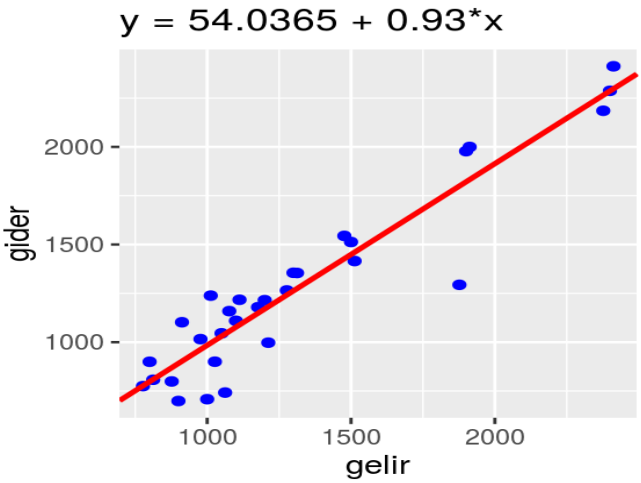
Bu yöntem veri madenciliğinde regresyon modellerini oluşturmak için kullanılan bir metottur (Şekil 1). Özellikle karar analizinde olmak suretiyle kompleks sorunların araştırmasında yaygın olarak kullanılmaktadır. Regresyon modelleri adı gibi tıpkı ağaç gibi bir yapı oluşturularak inşa edilir. Bu tür regresyon yöntemleri eğitici denetimli öğrenmesine sahiptirler. Bu tür özelliğe sahip olan öğretimlerde sonuç kolay bilinir. Kategorik ve sayısal veriler için karar ağaçları sıklıkla kullanılır [10].



Şekil 1. Karar ağaçları [17]

2.2. Lineer Regresyon

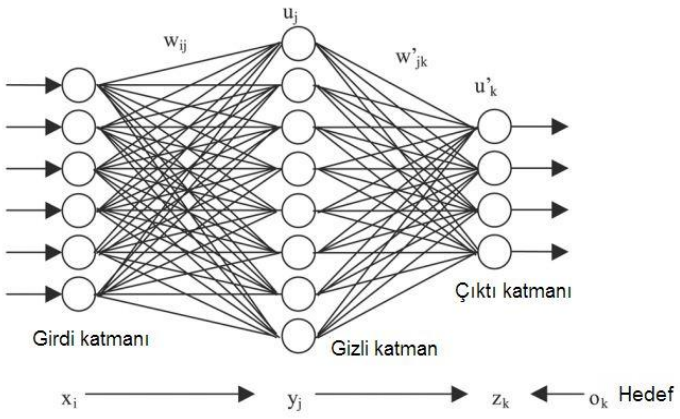
Bu yöntem, iki ya da daha fazla değişken arasındaki ilişkiyi modellemede kullanılan yöntemler arasında en çok tercih edilendir (Şekil 2). Bağımlı değişkeni bulmak için kullanılan modelde girdi olarak tek bir bağımsız parametre kullanılıyorsa tekli regresyon, birden çok bağımsız parametre kullanılıyorsa çoklu regresyon analizi olarak isimlendirilir. Bağımlı ve bağımsız parametre ya da parametreler arasındaki ilişki doğrusal (lineer) olabileceği gibi eğrisel de olabilir. Regresyon analizi ile bağımlı ve bağımsız parametreler arasında ilişkinin varlığı araştırılmaktadır. Eğer ilişki var ise bunun gücü hakkında bilgi edinilmektedir [18].



Şekil 2. Lineer Regresyon [19]

2.3. YSA

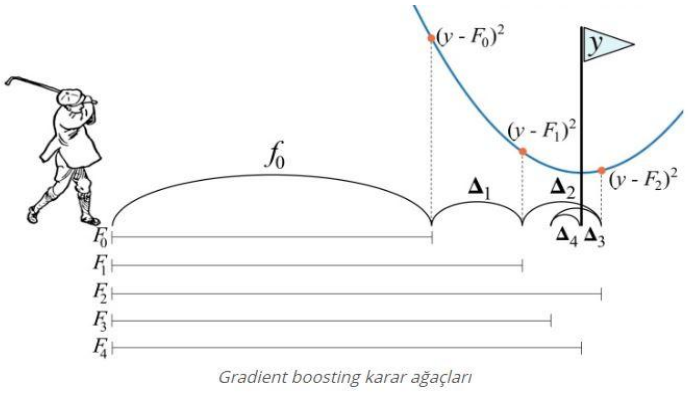
Yapay sinir ağları günümüzde en çok kullanılan makine öğrenimi tekniğidir (Şekil 3). İnsan beynini ve buna benzeyen sistemler göz önüne alınarak tasarlanmıştır. Çalışma prensibi sinir hücrelerine dayanır. Yapay zekânın bir alt başlığı olup bu alanda araştırma yapanların ilgisi haline gelmiştir. Genel anlamda giriş, gizli ve çıkış katmanı vardır. Katmanlar arası ağırlık hesaplamalarıyla tahmin yapar [20].



Şekil 3. YSA [21]

2.4. Gradyen Arttırıcı Regresyon

Makine öğrenmesine ait olan bu yöntem hem sınıflandırma hem de regresyon problemlerinin analizinde kullanılan bir algoritmadır (Şekil 4). Bu yöntemde yapılacak ilk iş ilk yaprak (initial leaf) oluşturmaktır. Daha sonra tahmin yanılmaları göz önünde bulundurularak yeni ağaçlar inşa edilir. Bu hal karar verilen ağaç adedine ya da modelden daha fazla büyüme kaydedilemeyinceye kadar devam eder. Yöntem Sınıflandırma ve regresyon problemlerinde kendine özgü karar ağaçları barındıran düşük tahmin modelleri üreten makine öğrenim tekniklerinden biridir [22].



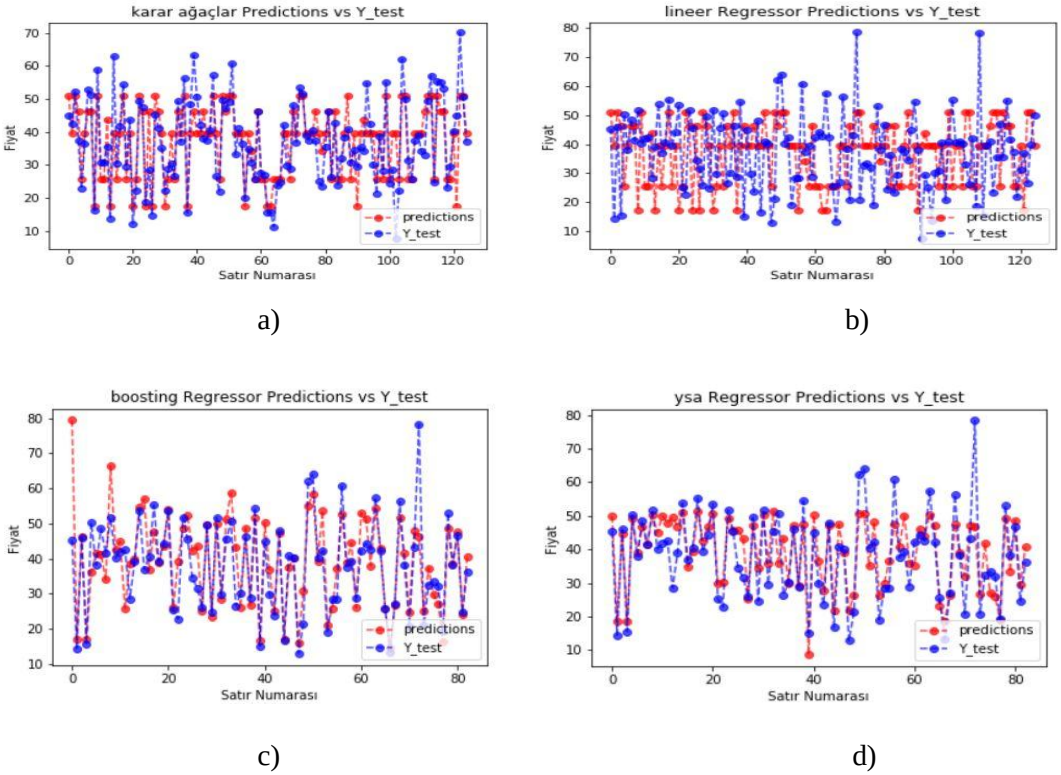
Şekil 4. Gradyen Arttırıcı Regresyon [23]

3. UYGULAMA

3.1. Regresyon Modellerinin Uygulanması

Bu çalışmada regresyon modellerindeki performansı görmek için MAE (Mean Absolute Error) hata metriği kullanılmıştır. Yapılan çalışmada dört tane regresyon modelini emlak verisine uygulayıp çıkan sonuçlar Şekil 5'deki gibi grafikselleştirilmiştir. Mavi noktalar gerçek değerleri, kırmızı noktalar metotların yaptığı tahmini değerleri ifade etmektedir. Grafikler sırasıyla karar ağaçları, lineer regresyon, Gradient Boosting ve YSA (Yapay

Sinir Ağı) şeklinde betimlenmiştir. Buna göre mavi ve kırmızı noktaların üst üste örtüştüğü en iyi senaryo karar ağaçlarında görülmüştür. Bu da yöntemin doğru sonuca yakın tahminler verdiğinin göstergesidir.



Şekil 5. Regresyon modellerine ait grafikler

3.2. Modellerin Sonuçları

Tablo 1. Analiz sonuçları ve karşılaştırma

Uygulanan Yöntem	**OMT (Ortalama Mutlak Hata)**
Karar Ağaçları	5.27
Lineer Regresyon	6.06
YSA (Yapay Sinir Ağı)	13.52
Gradient Boosting	14.84

Ortalama mutlak hata, model tahmini ile hedef değer arasındaki mutlak farkın ortasını verir. Çalışmada model sonuçlarında dört yöntem karşılaştırılmış ve Tablo 1'de de görüldüğü üzere en yüksek hatayı 14.84 ile Gradient Boosting yöntemi verirken en düşük hatayı ise 5.27 ile Karar ağaçları vermiştir. Gradient Boosting'in Şekil 5'de görüldüğü üzere tahmin değer farkları çok fazla olduğu için hata payı daha fazla çıkmıştır. Aslında Lineer Regresyon modelide diğer modeller arasında Karar ağaçlarına en yakın sonucu vermiştir.

Çalışmaya ait veri seti internet sitesinden temin edilmiştir. Verilerin alındığı ülke ise Tayvan'dır [24].

4. SONUÇLAR

Özellikle son yıllarda yaşadığımız 6 Şubat depremi ülkemiz üzerinde toparlanması uzun ve zor olan maddi ve manevi hasarlara yol açmıştır. Yıkılan binaların depreme dayanma noktasındaki çaresizliği konunun üzerinde yeterince durulmadığını göstermektedir. Binaların her ne kadar statik yönden düzgün projesi çizilse de uygulamada kullanılan malzemelerin özellikle betonun mukavemetinin düşük olması ya da belli sıcaklık periyotlarında dökülmemesi, ayrıca kullanılan donatı aralıklarının fazla bırakılması ve bağlantılarında hata yapılması, depremin şiddeti karşısında binaları oldukça zayıf bırakmıştır. Burada emlak sektöründe çalışan kişilerin özellikle inşaat yapım ve satış süreci hakkında yeterli bilgi ve donanıma sahip olması depreme karşı dayanıksız binaların alım ve satımında özellikle bu duruma engel olacak şekilde davranması elzemdir. Bu yüzden emlak sektöründe hem kaliteli hem depreme dayanıklı hem de maliyeti düşük olmak üzere üç ayrı yaklaşımla binaları tercih etmek gerekir. Hemen hemen her kesim ev alırken maliyeti ön planda tutmaktadır. Maliyet için birden fazla hesaplama yöntemi bulunmaktadır. Bu çalışmada Lineer Regresyon, YSA, Gradient Bosting, Karar ağaçları yöntemleri tercih edilmiştir. Yapılan çalışma ve karşılaştırma sonucunda ortalama mutlak hata olarak en iyi sonucu veren yöntem Karar ağaçları olmuştur. Buna göre emlak piyasasında Karar ağaçları yöntemi kullanılarak mevcut maliyet en az hatayla hesaplanabilir.

KAYNAKLAR

1. Öztürk, N. and E. Fitöz, Türkiye'de konut piyasasinin belirleyicileri: ampirik bir uygulama. Uluslararası Yönetim İktisat ve İşletme Dergisi, 5(10): p. 21-46, 2009.
2. Dunham, M.H., Data mining: Introductory and advanced topics: Pearson Education India, 2006.
3. Nazem, S.M. and B. Shin, Data mining: new arsenal for strategic decision-making. Journal of Database Management (JDM), 10(1): p. 39-42, 1999.
4. Bounsaythip, C. and E. Rinta-Runsala, Overview of data mining for customer behavior modeling. VTT Information Technology Research Report, Version, 1: p. 1-53, 2001.
5. Alan, V.F.K.İ.Y. and K.V.E.F. Arsa, Araştırma Makalesi. 2020.
6. Dan, H., External factors for the monetary policy transmission mechanism. The Annals of the University of Oradea, (1): p. 435-444, 2013.
7. Ivanov, M. and I. Lovrinović, Monetary transmission mechanism and behaviour of asset prices: the case of Croatia. Review of Business Research, 8: p. 1-18, 2008.
8. Chen, N.-K., Asset price fluctuations in Taiwan: Evidence from stock and real estate prices 1973 to 1992. Journal of Asian Economics, 12(2): p. 215-232, 2001.
9. Giuliodori, M., The role of house prices in the monetary transmission mechanism across European countries. Scottish journal of political economy, 52(4): p. 519-543, 2005.
10. Taşkın, G.G.E.V.Ç., Veri madenciliğinde karar ağaçları ve bir satış analizi uygulaması. Eskişehir Osmangazi Üniversitesi Sosyal Bilimler Dergisi, 6(2): p. 221-239, 2005.
11. Tuna, M., T. Türk, and O. Kitapçı, Lineer regresyon ve coğrafi bilgi sistemleri yardımıyla ev fiyatlarının tahmin edilmesi: Ankara örneği. TMMOB HKMO, 15, 2015.
12. Yılmazel, Ö., A. Afşar, and S. Yılmazel, Konut fiyat tahmininde yapay sinir ağları yönteminin kullanılması. 2018.
13. Rossini, P., Artificial neural networks versus multiple regression in the valuation of residential property. Australian Land Economics Review, 3(1): p. 1-12, 1997.

14. Zurada, J.M., A.S. Levitan, and J. Guan, Non-conventional approaches to property value assessment. Journal of Applied Business Research (JABR), 2006. 22(3).

15. Lu, S., et al. A hybrid regression technique for house prices prediction. in 2017 IEEE international conference on industrial engineering and engineering management (IEEM). IEEE, 2017.

16. Bilik, M. and Ü. Aydin, Konut sahibi olma kararlarını etkileyen faktörler: Lojistik regresyon ve destek vektör makinelerinin karşılaştırılması. Dumlupınar Üniversitesi Sosyal Bilimler Dergisi, (62): p. 184-199, 2019.

17. https://www.google.com/search?q=karar+a%c4%9fa%c3%a7lar%c4%b1&sca_esv=586941408&tbm=isch&source=lnms&sa=x&sqi=2&ved=2ahukewiq_uizke6caxvaaxaıhqfdbo0q_auoaxoecaqqaw&biw=1344&bih=711&dpr=1.25#imgrc=x8c_sbojphvuhm. (Erişim tarihi 30.11.2023).

18. Gujarati, D., Basic Econometrics 4th edition McGraw Hill: New York. NY, 2003.

19. https://www.google.com/search?q=lineer+regresyoan&tbm=isch&ved=caxutruukhxvbcqyq2ccegqıabaa&oq=lineer+regresyoan&gs_lcp=cgnpbwcqazokcaaqgaqqiguqqzofcaaqgaq6bggaeacqhjohcaaqgaqqgdogcaaqbraeoggıabcabbcxazolcaaqgaqqsqmqgwe6dggaeıaeeıofeledeımbogqıabadunpcwlzyjycawgacab4aıaboagıayyrkgeemc4xozgbakabaaobc2d3cy13axotaw1nwaeb&sclient=img&ei=gmnpzebsnzomlqf7gqcw&bih=711&biw=1344#imgrc=fmvftfouzd72nm. (Erişim tarihi 30.11.2023).

20. Budak, H. and S. Erpolat, Kredi Riski Tahmininde Yapay Sinir Ağları ve Lojistik Regresyon Analizi Karşılaştırılması. AJIT- e: Online Academic Journal of Information Technology, 3(9): p. 23-30, 2012.

21. https://www.google.com/search?q=ysa&tbm=isch&ved=2ahukewid_ow3k6caxxcwgıhhy4tdpwq2ccegqıabaa&oq=ysa&gs_lcp=cgnpbwcqazıfcaaqgaqybqgaeıaemguıabcabdıfcaaqgaqybqgaeıaemguıabcabdıfcaaqgaqybqgaeıaemguıabcabdıfcaaqgarq7azy7azg_q1oahaaeacaaw-ıadobkgedmc4ymaeaoaebqgelz3dzlxdpei1pbwfaaqe&sclient=img&ei=1cvpzd29mmkfi-gpjqew4a8&bih=711&biw=1344. (Erişim tarihi 30.11.2023).

22. Zemel, R.S. and T. Pitassi. A gradient-based boosting algorithm for regression problems. in Advances in neural information processing systems, 2001.

23. https://www.google.com/search?q=Gradyen+Artt%C4%B1r%C4%B1c%C4%B1+Regresyon&tbm=isch&ved=2ahukewikk9zvle6caxvwi_0hhwpsaekq2ccegqıabaa&oq=gradyen+artt%c4%b1r%c4%b1c%c4%b1+regresyon&gs_lcp=cgnpbwcqazokcaaqgaqqiguqqzofcaaqgarqmwzymwzgmw5oahaaeacaawıadkbkgedmc4ymaeaoaebqgelz3dzlxdpei1pbwfaaqe&sclient=img&ei=lchpzetıgdaw9u8p49idyaq&bih=711&biw=1344. (Erişim tarihi 30. 11. 2023).

24. https://archive.ics.uci.edu/dataset/477/real+estate+valuation+data+set. (Erişim tarihi 30. 11. 2023).

Araştırma Makalesi/Research Article

Tarihi Yapılarda Dron Kullanılarak Fotogrametrik 3B Nokta Bulutu Üretimi ile Rölöve Yapımı

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Özet

Kültürel mirasların korunması için rölöve işlemleri oldukça önemlidir. Tarihi yapıların dokusu, dönemin yansıttığı estetik unsurlar gibi özelliklerin değişmemesi açısından rölöve çalışması önem taşır. Rölöve çalışması yapıların mimari özelliklerinin değerlendirilmesi için yapının özgün halinin ölçekli çizimlerle anlatılarak oluşturulan mevcut proje için altlık veridir. Bu çalışmada, 2. derece tarihi eser niteliğindeki yapının mimari, restorasyon projesine altlık teşkil etmek için İnsansız Hava Aracı (İHA) veya Dron kullanılarak nokta bulutu üretimi (Point Cloud) ile hazırlanan rölöve çalışmasının yapımı anlatılmıştır. Rölöve çalışmasında, Total Station ile jeodezik kontrol noktaları ölçülmüştür. Tarihi yapının fotoğrafları, kalibrasyonu yapılmış yüksek çözünürlüklü İnsansız Hava Aracı (İHA) ile çekilmiştir. Çekilen fotoğraflardan Agisoft Metashape yazılımı ile 3B (3 Boyutlu) model oluşturulmuştur. Bu modelden yararlanarak Microstation programında rölöve çizimleri elde edilmiştir. Laser Scanner ile yapılan röleve ölçümlerine alternatif olarak kullanılan İHA ile çekilen fotoğraflardan rölöve çizimleri elde edilmiştir. Sonuç olarak Zaman, Maliyet, Hız ve Doğruluk açısından bu çalışmanın klasik fotogrametri yöntemine bir alternatif olacağı anlatılmıştır.

Anahtar Kelimeler: Restorasyon, Ortomozaik, Digital Fotogrametri, 3 Boyutlu Model, İnsansız Hava Aracı (İHA).

Drone Use in Historical Buildings and Surveying with Photogrammetric 3D Point Cloud Production

Abstract

Restoration processes are very important for the protection of cultural heritage. A meticulous application is required in order not to make different additional arrangements to historical buildings in the restoration process. The materials, the texture of the building, the aesthetic elements reflected by the period, etc. The survey work is important in terms of not changing the properties. It is the base data for the current project, which is created by explaining the original state of the building with scaled drawings (plan, section and views) in order to evaluate the architectural features of the buildings and to prepare the restoration works. The survey is a tool for closely examining the historical structure and urban fabric, documenting the existing features, evaluating it from an architectural point of view, and preparing the restoration project. In this study, the construction of the survey work prepared by the photogrammetric method in order to form a basis for the architectural and restoration project of the building, which is a 2nd degree historical monument, is explained. In the survey study, control points were measured with the Total Station. Photographs of the historic building were taken with a calibrated high-resolution UAV. A 3D Model was created from the photos taken with Agısoft Metashape software and drawings were prepared with three-dimensional point measurement. Relief drawings were created by preparing plan sections and views. In this study, information about the process steps described in the above framework is given.

Keywords: Restoration, Orthomosaic, Digital Photogrammetry, 3D Model, Dron.

1. GİRİŞ

Tarihi eserlerin korunamaması ve kaybolması durumunda bu eserlerin gelecek kuşaklara hasara uğramadan aktarılması için ilk olarak tarihi dökümantasyon sağlanmalıdır. Çünkü kültürel varlıkların mevcut durumuyla veya günümüzdeki durumlarından elde edilecek verilerle üretilecek özgün halleriyle dökümantasyonunu yapmak; oluşmuş ve oluşacak hasarları görmede oldukça önemlidir [23].

Tarihin yaşatılması için, tarihe tanıklık eden eserlerin korunması gerekmektedir. Bu nedenle rölöve yapımı çok önemlidir. Rölövenin amacı, tarihi yapıtların bugünkü durumunun ortaya çıkarılması (plan), restorasyon projesine altlık teşkil edecek şekilde geleceğe taşınmasını sağlamaktır. Bunu sağlamak için profesyonellik, teknik imkânlar ve mesleki bilgi gerekir. Başta üniversiteler olmak üzere birçok kurum ve kuruluş kültürel mirasların korunması için çeşitli görevler üstlenmişken, konusunda bilgili mühendislerin de bu yapıtların korunması için mesleki etiklere bağlı olarak hareket etmesi gerekmektedir [4].

Teknolojik gelişmeler doğrultusunda geliştirilen sayısal değerlendirme sistemleri yardımıyla fotogrametri, kültürel mirasların dökümantasyonunu ve korunmasında çok yararlı bir yöntem haline gelmiştir [1]. Tarihi yapıların sayısal ortamda dökümantasyonunu yapmak için günümüzde sayısal fotogrametri yöntemi ve İHA teknolojisinden yararlanılmıştır. Sayısal fotogrametrik yöntemde, istenilen formatta ürün alınabilmesi, hızlı olması, doğruluk olarak kıyaslanamayacak derecede üstün olması, verilerin sayısal ortamlarda alınması gibi nedenlerinden dolayı bu yöntemin rölöve çalışmalarında kullanımı kaçınılmaz olmuştur [16].

Bu çalışmada, 2. derece tarihi eser niteliğindeki İstanbul ili Beykoz ilçesi Çubuklu mahallesi'nde bulunan bitişik nizam 3 katlı ahşap yapının ön, arka ve çatı üzerinden İHA ile çekilen fotoğrafların Agisoft PhotoScan yazılımında işlenerek 3B nokta bulutu ve modellemesi oluşturulmuştur. Agisoft PhotoScan yazılımı SFM (Structure from Motion)-hareketten yapı oluşturma tekniğine dayanan bir modelleme yazılımıdır [7]. Çalışmanın amacı, tarihi yapının bugünkü durumunun ortaya çıkarılması ve restorasyon projesine altlık olacak rölöve çalışmasının yapılması ve arşivlenmesi, mimari özelliklerinin değerlendirilmesi, restorasyon çalışmalarının hazırlanabilmesi için yapının özgün halinin kentin dokusuna uygun bir proje oluşturmaktır [2-21-10].

2. SAYISAL FOTOGRAMETRİK SİSTEMLER VE İHA TEKNOLOJİSİ

Sayısal Fotogrametrik sistemler; Optik, elektronik, matematik, fotoğrafcılık ve bilgisayar teknolojisi gibi çeşitli bilim dallarından yararlanarak oluşturulmuş bir mühendislik uygulamasıdır. Son yıllarda bu alanlardaki gelişmeler sayesinde fotogrametrik yöntemlerin mimari uygulamalarda kullanımı genişletilmiştir. [22].

Sayısal Fotogrametri; Fiziksel cisimler ve oluşturdukları çevreden yansıyan ışınların şekillendirdiği görüntülerin ve yaydıkları elektromanyetik enerjilerin kayıt, ölçme ve yorumlama işlemleri sonucunda güvenilir bilgilerin elde edildiği bir teknoloji, bilim ve sanat dalıdır. Kısaca 2 boyutlu fotoğraflardan 3 boyutlu model ve üzerinden her türlü veri ve bilgi alınabilecek harita üretilebilen bir sistemdir [24].

Teknolojinin her geçen gün gelişmesi ile özellikle harita, inşaat, arkeloji ve mimari eserlerin restorasyon projelerinde altlık olması için yapılan rölöve çalışmalarında Yersel fotogrametriye ek olarak İHA teknolojisi gün geçtikçe daha etkin bir şekilde kullanılmaktadır. Özellikle yersel fotogrametri çalışmalarında çatı gibi ulaşılması güç alanlardan veri elde edilmesinde büyük kolaylık sağlamıştır. İnsansız Hava Araçları (İHA) özel amaçlar için tasarlanmış herhangi bir alandan kalkış ve iniş yapabilen uzaktan kumandalı yarı otomatik veya tam otomatik uçuş yeteneğine sahip araçlardır [24].

İHA Teknolojisi ile tarihi yapının yerden ve havadan fotoğraflarının çekilmesi ile rölöve planları, ortofoto, kesitler ve üç boyutlu modelleri elde edilebilmektedir. Yeterli veri elde edilebildiği ve bu veriler işlenip sonuç ürünü çıkarılabildiği takdirde tarihi bina ve yapıların sayısal ortamdaki 3 boyutlu modellerinden üç boyutlu koordinatlar (X,Y,Z) yardımıyla tekrar inşası, koruma veya restorasyon çalışmaları için altlık oluşturulabilir. Özellikle mimari yapılarda yerden fotoğraf çekmenin en büyük dezavantajı çatı gibi yerden görüntülenmesi güç olan kısımlarda yaşanmaktadır. Bu ve bunun gibi yerden veri toplaması zor olduğu durumlarda İHA teknolojisi kullanılması uygundur [22].

3. AMAÇ VE KAPSAM

Rölöve çalışmalarının en önemli amacı; Rölövesi yapılan tarihi eserlerde bir hasar olduğunda rölöve ölçüsünden yararlanarak aslına uygun bir şekilde eserin onarılmasını sağlamaktır [3]. Bu yüzden rölöve çalışması yapılırken tarihi yapılardaki detayların Jeodezik ve Fotogrametrik yöntemlerle ölçülmesi önemlidir.

Rölöve; Tarihi yapının, şehirlerin dokusuna uygun olarak mevcut özelliklerinin belgelenmesi, mimari açıdan değerlendirilmesi ve restorasyon projesinin hazırlanması için bir araçtır [13]. Tarihi yapıların, ölçekli çizimlerle hazırlanmış plan, kesit ve görünüşleri, restorasyon projeleri için altlık veri oluştururlar.

4. UYGULAMA

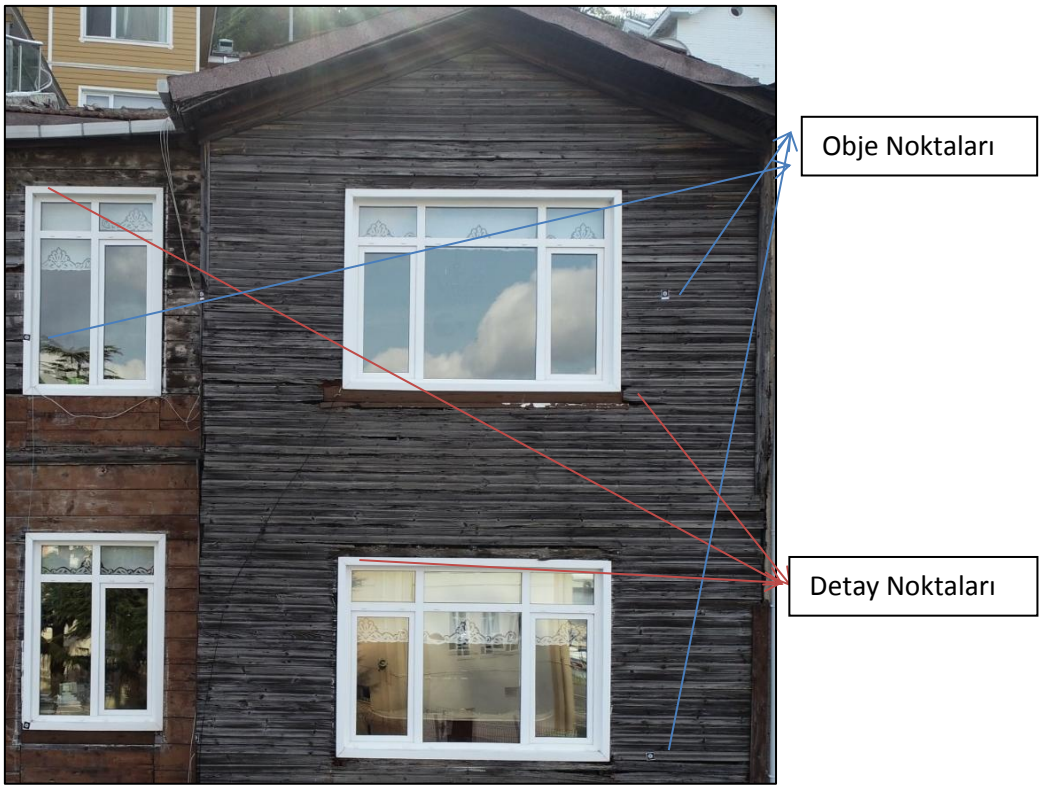
4.1. Materyal ve Yöntem

Çalışmanın yapılacağı alan İstanbul Beykoz ilçesi Çubuklu mahallesi, Çubuklu caddesi No:18'de bulunan ahşap kagir iki katlı 2. derece tarihi eser niteliğinde bitişik nizamlı yapıdır (Şekil 1). Bu çalışma; arazi çalışması ve ofis çalışması olarak iki aşamalı olarak gerçekleşmiştir.

Şekil 1. Çalışması yapılacak olan 2. derece tarihi eser niteliğindeki yapı

Arazi çalışmasında: İlk olarak istikşaf çalışması yapılarak zeminde 5 adet poligon noktası tesis edilmiştir. Poligon noktalarında GNSS (Global Navigitaion Satellite System) alıcısı ile Hızlı-Statik GNSS ölçme yöntemi 15 dakika ara ile 2 epok jeodezik amaçlı yapay uydulara gözlemler yapılmıştır.

Poligon noktalarına dayalı olarak yapının ön ve arka cephelerine, yöneltme işlemlerinde kullanılmak üzere 13 adet obje noktasında ve detay noktalarında (Şekil 2) Topcon GTS-105N Total Station ile üç boyutlu (3B) jeodezik ölçüler yapılmıştır [3]. (Şekil 3)



Şekil 2. Obje ve Detay Noktaları

Total Station	Topcon GTS-105N
3 - 25 m arasında mesafelerde	Ms = +10 mm
25 m'den büyük olan mesafelerde	Ms = +5 mm+2ppm x S
Reflektörlü ölçmelerde	Ms = +3mm+2ppm x S
Açı ölçümlerinde	M = 2.7 mgon

Şekil 3. Topcon GTS-105N total station ve özellikleri

Fotogrametrik değerlendirme için şekli ve teknik özellikleri verilen İnsansız Hava Aracı (İHA) DJI Phantom 4 Pro Dronu, yapının fotoğraflarının çekiminde kullanılmıştır [20-21]. (Şekil 4)

Dijital Kamera	**FC6310**
Sensör Tipi	CMOS
Sensör Boyutu	13 2*8.8
Piksel Boyutu	2.4
Piksel Numarası	20
Sensör Hassasiyeti	ISO 100 - 12800
Maksimum Açıklık	F2.8
Görüş Alanı	84
Görüntü Boyutu (piksel)	5472*3078
Odak Uzaklığı	8.8

Özellikleri	**Değerler**
Ağırlık	1350 gr – 1400 gr.
Batarya	5870 mAH LİPo.
Ebat	1 cm – 35 cm.
GPS Modu	GPS Var.
Kamera	4K.
Maksimum Hız	50 kmp – 70 kmp.
Uçuş Mesafesi	6500 m – 7000 m.
Uçuş Süresi	30 – 31 Dakika.
Kamera Sensörü	1’’CMOS Effect ve pixel:20 M
Mak.Video Çözünürlüğü	4K 60P
Çalışma Frekansı	2.4 GHz/5.8 GHz

Şekil 4. DJI phantom 4 pro dronu ve özellikleri

4.2. Jeodezik Yöntem

Tarihi yapı üzerindeki obje ve detay noktalarının koordinatlarının, ülke sisteminde ölçmek için zeminde 3 boyutlu koordinatları bilinen poligon noktalarına ihtiyaç vardır. Zeminde tesis edilen poligon noktalarında yapılan GNSS ölçülerinin değerlendirilmesi ile poligon noktalarına ilişkin koordinatlar hesaplanmıştır (Tablo 1).

Tablo 1. GNSS yöntemi ile hesaplanmış poligon noktalarının koordinatları

Nokta No	**X(m)**	**Y(m)**	**Z(m)**
P.101	422862.635	4552835.532	39.823
P.102	422866.490	4552831.424	39.754
P.103	422864.463	4552818.602	42.931
P.106	422853.173	4552807.769	49.177
P.107	422851.382	4552809.760	49.207

Dron (İHA) ile çekilen hava fotoğraflarından duyarlı ve ölçekli bir modelin oluşturulabilmesi için koordinatları hesaplanan poligon noktalarına dayalı olarak ahşap bitişik nizamlı yapının ön ve arka yüzeylerine kâğıt hedeflerle (target) tesis edilen obje noktaları ve detay (ayrıntı) noktaları (Şekil 5) Total Station ile ölçülerek bu noktalara ilişkin koordinatlar hesaplanmıştır (Tablo 2).

Şekil 5. Yapının ön ve arka görünümünde bulunan obje noktaları

Tablo 2. Yapının ön ve arka görünümünde bulunan obje noktalarının koordinatları

Ön Cephe Obje Noktalarının Koordinatları			
N.N	X(m)	Y(m)	Z(m)
K1	422853.028	4552847.905	43.505
K5	422860.134	4552827.697	43.207
K7	422853.548	4552848.105	45.161
K8	422853.485	4552848.083	49.055
K9	422859.566	4552849.415	49.366
K10	422859.466	4552849.406	45.109

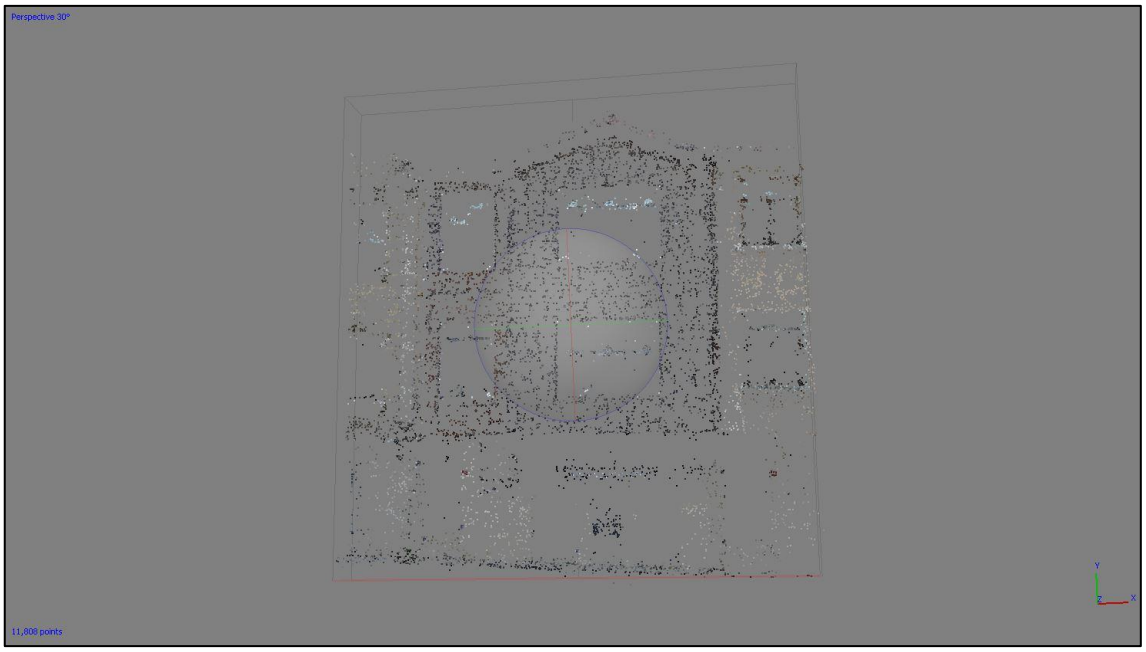
Arka Cephe Obje Noktalarının Koordinatları			
N.N	X(m)	Y(m)	Z(m)
N1	422851.735	4552826.262	50.147
N4	422851.695	4552826.472	46.585
N8	422850.706	4552822.876	48.381
N9	422850.815	4552821.788	48.729
N10	422851.864	4552820.129	50.248
N11	422851.695	4552820.837	47.052
N12	422851.631	4552820.132	45.769

4.3. Fotogrametrik Yöntem

Tarihi bitişik nizamlı yapının ön ve arka cephelerinin 1/100 ölçekli rölövesini üretmek için Dron üzerinde bulunan FC6310 model Kamera, %80 boyuna bindirme ve %30 enine bindirme olacak şekilde kameranın teknik özellikleri dikkate alınarak Ground Sample Distance (GSD) 0.5 cm kabul edilmiş ve uçuş yüksekliği 18 m olarak hesaplanmıştır. Bu değerlere göre her fotoğraf çekim arasındaki uzaklık 5 m olacak şekilde çatı üzerinde Dron uçuşları gerçekleştirilmiştir. 10 m alım uzaklığı ile 3 m aralıklarla ön ve arka cephe fotoğraf çekimi yapılmıştır. Toplam 364 adet görüntü elde edilmiştir.

5. DEĞERLENDİRME

Dron ile elde edilen görüntüler Metashape (Agisoft) yazılımı ile sisteme aktarılmıştır. Tüm görüntüler yazılımın iş akışına göre öncelikle hizalanmış (Align) bağlama noktaları tespit edilmiş bunun sonucunda Seyrek Nokta Bulutu oluşturulmuştur[19].(Şekil 6)



Şekil 6. Seyrek nokta bulutu

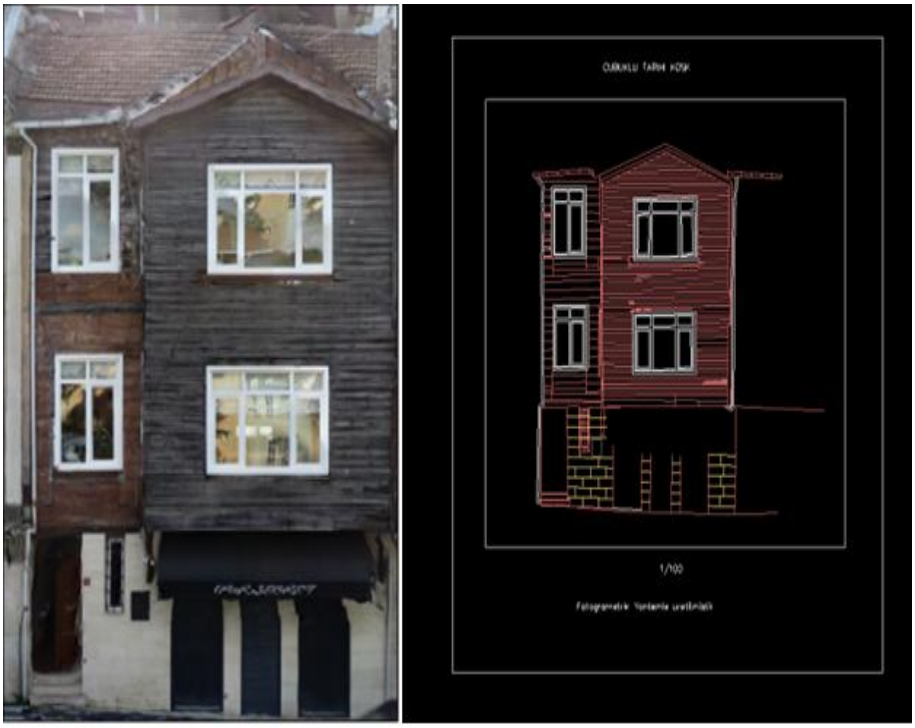
Seyrek Nokta bulutu oluşturulduktan sonra modelin ölçeklendirilmesinde kullanılan jeodezik yöntemle ölçülen obje ve detay noktalarının koordinatları Agisoft yazılımı ile sisteme aktarılmıştır. Sisteme aktarılan obje ve detay noktaları tüm görüntülerde ölçülerek koordinat hataları 2 cm'nin altında kalacak şekilde Metashape (Agisoft) yazılımı ile görüntü koordinatları jeodezik koordinatlara dönüştürülerek ölçeklendirme yapılmış ve Yüksek Yoğunluklu Nokta Bulutu oluşturulmuştur (Şekil 7).

Şekil 7. Yüksek yoğunluklu nokta bulutu

Yüksek Yoğunluklu Nokta Bulutu oluşturulduktan sonra buna dayalı olarak görüntülerden derinliğe bağlı Ortomozaik üretilmiştir[12]. (Şekil 8)

Şekil 8. Ön ve arka cephe ortomozaik

Üretilen Ortomozaik, MicroStation yazılımı ile restorasyon projesinin altığını oluşturan rölöve çizimi elde edilmiştir. Sonra bu yazılım ile 1/100 ölçekli tarihi yapının ön ve arka cephe rölöve çıktısı alınmıştır (Şekil 9 ve Şekil 10).



Şekil 9. Ön cephe rölövesi

Şekil 10. Arka cephe rölövesi

6. SONUÇ

Restorasyon projelerine altlık oluşturan rölöve planlarının duyarlı ölçüm teknikleri ile hazırlanması, tarihi yapıların korunabilmesi için restorasyon projelerinin doğru şekilde yapılabilmesi oldukça önemlidir. Mimari rölöve planları yapmak için jeodezik ve fotogrametrik yöntemler klasik yöntemlerle kıyaslandığında, hem doğruluk hem de zaman açısından daha çok tercih edilen bir yöntemdir.

Günümüzde teknolojik gelişmeler ışığında Dron ile yapılan rölöve çalışması, az maliyet ve arazide çalışacak ekip sayısının az olması, çekilen fotoğraflardan kaliteli veri alındığı için ölçümü tekrarlamadan zamandan tasarruf edilmesi, gibi avantajlar nedeniyle klasik yöntemlere göre daha iyi sonuçlar vermektedir. İnsansız Hava Aracı (İHA) tekniğinin kullanılması ile havadan görüntü alınarak ulaşılamayan yüksek yapıdaki çatıların detayları, endüstri bölgeleri ve arkeolojik alanlar gibi alanların ölçümlerinde tercih edilmesi uygun olan bir yöntemdir. Bu çalışmada İHA tekniği ile fotoğraflardan elde edilen ortomozaikler ile bitişik nizamlı tarihi ahşap kagir yapının ön ve arka cepheleri için rölöve çizimleri 2 cm altında doğrulukla elde edilmiştir. Ortomozaik elde edilirken %80 bindirme oranı ile fotoğraf çekmenin yeterli olduğu anlaşılmıştır.

Çalışma sonucunda elde edilen duyarlık değerleri göz önünde bulundurulduğunda, çalışmaya ait 3B model restorasyon çalışmalarında altlık olarak kullanılabilecektir. Ayrıca tarihi eserlerin sayısal verilerinin dijital kütüphanelerde bulundurulması çeşitli disiplinlerin daha sonraki çalışmalarında ve gelecek nesillere aktarılmasında büyük kolaylık sağlayacaktır [22].

Sonuç olarak klasik fotogrametri ile yapılan rölöve çalışmalarına göre zaman, hız, duyarlık ve ülkemizdeki ekonomik gelişmeler doğrultusunda değişen maliyet açısından İHA tekniği ile yapılan rölöve çalışmaları günümüzde mimarlara ışık tutacaktır.

KAYNAKLAR

1. Yılmaz, H.M., Karabörk, H., Yakar, M. 2000. Yersel Fotogrametrinin Kullanım Alanları, Niğde Üniversitesi Mühendislik Bilimleri Dergisi, Cilt 4 Sayı 1, 2000.

2. Sarıoğlu, Ö., 2004, Yersel Fotogrametrik Rölöve ÖlçümTekniğinin Ömer Duruk Evi Örneği Üzerinde Uygulanması. Gazi Üniversitesi, Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, Ankara

3. Ersoy N., Akdeniz G., Çetin İ., Güler E.,(2017). Laser Total Station Aletinin Rölöve Alımında Kullanımı. TUFUAB Kogresi. Antalya.

4. Freely J A (2011) History of Ottoman Architecture; WIT Press: Southampton, UK.

5. Fonstad M A, Dietrich J T, Courville B C, Jensen J L & Carbonneau P E (2013). Topographic structure from motion: a new development in photogrammetric measurement. Eart. Surf. Process. Landforms, 38, pp. 421-430.

6. Önal M (2015). Harran Örenyeri 2015 Yılı Arkeolojik Çalışmaları, Şanlıurfa Kültür Sanat ve Turizm Dergisi, sayı: 24, Ocak 2015.

7. Ulvi A, Yakar M, Yiğit A Y & Kaya Y (2020). İHA Ve Yersel Fotogrametrik Teknikler Kullanarak Aksaray Kızıl Kilisenin 3B Modelinin Ve Nokta Bulutunun Elde Edilmesi. Geomatik Dergisi, 5 (1), 22-30

8. Şanlıoğlu İ, Zeybek M & Karauğuz G (2013). Photogrammetric Survey and 3D Modeling of Ivriz Rock Relief in Late Hittite Er. Mediterranean Archaeology and Archaeometry, Vol. 13, No 2

9. Kaya Y, Yiğit A Y, Ulvi A & Yakar M (2021). Arkeolojik Alanların Dokümantasyonununda Fotogrametrik Tekniklerinin Doğruluklarının Karşılaştırmalı Analizi: Konya Yunuslar Örneği. Harita Dergisi, 165, 57-72

10. Alptekin A, Çelik M Ö & Yakar M (2019a). Anıtmezarın yersel lazer tarayıcı kullanarak 3B modellenmesi. Türkiye Lidar Dergisi, 1(1), 1-4.

11. Alptekin A, Çelik M Ö, Doğan Y & Yakar M (2019b). Mapping of a rockfall site with an unmanned aerial vehicle. Mersin Photogrammetry Journal, 1(1), 12- 16.

12. Çelik M Ö, Alptekin A, Ünel F B, Kuşak L & Kanun E (2020). The Effect of Different Flight Heights on Generated Digital Products: Dsm And Orthophoto. Mersin Photogrammetry Journal, 2(1), 1-9.

13. Yakar M & Yılmaz H M (2008). Kültürel Miraslardan Tarihi Horozluhan'ın Fotogrametrik Rölöve Çalışması Ve 3 Boyutlu Modellenmesi. Selçuk Üniversitesi Mühendislik, Bilim ve Teknoloji Dergisi, 23(2), 25-33.

14. Polat N, Önal M, Ernst F, Şenol H, Memduhoglu A, Mutlu S, Mutlu S, Budan M, Turgut M & Kara H (2020). Harran Ören Yeri Arkeolojik Kazı Alanınındın Çıkarılan Bazı Küçük Arkeolojik Buluntuların Fotogrametrik Olarak 3B Modellenmesi. Türkiye Fotogrametri Dergisi, 2 (2), 55-59. Retrieved from https://dergipark.org.tr/en/pub/tufod/issue/58 541/835434

15. Mutlu S İ (2019), 2014-2018 Yılları Arasında Harran Höyük Kazısı'nda Bulunan Erken ve Orta Tunç Çağı Pişmiş Toprak Figürinleri, Harran ve Çevresi, Arkeoloji, Ed. M.Önal, S.İ.Mutlu, S.Mutlu. Şanlıurfa 2019: 361-418. ISBN 978-975-7394-55-6, ŞURKAV Yayınları, 191-210. Oxford, UK, 2015.

16. Yakar M, Yıldız F & Yılmaz H M (2005). Tarihi ve Kültürel Miraslarin Belgelenmesinde Jeodezi Fotogrametri Mühendislerinin Rolü. TMMOB Harita ve Kadastro Mühendisleri Odası, 10.

17. Turan M H (2004). Mimari Fotogrametri Alanındaki Çağdaş Gelişimlerin Değerlendirilmesi. Gazi Üniversitesi Mühendislik Mimarlık Fakültesi Dergisi, 19(1).

18. Korumaz A G, Dülgerler O N & Yakar M (2011). Kültürel Mirasın Belgelenmesinde Dijital Yaklaşımlar. Selçuk Üniversitesi Mühendislik, Bilim ve Teknoloji Dergisi, 26(3), 67-83.

19. Yiğit A & Ulvi A. (2020). İHA Fotogrametrisi Tekniği Kullanarak 3B Model Oluşturma: Yakutiye Medresesi Örneği. Türkiye Fotogrametri Dergisi, 2 (2), 46-54.

20. Kaya Y, Şenol H İ, Memduhoğlu A, Akça Ş, Ulukavak M & Polat N (2019). Hacim Hesaplarında İHA Kullanımı: Osmanbey Kampüsü Örneği. Türkiye Fotogrametri Dergisi, 1 (1), 07-10.

21. Yiğit A Y, Orhan O & Ulvi A (2020). Investigation of The Rainwater Harvesting Potential at the Mersin University, Turkey. Mersin Photogrammetry Journal, 2(2), 64-75

22. Ulvi A, Murat Yakar M, Yiğit A.Y, Kaya Y (2020). İHA ve Yersel Fotogrametrik Teknikler Kullanarak Aksaray Kızıl Kilise'nin 3 Boyutlu Nokta Bulutu ve Modelinin Üretilmesi, Geomatik Dergisi 2020; 5(1); 19-26.

23. Duran Z. (2003). Tarihi Eserlerin Fotogrametrik Olarak Belgelenmesi ve Coğrafi Bilgi Sistemine Aktarılması. Doktora Tezi, İ.T.Ü. Fen Bilimleri Enstitüsü, İstanbul

24. Öksüz, M., Yıldırım, Ç., Sağlam, Ö., Karaarslan, Y., Görmüş, K., ve Kutoğlu, Ş.H. (2011). Zonguldak Kozlu Bölgesi'nin Su Baskınlarına Yönelik Risk Araştırması. TMMOB Harita ve Kadastro Mühendisleri Odası 13. Türkiye Harita Bilimsel ve Teknik Kurultayı. Ankara.

25. URL-1:https://tr.wikipedia.org/wiki/Beykoz

26. URL-2:https://www.teknikerler.com/dji-phantom-4-pro/
27. URL-3:https://www.mobilecadsurveying.co.uk/topcon-gts105n-non-reflectorless
28. URL-4:https://www.drone.net.tr/drone-modelleri/profesyonel-drone/dji-phantom-4-pro.v2.0.html
29. URL-5: https://providyo.com/phantom-4-pro/

Araştırma Makalesi/Research Article

Investigation of Polymer Hybrid Ball Bearings' Dynamic Behaviour

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Abstract

Contact mechanics must be analyzed to determine the dynamic characteristics of polymer hybrid bearings. Since the polymer bearings have contact surfaces of polymer-polymer, polymer-glass, or polymer-steel, the Hertz contact theory used to examine the contact mechanics of conventional bearings cannot be directly used. Due to the elastoplastic structure of polymer materials, elastoplastic contact mechanics is used in examining contact mechanics. In this study, the contact mechanics of the polymer bearing were analyzed as elastoplastic contact and were included in the shaft-bearing system model. An algorithm was developed in the MATLAB environment using the geometry of the 6203 bearings, and its dynamic characteristics were examined through simulations. The equations of motion are simulated at different shaft speeds with an elastic region assumption to determine the dynamic characteristics of polymer hybrid bearings. The results are discussed in the time-frequency domain.

Keywords: Elasto-Plastic Contact, Polymer Hybrid Ball Bearing, Vibration

Polimer Hibrid Rulmanların Dinamik Davranışının İncelenmesi

Özet

Polimer hibrid rulmanların dinamik özelliklerini belirlemek için temas mekaniğinin analiz edilmesi gerekmektedir. Polimer rulmanlar polimer-polimer, polimer-cam veya polimer-çelik temas yüzeylerine sahip olduğundan, geleneksel rulmanların temas mekaniğini incelemek için kullanılan Hertz temas teorisi doğrudan kullanılamamaktadır. Polimer malzemelerin elastoplastik yapısından dolayı temas mekaniğinin incelenmesinde elastoplastik temas mekaniği kullanılmaktadır. Bu çalışmada, polimer hibrid rulmanın temas mekaniği elastoplastik temas olarak analiz edilmiş ve şaft-rulman sistemi modeline dahil edilmiştir. 6203 rulmanın geometrisi kullanılarak MATLAB ortamında bir algoritma geliştirilmiş ve simülasyonlar aracılığıyla dinamik özellikleri incelenmiştir. Polimer hibrid rulmanların dinamik özelliklerini belirlemek için hareket denklemleri rulmanın elastik bölgede olduğu kabul edilerek farklı mil hızlarında simüle edilmiştir. Sonuçlar zaman-frekans alanında tartışılmıştır.

Anahtar Kelimeler: Elasto-Plastik Temas, Polimer Hibrid Rulman, Titreşim

1. INTRODUCTION

Polymer bearings, unlike steel bearings, have recently become more common in industry because they provide more advantages in places where the load-carrying capacity is not essential, hygiene is required, chemicals are used, and a quiet working environment is required. Polymer hybrid bearings are generally made of polymer inner race, outer race, and cage, and rolling elements (balls) could be polymer, glass, or steel balls, depending on the application. Figure 1 shows the unassembled view of the polymer hybrid deep groove ball bearing used in the simulations.

Figure 1. The distributed view of polymer hybrid deep groove ball bearing

The long lifespan of bearings is essential in terms of economy and continuity of production. For this reason, bearings are operated within the limits of the elastic region. Hertz contact is used to analyze the contact mechanics of conventional steel bearings. However, the polymer ball bearings' structure differs from steel bearings because the balls and races consist of different materials. So, Hertz's contact theory cannot be directly used to examine the contact in polymer bearings. When examining the contact mechanics of polymer bearings, elastoplastic contact is used instead of Hertz contact theory. Elasto-plastic contact examines elastic, elasto-plastic, and fully plastic regions in three parts and two kinds of model: the indentation model and the flattening model. The critical deformation rate must be known to classify the contact area formed in elasto-plastic contact, which is explained in detail in Section 2.

In elasto-plastic contact, the critical deformation rate, first proposed by Kogut and Etsion and later by Jackson and Green, to which the von Mises yield criterion of the material was added, is used to determine in which region the contact occurs. Kogut and Etsion determined frictionless elasto-plastic contact between the deformable sphere and the rigid surface. They indicated when contact $\delta/\delta_c \leq 1$ there is a fully elastic region, and it is compatible with Hertzian contact when $1 < \delta/\delta_c \leq 6$ a plastic zone has started under the sphere surface, but the whole contact area is elastic; when $6 < \delta/\delta_c \leq 68$ there is elastic-plastic contact, and when $\delta/\delta_c > 68$ the contact area is in the fully plastic region [2]. Later, unlike the model created by Kogut and Etsion, Jackson and Green added geometry and material effects to the model and created a model using the finite element method, accepting the Von Mises yield strength criterion as the yield point of the material and accepting it as $\delta/\delta_c < 1.9$ the elastic region. This model can use the material's yield point with the two deformable surfaces' weaker and lower yield points [3, 4]. Brake developed a new formulation for the elasto-plastic contact of two circular objects in the normal direction, taking into account the contact geometry and material properties [5]. Jamari and Schipper created a theoretical model for the elasto-plastic contact of ellipsoid bodies [6]. Zhao et al. modeled three regions between two flat surfaces: elastic, elasto-plastic, and plastic regions, and used the hardness of the material to determine the critical contact point [7]. Li et al. examined the rigid and elastoplastic spheres by modifying the theoretical model created by Johnson [8]. Jackson and Sharma investigated the cylindrical elasto-plastic contact between a solid flat surface and a cylinder modeled as a deformable quarter circle using the finite element method [9]. Yau et al. used elasto-plastic models to determine the stress distribution on the bearing in the elastic and elasto-plastic regions [10,11]. Komvopoulos and Song examined the deformation of elasto-plastic half-space and rigid cylindrical contact in four different deformation forms: linear elastic-plastic, nonlinear elastic-plastic, transition to full plastic and the steady-state part of plastic deformation using the finite element method [12].

Elasto-plastic contact is examined with two models: the indentation model and the flattening model. Some researchers have examined various contact surfaces using only the indentation and flattening contact model. Ghaednia et al. investigated the frictionless contact between an elasto-plastic surface and a sphere. They achieved this by developing a novel model that connects the flattening and indentation models, allowing for elasto-plastic deformation of both surfaces. [1]. Ogar et al. analyzed the flattening model with a sphere, considering the material's hardness with the finite element method [13]. Deng et al. investigated the similarities and differences between the elasto-plastic flattening and indentation contact model with the finite element method using five different materials whose yield strengths cover a typical range of steel materials used in engineering [14]. Ogar et al. investigated indentation and flattening in the contact between a rigid, rough surface and an elasto-plastic half-space, as well as between a rigid, smooth surface and a rough surface [15]. Jackson and Kogut examined the indentation and flattening contact model comparatively using the finite element method [16]. Mesarovic and Fleck examined the indentation contact between a rigid sphere and an elasto-plastic deformable surface with and without considering friction [17]. Sara et al. used slip-line theory to investigate the yield force and average pressure of the indentation

contact between the rigid sphere and the frictionless deformable surface, and they compared their findings with those obtained using the finite element method. [18].

Bearings have complex dynamics, unlike their simple structures. Bearings produce vibration even when they are healthy. When the vibration of healthy bearings is examined, high amplitude signals are seen at the frequency values known as Ball Pass Frequency. Gustafsson and Tallian first determined the Ball Pass Frequency (BPF) with a mathematical model [19,20]. Meyer et al. decided that Ball Pass Frequency (BPF) and its harmonics are seen even if the bearing is healthy after Gustafsson and Tallian's study [21,20].

This study models the shaft-bearing system mathematically to predict how bearings behave dynamically. The contact mechanics between the ball and races are also investigated and introduced to the shaft-bearing model. The dynamic behaviors of healthy and faulty bearings were compared with simulations at different shaft speeds and under various loading conditions [22,23,24,25]. The mathematical model of the 6203 series deep groove ball bearing with steel balls has two degrees of freedom along lateral and vertical, and simulations are run under elastic contact assumption.

2. ELASTO-PLASTIC CONTACT MODEL

a) Indentation Model

The indentation model was modeled to determine the contact between the sphere and the flat surface. According to this model, the hardness of the contacting surfaces is different from each other. Of the contacting surfaces, the sphere is more rigid, and the material used for the flat surface is softer than the material used for the sphere. Since the surface is more delicate, it is accepted that deformation occurs on the contact surface [1]. Figure 2 shows the schematic view of the indentation model.

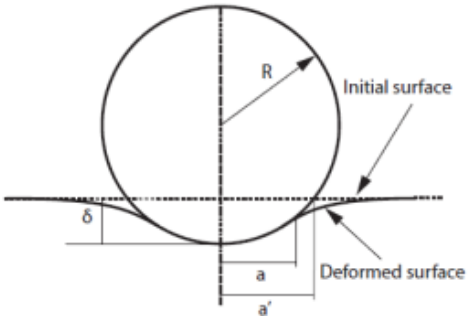

Figure 2. Indentation model [1]

b) Flattening Model

The flattening model is the other model of the elastoplastic model. In contrast to the indentation model, it is modeled to establish the contact model of the soft sphere, and the more rigid flat surface sphere is constructed of softer material in this model. Deformation is assumed to occur on the sphere using the contact model. Figure 3 shows the schematic view of the flattening model.

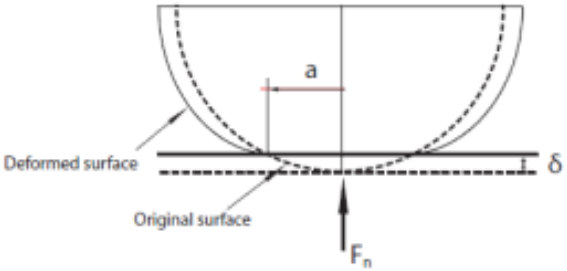

Figure 3. Flattening model [1]

To determine the contact area in elasto-plastic contact, the deformation ratio to the critical deformation amount is mathematically calculated using the contact properties of the contacting surfaces.

Critic Deformation

Critical deformation is an important criterion used to determine where the contact area occurs and is calculated by considering the material properties and geometries of the contacting surfaces. The mathematical formulation for the critical deformation amount is given in Eq. 1 [1,4].

$$\delta_c = \left(\frac{\pi.C.S_y}{2E'} \right)^2 R \tag{1}$$

$$\frac{1}{E'} = \frac{1-\nu_1^2}{E_1} + \frac{1-\nu_2^2}{E_2} \tag{2}$$

$$C = 1.295e^{0.736\nu_s} \tag{3}$$

E' indicates the equivalent elasticity modulus and is calculated using the formulation in Eq. 2 [1,4]. The elasticity modulus values of the materials from which the contacting objects are used in Eq. 1 are manufactured and calculated using the formulation given in Eq. 2. C is a constant specified by the mathematical formula shown in Eq. 3 [1,4]. R represents the radius of the sphere. This study calculates R by taking the resultant of the ball radius and the distances between the inner and outer race curvature radii. Sy is the yield stress value of the first deformed material. The coefficient νs seen in Eq. 3, used when calculating the constant C, represents the Poisson ratio of the first deformed material.

3. CONTACT MECHANICS

3.1. Total Deflection of Ball Bearing

Bearings transmit forces by deflection on the ball. The amount of deflection resulting from ball-inner race contact and ball-outer race contact is expressed as total deflection. The total deflection formulation is given in Eq. 4 [27]. δ_i indicates inner race-ball deflection, appears δ2 in Figure 4, and δ_o indicates outer race-ball deflection δ1 appears in Figure 4, δ the sum of the deformations on the ball as seen in Figure 4.

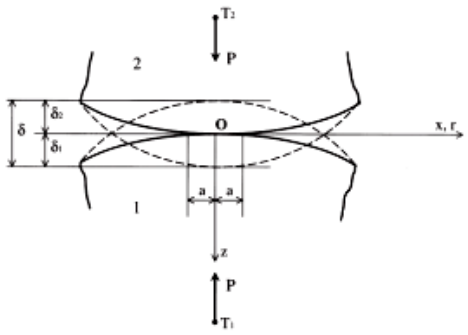

Figure 4. Total deflection of bearing [26]

$$\delta = \delta_i + \delta_o \tag{4}$$

$$\delta = \delta^* \left(\frac{3}{2} \frac{F}{\Sigma\rho} \left[\frac{1-\upsilon_1^{\,2}}{E_1} + \frac{1-\upsilon_2^{\,2}}{E_2} \right] \right)^{\frac{2}{3}} \frac{\Sigma\rho}{2} \tag{5}$$

The total deformation occurring on the bearing depends on the properties of the material used in the production of the parts forming the bearing and the geometric properties of the bearing. Eq. 5 indicates the mathematical representation of the amount of deformation calculated using the bearing's geometric properties and material properties [27]. The contact between the ball and the races has a point contact due to the structure of the balls and races. However, the point contact between the ball and the race turns into an elliptical area after loading. Primary and secondary elliptic integrals compute the parameters (a*,b*, and □*) needed to determine the contact area and deformation amount since the produced contact is elliptical. The dimensions of the elliptical area occurring in Hertz elastic contact and the deformation quantity can be roughly approximated when a*, b*, □* and dimensionless parameters are calculated.

3.2. Shaft-bearing system of polymer bearing

The shaft bearing system produces vibration even when the bearing on the system is healthy [21, 4]. This vibration is equal to the product of the cage frequency and the number of balls in the bearing and is called the Ball Pass Frequency (BPF). The equation used to determine the Ball Pass Frequency is given in Eq. 6. For this formulation, m represents the number of balls, and □c represents the angular velocity of the cage. The mathematical formulation seen in Eq. 7 calculates the angular velocity of the cage, and γ seen in Eq. 7 indicates the angle between the ball-bearing balls. Since the bearing used in this study is a deep groove ball bearing, α it is taken as zero, as seen in Eq. 8.

$$\omega_{bg} = m\omega_c \tag{6}$$

$$\omega_c = \frac{1}{2}\left(\omega_i(1-\gamma) + \omega_o(1+\gamma)\right) \tag{7}$$

$$\gamma = \frac{d_b}{d_m}\cos\alpha \tag{8}$$

The force on the bearing is calculated by the total deflection and stiffness, as seen in Eq. 9. F indicates the total force on the bearing, K denotes the bearing stiffness, and □ indicates the total deformation amount on the balls.

$$\mathbf{F = K\delta^{3/2}} \tag{9}$$

There is a nonlinear relationship between deflection and load, as seen in Eq. 9. To determine the nonlinear shaft-bearing system's dynamic behavior, the system's time solution at different loads and speeds must be obtained. For the theoretical part of this study, some assumptions were made, and the equations of motion were obtained.

The assumptions made are stated below;

- The shaft is assumed to have two degrees of freedom, x, and y, in the radial direction.
- The balls are placed at equal intervals around the inner and outer races. The outer race does not rotate.
- Balls are assumed to be massless.
- Races are rigid, and only local deformations occur.
- The shaft is assumed to be rigid.

The schematic view of the shaft-bearing system is given in Figure 5;

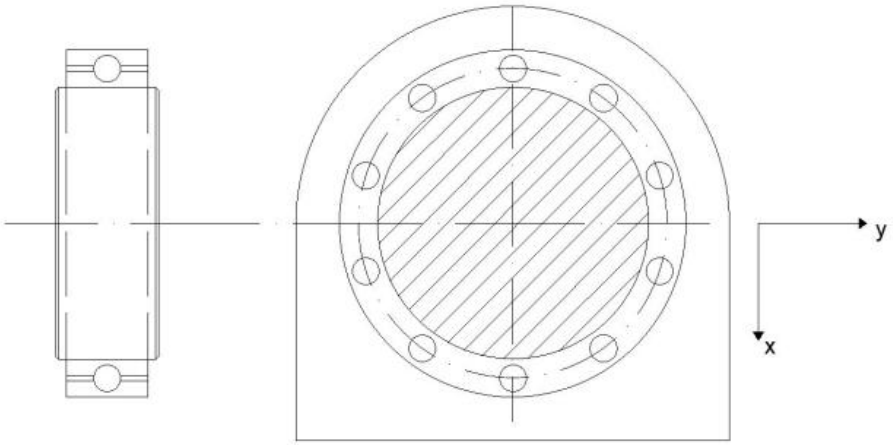

Figure 5. The schematic view of the shaft-bearing system

According to these assumptions, the equations of motion of the system model with two degrees of freedom are Eq. 11 and Eq. 12, which are stated below;

$$M\ddot{x} + \sum_{i=1}^{n} K_i \delta_i^{3/2} \cos(\theta_i) + P_x - Mg = 0 \quad (11)$$

$$M\ddot{y} + \sum_{i=1}^{n} K_i \delta_i^{3/2} \sin(\theta_i) + P_y = 0 \quad (12)$$

The equations of motion were solved using the fourth-order Runge-Kutta method and iterative methods. The system was solved with only the initial conditions to determine the system's natural frequency. P_x is the force in the x-axis direction and indicates the force on the bearing calculated by considering gravity's effect. Py indicates the force acting on the bearing in the y-axis direction.

4. RESULTS AND DISCUSSION

The geometry of the bearings, the quantity of rolling elements, rotational speeds, and system operating factors all affect how dynamically a bearing behaves. The bearings' geometric and material characteristics were included in a mathematical model. MATLAB is used to develop a code that simulates the mathematical model with differential equation solutions. The code is run for different shaft speeds, and vibration spectra are obtained for these speeds. In order to analyze dynamic characteristics in the time-frequency domain, waterfall diagrams are plotted for the simulated 6203 series polymer hybrid ball bearing in good and faulty condition. The 6203 deep groove ball bearing properties used for simulations are given in Table 1, and the x-axis direction waterfall graph and y-axis waterfall graph are shown in Figure 6 and Figure 7, respectively.

Table 1. Properties of 6203 ball bearing

The diameter of the inner race	D_i	0,017 m
The diameter of the inner raceway	d_i	0,02358 m
Outer raceway diameter	d_o	0,02841 m
Outer race diameter	D_o	0,04 m
Bearing width	w	0,012 m

Balls Diameter	d_b	0,00426 m
Radius of inner race groove	r_i	0,002480 m
Outer race groove radius	r_o	0,003340 m
Number of balls	m	10
Contact angle	α	0

In Figure 6, the resonance of the shaft-bearing system is clearly visible when the Ball Pass Frequency coincides with the shaft's natural frequency (critical speed) along the x-axis at 3050 rpm. The natural frequency of the shaft along the x-axis is determined as 212,40 Hz.

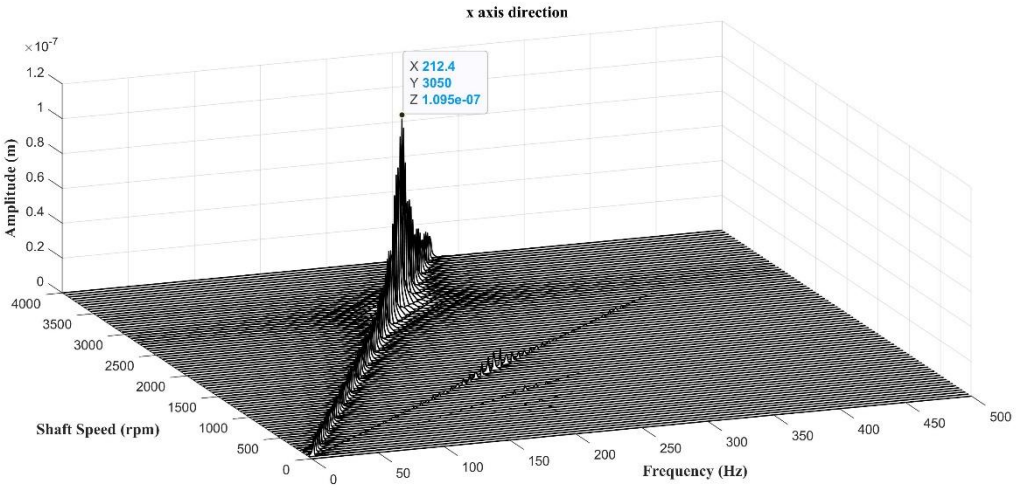

Figure 6. 6203 bearing elastic region shaft vibrations in the x-axis

The behavior of the shaft along the y-axis is similar to the x-axis, but the natural frequency of the shaft along the y-axis is 179.95 Hz. So, the shaft resonance along the y-axis occurs at 2500 rpm, as seen in Fig. 7. It should be noted that the superharmonics of the BPF are also visible in Fig. 6 and Fig. 7. However, their amplitudes, when coinciding with the natural frequencies, are lower than the BPF's.

The natural frequency along the x-axis (212.40 Hz) is higher than the natural frequency along the y-axis (179.95 Hz). The system is modeled as gravity along the x-axis. Due to the nonlinear contact between the ball and the races, the loading alon x-axis and y-axis are different. The more loaded contact along the x-axis causes a larger contact area, so the more stiffness along this axis leads to a higher natural frequency.

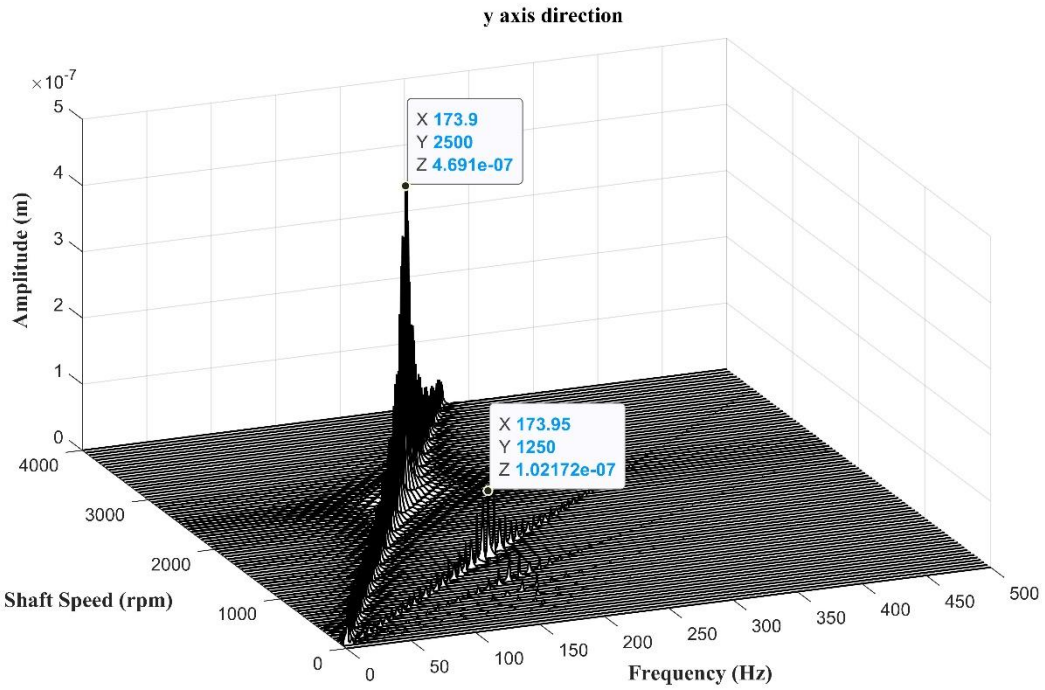

Figure 7. 6203 bearing elastic region shaft vibrations in the y-axis

5. CONCLUSION

Using the indentation contact model, a mathematical model was created to determine the dynamic characteristics of the 6203 polymer hybrid bearing. Since the system is modeled with 2 degrees of freedom, the shaft-bearing system has two natural frequencies along each axis. Gravitational force affects the x-axis, so the natural frequency along this axis is higher than the other axis due to the nonlinear contact between the ball and the races. As can be seen from the waterfall diagrams, resonance occurs when the Ball Pass Frequency (BPF) coincides with one of the system's natural frequencies. Since the resonance zone has a destructive effect, these kinds of systems should not be operated at this shaft speed, or the system's design must be altered to avoid these working conditions.

ACKNOWLEDGMENTS

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REFERENCES

1. Ghaednia, H., Pope, S. A., Jackson, R. L., and Marghitu, D. B. A comprehensive study of the elasto-plastic contact of a sphere and a flat. Tribology International, 93, 78-90, 2016.

2. Kogut, L., and Etsion, I. Elastic-plastic contact analysis of a sphere and a rigid flat. Journal of Applied Mechanics, 69(5), 657-662, 2002.

3. Jackson, R. L., and Green, I. A finite element study of elasto-plastic hemispherical contact against a rigid flat. Transactions of the ASME-F-Journal of Tribology, 127(2), 343-354, 2005.

4. Jackson, R. L., and Green, I. A finite element study of elasto-plastic hemispherical contact. International Joint Tribology Conference. 37068, 65-72, 2003.

5. Brake, M. R. An analytical elastic-perfectly plastic contact model. International Journal of Solids and Structures, 49(22), 3129-3141, 2012.

6. Jamari, J., and Schipper, D. J. Anelastic–plastic contact model of ellipsoid bodies. Tribology letters, 21(3), 262-271, 2006.

7. Zhao, Y., Maietta, D. M., and Chang, L. An asperity microcontact model incorporating the transition from elastic deformation to fully plastic flow. ASME
JOURNAL OF TRIBOLOGY,122(1), 86-93, 2000.

8. Li, L. Y., Wu, C. Y., and Thornton, C. A theoretical model for the contact of elastoplastic bodies. Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science, 216(4), 421-431, 2001.

9. Sharma, A., and Jackson, R. L. A finite element study of an elasto-plastic disk or cylindrical contact against a rigid flat in plane stress with bilinear hardening. Tribology Letters, 65(3), 1-12, 2017.

10. Yau, L. C., Zamri, W. F. H. W., Mohamed, I. F., Kamal, A., and Ariffin, M. F. M. D. An Elasto-Plastic Ball Bearing Contact with Bilinear Hardening. International Journal of Innovative Technology and Exploring Engineering, 9(4), 2020.

11. Yau, L. C., Zamri, W. F. H. W., Din, M. F. M., Fadhlina, I., and Mohamed, A. A. Elastic and Elasto-Plastic Contact Behavior on Ball Bearing. International Journal of Innovative Technology and Exploring Engineering, 8(6), 2020.

12. Song, Z., and Komvopoulos, K. Elastic–plastic spherical indentation: deformation regimes, evolution of plasticity, and hardening effect. Mechanics of Materials, 61, 91-100, 2013.

13. Ogar, P., Ugryumova, E., Gorokhov, D., and Zhuk, A. Influence of the of hardenable material on elastoplastic flattening of spherical asperities. Materials Today: Proceedings, 38, 1638-1643, 2021,

14. Deng, Q., Yin, X., and Abdel Wahab, M. A Comparative Study on Indentation and Flattening Contacts. Fracture, Fatigue and Wear, 67-79, Springer, Singapore, 2020.

15. Ogar, P., Gorokhov, D., and Ugryumova, E. Indentation and flattening of rough surfaces spherical asperities. International Journal of Engineering and Technology (UAE), 7(2.23), 188-191, 2018.

16. Jackson, R. L., and Kogut, L. A comparison of flattening and indentation approaches for contact mechanics modeling of single asperity contacts. Journal of Tribology, 128(1), 209-212, 2006.

17. Mesarovic, S. D., and Fleck, N. A. Spherical indentation of elastic–plastic solids. Proceedings of the Royal Society of London. Series A: Mathematical, Physical and Engineering Sciences, 455(1987), 2707-2728, 1999.

18. Jackson, R. L., Ghaednia, H., and Pope, S. A solution of rigid–perfectly plastic deep spherical indentation based on slip-line theory. Tribology Letters, 58(3), 1-7, 2015.

19. Gustafsson, O. G., and Tallian, T. Study of the vibration characteristics of bearings. SKF INDUSTRIES INC PHILADELPHIA PA, 1963.

20. Karaçay T. Açısal Temaslı Rulmanlarla Yataklanmış Şaftların Dinamiği ve Rulman Hatalarının Deneysel Analizi, Doktora Tezi, Gazi Üniversitesi Fen Bilimleri Enstitüsü, Ankara, 2006.

21. Meyer, L. D., Ahlgren, F. F., and Weichbrodt, B. An analytic model for ball bearing vibrations to predict vibration response to distributed defects. ASME. J. Mech. Des. 102(2): 205-210, 1980.

22. Patil, M. S., Mathew, J., Rajendrakumar, P. K., and Desai, S. A theoretical model to predict the effect of localized defect on vibrations associated with ball bearings. International Journal of Mechanical Sciences, 52.9, 1193-1201, 2010.

23. Mufazzal, S., Muzakkir, S. M., and Khanam, S. Theoretical and experimental analyses of vibration impulses and their influence on accurate diagnosis of ball bearing with localized outer race defect. Journal of Sound and Vibration, 513, 116407, 2021.

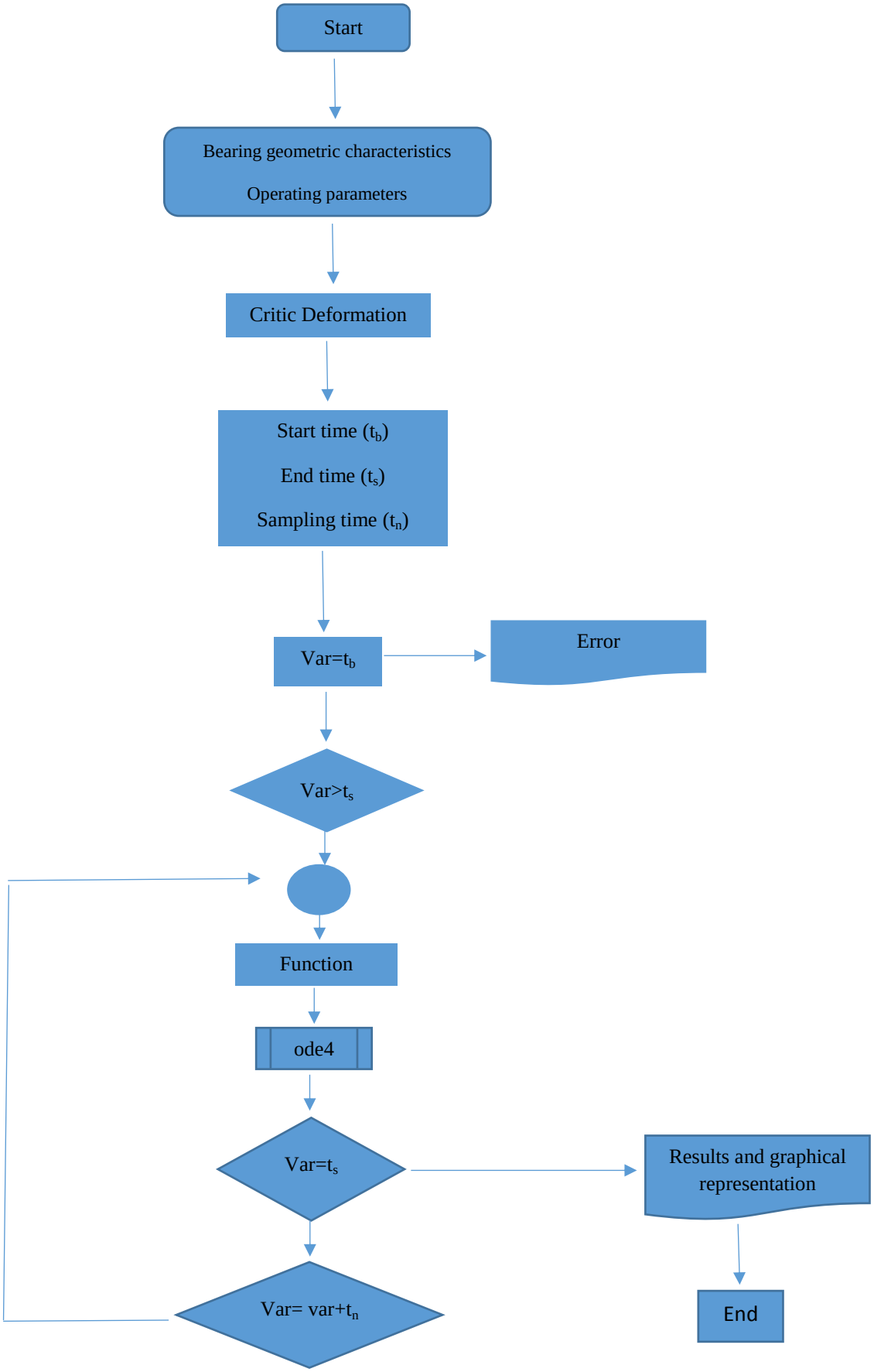
24. Yu, G., Su, M., Xia, W., Wu, R., and Wang, Q. Vibration characteristics of deep groove ball bearing based on 4-DOF mathematical model. Procedia Engineering, 174, 808-814, 2017.

25. Tandon, N., and Choudhury, A. An analytical model for the prediction of the vibration response of rolling element bearings due to a localized defect. Journal of sound and vibration, 205(3), 275-292, 1997.

26. Aliustaoğlu, C., Ocak, H. ve Ertunç, H. M. Rulman Titreşim analizi ile bölgesel hataların incelenmesi. Otomatik Kontrol Ulusal Toplantısı'07 Bildiriler Kitabı, 451- 456, 2007.

27. Harris, T.A., Rolling Bearing Analysis 4th edition, Jon Wiley&Sons, New York, 2001.

APPENDİX - Ball elasticity subroutine



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Araştırma Makalesi/Research Article

Statistical Selection of Effective Body Measurements: Waist Circumference Measurement Exercise

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Abstract

In this research, normality assumptions of body measurements are conducted according to five criteria, boxplots, and Kolmogorov-Smirnov and Shapiro-Wilk tests and proved normal. Besides, statistical selection of effective body measurements to define other body measurements is proposed for shorter, precise, time-cost saving. To support this proposel, correlation coefficients and multivariate multiple regression analyses (MMRAs) are conducted. Statistical selection of effective body measurements depend upon high correlation coefficient pairs of body measurements bases. MMRAs are handled from three different points of view; first, one body measurement being the dependent variable and other body measurements being independent variables enter Method; second, the same stepwise Method; and third, one body measurement being the dependent variable and statistically selected effective body measurements being independent variables enter Method; finally their Adj.r2's are compared. This research progressed by working on each body measurement, but the waist circumference measurement is only presented here. Enter and stepwise methods concluded the highest and similar results, unexpectedly proposing the least statistical selection of effective body measurements. More profound work with different mathematical sciences will be implemented further.

Keywords: Body Measurement, Assumptions of Normality, Correlation, Multivariate Multiple Regression Analyses, Statistical Selection

Etkili Beden Ölçülerinin İstatistiksel Seçimi: Bel Çevresi Ölçüsü Örneği

Özet

Bu araştırmada beden ölçülerinin normallik varsayımları; beş kriter kullanılarak, Boxplot, Kolmogorov-Smirnov ve Shapiro-Wilk testleri ile gerçekleştirilmiş ve beden ölçülerinin normal dağılım gösterdiği kanıtlanmıştır. Ayrıca, etkili beden ölçülerinin istatistiksel seçimi ile diğer beden ölçülerine ulaşmak için kısa, hassas, zaman ve maliyet tasarruflu bir yöntem önerilmiştir. Bu öneriyi desteklemek için korelasyon katsayıları ve çok değişkenli çoklu regresyon analizleri (MMRA) yapılmıştır. Etkili beden ölçülerinin istatistiksel seçilmesi, yüksek korelasyon katsayılı beden ölçüsü çiftlerinin tespiti temeline dayanmaktadır. MMRAlar ise, üç farklı bakış açışıyla; birinci, bir beden ölçüsü bağımlı değişken ve diğer beden ölçüleri bağımsız değişken enter metodu; ikinci, aynısı stepwise metodu; üçüncü, bir beden ölçüsü bağımlı değişken ve istatistiksel seçilen etkili beden ölçüleri bağımsız değişken enter metodu; olacak şekilde yapılmış ve bunların Adj.r2'leri karşılaştırılmıştır. Her bir beden ölçüsü ayrı ayrı çalışılmış ancak bu çalışmada sadece bel çevresi ölçüsü örnek olarak verilmiştir. Enter ve stepwise metodları en yüksek ve benzer sonuçları vermiş, beklenenin aksine, önerilen en etkili beden ölçülerinin istatistiksel seçimi en düşük sonuçları vermiştir. İleriki çalışmalarda daha derin matematik bilimleri uygulanacaktır.

Anahtar Kelimeler: Beden Ölçüsü, Normallik Varsayımları, Korelasyon, Çok Değişkenli Çoklu Regresyon Analizleri, İstatistiksel Seçim

1. INTRODUCTION

Body measurements and the relationships between body measurements (BM) have long been a concern of many researchers. First of all, BMs are the main concern in apparel production, either tailored or mass produced. In both kinds of production, the goal is to make a garment that fits the person who purchased it. To conform this goal, BMs have to be obtained precisely. BMs are obtained manually, or by body scanners, or by computer software developed recently, which are an immense subject being searched. On the other hand, the relationships between the BMs are also a great subject being searched. The advantage of studying the relationships between BMs is to reach certain BMs without measuring them, instead, to obtain them via the measured ones, spending less time but even attaining more precise meaurements than hand taken ones, besides time and cost saving.

Empirical formulas, statistical methods, or mathematical approaches are applied to reveal the relationships between BMs. Empirical formulas are based on experimental work and reach BMs almost correctly [1-5]. From the point of statistical methods, correlation and regression analyses are the most used statistical tools and many research can be found in the literature [6-9]. With the development of mathematical sciences, mathematical approaches are also applied for defining BMs, since this is also a recently developing study area; to give examples such as, cross-sectional areas of BMs (Figure 1) [10], extraction of feature points (Figure 2) [11], sharp body silhouettes for obtaining 3D BMs from 2D images (Figure 3) [12]; and pixel coordinates for obtaining 3D BMs from 2D images (Figure 4) [13].

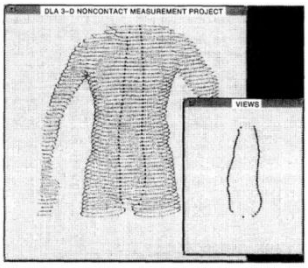

Figure 1. Developing software to extract body measurements [10]

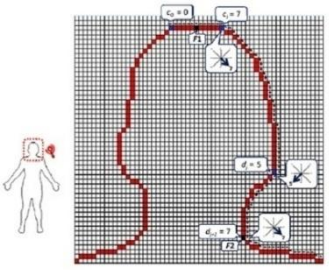

Figure 2. Extraction of feature points F1 and F2 for head size [11]

Figure 3. Background removed image and silhouette image [12]

Person 10. Front Pixel Coordinates

Regions	Beginning Coordinate (x_0, y_0)	Ending Coordinate (x_1, y_1)
Neck	(111, 5)	(150, 5)
Shoulder	(60, 42)	(207, 42)
Chest	(90, 97)	(189, 97)
Biceps_right	(51, 111)	(81, 111)
Biceps_left	(197, 116)	(228, 116)
Waist	(83, 176)	(198, 176)
Belly	(77, 205)	(204, 205)
Hip	(74, 252)	(212, 252)
Thigh_right	(77, 286)	(135, 286)
Thigh_left	(149, 286)	(207, 286)

Person 10. Side Pixel Coordinates

Regions	Beginning Coordinate (x_0, y_0)	Ending Coordinate (x_1, y_1)
Neck	(26, 4)	(60, 4)
Shoulder	(13, 41)	(81, 41)
Chest	(14, 95)	(114, 95)
Biceps_right	None	None
Biceps_left	None	None
Waist	(42, 178)	(106, 178)
Belly	(26, 209)	(106, 209)
Hip	(14, 250)	(101, 250)
Thigh_right	(23, 286)	(100, 286)
Thigh_left	None	None

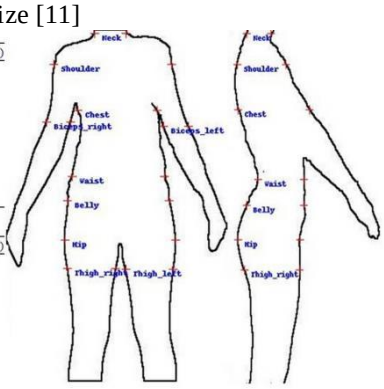

Figure 4. List of pixel coordinates of feature points for front and side and body silhouettes [13]

In previous research of the correspondent author, a study was initiated to obtain 3D BMs from 2D images to eliminate the need for the body when taking BMs manually or by body scanners, and to investigate a solution to the problem of unfit garment one's own body, which often occurs in e-shopping. The photographs of 500 female participants between ages 18-25, all volunteers, between weights 43-85 kg, wearing tight clothes, from 3 m distance, from the front and side rotated 90^0, from neck to knees, arms and legs slightly open, using a camera that focuses on the waist and parallel to the ground, were taken. Some examples of the photographs taken from the front and side

are given in Figure 5, Person-38, Person-119, Person-164, and Person-425, numbered by the author. Different BMs up to 20 (Horizontal : neck, shoulder, biceps, chest, waist, belly, hip, thigh circumferences, back neck girth, back width, shoulder width; and Vertical : inner leg, outer leg, inner arm, front, back, side lengths, arm length from neck, arm length from shoulder, chest fall) were manually measured according to ISO-8559 standards using a non-stretchable tape measure, and the same person's age, height, and weight were also recorded [14, 15].

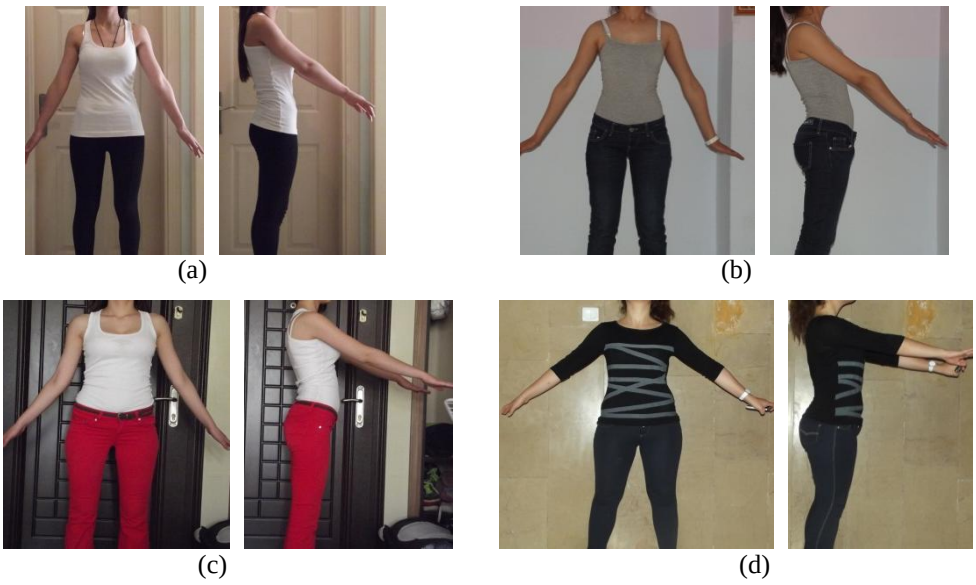

Figure 5. Front and side photographs of volunteers named (a) person-38, (b) person-119, (c) person-164, and (d) person-425 [14, 15]

Since running that research, it was noticed in literature papers applying statistical methods to BMs did not mainly first check the normality of BM data; which seems rather important. Because sample size, if mean represents the data set for comparison, parametric or nonparametric test decision, all depend on the normality assumption of data. Another important point noticed is that the BMs selected to define a specific BM with regression analyses were chosen at random. Still, it was thought that there has to be a reasonable selection. Therefore, these two points are emphasized and discussed in this manuscript; initially, the normality assumptions of BMs are presented, and afterward, statistical selection is conducted to determine a specific BM by regression analysis, not in the literature. This research aims to prove the normality assumptions of BMs and reach the BMs with regression analyses, especially, multivariate multiple regression analyses (MMRAs), both with all BMs and with statistically selected BMs, not randomly.

The steps followed in this research are defining the descriptive statistics of BMs; executing assumptions of normality with its five criteria, boxplots, and Kolmogorov-Smirnov and Shapiro-Wilk tests. This research uses correlation analyses for the statistical selection of MMRAs both with all the BMs and the statistically selected effective BMs. The last comparision tests whether the thought of statistical selection conforms to determining the relationships between some BMs to reach others.

2. MATERIAL AND METHOD

2.1. Material

To realize the purpose of this research, the material used is mainly BMs of female volunteers in Ref. [14,15]. The different BMs concerned here are up to 20 which are Neck Circumference (Circ.), Shoulder Circ., Biceps Circ., Chest Circ., Waist Circ., Belly Circ., Hip Circ., Thigh Circ., Back Neck Girth, Back Width, Shoulder Width, Inner Leg Length, Outer Leg Length, Inner Arm Length, Front Length, Back Length, Side Length, Arm Length1 (from the neck to the wrist), Arm Lenght2 (from shoulder to wrist), and Chest Fall. These BMs are obtained manually according to ISO-8559 standards using a non-stretchable tape measure, and the same person's age, height and weight are also recorded. Schematic presentations of the BMs mentioned above are given in Figure 6 [16].

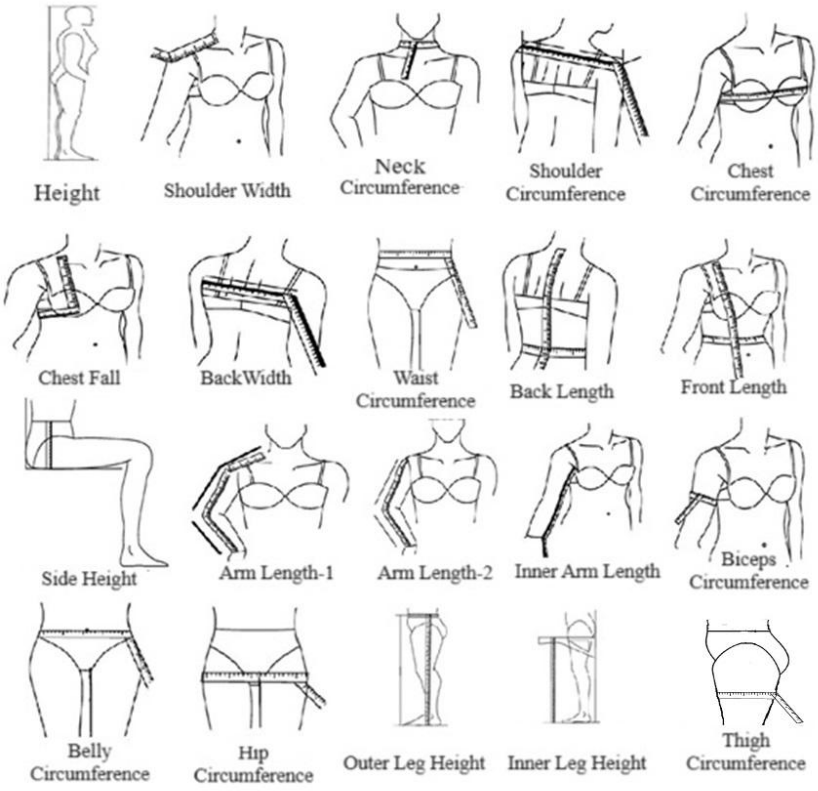

Figure 6. Examples of obtaining body measurements manually [16]

There are 500 female volunteers, consequently, 500 values for each of the 23 BMs are entered in the SPSS IBM Statistics (v23) Package software. Even though there are 500 values for each measurement, 50 of them are separated by the SPSS software for validation at the end of the research, so the rest of the study in this manuscript is continued with 450 values for each BM.

2.2. Method

In this research, the 450 values of each BM are experimented with statistical methods to reach its objective. The statistical methods applied are listed below:

2.2.1. Descriptive statistics

Descriptive statistics of BMs are presented to reach a brief understanding of the data which was obtained manually from the person's body and will be used in the following research step. The descriptive statistics here are the mean, standard error of the mean, median, mode, minimum, maximum, range, standard deviation, variance, skewness, kurtosis, coefficient of variation, standard error of skewness, and standard error of kurtosis.

2.2.2. Assumptions of normality

The criteria of normality assumptions, boxplots, and Kolmogorov-Smirnov and Shapiro-Wilk tests are regarded assumptions of normality. These methods are conducted in this research to study the normality assumptions of BM data.

Criteria of Normality Assumptions

In statistics literature, data normality assumptions are analyzed by considering the five standard distribution criteria:

1. Mean, median and mode values should be equal or close to each other;

2. Histograms should look like a standard distribution curve;
3. Skewness and kurtosis coefficients should be between -1 / +1 ;
4. A standard Q-Q plot should include points above or below but close to a 45^0 diagonal line;
5. CV% should be less than 25%.

If the data meets at least three of the five criteria listed above, it can be pronounced as displaying a normal distribution [17]. These criteria are applied to the BM data in the current research.

Boxplots

Boxpots are data charts with median values and interquartile ranges that point out the extremes and outliers within a variable. A boxpot shows the first quartile, median, third quartile, and minimum-maximum values [17, 18]. This research performs boxplots to visually assess normal distribution, outliers, and extreme values within the studied BM data.

Kolmogorov-Smirnov and Shapiro-Wilk Tests

Kolmogorov-Smirnov and Shapiro-Wilk tests are another test method for assumptions of normality. The suitability of the quantitative data to the normal distribution is tested with the Kolmogorov-Smirnov test when the sample size is $n \geq 50$, and with the Shapiro-Wilk test when $n < 50$, where it has more power to detect the non-normality. However, it can also be handled on larger sample sizes. Suppose their test results are $p > 0.05$ (statistically insignificant). In that case, the data is considered normally distributed, but normal distribution should not be decided based only on the p value of the Kolmogorov-Smirnov and Shapiro-Wilk tests alone. The important thing is that the data should also comply with the five criteria of normal distribution [17, 18]. In this research, Kolmogorov-Smirnov and Shapiro-Wilk tests are performed for assumptions of normality of BM data.

2.2.3. Correlation coefficients

The statistical analyses above determine which BMs exhibit normal distribution and to what extent. According to the information obtained, Pearson correlation coefficients, r , between each BM is calculated. The value of the coefficient indicates the strength of the relationship and the sign the direction, that is, the higher the correlation coefficient the stronger the relationship between that pair, and if a positive value it means that as one increases the other also increases; if a negative value it means that as one increases the other decreases. r can take a value between - 1 / + 1 , and regardless of the sign, values between 0.10-0.29 mean a weak correlation, 0.30-0.49 medium correlation, 0.50-1.00 strong correlation; besides, the $p < 0.05$ means that it is statistically significant [19].

In the current research, the correlation coefficients between each BM are listed from high to low to determine which BM affected the other BM the most and up to which degree. BMs with r greater than +0.5 ($r>+0.5$) are selected which symbolizes a strong correlation, this selection indicates they are the effective body measurements on a special BM. This is the statistical selection of effective BMs proposed in this paper. The statistically selected effective BMs are beneficial for determining a special BM for the comparisons.

2.2.4. Regression analyses

Regression analyses are conducted in cases where a parameter can be determined with the data of other parameters, and they are called the dependent variable and independent variables, respectively. Multivariate Multiple Regression Analyses (MMRAs) can further be used to model the linear relationship between more than one independent variable and more than one dependent variable [20]. In the current research, regression analyses are conducted with three different points of view for each BM one by one: 1) dependent variable is one of the BMs, independent variable is rest of the BMs, enter method; 2) dependent variable is one of the BMs, independent variable is rest of the BMs, stepwise method; and 3) dependent variable is one of the BMs, independent variable is the statistically selected effective BMs, enter method. The stepwise method is not conducted because correlation analyses already selected variables, no more selection is needed (Table 1).

Table 1. Multivariate multiple regression analyses conducted in this research

Dependent Variable	Independent Variable	Method	Results
1. One body meausurement	Rest of the body measurements	Enter	r^2's , Adj.r^2's
2. One body meausurement	Rest of the body measurements	Stepwise	r^2's , Adj.r^2's
3. One body meausurement	Statistically selected body measurements	Enter	r^2's , Adj.r^2's

2.2.5. Comparisons

The r^2's and Adj.r^2's results obtained by MMRAs are compared; where; Lines 1, 2 and 3 in Table 1, are compared to determine if there is a difference in applying the rest of the BMs as independent variables enter and stepwise methods and the statistically selected BMs as independent variables enter method. This comparison assesses the accuracy and adequate Method for the BM data.

2.2.6. Validation

It was mentioned above that there were BMs of 500 female volunteers but 50 were separated for the validation group at the beginning of the research. In this section, the information obtained by comparison is intended to be applied to this test group and the estimated BMs are aimed to be obtained. The estimated BMs and the manually taken BMs results are intended to compare and calculate their accuracy rates.

3. RESULTS AND DISCUSSIONS

The results of the statistical methods and the selected BMs described in Section 2. Material and Method are presented and discussed in this section.

3.1. Descriptive Statistics

Descriptive statistics of BMs are presented to attain a brief understanding of the data and to be used in the normality assumptions of BM data. The descriptive statistics of BMs studied in this research presented in Table 2 are the mean, standard error of the mean, median, mode, minimum, maximum, range, standard deviation, variance, skewness, kurtosis, coefficient of variation (CV%), standard error of skewness, and standard error of kurtosis.

Table 2. Descriptive statistics of body measurements studied in this research

Descriptive Statistics													
	N	Mean	Std. Error of Mean	Median	Mode	Minimum	Maximum	Range	Std. Deviation	Variance	Skewness[b]	Kurtosis[c]	Coefficient of Variation (%CV)
Height	450	164.531	0.245	165.0	160.0	150.0	176.0	26.0	5.203	27.074	-0.033	-0.482	3.162
Weight (kg)	450	55.993	0.351	55.0	55.0	42.0	85.0	43.0	7.447	55.452	1.123	1.877	13.299
Neck Circ.	450	31.040	0.082	31.0	31.0	26.0	36.0	10.0	1.733	3.005	0.430	0.560	5.584
Back Neck Girth	450	13.965	0.063	14.0	13.0	11.0	19.0	8.0	1.334	1.779	0.595	0.543	9.549
Shoulder Width	450	13.468	0.060	13.2	13.0	10.0	18.0	8.0	1.264	1.597	0.236	0.347	9.384
Shoulder Circ.	450	95.722	0.266	95.0	94.0	75.0	121.0	46.0	5.650	31.921	0.519	1.809	5.902
Chest Circ.	450	86.756	0.281	85.8	84.0[a]	74.0	109.0	35.0	5.964	35.574	0.882	1.126	6.875
Chest Fall	450	24.893	0.089	25.0	24.0	20.0	32.0	12.0	1.878	3.527	0.548	0.745	7.545
Back Width	450	35.771	0.129	36.0	36.0	29.0	47.0	18.0	2.726	7.432	0.544	1.225	7.621
Waist Circ.	450	69.922	0.286	69.0	68.0	59.0	97.0	38.0	6.058	36.699	1.143	2.264	8.664
Back Length	450	34.123	0.112	34.0	33.0	28.0	42.5	14.5	2.368	5.608	0.501	0.522	6.940
Front Length	450	36.881	0.135	37.0	38.0	29.0	46.0	17.0	2.868	8.225	0.320	0.368	7.776
Side Lenght	450	16.447	0.138	16.0	15.0	10.5	26.0	15.5	2.923	8.545	0.610	-0.122	17.773
Arm Length1	450	66.844	0.161	67.0	68.0	58.0	78.0	20.0	3.418	11.683	0.240	0.217	5.113
Arm Length2	450	55.370	0.151	55.2	56.0	47.0	63.0	16.0	3.203	10.262	0.084	-0.100	5.785
Inner Arm Lengt	450	43.934	0.117	44.0	45.0	34.0	55.0	21.0	2.475	6.126	0.043	1.618	5.633
Biceps Circ.	450	25.067	0.123	25.0	26.0	19.0	35.0	16.0	2.614	6.831	0.575	0.247	10.427

Belly Circ.	450	79.829	0.328	79.0	78.0	66.0	108.0	42.0	6.963	48.489	0.642	0.895	8.723
Hip Circ.	450	95.965	0.289	96.0	98.0	82.0	120.0	38.0	6.135	37.641	0.674	1.421	6.393
Outer Leg Lengt	450	92.650	0.300	93.0	90.0	74.0	112.0	38.0	6.363	40.486	0.089	-0.323	6.868
Inner Leg Length	450	66.844	0.179	66.0	65.0	57.0	80.0	23.0	3.792	14.377	0.308	-0.225	5.672
Thigh Circ.	450	52.012	0.206	52.0	53.0	39.0	65.0	26.0	4.376	19.148	0.463	0.448	8.413

a. Multiple modes exist. The smallest value is shown

b. Std. Error of Skewness 0.115

c. Std. Error of Kurtosis 0.230

3.2. Assumptions of Normality

3.2.1. Criteria of normality assumptions

Each BM is evaluated according to the five criteria of normality assumptions listed in Section 2.2. The overall evaluation is summarized in Table 3. If at least three of these five criteria are met by the data of a specific BM, then it can be pronounced that it exhibits a normal distribution listed as 3/5, 4/5, or 5/5 in the last column of Table 3.

Table 3. Overall evaluation of normality assumption criteria for all body measurements

Normal Distribution Assumptions / Descriptive Statistics									
	1. Criterion: mean, mode and median are close to each other			2. Criterion: The histogram distribution of the data is Normal Distribution	3. Criterion: Skewness and kurtosis coefficients are between -1/+1		4. Criterion: Normal Q-Q plot graph, with points above (or very close to) 45^0 lines	5. Criterion: The coefficient of variation (CV%) is below 25%	Conclusion
	Mean	Median	Mode		Skewness[b]	Kurtosis[c]	Normal Q-Q plot graph	Coefficient of Variation (CV%)	How many of the five criteria does this body measure meet?
Height	164.531	165.00	160.0	Normal Distr.	-0.033	-0.482	Very close to 45^0	3.162	4/5
Weight	55.993	55.00	55.0	Normal Distr.	1.123	1.877	Very close to 45^0	13.299	3/5
Neck Circ.	31.040	31.00	31.0	Normal Distr.	0.430	0.560	Very close to 45^0	5.584	5/5
Back Neck Girt	13.965	14.00	13.0	Normal Distr.	0.595	0.543	Very close to 45^0	9.549	5/5
Shoulder Width	13.468	13.20	13.0	Normal Distr.	0.236	0.347	Very close to 45^0	9.384	5/5
Shoulder Circ.	95.722	95.00	94.0	Normal Distr.	0.519	1.809	Very close to 45^0	5.902	3/5
Chest Circ.	86.756	85.80	84.0[a]	Normal Distr.	0.882	1.126	Very close to 45^0	6.875	3/5
Chest Fall	24.893	25.00	24.0	Normal Distr.	0.548	0.745	Very close to 45^0	7.545	5/5
Back Width	35.771	36.00	36.0	Normal Distr.	0.544	1.225	Very close to 45^0	7.621	4/5
Waist Circ.	69.922	69.00	68.0	Normal Distr.	1.143	2.264	Very close to 45^0	8.664	3/5
Back Length	34.123	34.00	33.0	Normal Distr.	0.501	0.522	Very close to 45^0	6.94	4/5
Front Length	36.881	37.00	38.0	Normal Distr.	0.320	0.368	Very close to 45^0	7.776	4/5
Side Height	16.447	16.00	15.0	Normal Distr.	0.610	-0.122	Very close to 45^0	17.773	4/5
Arm Length-1	66.844	67.00	68.0	Normal Distr.	0.240	0.217	Very close to 45^0	5.113	4/5
Arm Length-2	55.370	55.20	56.0	Normal Distr.	0.084	-0.100	Very close to 45^0	5.785	5/5
Inner Arm Leng	43.934	44.00	45.0	Normal Distr.	0.043	1.618	Very close to 45^0	5.633	3/5
Biceps Circ.	25.067	25.00	26.0	Normal Distr.	0.575	0.247	Very close to 45^0	10.427	5/5
Belly Circ.	79.829	79.00	78.0	Normal Distr.	0.642	0.895	Very close to 45^0	8.723	4/5
Hip Circ.	95.965	96.00	98.0	Normal Distr.	0.674	1.421	Very close to 45^0	6.393	3/5
Outer Leg Heigh	92.650	93.00	90.0	Normal Distr.	0.089	-0.323	Very close to 45^0	6.868	4/5
Inner Leg Heigh	66.844	66.00	65.0	Normal Distr.	0.308	-0.225	Very close to 45^0	5.672	4/5
Thigh Circ.	52.012	52.00	53.0	Normal Distr.	0.463	0.448	Very close to 45^0	8.413	5/5

a. Multiple modes exist. The smallest value is shown

b. Std. Error of Skewness 0.12

c. Std. Error of Kurtosis 0.23

Each criterion is studied separately below:

1. Mean, median, and mode values should be equal or close to each other;

Each BM's mean, median, and mode values seem to be quite equal or close. Their equality and closeness are tested by *t*-tests for each BM one by one, but as an example, only the *t*-test conducted for the waist circumference measurement (WCM) is given below:

Mean, median, and mode values should be equal or close to each other:
Waist Circumference example

WCMs are mean 69.922 cm, median 69 cm, and mode 68 cm. *t*-tests are performed to determine whether there is a statistically significant difference between the mean and median values, and mean and mode values (Table 4). In Table 4, Sig.(2-tailed) $p = 0.001$, and since $p < 0.05$, it is seen that there is a statistically significant difference between the mean-median and mean-mode values. It is stated that this criterion does not satisfy the necessary condition of normality assumption, hence the number of criteria met by WCM is 0/5 now.

Table 4. t-test between mean and median values of waist circumference

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Waist Circumference	450	69.922	6.0580	0.2856

One-Sample Test

	Test Value = 69 (Median)					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Waist Circumference	3.228	449	0.001	0.9218	0.361	1.483

One-Sample Test

	Test Value = 68 (Mode)					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Waist Circumference	6.730	449	0.000	1.9218	1.361	2.483

2. Histograms should look like a standard distribution curve;

The histogram of each BM is prepared and each of them displays somehow a symmetrical distribution around the mean in the form of a normal distribution curve. They are assessed visually one by one, but as an example, only the histogram of WCM is given below:

Histograms should look like a normal distribution curve:

Waist Circumference example

The histogram of WCM is given in Figure 7. When assessed visually, the histogram of WCM presents a normal distribution curve and also drawn in Figure 7. It is stated that this criterion satisfies the necessary condition of normality assumption, hence the number of criteria met by WCM is 1/5 up to now.

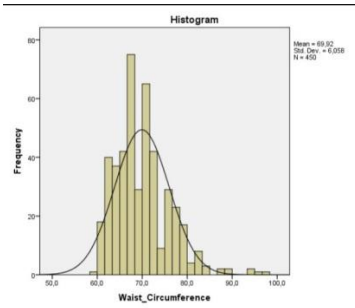

Figure 7. Histogram of waist circumference values

3. Skewness and kurtosis coefficients should be between -1 / +1 ;

Each BM's skewness and kurtosis values are analyzed if the values lie between - 1 / + 1 . In the skewness column of Table 2, coefficients vary between -0.033 and 1.143 . In the same table's kurtosis column, values vary between -0.482 and 2.264 . One by one, an analysis of each BM is carried on, but as an example, only the analysis of the WCM is given below:

Skewness and kurtosis coefficients should be between -1 / +1 :
Waist Circumference example

The skewness coefficient of WCM in Table 2 is 1.143 , when analyzed if it is between - 1 / + 1 , it is clearly seen that it is out of the higher limit of + 1. The kurtosis coefficient of WCM in the same table is 2.264 , when analyzed if it is between - 1 / + 1 , it is clearly seen that it is out of the higher limit of + 1 . It is stated that this criteria does not satisfy the necessary condition of normality assumption, hence, the number of criteria met by WCM is still 1/5 up to now.

4. A standard Q-Q plot should include points above or below but close to a 45^0 diagonal line;

The normal Q-Q plot of each BM is drawn and each somehow includes points above or below but close to a 45^0 diagonal line. They are assessed visually one by one, but as an example, only the normal Q-Q plot of WCM is given below:

A standard Q-Q plot should include points above or below but close to a 45^0 diagonal line:
Waist Circumference example

The normal Q-Q plot of WCM is given in Figure 8. When assessed visually, the normal Q-Q plot of WCM includes points above or below but is close to a 45^0 diagonal line. It is stated that this criterion satisfies the necessary condition of normality assumption, hence, the number of criteria met by WCM is 2/5 up to now.

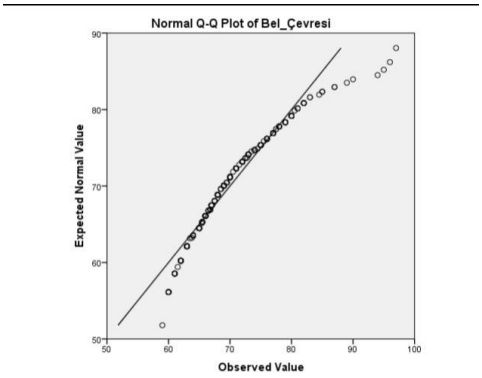

Figure 8. Normal Q-Q plot of waist circumference values

5. CV% should be less than 25% .

The CV% values of each BM are analyzed if the values are less than 25% . In the CV% column of Table 2, values vary between 3.162% and 17.773% . One by one, an analysis of each BM is carried on, but as an example, only the analysis of the WCM is given below:

CV% should be less than 25% :
Waist Circumference example

The CV% value of WCM is 8.664% , when analyzed if it is less than 25% , it is clearly seen that it is. It is stated that this criterion satisfies the necessary condition of normality assumption, hence, the number of criteria met by WCM is 3/5 up to now.

Since the WCM meets the 3 out of 5 necessary conditions of normality assumptions, it can be pronounced that WCM values display a normal distribution. In general, in the last column of Table 2, it is seen that six of the BMs meet 3/5 criteria of normality assumptions, nine of the BMs meet 4/5 criteria, and eight of the BMs meet 5/5 criteria, in general, it can be pronounced that all the different BM values studied in this research display normal distribution.

3.2.2. Boxplots

Boxplots are performed for each BM, and each BM's first quartile, median, third quartile, minimum-maximum values, outliers, and extreme values of each BM are assessed visually individually. The boxplots of all BMs are given in Figure 9. It is noticed that within the studied BMs, there are outliers and extreme values, high and low, in most of them. Even though it can be pronounced that they are distributed normally in Section 3.2.1., the boxplots precisely indicate the value's behavior; none of the BMs display a perfect normal distribution visually.

For example, the boxplot of the WCM values is given in Figure 10, which is enlarged. In particular, the outliers and extreme values are clearly seen, where the numbers on the boxplot indicate the number of the volunteers the authors gave. Which person possesses the outliers and extreme values for further research is evaluated.

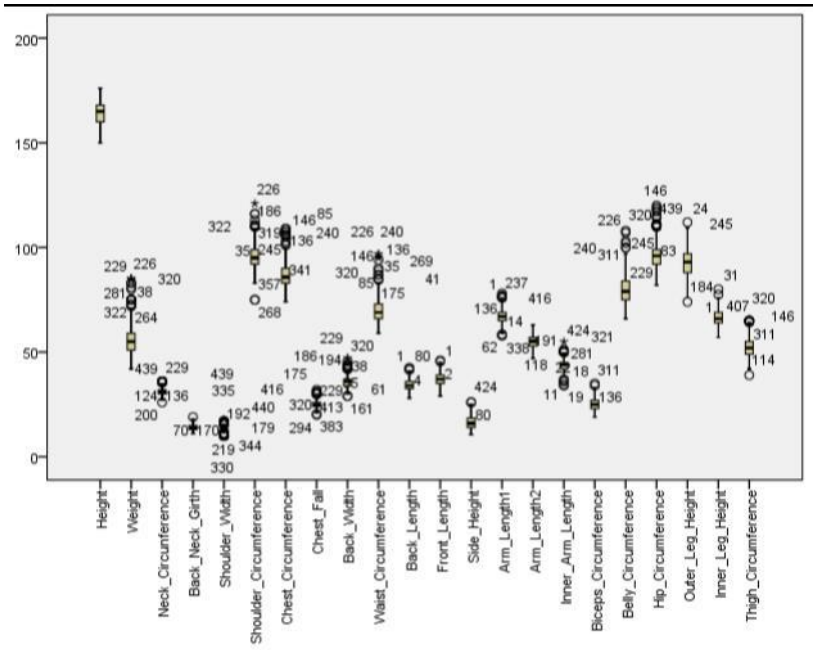

Figure 9. Number of people who have outliers with boxplot chart (n=450)

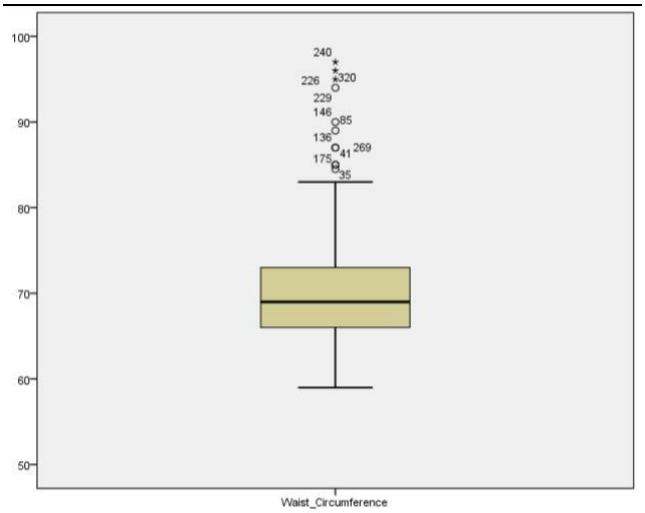

Figure 10. Boxplot of waist circumference values

3.2.3. Kolmogorov-smirnov and shapiro-wilk tests

Kolmogorov-Smirnov and Shapiro-Wilk tests are performed for each BM with each having 450 values in this research. Their p values are evaluated if $p > 0.05$ where statistically insignificance means normal distribution. According to both Kolmogorov-Smirnov and Shapiro-Wilk test results given in Table 5, all BMs are analyzed individually and they possess $p < 0.05$, meaning that none display normal distribution. Even though it can be pronounced that the BM data are distributed normally in Section 3.2 1., the Kolmogorov-Smirnov and Shapiro-Wilk tests indicate the opposite. It is evaluated that the outliers and extreme values visually assessed in boxplots are considered mathematically in these tests, none of the BMs display a normal distribution perfectly.

Table 5. Kolmogorov-Smirnov and Shapiro-Wilk test results

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Height	0.099	450	0.000	0.976	450	0.000
Weight	0.129	450	0.000	0.931	450	0.000
Neck Circ.	0.131	450	0.000	0.967	450	0.000
Back Neck Girth	0.161	450	0.000	0.946	450	0.000
Shoulder Width	0.142	450	0.000	0.965	450	0.000
Shoulder Circ.	0.081	450	0.000	0.971	450	0.000
Chest Circ.	0.106	450	0.000	0.954	450	0.000
Chest Fall	0.146	450	0.000	0.965	450	0.000
Back Width	0.102	450	0.000	0.971	450	0.000
Waist Circ.	0.119	450	0.000	0.934	450	0.000
Back Length	0.102	450	0.000	0.972	450	0.000
Front Length	0.081	450	0.000	0.982	450	0.000
Side Height	0.130	450	0.000	0.959	450	0.000
Arm Length-1	0.105	450	0.000	0.986	450	0.000
Arm Length-2	0.078	450	0.000	0.987	450	0.001
Inner Arm Length	0.089	450	0.000	0.974	450	0.000
Biceps Circ.	0.096	450	0.000	0.973	450	0.000
Belly Circ.	0.059	450	0.001	0.975	450	0.000
Hip Circ.	0.083	450	0.000	0.968	450	0.000
Outer Leg Height	0.050	450	0.008	0.994	450	0.075
Inner Leg Height	0.106	450	0.000	0.984	450	0.000
Thigh Circ.	0.068	450	0.000	0.981	450	0.000

a. Lilliefors Significance Correction

An overall evaluation of BM data studied in this research is realized in the light of the information obtained about normal distribution. The assumptions of normality in Section 3.2.1. indicate that each of the BM data displays normal distribution, on the other hand, boxplots in Section 3.2.2., and Kolmogorov-Smirnov and Shapiro-Wilk tests in Section 3.2.3. indicate the opposite. The results of the Kolmogorov-Smirnov and Shapiro-Wilk tests cannot be considered alone for normal distribution. Consequently boxplots show the behavior of BM data visually related to these tests. The sample size is large with 450 values for each BM. Finally, it is considered that BM data display normal distribution according to the assumptions of normality is proven.

3.3. Statistical Selection of Effective Body Measurements with Correlation Analyses

Correlation coefficients are calculated between each BM studied in this research. In this calculation of correlation coefficients, the Pearson method is conducted because it was proved that BM values display normal distribution in the previous section.

The correlation coefficients between each BM are a total of 231 pairs, 225 of them have positive correlation coefficients ranging between 0.835 and 0.000 , meaning that if one incresases the other increases also, 6 of them have negative correlation coefficients ranging between -0.008 and -0.090 , meaning that if one increases the other further decreases (Table 6). These correlation coefficients are in accordance with the correlation coefficient studies found in literature like chest circumference measurement – height pair, thigh circumference –hip circumference etc.,

but also differences were noticed like back length – waist circumference, belly circumference – chest circumference, etc. [6-9].

Table 6. Pearson correlation coefficients and significance values for each body measurement

Correlations

		Height	Weight	Neck Circ.	Back Neck Girth	Shoulder Width	Shoulder Circ.	Chest Circ.	Chest Fall	Back Width	Waist Circ.	Back Length	Front Length	Side Height	Arm Length1	Arm Length2	Inner Arm Length	Biceps Circ.	Belly Circ.	Hip Circ.	Outer Leg Height	Inner Leg Height	Thigh Circ.
Height	Pearson Correlation	1																					
	Sig. (2-tailed)																						
Weight	Pearson Correlation	0,395**	1																				
	Sig. (2-tailed)	0,000																					
Neck Circ.	Pearson Correlation	0,221**	0,611**	1																			
	Sig. (2-tailed)	0,000	0,000																				
Back Neck Girth	Pearson Correlation	0,094*	0,265**	0,302**	1,000																		
	Sig. (2-tailed)	0,046	0,000	0,000																			
Shoulder Width	Pearson Correlation	0,164**	0,206**	0,070	0,021	1,000																	
	Sig. (2-tailed)	0,000	0,000	0,140	0,651																		
Shoulder Circ.	Pearson Correlation	0,269**	0,683**	0,538**	0,152**	0,264**	1,000																
	Sig. (2-tailed)	0,000	0,000	0,000	0,001	0,000																	
Chest Circ.	Pearson Correlation	0,189**	0,785**	0,591**	0,228**	0,125**	0,673**	1,000															
	Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,008	0,000																
Chest Fall	Pearson Correlation	0,193**	0,454**	0,315**	0,081	0,152**	0,399**	0,496**	1,000														
	Sig. (2-tailed)	0,000	0,000	0,000	0,086	0,001	0,000	0,000															
Back Width	Pearson Correlation	0,222**	0,565**	0,478**	0,218**	0,178**	0,621**	0,576**	0,307**	1,000													
	Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000														
Waist Circ.	Pearson Correlation	0,130**	0,774**	0,632**	0,219**	0,101*	0,641**	0,769**	0,459**	0,570**	1,000												
	Sig. (2-tailed)	0,006	0,000	0,000	0,000	0,032	0,000	0,000	0,000	0,000													
Back Length	Pearson Correlation	0,276**	0,231**	0,223**	-0,023	0,229**	0,255**	0,201**	0,164**	0,193**	0,133**	1,000											
	Sig. (2-tailed)	0,000	0,000	0,000	0,629	0,000	0,000	0,000	0,000	0,000	0,005												
Front Length	Pearson Correlation	0,250**	0,320**	0,202**	-0,068	0,365**	0,331**	0,323**	0,494**	0,268**	0,175**	0,380**	1,000										
	Sig. (2-tailed)	0,000	0,000	0,000	0,152	0,000	0,000	0,000	0,000	0,000	0,000	0,000											
Side Height	Pearson Correlation	0,202**	0,093*	0,070	-0,008	0,398**	0,042	0,039	0,053	0,042	-0,090	0,361**	0,624**	1,000									
	Sig. (2-tailed)	0,000	0,049	0,139	0,865	0,000	0,371	0,412	0,259	0,377	0,056	0,000	0,000										
Arm Length1	Pearson Correlation	0,605**	0,444**	0,300**	0,071	0,266**	0,400**	0,268**	0,285**	0,355**	0,275**	0,307**	0,292**	0,164**	1,000								
	Sig. (2-tailed)	0,000	0,000	0,000	0,133	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000									
Arm Length2	Pearson Correlation	0,578**	0,363**	0,229**	0,125**	0,072	0,273**	0,201**	0,172**	0,286**	0,244**	0,169**	0,091	0,020	0,824**	1,000							
	Sig. (2-tailed)	0,000	0,000	0,000	0,008	0,125	0,000	0,000	0,000	0,000	0,000	0,000	0,053	0,676	0,000								
Inner Arm Length	Pearson Correlation	0,623**	0,251**	0,095*	0,068	0,263**	0,170**	0,064	0,078	0,152**	0,014	0,242**	0,226**	0,231**	0,673**	0,661**	1,000						
	Sig. (2-tailed)	0,000	0,000	0,043	0,151	0,000	0,000	0,173	0,099	0,001	0,773	0,000	0,000	0,000	0,000	0,000							
Biceps Circ.	Pearson Correlation	0,042	0,680**	0,548**	0,204**	0,161**	0,587**	0,692**	0,449**	0,425**	0,724**	0,198**	0,265**	0,039	0,237**	0,178**	-0,033	1,000					
	Sig. (2-tailed)	0,378	0,000	0,000	0,000	0,001	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,405	0,000	0,000	0,488						
Belly Circ.	Pearson Correlation	0,195**	0,759**	0,531**	0,163**	0,164**	0,649**	0,710**	0,493**	0,465**	0,763**	0,254**	0,319**	0,068	0,331**	0,246**	0,172**	0,652**	1,000				
	Sig. (2-tailed)	0,000	0,000	0,000	0,001	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,151	0,000	0,000	0,000	0,000					
Hip Circ.	Pearson Correlation	0,210**	0,835**	0,605**	0,245**	0,211**	0,661**	0,725**	0,433**	0,516**	0,765**	0,197**	0,258**	0,047	0,344**	0,288**	0,128**	0,721**	0,728**	1,000			
	Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,316	0,000	0,000	0,006	0,000	0,000				
Outer Leg Height	Pearson Correlation	0,665**	0,301**	0,150**	0,066	0,222**	0,119*	0,156**	0,207**	0,118*	0,100*	0,276**	0,339**	0,383**	0,352**	0,255**	0,419**	0,026	0,189**	0,151**	1,000		
	Sig. (2-tailed)	0,000	0,000	0,001	0,160	0,000	0,011	0,001	0,000	0,012	0,034	0,000	0,000	0,000	0,000	0,000	0,000	0,589	0,000	0,001			
Inner Leg Height	Pearson Correlation	0,719**	0,267**	0,074	0,000	0,215**	0,168**	0,125**	0,169**	0,128**	0,052	0,198**	0,241**	0,253**	0,519**	0,487**	0,659**	0,028	0,205**	0,135**	0,642**	1,000	
	Sig. (2-tailed)	0,000	0,000	0,116	0,997	0,000	0,000	0,008	0,000	0,007	0,274	0,000	0,000	0,000	0,000	0,000	0,000	0,561	0,000	0,004	0,000		
Thigh Circ.	Pearson Correlation	0,082	0,724**	0,518**	0,182**	0,128**	0,530**	0,657**	0,389**	0,415**	0,662**	,115*	0,217**	0,063	0,148**	0,110*	-0,020	0,703**	0,629**	0,778**	0,180**	0,060	1,000
	Sig. (2-tailed)	0,083	0,000	0,000	0,000	0,006	0,000	0,000	0,000	0,000	0,000	0,015	0,000	0,184	0,002	0,020	0,673	0,000	0,000	0,000	0,000	0,205	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The 231 correlation coefficients of BMs are listed in pairs from high to low to determine which BM affected the other BM the most and up to which degree.. BM pairs having correlation coefficients r greater than +0.5 ($r > +0.5$) and $p < 0.05$ are selected because it is evaluated that they demonstrate a strong relationship between the BM pairs and are the effective BM on a special BM. It is what is meant by statistical selection purpose in this research. 53 of them, which suffice $r > +0.5$ and $p < 0.05$ are listed which were selected among the 231. These selected BMs benefited from the rest of this research to determine a special BM by other BMs one by one.

Following the objective of this research, the statistical selection of effective BMs, WCM is given as an example. WCM pairs having correlation coefficients $r > 0.5$ strong relationships are selected. There are nine BM pairs which are Waist Cir.-Weight, Waist Cir.-Chest Circ., Waist Cir.-Hip Circ., Waist Circ.-Belly Circ., Waist Cir.-Biceps Circ., Waist Cir.-Thigh Circ., Waist Cir.-Shoulder Circ., Waist Cir.-Neck Circ., and Waist Cir.-Back Width. Their list is given in Table 7. Also, the bar chart of r values is given in Figure 11. Furthermore, these WCM pairs will benefit in the rest of this research.

Table 7. List of nine waist circumference measurement pairs

Number	Body Measurements	Pearson Correlation (r)	Sig.
1	Waist Circ., Weight	0.774	0.000
2	Waist Circ., Chest Circ.	0.769	0.000
3	Waist Circ., Hip Circ.	0.765	0.000
4	Waist Circ., Belly Circ.	0.763	0.000
5	Waist Circ., Biceps Circ.	0.724	0.000
6	Waist Circ., Thigh Circ.	0.662	0.000
7	Waist Circ., Shoulder Circ.	0.641	0.000
8	Waist Circ., Neck Circ.	0.632	0.000
9	Waist Circ., Back Width	0.570	0.000

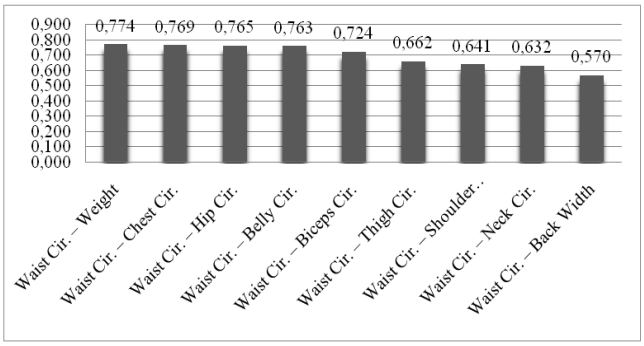

Figure 11. Bar chart of r values of waist circumference measurement pairs

3.4. Regression Analysis

In the current research, one BM is determined by the rest of the BMs but by applying different points of view to MMRAs and the statistically selected effective BMs, which are also used for the approach of shorter, more precise, and time and cost saving. Each BM is studied one by one, and every time one BM is considered as the dependent variable. The rest of the BMs as the independent variables in an MMRA equation, conducted in the first enter method and then stepwise method. The same is repeated with the statistically selected effective BMs where each BM is considered as a dependent variable. The statistically selected effective BMs as the independent variables in an MMRA equation enter method, stepwise method is not needed because the effective BMs are already selected (Table 7 and Figure 11). In each study, the results r^2's, Adj.r^2's and regression coefficients to construct an MMRA equation are noted, and the equations are written. The same work is done for each BM one by one, but as an example, only the MMRA study conducted for the WCM is given below:

Experimenting waist circumference with all the rest of the body measurements enter method

WCM first experiments with all the rest of BMs' enter method. In this case the WCM is the dependent variable in the regression analysis and all the rest of BMs which are the Weight, Height, Chest Circ., Hip Circ., Front Length, Biceps Circ., Inner Leg Length, Outer Leg Length, Back Width, Shoulder Width, Belly Circ., Arm Length1, Arm Length2, Inner Arm Length, Neck Circ., Shoulder Circ., Back Length, Back Neck Girth, Chest Fall, Side Height, and Thigh Circ. are the independent variables, the aim is always to obtain the highest r^2, consequently the Adj.r^2.

The results are given in Table 8 where it is seen in the Model Summary that the obtained r^2 is 0.796 and Adj.r^2 is 0.786, which seems to be quite high, nearly 0,8, in ANOVA Table that $p < 0.05$, which indicates that regression analysis is worth to conduct. In the Regression Coefficient list, it is each BM's effect. Equation 1 is the MMRA equation enter method of WCM with all the rest of the BMs.

Table 8. Model summary, ANOVA table, and regression coefficients enter method of all body measurements to determine waist circumference

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.892[a]	0.796	0.786	2.802

a. Predictors: (Constant), Thigh Circ., Inner Arm Length, Back Neck Girth, Side Height, Chest Fall, Back Length, Shoulder Width, Back Width, Outer Leg Height, Neck Circ., Arm Length2, Belly Circ., Shoulder Circ., Inner Leg Height, Biceps Circ., Front Length, Chest Circ., Height, Hip Circ., Arm Length1, Weight

b. Dependent Variable: Waist Circumference

ANOVA[a] Table

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13118.159	21	624.674	79.581	0.000[b]
	Residual	3359.608	428	7.850		
	Total	16477.767	449			

a. Dependent Variable: Waist Circumference

b. Predictors: (Constant), Thigh Circ., Inner Arm Length, Back Neck Girth, Side Height, Chest Fall, Back Length, Shoulder Width, Back Width, Outer Leg Height, Neck Circ., Arm Length2, Belly Circ., Shoulder Circ., Inner Leg Height, Biceps Circ., Front Length, Chest Circ., Height, Hip Circ., ArmLength1, Weight

Regression Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	14.152	6.541		2.164	0.031	1.295	27.009
	Height	-0.070	0.049	-0.060	-1.422	0.156	-0.166	0.027
	Weight	0.153	0.045	0.188	3.428	0.001	0.065	0.240
	Neck Circ.	0.462	0.107	0.132	4.298	0.000	0.251	0.673
	Back Neck Girth	-0.188	0.110	-0.041	-1.712	0.088	-0.404	0.028
	Shoulder Width	0.128	0.127	0.027	1.013	0.312	-0.121	0.378
	Shoulder Circ.	-0.011	0.040	-0.011	-0.286	0.775	-0.089	0.066
	Chest Circ.	0.159	0.043	0.156	3.728	0.000	0.075	0.242
	Chest Fall	0.143	0.099	0.044	1.448	0.148	-0.051	0.338
	Back Width	0.270	0.067	0.121	4.030	0.000	0.138	0.402
	Back Length	-0.103	0.066	-0.040	-1.568	0.118	-0.232	0.026
	Front Length	-0.169	0.079	-0.080	-2.154	0.032	-0.324	-0.015
	Side Height	-0.166	0.070	-0.080	-2.385	0.018	-0.303	-0.029
	Arm Length-1	-0.102	0.084	-0.057	-1.216	0.225	-0.266	0.063
	Arm Length-2	0.232	0.085	0.123	2.723	0.007	0.065	0.400
	Inner Arm Length	-0.231	0.092	-0.095	-2.506	0.013	-0.413	-0.050
	Biceps Circ.	0.376	0.089	0.162	4.242	0.000	0.202	0.550
	Belly Circ.	0.241	0.034	0.277	7.141	0.000	0.175	0.307
	Hip Circ.	0.114	0.048	0.115	2.377	0.018	0.020	0.208
	Outer Leg Height	0.085	0.034	0.089	2.507	0.013	0.018	0.151
	Inner Leg Height	-0.098	0.060	-0.062	-1.631	0.104	-0.217	0.020
	Thigh Circ.	-0.094	0.056	-0.068	-1.670	0.096	-0.204	0.017

a. Dependent Variable: Waist Circumference

Regression equation of WCM obtained with all the rest of BMs enter method:

Waist Circ. = 14.152 – 0.070 Height + 0.153 Weight + 0.462 NeckCirc. – 0.188 Back Neck Girth
+ 0.128 Shoulder Width – 0.011 Shoulder Circ. + 0.159 Chest Circ. + 0.143 ChestFall
+ 0.270 Back Width – 0.103 Back Length – 0.169 Front Length – 0.166 Side Height – 0.102 Arm Length1
+ 0.232 Arm Length2 – 0.231 Inner Arm Length + 0.376 Biceps Circ. + 0.241 Belly Circ.
+ 0.114 Hip Circ. + 0.085 Outer Leg Height – 0.098 Inner Leg Height - 0.094 Thigh Circ. (1)

Experimenting waist circumference with all the rest of body measurements using the stepwise method

WCM is conducted with all the rest of BMs' stepwise methods secondly. In this case, the dependent and the independent variables are the same as the enter method, but the method changes to stepwise here, aiming to obtain the highest r^2, consequently the Adj.r^2.

The model summary, ANOVA table, and regression coefficients stepwise method of all BMs to determine waist circumference tables are obtained but not presented here. In Model Summary, the best obtained values are in the tenth step of the model and are $r^2 = 0.786$ and Adj.$r^2 = 0.782$, which seem to be near to 0.8. Still, the adjusted regression coefficient is slightly less in the stepwise method than in the enter method, which is 0.782 and 0.786, respectively. In ANOVA, $p < 0.05$ is in every step, which indicates that regression analysis is worth conducting. In the regression coefficient list, it is each BM's effect. Equation 2 is the MMRA equation stepwise method of WCM with all the rest of the BMs.

Regression equation of WCM obtained with all the rest of the BMs stepwise method:

Waist Circ. = 2.958 + 0.127 Weight + 0.325 Biceps Circ. + 0.240 Belly Circ. – 0.253 Side Height + 0.152 Chest Circ.
+ 0.418 Neck Circ. + 0.230 Back Width – 0.337 Inner Arm Length + 0.136 Arm Length-2
+ 0.101 Hip Circ. (2)

Experimenting waist circumference with the statistically selected effective body measurements enter method

WCM is experimented with the selected BMs enter method finally. In this case, Weight, Chest Circ., Hip Circ., Belly Circ., Biceps Circ., Thigh Circ., Shoulder Circ., Neck Circ., and Back Width are the independent variables, which are statistically selected in correlation coefficients analysis, the aim being to obtain the highest r^2, consequently the Adj.r^2.

The model summary, ANOVA table, and regression coefficients stepwise method of statistically selected effective BMs to determine waist circumference tables are obtained but not presented here. In Model Summary, the obtained r^2 is 0.756 and Adj.r^2 is 0.751, which seems to be quite high, nearly 0.8, but the adjusted regression coefficient is less in the statistical selection method than the stepwise method, which is 0.751 and 0.782, respectively. In ANOVA, $p < 0.05$ indicates that regression analysis is worth conducting. In the regression coefficient list, it is each BM's effect. Equation 3 is the MMRA equation enter method of WCM with the statistically selected effective BMs.

Regression equation of WCM obtained with our selected BMs enter method:

Waist Circ. = -9.205 + 0.074 Weight + 0.189 Chest Circ. + 0.139 Hip Circ. + 0.226 Belly Circ. + 0.430 Biceps Circ.
- 0.020 Thigh Circ. – 0.047 Shoulder Circ. + 0.412 Neck Circ. + 0.258 Back Width (3)

3.5. Comparisons

MMRSs are conducted with three different points of view for each BM one by one, but only the waist circumfernce measurement is given as an example. In this case, WCM is the dependent variable, and 1) all BMs enter method, 2) all the BMs stepwise method, and 3) statistically selected BMs are the independent variables in each case. It was thought at the beginning of this research that statistical selection would be shorter, more precise, and save time and cost, or at least be comparable with the stepwise method, for both are making a selection. The enter method is to get a general idea.

The resultant Adj.r^2 is 0.786 in the enter method, (1) above paragraph; the resultant Adj.r^2 is 0.782 stepwise method, (2) above paragraph; and the resultant Adj.r^2 is 0.751 in the statistical selection method, (3) above paragraph. As seen from these results of the stepwise method, the analysis ends its work with 10 BMs which are Weight, Biceps Circ., Belly Circ., Side Height, Chest Circ., Neck Circ., Back Width, Inner Arm Length, Arm Length-2, and Hip Circ. .However, in Section 3.3., the statistically selected effective BMs are nine which are Weight, Chest Circ., Hip Circ., Belly Circ., Biceps Circ., Thigh Circ., Shoulder Circ., Neck Circ., and Back Width. The similar body measurements in both methods are Weight, Chest Circ., Hip Circ., Belly Circ., Biceps Circ., Neck Circ., and Back Width, whereas stepwise method extra includes Side Height, Inner Arm Length, and Arm Length-2; and the statistical selection method differently includes Thigh Circ. and Shoulder Circ. It can be pointed out that the difference in the extra BMs may be why the stepwise method and the statistical selection method give different results. It is also worth noting that at the beginning of this research, it was thought that it would finalize just the opposite; this was an unexpected result because it was thought that the selection of effective BMs according to their high correlation coefficients would be a shorter, more precise, and time and cost saved, but not. The highest adjusted regression coefficient is achieved in the enter method, and which is similar to the stepwise method.

The same procedure is repeated for all the BMs and the results of the three different points of view are presented in Table 9. As seen from the table, the enter method mostly results from the highest adjusted regression coefficients, but the statistical selection method could not calculate the results for four measurements which are Back Length, Back Neck Grith, Shoulder Width, and Chest Fall. This is because none of the BM pairs satisfy the $r \geq 0.5$ condition in the correlation coefficient analysis in Section 3.3. In Figure 12, the three different points of view are drawn.

Table 9. Adjusted regression coefficients of three different points of view for each body measurement

	Enter Adj.R^2	**Stepwise Adj.R^2**	**Selected Adj.R_S^2 ***
Chest Circ.	0.724	0.725	0.711
Waist Circ.	0.786	0.782	0.751
Neck Circ.	0.493	0.486	0.451
Outer Leg Height	0.608	0.596	0.496
Belly Circ.	0.703	0.703	0.669
Inner Arm Length	0.654	0.642	0.604
Hip Circ.	0.790	0.791	0.786
Arm Length-1	0.776	0.771	0.716
Arm Length-2	0.758	0.756	0.700
Shoulder Circ.	0.632	0.623	0.599
Front Length	0.643	0.634	0.388
Biceps Circ.	0.672	0.660	0.636
Back Width	0.470	0.477	0.337
Height	0.720	0.717	0.672
Weight	0.838	0.838	0.790
Thigh Circ.	0.698	0.699	0.655
Side Height	0.565	0.561	0.388
Inner Leg Height	0.651	0.645	0.634
Back Length	0.243	0.221	**
Back Neck Girth	0.150	0.122	**
Shoulder Width	0.288	0.289	**
Chest Fall	0.471	0.464	**

* These are the R^2 values found when the ones with high correlations are selected among the correlation coefficients and worked with the Enter method.
** These measurements have not been studied because they do not meet the $r \geq 0.5$ condition.

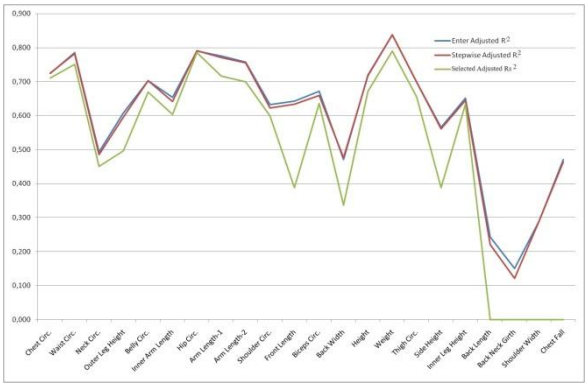

Figure 12. Drawing of adjusted regression coefficients of three different points of view for each body measurement

3.6. Validation

As mentioned at the beginning of this manuscript, there are 500 volunteers and 50 were separated for validation. The whole research was conducted with 450 volunteer BMs. Since the results of the statistical selection idea were not satisfying and couldn't reach meaningful results, no work was done for validation.

4. CONCLUSIONS

In this research, the normality assumptions of BMs are first conducted, and then a statistical selection of effective BMs to define other BMs is proposed. It was noticed in the literature that papers applying statistical methods to BMs did not mostly first check the normality of BM data and definition choices were random. Still, they were thought to have to be statistically selected for shorter, more precise, time-saving and cost-saving work. This research is done for these two purposes.

Normal distribution of BM data is proven by the five criteria of assumptions of normality which are mean, median and mode values should be equal or close to each other; histograms should look like a normal distribution curve; skewness and kurtosis coefficients should be between -1 / +1 ; normal Q-Q plot should include points above or below but close to a 45^0 diagonal line; and CV% should be less than 25%. For data to be normally distributed, it has to meet three out of five of these criteria, since the BMs of 450 volunteers met at least three or more of these criteria, it is proven that the BMs display normal distribution. Besides, boxplots and Kolmogorov-Smirnov and Shapiro-Wilk tests, which are tests not applied for normality analysis alone, were also conducted. The results did not match the assumptions of normality analysis. This research progressed by working with each BM one by one, but as an example, only the WCM is presented in this manuscript.

Correlation coefficients of each BM with the other BM are obtained and the 53 out of 231 conforming $r \geq 0.05$ condition are listed from high to low. Statistical selection is managed to specify the highly correlated pairs for each BM with the other BM to prevent random work. Multivariate multiple regression analyses are conducted for each BM with three different points of view: one BM is the dependent variable and all the other independent variables enter method, the same stepwise method, and one BM is the dependent variable and the statistically selected effective BMs independent variables enter method. Stepwise is not conducted because the proposed statistical selection already selects the variables. The Adj.r^2's of the three different points of view are compared, and the enter and stepwise methods contained high and similar results, respectively. Still, the proposed statistical selection method gave the least results and could not even be calculated for some BMs. It is assumed that this much difference in the results is because of the different variables chosen in the stepwise method but not the same in the statistical selection method. These analyses are done with each BM one by one, but as an example, only the WCM is presented in this manuscript. The resultant Adj.r^2 of WCM is 0.786 in the enter method, 0.782 in the stepwise method, 0.751 in the proposed statistical selection method, where it is seen that it is the least among the three different points of view. The proposed statistical selection method is not proven right; consequently, there was no need to validate the 50 volunteers' BM, which were separated for validation at the beginning of this research.

For future work, the proposed statistical selection method will be deeply analyzed and improved to receive shorter, more precise results and save time and cost. For further research, an arrangement must be developed for the outliers and extreme values clearly seen in boxplots. Advanced mathematical sciences like artificial neural networks, machine learning, and compound statistical methods will be implemented for body measurements.

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REFERENCES

1. Eğri Ş. A. Problems Encountered in The Sample Review on a Threedimensional Body Scanner Systems (Kardem and Ima example), Master's thesis, Gazi University, Dressing Industry and Arts of Dressing Main Science Branch, Ankara, 2011.

2. Şener H. F. Developing a method for drawing patterns suitable for women's body characteristics. PhD thesis, Gazi University, Institute of Social Sciences, Ankara, 1995.

3. Kurt Ç. Müller Pattern System 36-42 Size, Examination and Development of Anthropometric and Ergonomic Compatibility of Basic Body and Basic Sleeve Patterns, Master's thesis, Selçuk University Institute of Social Sciences, Konya, 2007.

4. Seyhun G. Modeling from A to Z. Clothing Pattern Obtaining Techniques, Published personally, İstanbul, 1993.

5. Taylor J. P., Shoben M.M. Serialization Rules and Practice for the Apparel Industry. (Translated by: H. Bal & R. Akay), Gaye Filmcilik Printing Industry. Tic. Inc., Ankara, 1995.

6. Vural T., Çileroğlu B., Çoruh E. Body Size Standardization in Terms of Underwear Production of Women of 60 Years and Above, Textile and Apparel, 18(2), 149-153, 2008.

7. Kılınç N., Bor A. Examination of the Variance of Other Anthropometric Measurements of Lower Body in Respect to the Hip Size of the Women over the Age of Fifty: an Example of a Application, International Journal of Sport Culture and Science, 4(Special Issue 3), 744-761, 2016.

8. Liu K., Wang J., Tao X., Zeng X., Bruniaux P., Kamalha E. Fuzzy classification of young women's lower body based on anthropometric measurement, International Journal of Industrial Ergonomics, 55, 60-68, 2016.

9. Tsakalidou M. Analysing Anthropometric Measurement and Body Shape Data to Incorporate Body Asymmetry, due to Scoliosis, into Improved Clothing Sizing Systems, Fashion Practice, 9(3), 398-424, 2017. DOI: 10.1080/17569370. 2017.1368164

10. Pargas P. R., Staples J. N., Davis J. S. Automatic Measurement Extraction for Apparel from a 3 Dimensional Body Scan, Elsevier Science Limited, USA, 157–172, 1997.

11. Lin Y. L., Wang M. J. Automated body feature extraction from 2D images, Expert Systems with Applications, 38, 2585–2591, 2011.

12. Şengöz N. G., Zeybek F. Sharp Silhouettes for Obtaining 3D Body Measurements from 2D Images, Necmettin Erbakan University Journal of Science and Engineering, 4(2), 8-25, 2022.

13. Şengöz N. G., Zeybek F. Pixel Coordinates for Obtaining 3D Body Measurements from 2D Images, Textile and Apparel, (Accepted on April 28, 2023, being published). DOI: 10.32710/tekstilvekonfeksiyon.1201436

14. Eren R. C., Güngör A. A Different Method for Reaching Body Measurements, Graduation Project, Uşak University, Faculty of Engineering, Department of Textile Engineering, Uşak, Supervisor: Doctoral Lecturer N. G. Şengöz (Received support from TÜBİTAK 2209-A-2012-1), 2013.

15. Şengöz N. G., Eren R. C., Güngör A. Initiation of a Method for Obtaining Body Measurements from Two-Dimensional Images, XIV. International Textile and Apparel Symposium (IITAS-2017), 26-28 October, İzmir, TÜRKİYE, 109-112, 2017.

16. Bayraktar F. Setting the standardization for body size to be employed in the production of ready-made apparel for plus size women, PhD thesis, Gazi University, Institute of Educational Sciences, Department of Clothing Industry and Fashion Design Education, Ankara, 2007.

17. Cevahir E. Guide to Quantitative Data Analysis with SPSS, Kibele Publications No: 116 Review Research Series: 23, İstanbul, 2020.

18. Demir E., Saatçioğlu Ö., İmrol F. Examination of educational researches published in international journals in terms of normality assumptions, Current Research in Education, 2(3), 130-148, 2016.

19. Terzi Y., Basic Statistics-2 Lecture Notes, Ondokuz Mayıs University, Faculty of Science and Letters, Department of Statistics, Samsun, 1-90, 2018.

20. Dattalo P. Multivariate Multiple Regression, https://academic.oup.com/book/11361/chapter-abstract/160012687?redirected From= fulltext#, (Access date: November 18, 2023).

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YAZIM KURALLLARI

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Genel

Hakem değerlendirmesi sonrası yayına kabul edilen çalışmalar, yazarlar tarafından baskı formatına uygun şekilde tekrar düzenlendikten sonra sisteme yüklenmelidir. Editörlerimizin formatla ilgili uygulama işlemleri dışında herhangi bir dizgi işlemi yapılmayacaktır. Çalışmalar Office 2013 veya daha üst versiyon bir kelime işlem uygulaması ile yazılmalıdır.

Sayfa Yapı ve Düzeni

A4 boyutunda hazırlanacak çalışmalarda, tüm kenarlardan 2.5 cm boşluk bırakılmalıdır. Üstbilgi, tek ve çift sayfalarda farklı olarak işaretlenmelidir. Üstbilgi, 8 punto büyüklüğünde ve Times New Roman fontu ile yazılmalıdır. Sayfa, tek sütun olarak düzenlenmelidir.

Makale Ana Başlığı

Türkçe: Makale başlığı Times New Roman fontuyla 12 punto, sadece baş harfleri büyük olacak şekilde, her iki yana ortalı ve koyu font ile yazılmalı, ayrıca Türkçe başlıktan önce ve sonra 1 satır boşluk bırakılmalıdır.
İngilizce: Sadece baş harfleri büyük, ortalı ve koyu olarak Times New Roman fontu ile 10 punto olarak yazılmalıdır. İngilizce başlıktan sonra 1 satır boşluk bırakılmalıdır.

Yazar Adları

Yazar adları Times New Roman fontu ile ortalı, koyu ve 10 punto olarak yazılmalıdır. Yazar adları ile adres arasında boşluk olmamalıdır. Yazar adlarına ait adres referansları üslü ifade 5 font büyüklüğünde belirtilmelidir.

Adresler

Adresler Times New Roman fontu ile ortalı ve 9 punto olarak yazılmalı. Sadece sorumlu yazarın e-posta adresi, adres satırlarının alt kısmına yine aynı font ve punto ile yazılmalıdır. Adresin hemen alt satırında boşluk bırakmadan 9 punto ile e-posta adresi yazılmalıdır.

Özet

Türkçe: Özet, koyu Times New Roman fontunda 9 punto ile yazılmalı, baş harfi büyük ve ilk satırın başına yazılmalıdır. Özet tek paragraf ve en az 50 olmak üzere 150 kelimeyi geçmeyecek şekilde yazılmalıdır.
İngilizce: Abstract, Türkçe özette olduğu gibi koyu Times New Roman fontu ile 9 punto büyüklüğünde, baş harfi büyük, tek paragraf en az 50 olmak üzere 150 kelimeyi geçmeyecek şekilde yazılmalıdır.

Anahtar Kelimeler

Türkçe: Özet metinin altına 1 satır boşluk bırakıldıktan sonra, harfleri büyük ve koyu Times New Roman formatında 9 punto ile yazılacak anahtar kelimeler, en az 3 en fazla 6 adet olmalıdır. Anahtar kelimelerden sonra 2 satır boşluk olmalıdır.
İngilizce: Abstract metinin altına 1 satır boşluk bırakıldıktan sonra, harfleri büyük ve koyu Times New Roman formatında 9 punto ile yazılacak anahtar kelimeler, en az 3 en fazla 6 adet olmalıdır. Anahtar kelimelerden sonra 2 satır boşluk olmalıdır.

Makale Başlıkları

Başlıklar numaralandırılmalı, bütün başlıklar Times New Roman fontunda 10 punto büyüklüğünde olmakla birlikte;

- Birinci derece başlıklarda tüm kelimelerin tüm harfleri büyük koyu,
- İkinci derece alt başlıklarda tüm kelimelerin ilk harfi büyük,
- Üçüncü derece başlıklarda sadece ilk kelimenin baş harfi büyük olacak şekilde yazılmalıdır.

Başlıklardan önce ve sonra bir satır boşluk bırakılmalı. Başlıklar sola dayalı olmalıdır.
Makalelerin başlıkları sırayla şu içerikleri ifade edebilecek şekilde olmalıdır;

- Giriş
- Materyal ve Metod
- Deneysel Kısım
- Gereç ve Yöntemler
- Tartışma
- Sonuç

Metin Hakkında

Metin, Keywords'den sonra 1 satır boşluk (10 punto) bırakılarak tek satır aralıklı 10 punto ile yazılmalıdır. Paragraf girintisi 0,7 cm olmalı ve paragraflardan önce ve sonra 6nk boşluk bırakılmalıdır. Metin iki yana yaslı şekilde yazılmalıdır.

Tablo, Şekil ve Denklemler

Tablo ve şekiller, kullanıldıkları sıraya göre numaralandırılmalıdır. Tabloların başlıkları üst-orta hizada, şekillerin başlıkları ise alt-orta hizada olmalıdır. Her tablo ve şekil mutlaka sırası bozulmadan Tablo 1., Şekil 1. gibi yazılmalı, koyu Times New Roman 10 punto olmalıdır. Tablo ve şekillere ait açıklamalarda sadece ilk harf büyük, Times New Roman 10 punto olmalı ve koyu font ile yazılmamalıdır. Formüller ve denklemler Math Type ya da Word Denklem Düzenleyici kullanılarak yazılmalıdır.

Kaynak Belirtme

Makalemizde kaynak gösterimi köşeli parantez içerisinde numara vererek yapılmalı "[1]", kaynaklar orijinal dilinde verilmelidir. Kaynakların yazıldığı kısım Times New Roman 9 punto olmalıdır. Örnek kaynakça içeriği aşağıdaki gibidir:

1. Chen Y. R., Chao K., Kim M. S. Machine vision technology for agricultural applications, Computers and Electronics in Agriculture, 36 173-191, 2002.
2. Kumar A. Computer vision based fabric defect detection: a survey, IEEE Transactions on Industrial Electronics, 55 348-363, 2008.
3. Yetis H., Baygin M., Karaköse M. A New Micro Genetic Algorithm Based Image Stitching Approach for Camera Arrays at Production Lines, The 5th International Conference on Manufacturing Engineering and Process (ICMEP 2016), 25-27 May, 2016.

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Instruction for Authors

The articles submitted for publication in our journal should be prepared in accordance with the journal article writing format. General information about the rules of the literature is summarized below.

General

Studies accepted for publication after peer-review should be uploaded to the system after they are rearranged by the authors in accordance with the print format. No typesetting will be done except for the format-related application procedures of our editors. Studies must be written with an Office 2013 or higher word processing application.

Page Structure and Layout

For works to be prepared in A4 size, 2.5 cm margins should be left on all sides. The header should be marked differently on odd and even pages. The header should be written in 8-point Times New Roman font. The page should be arranged as a single column.

Article Main Title

Turkish: The title of the article should be written in Times New Roman font, 12 points, only the initials should be capitalized, centered on both sides and in dark font, and 1 line space should be left before and after the Turkish title.

English: Only the initials should be capitalized, centered and bold, with Times New Roman font and 10 points. One line space should be left after the English title.

Author Names

Author names should be written in Times New Roman font, centered, bold and 10 point. There should be no spaces between the names of the authors and the address. Address references of author names should be specified in exponential 5 font size.

Addresses

Addresses should be written in Times New Roman font, centered and 9 points. Only the e-mail address of the responsible author should be written at the bottom of the address lines in the same font and size. The e-mail address should be written in 9 points, without leaving any spaces, just below the address.

Summary

Turkish: The abstract should be written in bold Times New Roman font, 9 points, the initials should be capitalized and written at the beginning of the first line. The abstract should be written in a single paragraph and not exceeding 150 words, at least 50.

English: The abstract should be written in bold Times New Roman font, as in the Turkish abstract, in 9 font size, with capital letters, and not exceeding 150 words, with a single paragraph of at least 50.

Keywords

Turkish: Key words to be written in 9 font size, capitalized and bold Times New Roman format, after leaving 1 line of space under the abstract text, must be at least 3 and at most 6 words. There should be 2 lines of space after the keywords.

English: Key words to be written in 9 font size, capitalized and bold Times New Roman, after leaving 1 line space under the abstract text, must be at least 3 and at most 6 words. There should be 2 lines of space after the keywords.

Article Titles

Headings should be numbered, all headings should be in Times New Roman font and 10 points;

- In first-degree titles, all letters of all words are capitalized,
- In secondary sub-headings, the first letter of all words is capitalized,
- In third degree titles, only the first letter of the first word should be capitalized.

One line space should be left before and after the headings. Headings should be left aligned.
The titles of the articles should be able to express the following contents in order;

- Introduction
- Material and Method
- Experimental Part
- Materials and Methods Discussion
- Conclusion

About the Text

The text should be written in 10 font size with single line spacing, leaving 1 line space (10 points) after the Keywords. Paragraph indent should be 0.7 cm and 6 pt spacing should be left before and after paragraphs. The text should be written in justified form.

Table, Figure and Equations

Tables and figures should be numbered in the order in which they are used. The titles of the tables should be in the upper-middle position, and the titles of the figures must be in the lower-middle position. Each table and figure must be written as Table 1, Figure 1 without breaking the order, and must be in 10 pt Times New Roman bold. In the explanations of tables and figures, only the first letter should be capitalized, Times New Roman 10 points and should not be written in bold font. Formulas and equations should be written using Math Type or Word Equation Editor.

References

References in our article should be cited in square brackets by numbering "[1]", references should be given in their original language. References should be written in Times New Roman 9 points. Sample bibliography content is as follows:

1. Chen Y. R., Chao K., Kim M. S. Machine vision technology for agricultural applications, Computers and Electronics in Agriculture, 36 173-191, 2002.
2. Kumar A. Computer vision based fabric defect detection: a survey, IEEE Transactions on Industrial Electronics, 55 348-363, 2008.
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Değerlendirme Süreci

Muş Alparslan Üniversitesi Mühendislik-Mimarlık Fakültesi Dergisi'ne gönderilen yazılar, öncelikle Yayın Kurulunca dergi ilkelerine uygunluk açısından ön değerlendirmeye tabi tutulur. Dergi kapsamına girmeyen veya bilimsel bir yazı formatına içerik ve şekil açısından uymayan yazılar, hakemlik süreci başlatılmadan geri çevrilir veya bazı değişiklikler istenebilir. Yayın için teslim edilen makalelerin değerlendirilmesinde akademik tarafsızlık ve bilimsel kalite en önemli şartlardır.

Muş Alparslan Üniversitesi Mühendislik-Mimarlık Fakültesi Dergisi'ne yayın kurallarına uygun olarak gönderilen makaleler, daha sonraki aşamada intihal denetiminden geçirilir. Muş Alparslan Üniversitesi Mühendislik-Mimarlık Fakültesi Dergisi'nde intihal denetimi, Ithenticate paket programı aracılığıyla gerçekleştirilmekte ve intihal denetiminde, benzerlik oranının %20'nin üstüne çıkmaması gerekmektedir. İlgili çalışmada herhangi bir intihale rastlanmadığı takdirde değerlendirilmek üzere o alandaki çalışmalarıyla tanınmış iki hakeme gönderilir. MSUFBD Dergisi, sürecin her aşamasında, hakem ve yazarların isimlerinin saklı tutulduğu çift-kör hakemlik sistemini kullanmaktadır. Hakem raporlar beş yıl süreyle saklanır. Makaleyi değerlendiren iki hakemden birisinin olumlu diğerinin olumsuz rapor vermesi durumunda makale üçüncü hakeme gönderilmekte veya Yayın Kurulu, hakem raporlarını inceleyerek nihai kararı vermektedir.

Muş Alparslan Üniversitesi Mühendislik-Mimarlık Fakültesi Dergisi'ne gönderilen çalışmalarda yazarlar, hakem ve Yayın Kurulunun eleştiri ve önerilerini dikkate alırlar. Katılmadıkları hususlar varsa gerekçeleriyle birlikte itiraz etme hakkına sahiptirler. Dergideki hakemlik sürecinde, akademik unvana sahip kişilerin yayınları için ancak eşit ya da üst derecede akademik unvana sahip kişiler hakem olabilir.

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Muş Alparslan Üniversitesi Mühendislik-Mimarlık Fakültesi Dergisi'ne makale gönderen yazar/yazarlar, Derginin söz konusu hakem değerlendirme koşullarını ve sürecini kabul etmiş sayılırlar.

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devredilmiş sayılır.

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Peer Review Process

Articles submitted to the Muş Alparslan University Journal of the Faculty of Engineering and Architecture are first evaluated by the Editorial Board in terms of compliance with the journal's principles. Artciles that are not covered by the journal or that do not comply with a scientific writing format in terms of content and form are rejected or some changes may be requested without starting the refereeing process. Academic impartiality and scientific quality are the most important conditions in the evaluation of the articles submitted for publication.

Articles submitted to the Muş Alparslan University Journal of the Faculty of Engineering and Architecture in accordance with the publication rules are then checked for plagiarism. In Muş Alparslan University Journal of the Faculty of Engineering and Architecture, plagiarism control is carried out through the Ithenticate package program and the similarity rate should not exceed 20% in plagiarism control. If no plagiarism is found in the relevant work, it is sent to two referees who are known for their work in that field for evaluation. Muş Alparslan University Journal of the Faculty of Engineering and Architecture uses the double-blind peer-review system where the names of the referees and authors are kept at every stage of the process. Referee reports are kept for five years. If one of the two referees evaluating the article gives a positive report and the other a negative report, the article is sent to the third referee or the Editorial Board makes the final decision by examining the referee reports.

In the articles submitted to the Muş Alparslan University Journal of the Faculty of Engineering and Architecture, the authors take into account the criticisms and suggestions of the referee and the Editorial Board. If there are issues that they do not agree with, they have the right to object together with their reasons. During the refereeing process in the journal, only people with equal or higher academic titles can be referees for the publications of people with academic titles.

The referee evaluation process for Muş Alparslan University Journal of the Faculty of Engineering and Architecture can sometimes take a long time due to undesirable reasons. Under normal circumstances, the preliminary evaluation phase by the editor is 20 days; The referee evaluation process is also planned as 60 days. However, due to the lack of timely return from the referees, re-appointment etc. For reasons, the referee evaluation process may take longer.

The author(s) who submit an article to Muş Alparslan University Journal of the Faculty of Engineering and Architecture are deemed to have accepted the referee evaluation conditions and process of the Journal.

The copyright of the articles decided (accepted) to be published in the Journal of the Faculty of Engineering and Architecture of Muş Alparslan University is deemed to have been transferred to Muş Alparslan University.

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The study to be submitted to Muş Alparslan University Journal of the Faculty of Engineering and Architecture should be an original article that will fill a gap in its field, or it should be a review that evaluates previously published studies and presents new and remarkable views on the subject.

Articles to be sent to Muş Alparslan University Journal of the Faculty of Engineering and Architecture should be in the form of articles, translations and book presentations. For the translated articles sent to our journal, the publication permission of the article owner and the original text are required.

The publication languages of Muş Alparslan University Journal of the Faculty of Engineering and Architecture are Turkish and English.

Studies submitted to Muş Alparslan University Journal of the Faculty of Engineering and Architecture must not have been published anywhere before and should not have been submitted for publication. Papers presented at a scientific meeting can be sent to the journal, provided that the situation is clearly stated.

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