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Research Article

A Model Proposal for Estimate the Approximate Costs and Contract Fees of Public Education Buildings

Servet KESİM [a,*], Latif Onur UĞUR [b]

[a] *Department of Civil Engineering, Institute of Science, Düzce University, Düzce, TURKEY*
[b] *Department of Civil Engineering, Fakulty of Engineering, Düzce University, Düzce, TURKEY*
** Corresponding author's e-mail address: servetkesim@gmail.com*
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ABSTRACT

In this study, a method is proposed for the preliminary estimation of school building costs. For this purpose, the projects of 96 school buildings, which were put out to tender by public institutions and the result announcement was published, were provided from the Electronic Public Procurement Platform. These projects are divided into 81 training data and 15 test data. The construction cost of educational buildings through projects may affect the output vectors; "Number of Classrooms, Construction Duration, Total Number of Floors, Floor Height, Building Height, Building Height Class, Basement Height, Earthquake Design Class, Floor Class, Ground Safety Stress, Bed Coefficient, Concrete Class, Number of Elevators, Wet Area, Raft Foundation Height, Floor Area, Basement Area, Total Area" parameters were determined and used in modeling and analysis. Analyzes were carried out with "SPSS Statistics 26" software. Using these parameters, Regression Analyzes (RA) were performed and equations were developed to estimate the costs of educational structures. Approximate Costs and Contract Prices were tried to be estimated with the developed models. The model in which all parameters were used with the created equations was the model with the best correlation level, with the determination coefficient R^2=0.900 for the Approximate Cost Price and R^2=0.927 for the Contract Price. An error rate of 17,5% was found between the approximate cost estimates obtained using the model and the actual costs. It was determined that there was an 18,2% error between the estimated contract prices and the actual contract prices. The Durbin-Watson criterion was used to check the consistency between predicted results and actual results. As a result, an approach that can estimate the approximate costs and contract prices of school buildings of different types and coefficients with error rates lower than 20% has been created. Both public institutions and contracting construction companies will be able to make realistic cost estimates by benefiting from these modeling, providing time savings. Conducting similar studies by increasing the number of data may be a solution to minimize the error rate in subsequent modeling.

Keywords: *Building Cost Model, Multiple Linear Regression Model, School Buildings, Building Cost Estimation*

Kamu Eğitim Yapılarının (Okul Binalarının) Yaklaşık Maliyetleri ve Sözleşme Bedellerinin Tahmini için Bir Model Önerisi

ÖZ

Bu çalışmada, okul binası maliyetlerinin ön tahmini için bir yöntem önerisinde bulunulmuştur. Bu amaçla, Kamu Kurumları tarafından ihaleye çıkılmış ve sonuç ilanı yayınlanmış 96 adet okul binasına ait projeler Elektronik Kamu Alımları Platformu (EKAP)'tan sağlanmıştır. Bu projeler 81 adet eğitim, 15 adet test verisi olacak şekilde ayrılmıştır. Projeler üzerinden eğitim yapılarının inşaat maliyeti çıktı vektörlerini etkileyebilecek; "Derslik Sayısı, Yapım Süresi, Toplam Kat Sayısı, Kat Yüksekliği, Bina Yüksekliği, Bina Yükseklik Sınıfı (BYS), Bodrum Yüksekliği, Deprem Tasarım Sınıfı (DTS), Zemin Sınıfı, Zemin Emniyet Gerilmesi, Yatak Katsayısı, Beton Sınıfı, Asansör Sayısı, Islak Alan, Radye Temel Yüksekliği, Kat Alanı, Bodrum Alanı, Toplam Alan" parametreleri

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belirlenerek modelleme ve analizlerde kullanılmıştır. Analizler "SPSS Statistics 26" yazılımı ile gerçekleştirilmiştir. Bu parametreler kullanılarak Regresyon Analizleri (RA) yapılmış ve eğitim yapılarının maliyetlerini tahmin etmek için denklemler geliştirilmiştir. Geliştirilen modellerle Yaklaşık Maliyetleri ve Sözleşme Bedelleri tahmin edilmeye çalışılmıştır. Oluşturulan denklemlerle tüm parametrelerin kullanıldığı model Yaklaşık Maliyet Bedeli için determinasyon katsayısı R^2=0.900, Sözleşme Bedeli için ise R^2=0.927 ile en iyi ilişki düzeyine sahip model olmuştur. Modelin kullanılması ile elde edilen yaklaşık maliyet tahminleri ve gerçek maliyetler arasında %17,5 düzeyinde hata oranı saptanmıştır. Tahmin edilen sözleşme bedelleri ile gerçek sözleşme bedelleri arasında ise %18,2 hata olduğu belirlenmiştir. Tahmin edilen sonuçlar ile gerçek sonuçlar arasındaki tutarlılığı kontrol etmek amacıyla Durbin-Watson kriteri kullanılmıştır. Sonuç olarak, farklı tip ve katsayılarına sahip okul yapılarının yaklaşık maliyetlerini ve sözleşme bedellerini %20'den düşük hata oranları ile tahmin edebilen bir yaklaşım oluşturulmuştur. Gerek kamu kuruluşları gerekse taahhütçü yapım firmaları bu modellemelerden istifade ederek zamansal tasarruflar sağlayarak gerçekçi maliyet tahminlerinde bulunabileceklerdir. Benzer çalışmaların veri adetleri arttırılarak yapılması, daha sonraki modellemelerde hata oranı minimizasyonu için bir çözüm olabilir.

Anahtar Kelimeler: *Yapı Maliyeti Modeli, Çoklu Doğrusal Regresyon Modeli, Okul Binaları, Yapı Maliyeti Tahmini*

I. INTRODUCTION

Cost is defined as the total expenses incurred to produce a product. Building cost, on the other hand, is evaluated as the total expenses from the formation of the building need to the construction process [1].

The primary objective of cost estimation is to determine the cost required to provide a desired quality of service or product by using scarce resources as effectively as possible. To achieve maximum production and complete the project at the anticipated quality, it is necessary to accurately predict the expenses that will be incurred and, at the same time, monitor these expenses with an effective cost control system within the specified cost limits [2]. Given the limited investment resources, it is essential to determine, plan, and control cost accounting with great precision. An incomplete or excessive cost estimate can lead to the failure of a construction project in terms of cost [3]. With well-prepared cost estimation, necessities such as materials for application, equipment and other resources can be specified. In order to make effective planning and actual budget preparation, all projects require cost estimation[4]. In the construction industry, it is quite important to create the financial model correctly during the idea phase of the project, in order to prevent cash flow problems and national wealth losses. This is only possible by estimating the cost correctly in predesign period [5].

A tender is the process of awarding a service or goods to the most suitable bidder among multiple applicants. In situations where the market price of the components of the job is not fully known or is uncertain, the tender process plays a significant role in price formation [6]. Public procurement refers to the purchase of goods, services, and construction works to meet the demands of administrative institutions of the state and the needs of the public. These tenders are crucial for national economies, and thus hold significant importance for the future of countries [7]. In Turkey, the Public Procurement Law No. 4734, enacted in 2002, has established the principles and procedures for tenders conducted by public institutions and organizations subject to public law or under public control or using public resources [8].

Since the 1970s, regression-based estimation models have been developed for construction cost estimation. These are based on statistical and mathematical tools, and regression techniques have been found to be successful in interpreting of the cost and the variables relationships[4].

II. BUILDING COST ESTIMATION METHODS

Cost models used for cost estimation at every stage of the construction process can be classified according to their intended use. The concept of cost modeling, which initially emerged as a simple planning method for residential and public buildings in Europe in the 1950s, began to be classified following research conducted in the 1970s and 1980s. These include traditional models, descriptive models, realistic models, and information system approach models [1].

A. TRADITIONAL MODELS

Traditional models can be categorized into Analytical models, Functional element-based models, Resource-based models, and Production unit-based models [1].

A.1. Analytical Models

These are models used from the initial stages of preliminary design when the scope of available information is very limited. The goal is to provide the most accurate cost estimate as quickly as possible and present it to users [1].

A.2. Functional Element-Based Models

Cost accounting based on elements is a type of cost accounting used during the design phase of the building production process to allow for cost planning and control [3].

A.3. Resource-Based Cost Models

These models, used during the construction phase of building production, help organize the site and perform effective site management by defining the lists of labor, materials, and equipment for each task and determining their costs [3].

A.4. Production Unit-Based Models

In the production phase of building construction, the production units and processes required to create the building constitute the production units. The production unit-based cost model is based on multiplying the previously determined unit prices for each unit by the quantities measured on the application project and summing these results to calculate the total cost of the building [3].

B. REALISTIC MODELS

Realistic models have lower estimation accuracy compared to quantity-based models. Despite this, while quantity-based models have nearly completed their development, it is suggested that realistic models have a much higher potential for development [1].

C. EXPERT SYSTEMS

These models use databases and computers for cost estimation. For successful cost estimation, these systems must be directed by experts [1].

D. DESCRIPTIVE MODELS

This approach is based on linking costs to the descriptive features of the design rather than quantities. Descriptive models are developed using regression analysis. The idea of using regression analysis was developed to determine the cost of the building both during the design phase and to allow the contractor to estimate the approximate cost [3].

D.1. Regression Analysis

Regression is the expression of the relationship between two or more variables with a cause-and-effect relationship using an equation. The direction or magnitude of the relationship between any two or more variables is determined by regression analysis. In regression analysis, the parameters of the variables in the model are estimated by making predictions based on the regression equation, thus mathematically revealing the relationships between dependent and independent variables. While there is only one dependent variable, the number of independent variables can vary. Models with one dependent and one independent variable are called simple regression models, while those with one dependent and multiple independent variables are called multiple regression models.

In regression analysis, the coefficients related to the variables forming the model are estimated. These coefficients indicate the direction and magnitude of the relationships between the dependent variable and independent variables. In short, regression analysis is a method that reveals the mathematical relationships between two or more variables with a cause-and-effect relationship [9].

D.1.1. Linear Regression Model

Regression analysis fundamentally relies on the assumption that one variable is explained by other variables. Here, a variable is mathematically modeled with other variables that have a cause-and-effect relationship, and this model is called the regression model. The regression model can be expressed in functional form as follows:

$$Y = \beta 0 + \beta 1X \quad (1)$$

Equation (1.1) shows the functional form of the relationship between two variables. These variables are Y and X. Here, Y is referred to as the explained or dependent variable, while X is called the explanatory or independent variable. β0 represents the constant coefficient, and β1 denotes the coefficient that indicates the direction and magnitude of the relationship between the Y and X variables [9].

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D.1.1.1. Dependent and Independent Variables

The dependent variable is, in brief, the variable that changes depending on the independent variables, which explains it. The independent variable is the variable that explains the dependent variable and is not influenced by any other variable. In Equation (1), Y and X represent the dependent and independent variables, respectively. Thus, the dependent variable Y is explained by the independent variable X [9].

D.1.1.2. β0 and β1 Coefficients

The coefficient β0 in the model represents the constant coefficient. Essentially, the constant coefficient indicates the value that the dependent variable would take when the independent variable is zero. The β0 coefficient is commonly found in linear regression models unless strong theoretical reasons suggest otherwise. On the other hand, the β1 coefficient in the model is the coefficient of the independent variable, showing how changes in the independent variable affect the direction and magnitude of the dependent variable [9].

D.1.2. Multiple Linear Regression Model

Linear regression analysis involves dependent and independent variables. When there is only one independent variable, it is referred to as simple linear regression, while if there are two or more independent variables, it is called multiple linear regression. The goal of regression analysis is to functionally understand and model the relationship between variables [10]. It is based on the principle of keeping one of the variables or the category of the variable at predetermined levels and examining how the other variable changes according to that level. Regression can also be interpreted as finding unknown values using known values in modern statistics[11]. In the multiple regression equation, y represents the dependent variable, a is the constant coefficient, $x1 \ldots xn$ are the independent variables, and $\beta 1 \ldots \beta n$ are the coefficients for each independent variable.

$$y = a + \beta 1 x1 + \beta 2 x2 + \cdots + \beta n xn \quad (2)$$

III. RESEARCH AND FINDINGS

A. OBJECTIVE AND METHOD

This study will also contribute to the literature on accurately predicting approximate costs and contract amounts and alleviating the burden of lengthy measurement processes. In this context, the method of this study consists of two steps, outlined as follows:

1. Obtaining numerous similar projects through the Electronic Public Procurement Platform.

2. Conducting measurement studies and updating the approximate costs and contract amounts:
   a. Performing measurement studies on 96 public education projects.
   b. Updating the approximate cost and contract amounts of the projects according to Turkish Statistical Institute (TÜİK) data.

3. Finding the estimation equation for approximate cost and contract amount using multiple linear regression:
   a. Analyzing the correlations between independent variables and determining the regression datasets.
   b. Estimating approximate cost and contract amounts using regression analysis with the datasets obtained from correlation analysis.
   c. Examining the error rate in cost prediction for approximate cost and contract amount predictions with different variable selections based on correlation analysis.

B. FINDINGS

A total of 96 education buildings tendered and contracted by public institutions between 2020 and 2022 were examined, sourced through the Electronic Public Procurement Platform (EKAP) from various provinces in Turkey. In the regression analysis, 81 projects were designated as the training series, while 15 projects were reserved for testing purposes.

Due to annual unit price fluctuations, there is a time-dependent cost variation among the projects that have been tendered. To eliminate the time-dependent difference, the building construction cost index and change rate table published annually by TÜİK, as shown in Table 1, were used.

According to Table 1, coefficients for each month between 2020 and 2022 were determined based on the average cost rate for January 2023. All projects in the dataset were updated using these coefficients according to the year and month they were tendered. The figures for the approximate cost and contract amount for the years of tendering and the updated values are shown in Table 2 and Table 3.

Table 1. *Building construction cost index and change rates [12]*

Year	January	February	March	April	May	June	July	August	September	October	November	December
						Index						
2015	97,13	97,65	98,27	99,14	100,17	100,03	100,83	101,35	102,25	101,56	101,01	100,60
2016	108,19	108,12	109,39	110,26	112,11	111,60	111,52	111,90	112,19	113,06	115,83	118,90
2017	124,69	125,09	126,43	126,84	127,26	127,06	128,16	129,51	130,94	132,76	136,09	138,14
2018	144,92	146,60	149,08	152,10	156,58	160,17	162,78	172,71	182,87	182,57	176,85	173,57
2019	184,83	186,51	189,25	192,27	195,51	193,97	192,76	191,35	190,23	190,36	190,32	192,25
2020	202,04	202,34	202,34	204,08	206,85	208,46	210,43	216,30	220,87	227,47	234,07	240,35
2021	258,24	258,16	267,03	276,48	288,67	297,02	304,61	307,43	308,20	322,84	348,46	403,16
2022	464,60	491,20	538,26	571,22	593,87	614,46	654,13	667,06	677,52	700,80	709,02	719,25
2023	829,42	846,70	864,96	873,91	878,63	917,53	1061,35	1110,41				

Table 2. *Training Set*

Number	Project Name	EKAP Number	Approximate Cost (TL)	Contract Price (TL)	Updated Approximate Cost (2023 January)	Updated Contract Price (2023 January)
1	Selim Bozkuş 2 Derslikli Okul Yapım işi	2020/ 329035	₺1,021,314.10	₺729,700.00	₺4.025.558,81	₺2.876.147,76
2	Mersin Tarsus Günyurdu Ortaokulu 16 Derslikli Bina İnşaatı	2020/ 342776	₺6,322,113.59	₺4,103,796.00	₺24.918.915,81	₺16.175.309,98
3	Bozkır 8 Derslikli Okul Binası	2020/ 383719	₺3,774,808.69	₺2,869,000.00	₺14.474.811,94	₺11.001.414,61
4	İstanbul İli Küçükçekmece İlçesi 12 Derslikli Halk Eğitim Merkezi Yapım İşi	2020/ 399854	₺11,092,394.94	₺7,862,000.00	₺41.654.612,27	₺29.523.701,91
5	Altınekin İlçesi 16 Derslik Anadolu Lisesi Yapım İşi	2020/ 472257	₺4,957,008.20	₺4,093,000.00	₺18.074.654,86	₺14.924.236,43
6	Nevşehir Merkez 16 Derslikli Mesleki Teknik Anadolu Lisesi Yapım İşi	2020/ 681344	₺11,337,320.39	₺9,139,000.00	₺36.413.414,95	₺29.352.808,94
7	Manisa Saruhanlı Azimli (B+Z+1) İlkokulu Yapım İşi	2021/ 651850	₺9,636,299.46	₺7,177,000.00	₺22.936.748,83	₺17.083.014,81
8	Sorgun 12 Derslikli Bilim Sanat Merkezi Binası Yapım İşi	2021/ 662228	₺7,275,061.61	₺6,448,000.00	₺17.316.425,42	₺15.347.816,56
9	Ilgın Atatürk 24 Derslik İlkokul Yapım İşi	2021/ 672352	₺10,370,741.86	₺10,488,000.00	₺24.684.901,32	₺24.964.004,36

10	Kavak Anadolu Lisesi Yapımı	2021/ 697755	₺14,248,394.86	₺10,397,000.00	₺29.313.185,00	₺21.389.720,56
11	Selçuklu Öğretmen Fethiye Onsun 32 Derslik İlkokul Yapım İşi	2021/ 718485	₺14,200,647.79	₺15,480,000.00	₺29.214.955,08	₺31.846.962,99
12	Tuzlukçu 8 Derslik Ortaokul Yapım İşi	2021/ 739104	₺5,512,081.77	₺6,150,000.00	₺11.339.991,22	₺12.652.378,71

Table 2 (cont). *Training Set*

13	Aydın İli Didim İlçesi 24 Derslikli Atatürk İlkokulu Ek Bina Yapım İşi	2021/ 744558	₺13,064,889.41	₺12,913,000.00	₺26.878.362,37	₺26.565.880,69
14	Sinop Türkeli İmam Hatip Ortaokulu(16 Derslik) Yapım İşi	2021/ 781382	₺10,833,936.25	₺12,656,936.25	₺22.288.628,35	₺26.039.081,42
15	Artvin Kemalpaşa İlçesi İlkokul ve Ortaokul Yapım İnşaatı	2021/ 900450	₺34,750,666.37	₺31,500,000.00	₺62.038.092,34	₺56.234.890,23
16	Manisa Köprübaşı 8 Derslikli Halk Eğitim Merkezi Yapım İşi	2022/ 74214	₺17,762,641.35	₺15,549,000.00	₺27.370.954,54	₺23.959.892,21
17	Ağrı İli Eleşkirt İlçesi Yanıkdere Köyü 4 Derslikli İlkokul Yapım İşi	2022/ 76912	₺2,956,400.85	₺2,311,000.00	₺4.555.601,37	₺3.561.085,01
18	Ağrı Merkez Taştekne Köyü 4 Derslikli İlkokul Yapım İşi	2022/ 77623	₺2,733,603.94	₺2,076,760.00	₺4.615.850,53	₺3.506.731,02
19	İlkadım İstasyon Ortaokulu Yapım İşi	2022/ 85979	₺21,227,950.37	₺16,870,000.00	₺32.710.746,84	₺25.995.458,33
20	Antalya Kepez Esentepe 24 Derslikli İlkokul Yapım İşi	2022/ 90520	₺28,850,368.32	₺28,230,000.00	₺44.456.345,43	₺43.500.402,41
21	Dazkırı İlçesi Kızılören Köyü 4 Derslikli Ortaokul Yapım İşi	2022/ 104707	₺2,609,234.35	₺2,175,000.00	₺4.405.845,18	₺3.672.615,02
22	Hamur İlçesi Karakozan Köyü 8 Derslikli İlkokul Yapım İşi	2022/ 139925	₺7,917,781.10	₺7,815,000.00	₺12.200.731,99	₺12.042.353,70
23	Amasya Merkez 12 Derslikli Tuğgeneral Hikmet Akıncı İlkokulu Yapım İşi	2022/ 510058	₺14,075,742.45	₺17,000,000.00	₺18.999.938,65	₺22.947.205,68
24	Yomra Merkez İlkokul İnşaatı Yapımı	2022/ 552400	₺28,043,333.11	₺31,416,000.00	₺43.212.762,14	₺48.409.799,58
25	Malatya Doğanşehir Karşıyaka Merkez 12 Derslikli Ortaokulu Yapım İşi	2022/ 555268	₺21,248,716.02	₺18,444,000.00	₺32.742.745,22	₺28.420.879,28
26	Ağrı İli Patnos İlçesi Alparslan Mahallesi 12 Derslikli İmamhatip Ortaokulu Yapım İşi	2022/ 573373	₺19,271,467.82	₺18,790,000.00	₺29.695.947,76	₺28.954.040,43
27	Isparta Gönen Güneykent Yunus Emre 8 Derslikli İlkokul İnşaatı Yapım işi	2022/ 578065	₺13,625,023.08	₺12,723,777.00	₺20.995.181,96	₺19.606.426,48
28	Ağrı İli Patnos İlçesi İnönü Mahallesi 16 Derslikli 75. Yıl Ortaokulu Yapım İşi	2022/ 580323	₺23,284,974.69	₺21,289,000.00	₺35.880.473,58	₺32.804.819,94
29	Afyonkarahisar Sandıklı Miralay Reşat Bey 16 Derslikli İlkokul Yapım İşi	2022/ 599172	₺16,592,094.02	₺16,283,000.00	₺25.567.225,17	₺25.090.933,49
30	Antalya Konyaaltı Çakırlar 16 Derslik İlkokul Yapım İşi	2022/ 623726	₺24,732,702.37	₺23,749,000.00	₺38.111.317,95	₺36.595.503,25
31	Antalya Kepez General Şadi ÇETİNKAYA İlkokulu Yapım İşi	2022/ 625536	₺ 45,588,409.64	₺ 45,487,000.00	₺57.804.929,79	₺57.676.344,98
32	Antalya Kepez Yeni Mahalle 32 Derslik İlkokul Yapım İşi	2022/ 635162	₺ 47,466,964.79	₺ 46,919,660.00	₺60.186.889,36	₺59.492.920,97

33	Gaziantep İli Şahinbey İlçesi Dayı Ahmet Ağa İlkokulu Ek Bina Şahintepe Mah. 349 ada 1 parsele 24 Derslik İlkokul Yapım İşi	2022/ 636291	₺ 21,903,191.66	₺ 19,456,000.00	₺27.772.683,15	₺24.669.707,12
34	İlimiz Merkez Atatürk Anadolu Lisesi Binası Yapım İşi	2022/ 638323	₺ 31,748,903.66	₺ 27,378,378.78	₺48.922.780,21	₺42.188.115,27

Table 2 (cont). *Training Set*

35	Malatya Doğanşehir Gedikağzı 8 Derslikli Mustafa Kemal İmam Hatip Ortaokulu Yapım İşi	2022/ 643647	₺ 18,791,425.85	₺ 16,717,000.00	₺28.956.237,56	₺25.759.696,32
36	Diyarbakır İli Kulp İlçesi Uzunova Mahallesi 212 Ada 21 Nolu Parselde 8 Derslikli Ortaokul yapım İşi	2022/ 658379	₺ 16,040,560.04	₺ 12,253,000.00	₺20.339.017,18	₺15.536.488,56
37	Elazığ Merkez 24 Derslikli İmam Hatip Lisesi Yapım İşi	2022/ 685257	₺ 20,158,630.32	₺ 18,545,000.00	₺25.065.168,29	₺23.058.786,17
38	Hafik 12 Derslikli Okul Yapım İşi	2022/ 691992	₺ 17,599,626.62	₺ 16,225,700.00	₺21.883.312,31	₺20.174.976,90
39	Altıeylül İlçesine 24 Derslikli İlkokul Yapım İşi	2022/ 693431	₺ 19,579,105.78	₺ 19,579,105.78	₺24.344.589,57	₺23.624.531,53
40	Sivas Merkez Kurtlapa 12 Derslikli Okul Yapım işi	2022/ 695001	₺ 20,054,438.30	₺ 19,400,000.00	₺24.935.616,31	₺24.121.890,08
41	Bandırma İlçesine 24 Derslikli İlkokul Yapım İşi	2022/ 712397	₺ 35,019,324.53	₺ 33,033,000.00	₺43.542.901,92	₺41.073.113,15
42	İzmir İli Bergama İlçesi 643 Ada 7 Parsel 24 Derslik Ortaokul Yapım İşi	2022/ 724543	₺ 38,419,956.94	₺ 32,545,000.00	₺47.771.236,00	₺40.466.335,10
43	Şırnak İli Silopi İlçesi 111 Ada 49 Parsel 24 Derslikli Ortaokul Yapım İşi	2022/ 752039	₺ 19,289,958.49	₺ 15,730,000.00	₺23.985.064,87	₺19.558.625,31
44	Yenimahalle İlçesi, (Yenibatı Mh 13384 Ada 28 Parsel) Ortaokul (32 Derslik) Yapım İşi	2022/ 761112	₺ 55,637,918.72	₺ 47,407,000.00	₺69.179.987,62	₺58.945.692,95
45	Bilecik Merkez 24 Derslikli İlkokul Bina Yapım İşi	2022/ 777106	₺ 30,502,947.97	₺ 28,433,000.00	₺37.341.709,63	₺34.807.679,27
46	Gaziantep İli Nizip İlçesi Fatih Sultan Mah Ortaokulu Fatih Sultan MAH 1538 ada 94 parsel 32 derslik ortaokul Yapım İşi	2022/ 800074	₺ 39,172,466.01	₺ 32,700,000.00	₺47.954.933,81	₺40.031.340,77
47	Çaykara Karaçam İlkokul ve Ortaokul İnşaatı Yapım İşi	2022/ 1112069	₺11,696,327.44	₺11,619,000.00	₺13.682.502,48	₺13.592.043,92
48	Akyazı Kuzuluk İlkokulu 16 Derslik Yeni Bina Yapım İşi	2022/ 1129907	₺22,843,656.56	₺22,344,600.00	₺26.722.780,21	₺26.138.977,93
49	Sinop Durağan İlçesi 4 Derslikli İlkokul Binası Yapım İşi	2022/ 1145373	₺14,731,171.57	₺12,355,000.00	₺17.232.699,11	₺14.453.025,44
50	Altıeylül 12 Derslikli Edip Gürcün İlkokulu Yapım İşi	2022/ 1147319	₺18,623,901.98	₺16,713,000.00	₺21.786.461,28	₺19.551.065,50
51	Elazığ Merkez 24 Derslikli Fatih Anadolu Lisesi Yapım İşi	2022/ 1150115	₺36,198,279.01	₺26,417,000.00	₺42.345.175,84	₺30.902.919,72
52	Malatya Üçbağlar Hacı İbrahim Işık 32 Derslikli İlkokul Yapım İşi	2022/ 1151197	₺41,288,031.82	₺38,418,999.00	₺47.612.261,87	₺44.303.769,41
53	Karatay Fevzi Çakmak 32 Derslikli İlkokul Yapım İşi	2022/ 1159441	₺35,434,674.06	₺34,400,000.00	₺41.451.901,72	₺40.241.527,74
54	Meram Kalfalar 32 Derslik Ortaokulu Yapım İşi	2022/ 1159448	₺35,532,274.56	₺32,305,000.00	₺40.974.875,45	₺37.253.268,13

55	Diyarbakır İli Kayapınar İlçesi Taban Mahallesi 154 Ada 4 Parselde 12 Derslikli İlkokul Yapım İşi	2022/ 1163306	₺21,120,484.73	₺15,421,000.00	₺24.355.582,13	₺17.783.087,69
56	Diyarbakır İli Kayapınar İlçesi Kaldırım Mahallesi 101 Ada 431 Parselde 8 Derslikli İlkokul Yapım İşi	2022/ 1163671	₺16,088,016.29	₺11,058,000.00	₺18.819.952,15	₺12.935.779,47

Table 2 (cont). *Training Set*

57	Susurluk 12 Derslikli Şerafettin Tunalı İlkokulu Yapım İşi	2022/ 1182770	₺17,828,680.69	₺16,813,000.00	₺20.559.561,12	₺19.388.305,12
58	Sındırgı 12 Derslikli Kurtuluş İlkokulu Yapım İşi	2022/ 1182883	₺19,062,193.70	₺16,667,000.00	₺21.982.015,57	₺19.219.941,80
59	Bursa İli Osmangazi İlçesi Yunuseli Mahallesi 8849 Ada 19 Parsel 32 Derslikli İlkokul Yapım İşi	2022/ 1199194	₺47,702,294.86	₺45,813,061.00	₺55.009.019,68	₺52.830.405,36
60	Bursa İli Yıldırım İlçesi Millet Mahallesi 3086 Ada 1 Parsel 32 Derslikli Ortaokul Yapım İşi	2022/ 1200774	₺52,764,920.28	₺46,912,000.00	₺60.847.104,87	₺54.097.672,63
61	Bursa İli Osmangazi İlçesi Emek Mahallesi 518 Ada 1 Parsel 32 Derslik İlkokul Yapım İşi	2022/ 1201929	₺36,704,767.18	₺32,363,000.00	₺42.326.962,80	₺37.320.152,19
62	Bursa İli Yıldırım İlçesi Şirinevler 32 Derslikli Ortaokul Yapım İşi	2022/ 1202204	₺32,993,060.65	₺30,887,000.00	₺38.046.721,40	₺35.618.068,18
63	Bursa İli Yıldırım İlçesi Millet Mahallesi 3065 Ada 5 Parsel 32 Derslikli Ortaokul Yapım İşi	2022/ 1202463	₺37,702,698.91	₺33,000,000.00	₺43.477.751,17	₺38.054.723,67
64	Bingöl Altınçağ 16 Derslikli Ortaokul Yapım İşi	2022/ 1206460	₺23,038,739.40	₺22,366,000.00	₺26.567.662,47	₺25.791.877,26
65	Hanönü 8 Derslikli Ortaokulu Binası Yapım İşi	2022/ 1208747	₺20,727,363.51	₺20,621,000.00	₺23.902.245,18	₺23.779.589,60
66	Başçiftlik Çok Programlı Anadolu Lisesi Yapım İşi	2022/ 1219402	₺17,322,391.55	₺16,360,660.00	₺19.975.721,93	₺18.866.678,65
67	Karatay Hacısadık Ortaokulu 32 Derslik Yapım İşi	2022/ 1230517	₺37,042,028.46	₺38,732,000.00	₺42.715.883,55	₺44.664.713,85
68	Tarsus 100 Yıl İlkokulu Yapım İşi	2022/ 1247968	₺30,306,745.60	₺28,880,000.00	₺34.948.934,22	₺33.303.649,08
69	Mersin Akdeniz Fevzi Çakmak 32 Derslik Okul İnşaatı Yapım	2022/ 1248332	₺46,044,311.83	₺37,370,049.00	₺53.097.077,68	₺43.094.148,13
70	Gönen 16 Derslikli Mehmet Çanakçı İlkokulu Yapım İşi	2022/ 1250375	₺19,270,325.27	₺17,733,000.00	₺22.222.027,37	₺20.449.224,69
71	Erdek 12 Derslikli Kapıdağ MTAL Yapım İşi	2022/ 1264907	₺19,062,178.42	₺18,213,000.00	₺21.981.997,95	₺21.002.747,95
72	Siirt İli Kurtalan İlçesi Aksöğüt Köyü 8 Derslik İlk-Orta Okulu Yapım İşi	2022/ 1284341	₺9,349,630.19	₺7,273,000.00	₺10.781.745,25	₺8.387.030,46
73	Mersin Toroslar Arpaçsakarlar 32 Derslik Ortaokul İnşaatı	2022/ 1295596	₺50,507,014.25	₺41,821,000.00	₺58.243.347,60	₺48.226.866,62
74	Mersin Yenişehir Cumhuriyet İlkokulu Bina	2022/ 1296202	₺46,257,833.94	₺36,940,000.00	₺53.343.305,70	₺42.598.227,04
75	Ereğli Aziziye 24 Derslik İlkokulu Yapım İşi	2022/ 1298030	₺24,245,858.84	₺23,260,000.00	₺27.959.680,55	₺26.822.814,32
76	Karesi 24 Derslikli Atatürk MTAL Lise Yapım İşi	2022/ 1298485	₺32,722,272.37	₺29,940,000.00	₺37.734.455,54	₺34.526.012,93

77	Bandırma 24 Derslikli İmam Hatip Lisesi Yapım İşi	2022/ 1298510	₺32,969,222.65	₺29,250,000.00	₺38.019.232,05	₺33.730.323,25
78	Çorum İskilip İlçesi Ebussud Efendi İlkokulu Yapımı İnşaatı	2022/ 1299346	₺18,029,054.38	₺19,376,000.00	₺20.790.626,74	₺22.343.888,66

Table 2 (cont). *Training Set*

79	Mersin Tarsus 100. Yıl Ortaokulu Yapım İşi	2022/ 1336676	₺30,001,902.75	₺29,990,000.00	₺34.597.397,54	₺34.583.671,60
80	Ordu İli Kumru İlçesi Şehit Neşe Eryetim İmam Hatip Ortaokulu Yapım İşi	2022/ 1339580	₺17,441,476.32	₺17,647,000.00	₺17.441.476,32	₺17.647.000,00
81	Mersin Yenişehir Dr.Kamil TARHAN Orta Okulu Yapım İşi	2022/ 1352397	₺30,240,371.36	₺25,921,000.00	₺34.872.393,21	₺29.891.408,86

Table 3. *Test Set*

Number	**Project Name**	**EKAP Number**	**Approximate Cost (TL)**	**Contract Price (TL)**	**Updated Approximate Cost (2023 January)**	**Updated Contract Price (2023 January)**
1	Yalova Teşfikiye 8 Derslikli İlköğretim Okulu Yapım İşi	2020/ 652247	₺5,144,773.67	₺4,145,000.00	₺17.754.017,80	₺14.303.914,71
2	Seyhan İlçesi Fatih Mehmet 24 Derslikli İlkokul Yapım İşi	2021/ 678349	₺11,549,480.83	₺9,645,600.00	₺27.490.588,27	₺22.958.886,39
3	Tunceli Merkez 12 Derslikli Ortaokulu Yapımı	2021/ 788903	₺14,732,311.59	₺12,289,000.00	₺30.308.745,61	₺25.282.127,15
4	Akyazı Alaağaç İlkokulu-Ortaokulu 8 Derslikli Yeni Bina	2021/ 872200	₺5,732,314.68	₺6,329,000.00	₺10.233.526,56	₺11.298.749,85
5	Dazkırı İlçesi Şerife Memiş UÇAR 4 Derslikli İlkokul Yapım İşi	2022/ 103527	₺2,753,214.86	₺2,594,800.00	₺4.648.964,72	₺4.381.471,94
6	Ağrı Merkez Cumhuriyet Mahallesi 12 Derslikli İlkokul Yapım İşi	2022/ 571617	₺20,821,311.83	₺18,485,000.00	₺32.084.146,06	₺28.484.057,33
7	Mersin İli Akdeniz İlçesi Ulubatlı Hasan 24 Derslikli Ortaokul Bina İnşaatı	2022/ 1123063	₺29,920,269.76	₺25,965,000.00	₺34.503.260,54	₺29.942.148,49
8	Malatya İli Battalgazi İlçesi Hatunsuyu Saray 4 Derslikli İlkokul Yapım İşi	2022/ 1151194	₺14,882,398.57	₺12,144,444.00	₺17.409.606,25	₺14.206.714,54
9	Bursa İli İnegöl İlçesi 1767 Ada 1 Parsel 32 Derslik Ortaokul Yapım İşi	2022/ 1191537	₺39,678,634.50	₺36,780,000.00	₺45.756.347,62	₺42.413.719,29
10	Bursa İli Gürsu İlçesi 217 Ada 5 Parsel 32 Derslik Ortaokul Yapım İşi	2022/ 1201569	₺40,502,163.31	₺34,850,000.00	₺46.706.019,18	₺40.188.094,54
11	Gürpınar İlçesi Atatürk İlkokulu 8 Derslik Yapımı ve Çevre Düzenleme İşi	2022/ 1211745	₺21,570,694.37	₺15,365,000.00	₺24.874.751,93	₺17.718.509,98
12	Burhaniye 12 Derslikli Şehit Yılmaz Kobak İlkokulu Yapım İşi	2022/ 1259556	₺20,764,093.35	₺18,649,000.00	₺23.944.601,05	₺21.505.531,57
13	Ereğli Mehmet Akif Mahallesi 24 Derslik İlkokulu Yapım İşi	2022/ 1297609	₺22,539,471.31	₺22,342,000.00	₺25.991.919,77	₺25.764.201,10
14	Bandırma 24 Derslikli Haydar Çavuş MTAL Lise Yapım İşi	2022/ 1298507	₺32,454,585.73	₺30,942,000.00	₺37.425.766,42	₺35.681.492,72

15	Ayvalık Altınova 12 Derslikli İlkokulu Yapım İşi	2022/ 1333690	₺20,099,949.64	₺17,182,000.00	₺23.178.728,16	₺19.813.826,12

C. DATA SET CREATION

This section provides information about the construction projects for educational buildings tendered under Law No. 4734 on Public Procurement.

C.1. Characteristics of Projects Used in the Analysis

In this study, 96 construction projects for educational buildings, tendered and contracted by institutions subject to Law No. 4734 between 2020 and 2022, were utilized.

C.2. Measurement Calculation

Measurement calculation is the process of determining quantities by measuring each work item from the construction drawings. The measurement work performed to determine the cost of the building is a detailed and time-consuming phase carried out by both the public institution tendering the work and the bidders.

This section describes the measurement work conducted to create the dataset used in the study. Measurement items deemed suitable for educational building cost modeling were selected. For this study, 18 main measurement items known to affect building costs were chosen, and these items form the independent variables of the dataset. The characteristics of these independent variables are described below:

C.2.1. Number of Classrooms

This refers to the number of classrooms in the educational buildings to be constructed. The dataset includes buildings with a minimum of 2 classrooms and a maximum of 32 classrooms.

C.2.2. Construction Duration

This is the duration proposed by the contracting institution for the completion of construction, as stated in the tender documents. The minimum project duration in the dataset is 100 days, and the maximum is 750 days.

C.2.3. Total Number of Floors

Buildings consisting of a single block were preferred in the projects. Among the projects in the dataset, the minimum number of floors, including the basement, is 1, and the maximum is 5.

C.2.4. Floor Height

This independent variable refers to the floor height specified for the normal floors of a building in the project. The measurement of height is from the top of one floor slab to the top of the next floor slab. The minimum floor height in the dataset is 3.20 meters, and the maximum is 4.00 meters.

C.2.5. Building Height

This independent variable represents the difference between the building's +0.00 elevation and the top of the uppermost floor slab (excluding roof height). The minimum building height in the dataset is 3.20 meters, and the maximum is 20.50 meters.

C.2.6. Building Height Class

This independent variable refers to the Building Height Classes defined by the 2018 Earthquake Regulation. Buildings are categorized into eight Building Height Classes (BHC) based on their heights. The height ranges defined for these classes are determined according to the Earthquake Design Classes. In the dataset, the Building Height Class is named according to its number. The minimum value in the dataset is 5, and the maximum value is 8.

Table 4. *Building Height Ranges Defined According to Building Height Classes and Earthquake Design Classes [13]*

Building Height Class	**Building Height Ranges Defined According to Building Height Classes and Earthquake Design Classes [m]**		
	DTS = 1, 1a, 2, 2a	**DTS = 3, 3a**	**DTS = 4, 4a**
BYS=1	$H_N > 70$	$H_N > 91$	$H_N > 70$
BYS=2	$56 > H_N \geq 70$	$70 > H_N \geq 91$	$H_N > 70$
BYS=3	$42 > H_N \geq 56$	$56 > H_N \geq 70$	$H_N > 70$
BYS=4	$28 > H_N \geq 42$	$42 > H_N \geq 56$	
BYS=5	$17.5 > H_N \geq 28$	$28 > H_N \geq 42$	
BYS=6	$10.5 > H_N \geq 17.5$	$17.5 > H_N \geq 28$	
BYS=7	$7 > H_N \geq 10.5$	$10.5 > H_N \geq 17.5$	
BYS=8	$H_N \leq 7$	$H_N \leq 10.5$	

C.2.7. Basement Floor Height

This independent variable represents the number of floors located below the natural ground level (zero elevation) in the projects. A total of 16 buildings do not have a basement. There are basements in 80 buildings. In the dataset, the minimum basement floor height is 0.00 meters, and the maximum basement height is 5.15 meters.

C.2.8. Earthquake Design Class

This independent variable is determined based on the Building Use Classes defined by the 2018 Earthquake Regulation and the Short Period Design Spectral Acceleration Coefficient for the DD-2 earthquake ground motion level. The Earthquake Design Classes to be considered in design under earthquake effects are specified according to this Regulation.

Table 5. *Short Period Design Spectral Acceleration Coefficient at DD-2 Earthquake Ground Motion Level [13]*

Short Period Design Spectral Acceleration Coefficient (S_{DS}) at DD-2 Earthquake Ground Motion Level	**Building Usage Class**	
	BKS = 1	**BKS = 2, 3**
$S_{DS} < 0.33$	DTS = 4a	DTS = 4
$0.33 \leq S_{DS} < 0.50$	DTS = 3a	DTS = 3
$0.50 \leq S_{DS} < 0.75$	DTS = 2a	DTS = 2
$0.75 \leq S_{DS}$	DTS = 1a	DTS = 1

Table 6. *Values defined according to Earthquake Design Class in the Data Set*

DTS	Defined Value
1a	**1**
2a	**2**
3a	**3**
4a	**4**
1	**5**
2	**6**
3	**7**
4	**8**

The minimum value in the dataset is 1, and the maximum value is 5.

C.2.9. Soil Class

This independent variable represents the soil classification based on particle size and consistency, ranging between ZA and ZF. The soil classes for the projects in this study have been determined based on information from structural projects or geotechnical reports. The dataset includes projects representing all soil classes ranging from ZB to ZE.

Table 7. *Ground Class Values [13]*

Local Ground Class	Soil Type	Average in the upper 30 meters		
		$(V_S)_{30}$ [m/s]	$(N_{60})_{30}$ [darbe/30 cm]	$(C_u)_{30}$ [kPa]
ZA	Solid, hard rocks	> 1500	-	-
ZB	Slightly weathered, medium-solid rocks	760 - 1500	-	-
ZC	Very dense layers of sand, gravel and hard clay or weathered, weak rocks with many cracks	360 - 760	> 50	> 250
ZD	Medium-tight sand, gravel or very solid clay layers	180 - 360	15 - 50	70 - 250
ZE	Loose sand, gravel or soft-solid clay layers Profiles with a total thickness of more than 3 meters of soft clay layer (cu < 25 kPa) that meet the conditions of PI > 20 and w> 40%.	< 180	< 15	< 70
ZF	ZF Grounds requiring site-specific research and evaluation: 1) Soils at risk of collapse and potential collapse under the influence of earthquake (liquefiable soils, highly sensitive clays, collapsible weakly cemented soils, etc.), 2) Peat and/or clays with high organic content, with a total thickness of more than 3 meters, 3) High plasticity (PI > 50) clays with a total thickness of more than 8 meters, 4) Very thick (> 35 m) soft or medium solid clays.			

Table 8. *Values defined according to Soil Class in the Data Set*

Graund Class	Defined Value
ZA	1
ZB	2
ZC	3
ZD	4
ZE	5
ZF	6

C.2.10. Soil Bearing Capacity

This independent variable, like the soil class variable, varies according to the structure of the soil on which the projects will be built. It represents the maximum stress that the soil can safely bear. In this study, soil bearing capacity values were determined based on information found in static projects or geotechnical reports. The dataset includes projects with a maximum soil bearing capacity of 116 t/m² and a minimum of 8.50 t/m².

C.2.11. Soil Bedding Coefficient

Another independent variable calculated to determine the structure of the soil on which the projects will be built is the bedding coefficient. This variable represents the volumetric change in the soil due to the weight that will affect the soil as a result of the building's construction. In this study, the bedding coefficient was determined based on information found in static projects or geotechnical reports. The dataset shows that the bedding coefficient ranges from a maximum of 15,000 t/m³ to a minimum of 1,100 t/m³.

C.2.12. Concrete Class

This independent variable represents the concrete class value found in static calculations and projects. The concrete class is determined by the results of tests performed on cube and cylinder samples used in static calculations and expresses the compressive strength of the concrete. The dataset includes projects with concrete classes of C25, C30, C35, and C40. In the analyses, a value of 25 represents C25, 30 represents C30, 35 represents C35, and 40 represents C40.

C.2.13. Number of Elevators

This independent variable indicates the number of elevators in the project. There are 7 buildings with no elevators, 70 buildings with 1 elevator, and 19 buildings with 2 elevators in the dataset.

C.2.14. Wet Area

The bathroom and WC areas in architectural projects are referred to as "Wet Areas." This independent variable is determined by the total of the wet areas on each floor in the project. The projects in the dataset have a minimum wet area of 22.62 m² and a maximum wet area of 387.91 m².

C.2.15. Height of Raft Foundation Type

This independent variable is determined based on the foundation drawings and details in the static projects. The dataset shows that the minimum value is 0.30 m and the maximum value is 1.20 m.

C.2.16. Floor Area

This independent variable represents the area of a typical floor in the projects that make up the dataset. If a building has different typical floor areas, the value of the most common typical floor is taken. The projects in the dataset have a minimum floor area of 413.29 m² and a maximum floor area of 1,270.32 m².

C.2.17. Basement Area

This independent variable represents the area of the floors below the ground level, which is defined as the zero level, determined by the architectural and static calculations of the projects. The dataset includes projects with a minimum basement area of 0 m² and a maximum of 1,427.60 m².

C.2.18. Total Construction Area

This independent variable represents the total construction area of the floors in the project. The dataset shows that the floor area ranges from a minimum of 325.00 m² to a maximum of 9,113.12 m².

Using the 18 calculated variables above, an analysis was conducted to estimate the Contract Amount and Approximate Cost.

D. MODEL DEVELOPMENT USİNG MULTİPLE LİNEAR REGRESSİON

In the modeling study, variables such as Number of Classrooms, Construction Duration (days), Total Number of Floors, Floor Height (meters), Building Height (from +0.00 level, meters), Building Height Class (BYS), Basement Height (meters), Earthquake Design Class (DTS), Soil Class, Soil Bearing Capacity (t/m²), Bedding Coefficient (t/m³), Concrete Class, Number of Elevators, Wet Area (m²), Height of Raft Foundation (meters), Floor Area (m²), Basement Area (m²), and Total Area (m²) were taken as independent variables. The aim was to explain the project's Contract Amount and approximate cost values using these variables. The SPSS software package was used to develop a multiple regression model. The regression analysis of 81 school projects yielded the following results:

D.1. Contract Amount Regression Model

Contract Amount = − 2349012.559 + 46452.464 × **(Number of Classrooms)** − 277.169 × **(Construction Duration)** + 496947.262 × **(Total Number of Floors)** + 2021313.907 × **(Floor Height)** − 445038.095 × **(Building Height)** − 2020336.669 × **(Building Height Class)** − 2413730.060 × **(Basement Height)** + 21079.829 × **(Earthquake Design Class)** + 196257.334 × **(Soil Class)** − 34217.334 × **(Soil Bearing Capacity)** + 207.823 × **(Bedding Coefficient)** + 427461.327 × **(Concrete Class)** + 5537494.092 × **(Number of Elevators)** + 16687.841 × **(Wet Area)** + 9752894.338 × **(Height of Raft Foundation)** − 2534.565 × **(Floor Area)** + 12246.067 × **(Basement Area)** + 3711.671 × **(Total Area)**

Table 9. *Regression model prediction results of educational structures*

Number	Project Name	Updated Contract Price (2023 January)	Contract Price Estimated by Regression Equation	Error rate
1	Yalova Teşfikiye 8 Derslikli İlköğretim Okulu Yapım İşi	₺14.303.914,71	₺19.749.333.37	38.1%
2	Seyhan İlçesi Fatih Mehmet 24 Derslikli İlkokul Yapım İşi	₺22.958.886,39	₺30.063.223.09	30.9%
3	Tunceli Merkez 12 Derslikli Ortaokulu Yapımı	₺25.282.127,15	₺22.520.388.60	10.9%
4	Akyazı Alaağaç İlkokulu-Ortaokulu 8 Derslikli Yeni Bina	₺11.298.749,85	₺16.064.295.08	42.2%
5	Dazkırı İlçesi Şerife Memiş UÇAR 4 Derslikli İlkokul Yapım İşi	₺4.381.471,94	₺2.569.036.56	41.4%
6	Ağrı Merkez Cumhuriyet Mahallesi 12 Derslikli İlkokul Yapım İşi	₺28.484.057,33	₺30.083.289.02	5.6%
7	Mersin İli Akdeniz İlçesi Ulubatlı Hasan 24 Derslikli Ortaokul Bina İnşaatı	₺29.942.148,49	₺28.215.690.19	5.8%
8	Malatya İli Battalgazi İlçesi Hatunsuyu Saray 4 Derslikli İlkokul Yapım İşi	₺14.206.714,54	₺15.463.565.98	8.8%

Table 9. (cont.) *Regression model prediction results of educational structures*

9	Bursa İli İnegöl İlçesi 1767 Ada 1 Parsel 32 Derslik Ortaokul Yapım İşi	₺42.413.719,29	₺47.098.209.85	11.0%
10	Bursa İli Gürsu İlçesi 217 Ada 5 Parsel 32 Derslik Ortaokul Yapım İşi	₺40.188.094,54	₺44.822.007.71	11.5%
11	Gürpınar İlçesi Atatürk İlkokulu 8 Derslik Yapımı ve Çevre Düzenleme İşi	₺17.718.509,98	₺18.507.047.52	4.5%
12	Burhaniye 12 Derslikli Şehit Yılmaz Kobak İlkokulu Yapım İşi	₺21.505.531,57	₺24.547.419.40	14.1%
13	Ereğli Mehmet Akif Mahallesi 24 Derslik İlkokulu Yapım İşi	₺25.764.201,10	₺23.973.879.22	6.9%
14	Bandırma 24 Derslikli Haydar Çavuş MTAL Lise Yapım İşi	₺35.681.492,72	₺29.420.229.43	17.5%
15	Ayvalık Altınova 12 Derslikli İlkokulu Yapım İşi	₺19.813.826,12	₺24.386.985.98	23.1%
	AVERAGE ERROR VALUE			18,20%

Table 10. *Statistical data on Educational Buildings*

Model	Sum of Squares	Df	Mean Squares	F	p
Regression Sum of Squares	13408311421886500,000	18	744906190104806,000	43,620	,000[b]
Residual Sum of Squares	1058793525979290,000	62	17077314935149,900		
Grand Sum of Squares	14467104947865800,000	80			

Based on the calculations, the F-statistic value was determined to be 43.620. Using the F-table, it was found that the p-value is $p<0.05$, indicating that the model is statistically significant.

Table 11. *Statistical data on educational structures (Relationships Between Independent Variables)*

		Updated Contract Price (TL)	Number of Classrooms	Construction Time (Days)	Total Number of Floors	Floor Height (m)	Building Height (m)	Building Height Class	Basement Height (m)	Earthquake Design Class	Ground Class	Ground safety tension	Ground Bed Coefficient	Concrete Grade	Number of Elevators	Wet Area (m²)	Raft Foundation Height (m)	Floor Area (m²)	Basement Area (m²)	Total Area (m²)
Updated Contract Price (TL)	r	1,00	0,84	0,46	0,67	0,40	0,66	-0,49	0,49	0,12	-0,04	-0,03	-0,02	0,28	0,75	0,86	0,71	0,81	0,81	0,93
	p		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,15	0,37	0,38	0,45	0,01	0,00	0,00	0,00	0,00	0,00	0,00
Number of Classrooms	r	0,84	1,00	0,39	0,75	0,25	0,71	-0,42	0,51	0,15	0,00	-0,09	-0,08	0,31	0,64	0,77	0,63	0,68	0,76	0,89
	p	0,00		0,00	0,00	0,01	0,00	0,00	0,00	0,09	0,48	0,21	0,25	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Construction Time (Days)	r	0,46	0,39	1,00	0,52	0,29	0,47	-0,41	0,45	-0,01	0,09	-0,05	0,20	0,06	0,45	0,34	0,25	0,27	0,42	0,43
	p	0,00	0,00		0,00	0,00	0,00	0,00	0,00	0,48	0,22	0,34	0,04	0,30	0,00	0,00	0,01	0,01	0,00	0,00
Total Number of Floors	r	0,67	0,75	0,52	1,00	0,37	0,93	-0,68	0,77	0,18	0,01	-0,13	-0,12	0,25	0,60	0,64	0,59	0,35	0,68	0,72
	p	0,00	0,00	0,00		0,00	0,00	0,00	0,00	0,05	0,45	0,12	0,15	0,01	0,00	0,00	0,00	0,00	0,00	0,00
Floor Height (m)	r	0,40	0,25	0,29	0,37	1,00	0,48	-0,45	0,38	0,12	-0,16	-0,11	-0,04	0,24	0,46	0,30	0,27	0,34	0,37	0,34
	p	0,00	0,01	0,00	0,00		0,00	0,00	0,00	0,14	0,08	0,17	0,38	0,01	0,00	0,00	0,01	0,00	0,00	0,00
Building Height (m)	r	0,66	0,71	0,47	0,93	0,48	1,00	-0,71	0,67	0,11	-0,05	-0,09	-0,12	0,28	0,62	0,62	0,56	0,38	0,63	0,70
	p	0,00	0,00	0,00	0,00	0,00		0,00	0,00	0,17	0,33	0,21	0,14	0,01	0,00	0,00	0,00	0,00	0,00	0,00
Building Height Class	r	-0,49	-0,42	-0,41	-0,68	-0,45	-0,71	1,00	-0,49	0,09	-0,02	0,19	0,18	-0,41	-0,34	-0,49	-0,43	-0,15	-0,39	-0,42
	p	0,00	0,00	0,00	0,00	0,00	0,00		0,00	0,22	0,44	0,04	0,05	0,00	0,00	0,00	0,00	0,09	0,00	0,00

***Table 11.(cont.)** Statistical data on educational structures (Relationships Between Independent Variables)*

Basement Height (m)	r	0,49	0,51	0,45	0,77	0,38	0,67	-0,49	1,00	0,19	-0,07	-0,05	-0,06	0,29	0,47	0,53	0,47	0,30	0,79	0,55
	p	0,00	0,00	0,00	0,00	0,00	0,00	0,00		0,04	0,26	0,32	0,28	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Earthquake Design Class	r	0,12	0,15	-0,01	0,18	0,12	0,11	0,09	0,19	1,00	-0,39	0,07	0,27	-0,17	0,17	0,08	0,10	0,19	0,22	0,18
	p	0,15	0,09	0,48	0,05	0,14	0,17	0,22	0,04		0,00	0,27	0,01	0,06	0,06	0,24	0,18	0,05	0,03	0,05
Ground Class	r	-0,04	0,00	0,09	0,01	-0,16	-0,05	-0,02	-0,07	-0,39	1,00	-0,33	-0,48	0,07	-0,17	-0,09	-0,08	-0,12	-0,07	-0,05
	p	0,37	0,48	0,22	0,45	0,08	0,33	0,44	0,26	0,00		0,00	0,00	0,26	0,07	0,21	0,25	0,14	0,26	0,34
Ground safety tension	r	-0,03	-0,09	-0,05	-0,13	-0,11	-0,09	0,19	-0,05	0,07	-0,33	1,00	0,45	-0,01	-0,01	0,02	0,04	0,02	-0,01	-0,06
	p	0,38	0,21	0,34	0,12	0,17	0,21	0,04	0,32	0,27	0,00		0,00	0,45	0,46	0,42	0,37	0,42	0,46	0,29
Ground Bed Coefficient	r	-0,02	-0,08	0,20	-0,12	-0,04	-0,12	0,18	-0,06	0,27	-0,48	0,45	1,00	-0,31	0,09	-0,13	-0,12	0,03	-0,04	-0,05
	p	0,45	0,25	0,04	0,15	0,38	0,14	0,05	0,28	0,01	0,00	0,00		0,00	0,21	0,12	0,13	0,38	0,37	0,34
Concrete Grade	r	0,28	0,31	0,06	0,25	0,24	0,28	-0,41	0,29	-0,17	0,07	-0,01	-0,31	1,00	0,01	0,31	0,38	0,11	0,29	0,23
	p	0,01	0,00	0,30	0,01	0,01	0,01	0,00	0,00	0,06	0,26	0,45	0,00		0,45	0,00	0,00	0,15	0,00	0,02
Number of Elevators	r	0,75	0,64	0,45	0,60	0,46	0,62	-0,34	0,47	0,17	-0,17	-0,01	0,09	0,01	1,00	0,63	0,47	0,73	0,66	0,78
	p	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,06	0,07	0,46	0,21	0,45		0,00	0,00	0,00	0,00	0,00
Wet Area (m²)	r	0,86	0,77	0,34	0,64	0,30	0,62	-0,49	0,53	0,08	-0,09	0,02	-0,13	0,31	0,63	1,00	0,69	0,72	0,76	0,87
	p	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,24	0,21	0,42	0,12	0,00	0,00		0,00	0,00	0,00	0,00
Raft Foundation Height (m)	r	0,71	0,63	0,25	0,59	0,27	0,56	-0,43	0,47	0,10	-0,08	0,04	-0,12	0,38	0,47	0,69	1,00	0,47	0,65	0,65
	p	0,00	0,00	0,01	0,00	0,01	0,00	0,00	0,00	0,18	0,25	0,37	0,13	0,00	0,00	0,00		0,00	0,00	0,00
Floor Area (m²)	r	0,81	0,68	0,27	0,35	0,34	0,38	-0,15	0,30	0,19	-0,12	0,02	0,03	0,11	0,73	0,72	0,47	1,00	0,71	0,88
	p	0,00	0,00	0,01	0,00	0,00	0,00	0,09	0,00	0,05	0,14	0,42	0,38	0,15	0,00	0,00	0,00		0,00	0,00
Basement Area (m²)	r	0,81	0,76	0,42	0,68	0,37	0,63	-0,39	0,79	0,22	-0,07	-0,01	-0,04	0,29	0,66	0,76	0,65	0,71	1,00	0,85
	p	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,03	0,26	0,46	0,37	0,00	0,00	0,00	0,00	0,00		0,00
Total Area (m²)	r	0,93	0,89	0,43	0,72	0,34	0,70	-0,42	0,55	0,18	-0,05	-0,06	-0,05	0,23	0,78	0,87	0,65	0,88	0,85	1,00
	p	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,05	0,34	0,29	0,34	0,02	0,00	0,00	0,00	0,00	0,00	

According to the table, there are strong correlations between some variables. Including these variables in the model simultaneously could lead to multicollinearity issues. Therefore, multicollinearity checks will need to be performed in the developed model.

***Table 12.** Statistical data of educational structures (Autocorrelation and Multicollinearity Assumptions Controls)*

Durbin-Watson	**1,523**
Collinearity (VIF)	
Number of Classrooms	7.524
Construction Time (Days)	1.889
Total Number of Floors	32.216
Floor Height (m)	2.179
Building Height (m)	10.897
Building Height Class	3.301
Basement Height (m)	10.720
Earthquake Design Class	1.632
Ground Class	1.981
Ground safety tension	1.698
Ground Bed Coefficient	2.340
Concrete Grade	1.913
Number of Elevators	3.905
Wet Area (m²)	6.505
Raft Foundation Height (m)	2.551
Floor Area (m²)	24.326
Basement Area (m²)	14.567
Total Area (m²)	73.277

Autocorrelation is the condition where there is a correlation between the errors in the created model. There should be no autocorrelation in a regression model, and the errors in the created model should be random. This is checked with the Durbin-Watson test. A result around 2 indicates that there is no autocorrelation problem in the model. After analysis, the Durbin-Watson test result was found to be 1.523, indicating that there is no autocorrelation problem in our model.

To check for multicollinearity in the model, we look at the Variance Inflation Factor (VIF) values for the variables. The VIF value should not exceed 10. Among the 18 independent variables included in the model, it was found that the VIF value for 12 variables is below 10. This suggests that there is no multicollinearity problem for these 12 variables. However, there is evidence of multicollinearity for the variables Total Number of Floors, Building Height, Basement Height, Floor Area, Basement Area, and Total Area.

Table 13. *Statistical data of educational structures (Autocorrelation and Multicollinearity Assumptions*

Adjusted R^2	**F**	**p**
0.927	43,620	,000[b]

.000b: means p<0.05.

The model created to explain the Contract Amount variable is seen to be a significant model (F: 43.620, p<0.05). In this significant model, the independent variables can explain 92.7% of the variation in the dependent variable.

D.2. Regression Model for Approximate Cost

Approximate Cost = − 2349012.559 + 46452.464 × **(Number of Classrooms)** − 277.169 × **(Construction Duration)** + 496947.262 × **(Total Number of Floors)** + 2021313.907 × **(Floor Height)** − 445038.095 × **(Building Height)** − 2020336.669 × **(Building Height Class)** − 2413730.060 × **(Basement Height)** + 21079.829 × **(Earthquake Design Class)** + 196257.334 × **(Soil Class)** − 34217.334 × **(Soil Bearing Capacity)** + 207.823 × **(Bedding Coefficient)** + 427461.327 × **(Concrete Class)** + 5537494.092 × **(Number of Elevators)** + 16687.841 × **(Wet Area)** + 9752894.338 × **(Height of Raft Foundation)** − 2534.565 × **(Floor Area)** + 12246.067 × **(Basement Area)** + 3711.671 × **(Total Area)**

Table 14. *Regression model prediction results of educational structures*

Number	**Project Name**	**Updated Approximate Cost (2023 January)**	**Approximate Cost Estimated by Regression Equation**	**Error rate**
1	Yalova Teşfikiye 8 Derslikli İlköğretim Okulu Yapım İşi	₺17.754.017,80	₺21.922.242.40	23.5%
2	Seyhan İlçesi Fatih Mehmet 24 Derslikli İlkokul Yapım İşi	₺27.490.588,27	₺32.098.337.10	16.8%
3	Tunceli Merkez 12 Derslikli Ortaokulu Yapımı	₺30.308.745,61	₺25.447.991.92	16.0%
4	Akyazı Alaağaç İlkokulu-Ortaokulu 8 Derslikli Yeni Bina	₺10.233.526,56	₺18.925.837.07	84.9%
5	Dazkırı İlçesi Şerife Memiş UÇAR 4 Derslikli İlkokul Yapım İşi	₺4.648.964,72	₺3.599.820.94	22.6%
6	Ağrı Merkez Cumhuriyet Mahallesi 12 Derslikli İlkokul Yapım İşi	₺32.084.146,06	₺31.063.351.51	3.2%
7	Mersin İli Akdeniz İlçesi Ulubatlı Hasan 24 Derslikli Ortaokul Bina İnşaatı	₺34.503.260,54	₺31.371.867.31	9.1%
8	Malatya İli Battalgazi İlçesi Hatunsuyu Saray 4 Derslikli İlkokul Yapım İşi	₺17.409.606,25	₺19.396.878.43	11.4%
9	Bursa İli İnegöl İlçesi 1767 Ada 1 Parsel 32 Derslik Ortaokul Yapım İşi	₺45.756.347,62	₺50.840.134.38	11.1%

Table 14. (cont.) Regression model prediction results of educational structures

10	Bursa İli Gürsu İlçesi 217 Ada 5 Parsel 32 Derslik Ortaokul Yapım İşi	₺46.706.019,18	₺48.573.590.66	4.0%
11	Gürpınar İlçesi Atatürk İlkokulu 8 Derslik Yapımı ve Çevre Düzenleme İşi	₺24.874.751,93	₺20.487.483.32	17.6%
12	Burhaniye 12 Derslikli Şehit Yılmaz Kobak İlkokulu Yapım İşi	₺23.944.601,05	₺26.439.331.02	10.4%
13	Ereğli Mehmet Akif Mahallesi 24 Derslik İlkokulu Yapım İşi	₺25.991.919,77	₺26.703.014.36	2.7%
14	Bandırma 24 Derslikli Haydar Çavuş MTAL Lise Yapım İşi	₺37.425.766,42	₺31.760.801.94	15.1%
15	Ayvalık Altınova 12 Derslikli İlkokulu Yapım İşi	₺23.178.728,16	₺26.294.332.91	13.4%
	AVERAGE ERROR VALUE			17,50%

Table 15. Statistical data on Educational Buildings

Model	Sum of Squares	Df	Mean Squares	F	p
Regression Sum of Squares	15804502379673800,00	18	878027909981875,00	39,47	,000b
Residual Sum of Squares	1379190948240060,00	62	22245015294194,60		
Grand Sum of Squares	17183693327913800,00	80			

Based on the calculations, the F-statistic value was determined to be 39.47. Using the F-table, it was found that the p-value is $p<0.05$, indicating that the created model is statistically significant.

Table 16. Statistical data on educational structures (Relationships between Independent Variables)

		Updated Approximate Cost (TL)	Number of Classrooms	Construction Time (Days)	Total Number of Floors	Floor Height (m)	Building Height (m)	Building Height Class	Basement Height (m)	Earthquake Design Class	Ground Class	Ground safety tension	Ground Bed Coefficient	Concrete Grade	Number of Elevators	Wet Area (m²)	Raft Foundation Height (m)	Floor Area (m²)	Basement Area (m²)	Total Area (m²)
Updated Approximate Cost (TL)	r	1,00	0,83	0,41	0,66	0,39	0,65	-0,47	0,50	0,14	-0,06	-0,06	-0,05	0,31	0,77	0,84	0,72	0,81	0,82	0,93
	p		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,11	0,30	0,29	0,32	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Number of Classrooms	r	0,83	1,00	0,39	0,75	0,25	0,71	-0,42	0,51	0,15	0,00	-0,09	-0,08	0,31	0,64	0,77	0,63	0,68	0,76	0,89
	p	0,00		0,00	0,00	0,01	0,00	0,00	0,00	0,09	0,48	0,21	0,25	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Construction Time (Days)	r	0,41	0,39	1,00	0,52	0,29	0,47	-0,41	0,45	-0,01	0,09	-0,05	0,20	0,06	0,45	0,34	0,25	0,27	0,42	0,43
	p	0,00	0,00		0,00	0,00	0,00	0,00	0,00	0,48	0,22	0,34	0,04	0,30	0,00	0,00	0,01	0,01	0,00	0,00
Total Number of Floors	r	0,66	0,75	0,52	1,00	0,37	0,93	-0,68	0,77	0,18	0,01	-0,13	-0,12	0,25	0,60	0,64	0,59	0,35	0,68	0,72
	p	0,00	0,00	0,00		0,00	0,00	0,00	0,00	0,05	0,45	0,12	0,15	0,01	0,00	0,00	0,00	0,00	0,00	0,00
Floor Height (m)	r	0,39	0,25	0,29	0,37	1,00	0,48	-0,45	0,38	0,12	-0,16	-0,11	-0,04	0,24	0,46	0,30	0,27	0,34	0,37	0,34
	p	0,00	0,01	0,00	0,00		0,00	0,00	0,00	0,14	0,08	0,17	0,38	0,01	0,00	0,00	0,01	0,00	0,00	0,00
Building Height (m)	r	0,65	0,71	0,47	0,93	0,48	1,00	-0,71	0,67	0,11	-0,05	-0,09	-0,12	0,28	0,62	0,62	0,56	0,38	0,63	0,70
	p	0,00	0,00	0,00	0,00	0,00		0,00	0,00	0,17	0,33	0,21	0,14	0,01	0,00	0,00	0,00	0,00	0,00	0,00
Building Height Class	r	-0,47	-0,42	-0,41	-0,68	-0,45	-0,71	1,00	-0,49	0,09	-0,02	0,19	0,18	-0,41	-0,34	-0,49	-0,43	-0,15	-0,39	-0,42
	p	0,00	0,00	0,00	0,00	0,00	0,00		0,00	0,22	0,44	0,04	0,05	0,00	0,00	0,00	0,00	0,09	0,00	0,00
Basement Height (m)	r	0,50	0,51	0,45	0,77	0,38	0,67	-0,49	1,00	0,19	-0,07	-0,05	-0,06	0,29	0,47	0,53	0,47	0,30	0,79	0,55
	p	0,00	0,00	0,00	0,00	0,00	0,00	0,00		0,04	0,26	0,32	0,28	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Earthquake Design Class	r	0,14	0,15	-0,01	0,18	0,12	0,11	0,09	0,19	1,00	-0,39	0,07	0,27	-0,17	0,17	0,08	0,10	0,19	0,22	0,18
	p	0,11	0,09	0,48	0,05	0,14	0,17	0,22	0,04		0,00	0,27	0,01	0,06	0,06	0,24	0,18	0,05	0,03	0,05

Table 16.(cont.) *Statistical data on educational structures (Relationships between Independent Variables)*

Ground Class	r	-0,06	0,00	0,09	0,01	-0,16	-0,05	-0,02	-0,07	-0,39	1,00	-0,33	-0,48	0,07	-0,17	-0,09	-0,08	-0,12	-0,07	-0,05
	p	0,30	0,48	0,22	0,45	0,08	0,33	0,44	0,26	0,00		0,00	0,00	0,26	0,07	0,21	0,25	0,14	0,26	0,34
Ground safety tension	r	-0,06	-0,09	-0,05	-0,13	-0,11	-0,09	0,19	-0,05	0,07	-0,33	1,00	0,45	-0,01	-0,01	0,02	0,04	0,02	-0,01	-0,06
	p	0,29	0,21	0,34	0,12	0,17	0,21	0,04	0,32	0,27	0,00		0,00	0,45	0,46	0,42	0,37	0,42	0,46	0,29
Ground Bed Coefficient	r	-0,05	-0,08	0,20	-0,12	-0,04	-0,12	0,18	-0,06	0,27	-0,48	0,45	1,00	-0,31	0,09	-0,13	-0,12	0,03	-0,04	-0,05
	p	0,32	0,25	0,04	0,15	0,38	0,14	0,05	0,28	0,01	0,00	0,00		0,00	0,21	0,12	0,13	0,38	0,37	0,34
Concrete Grade	r	0,31	0,31	0,06	0,25	0,24	0,28	-0,41	0,29	-0,17	0,07	-0,01	-0,31	1,00	0,01	0,31	0,38	0,11	0,29	0,23
	p	0,00	0,00	0,30	0,01	0,01	0,01	0,00	0,00	0,06	0,26	0,45	0,00		0,45	0,00	0,00	0,15	0,00	0,02
Number of Elevators	r	0,77	0,64	0,45	0,60	0,46	0,62	-0,34	0,47	0,17	-0,17	-0,01	0,09	0,01	1,00	0,63	0,47	0,73	0,66	0,78
	p	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,06	0,07	0,46	0,21	0,45		0,00	0,00	0,00	0,00	0,00
Wet Area (m²)	r	0,84	0,77	0,34	0,64	0,30	0,62	-0,49	0,53	0,08	-0,09	0,02	-0,13	0,31	0,63	1,00	0,69	0,72	0,76	0,87
	p	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,24	0,21	0,42	0,12	0,00	0,00		0,00	0,00	0,00	0,00
Raft Foundation Height (m)	r	0,72	0,63	0,25	0,59	0,27	0,56	-0,43	0,47	0,10	-0,08	0,04	-0,12	0,38	0,47	0,69	1,00	0,47	0,65	0,65
	p	0,00	0,00	0,01	0,00	0,01	0,00	0,00	0,00	0,18	0,25	0,37	0,13	0,00	0,00	0,00		0,00	0,00	0,00
Floor Area (m²)	r	0,81	0,68	0,27	0,35	0,34	0,38	-0,15	0,30	0,19	-0,12	0,02	0,03	0,11	0,73	0,72	0,47	1,00	0,71	0,88
	p	0,00	0,00	0,01	0,00	0,00	0,00	0,09	0,00	0,05	0,14	0,42	0,38	0,15	0,00	0,00	0,00		0,00	0,00
Basement Area (m²)	r	0,82	0,76	0,42	0,68	0,37	0,63	-0,39	0,79	0,22	-0,07	-0,01	-0,04	0,29	0,66	0,76	0,65	0,71	1,00	0,85
	p	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,03	0,26	0,46	0,37	0,00	0,00	0,00	0,00	0,00		0,00
Total Area (m²)	r	0,93	0,89	0,43	0,72	0,34	0,70	-0,42	0,55	0,18	-0,05	-0,06	-0,05	0,23	0,78	0,87	0,65	0,88	0,85	1,00
	p	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,05	0,34	0,29	0,34	0,02	0,00	0,00	0,00	0,00	0,00	

According to the table, there are strong correlations between some variables. Including these variables in the model simultaneously could lead to multicollinearity issues. Therefore, multicollinearity checks will need to be performed in the developed model.

Table 17. *Statistical data of educational structures (Autocorrelation and Multicollinearity Assumptions Controls)*

Durbin-Watson	**1,950**
Collinearity (VIF)	
Number of Classrooms	7.524
Construction Time (Days)	1.889
Total Number of Floors	32.216
Floor Height (m)	2.179
Building Height (m)	10.897
Building Height Class	3.301
Basement Height (m)	10.720
Earthquake Design Class	1.632
Ground Class	1.981
Ground safety tension	1.698
Ground Bed Coefficient	2.340
Concrete Grade	1.913
Number of Elevators	3.905
Wet Area (m²)	6.505
Raft Foundation Height (m)	2.551
Floor Area (m²)	24.326
Basement Area (m²)	14.567
Total Area (m²)	73.277

Autocorrelation occurs when there is a correlation between the errors in the created model. In a regression model, autocorrelation should not be present; the errors should be random. This is checked using the Durbin-Watson test. A Durbin-Watson result close to 2 indicates that there is no autocorrelation problem in the model. The analysis revealed a Durbin-Watson result of 1.950, indicating that there is no autocorrelation problem in the model.

To assess multicollinearity in the model, we examine the Variance Inflation Factor (VIF) values for the variables. The VIF value should not exceed 10. Among the 18 independent variables included in the model, 12 variables have VIF values below 10. This suggests that there is no multicollinearity problem for these 12 variables. However, multicollinearity issues are present in the variables Total Number of Floors, Building Height, Basement Height, Floor Area, Basement Area, and Total Area.

Table 18. *Statistical data of educational structures (Autocorrelation and Multicollinearity Assumptions*

Adjusted R²	F	p
0.900	39,470	,000[b]

.000b: means p<0.05.

The model created to explain the Contract Amount variable is found to be significant (F: 39.470, p<0.05). In this significant model, the independent variables can explain 90% of the variation in the dependent variable.

Table 19. *Statistical result data of educational structures*

	Approximate Cost	Contract Price
Error rate	%17,50	%18,20
Adjusted R²	0,900	0,927
Durbin-Watson	1,950	1,523

IV. CONCLUSION

In this study, 96 school building projects that were tendered by public institutions and had published results were downloaded from the Electronic Public Procurement Platform. The projects were divided into 81 training data and 15 test data sets. The construction cost indices and change rates obtained from the Turkish Statistical Institute were used to adjust the approximate cost and contract amount to January 2023.

Parameters known to affect the construction cost of educational buildings were identified, including Number of Classrooms, Construction Duration, Total Number of Floors, Floor Height, Building Height, Building Height Class (BYS), Basement Height, Earthquake Design Class (DTS), Soil Class, Soil Bearing Capacity, Bedding Coefficient, Concrete Class, Number of Elevators, Wet Area, Height of Raft Foundation, Floor Area, Basement Area, and Total Area. These parameters were used in regression analysis performed with "SPSS Statistics 26" software. Regression analyses were conducted, and formulas were developed to estimate the costs of educational buildings.

The developed formulas were used to predict the Contract Amount and Approximate Cost. The error rates for the 15 test projects selected as test data were determined using the developed formulas. Among the models, the one using all parameters provided the best fit, with $R^2 = 0.927$ for the Contract Amount and $R^2 = 0.900$ for the Approximate Cost. The Durbin-Watson criterion was used to check the consistency between predicted and actual results.

The normal distribution condition for multiple regression analysis was met, and no multicollinearity or autocorrelation problems were detected ($p<0.05$). The average error rate for the Approximate Cost prediction model was found to be 17.50%, while the error rate for the Contract Amount prediction model was 18.20%. However, more accurate results could be achieved with a sufficient number of samples representing different variations.

In conclusion, an approach was developed that can predict the approximate costs and contract amounts of school buildings with different types and coefficients with error rates below 20%. Both public institutions and contracting construction firms can benefit from these models to achieve time savings and more realistic cost estimates. Increasing the data size in similar studies could be a solution for minimizing error rates in future models.

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