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A building cost estimation model based on functional elements

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Abstract:
The objectives of this paper is to introduce a generic computer aided building cost estimation model based on functional elements for Turkish construction sector projects which will be used in feasibility and schematic design phases. The research design was based on the building functional elements method and a building cost estimation model based on functional elements works on a cost database was suggested. Underlying principles and basic steps of cost estimation based on functional elements was explained by means of computer-based cost estimation process. In order to automate the manual building cost estimation process, the software based on functional elements was developed. The software is currently in the testing phase and is being used for educational purposes. Making use of both public sector and current market prices in the cost estimation process, increasing number of projects stored in the database for more accurate results, estimating costs of different types of projects and estimating the structural functional element percent more precisely are suggested for future research. As the number of the similar projects in database is increased, the accuracy of the cost estimation is also increased. Estimators and graduate students can use the software to estimate building cost of residential projects in feasibility and schematic design phases.

***Keywords**: Building cost estimation, cost models, building functional elements, cost database, computer-aided cost estimation, Turkish construction industry.*

Introduction

As the industrial development directly affects the construction sector, the projects are getting more complicated and their scales are getting larger. Hence it is getting more difficult to complete the projects within quality standards, budgeted cost limits and on time. The risk and uncertainties met by managers during the construction process result in some difficulties, thus the decisions to be taken may be delayed. One of these difficulties is caused by the lack of cost data whenever needed and in demanded quality. Therefore, the budgeted cost limits are often exceeded.

However, it is a well-known fact that the earlier cost planning is started on; the more suitable results are obtained. Several cost estimation and calculation models can be used during construction process; beginning with the conception phase of the construction project and the schematic design, design development, construction documents phases respectively. However, building cost estimation is an important issue due to the incomplete nature of the project data in the schematic design phase.

A research project has been carried out in Istanbul Technical University Faculty of Architecture intending to estimate most probable building cost in the early stage of the construction process taking the advantage of recent developments in the information and communication technology (ICT) [Orhon et.al., 1996], [Tas and Yaman, 2002]. The main objectives of the project were:

- Collecting building construction cost data,
- Processing data and transforming it into building cost information,
- Storing and retrieving the cost data and information,
- Connecting private and public sector data as well as information through a database,
- Saving time and minimizing mistakes, by avoiding reproduction of the information that has already been stored somewhere in the sector.

The objective of this paper is to introduce the computer-aided cost estimation model based on functional elements. The model is one of the two modules of the software called as “BMBS”, stands for the first letters of “Building Cost Information System” in Turkish. The other model is cost estimation based on cost significant items. [Tas & Yaman, 2005] The BMBS is a relational database management system that is designed using Progress 4GL RDBMS software [Progress™, 2007] on Novell Netware v.3.2 [Novell™, 2007].

The definition of building cost
The concept of cost is defined in various ways. In the most general sense, cost means the monetary value of the all goods and services used in order to perform an operation.
In terms of building construction participants of the projects, the owner, the designer, the contractor, the user and the society are concerned with the building cost in various ways, due to the diverse expectations and the objectives of the participants.

In building construction projects, the direct cost is often emphasized and it is underlined in the cost estimation and cost control studies as the direct cost generally is very high compared with indirect cost within the building cost. Besides, decisions on investment of building projects, owner’s evaluation of bids prepared by contractors, calculation of the tender price of the contractors, cost control during the decisions on design are all bound to the correct or almost correct cost estimation.

Cost is a measurement of the function and the performance of a building. Therefore, in order to appraise the design of a building it is necessary to use a convenient cost model.

The first step in using a cost model is collecting the data required. Then, these data must be analyzed and updated. In the meantime, the quality and the level of data and thus the convenience of the chosen model must be evaluated. As soon as new data are acquired during the implementation of the model, they must be appended to the previous data.

Background to building cost estimation models

Since 1950's, efforts have been made in order to understand the cause-effect relation between the design parameters and the building cost, and to develop models in order to estimate the building cost. Cost modeling may be defined as a symbolic formation of a system and the content of it is defined with the factors affecting the cost [Holm, 2005].

According to their historical developments the cost models can be classified in three different groups. The first-generation models originated from functional elements of building oriented cost planning approach in England at the end of 1950's extensively used until the end of 1960's. The second-generation models derived from the regression analysis and have been used since mid 1970's [McCaffer, 1975]. The third-generation models started to develop in the beginning of 1980's and generally based on Monte Carlo simulation technique [Touran, 1992].

The cost models can also be divided into two groups: deterministic and probabilistic models. In deterministic models, it is assumed that the values can be qualified with any kind of variables and all these are exactly known or can be estimated accurately. On the other hand, in probabilistic models, it is accepted that although the values of some variables are not absolutely certain they can be calculated.

The cost estimation models can also be classified according to their characteristics. In general, the first one is the traditional cost estimation models based on quantities; e.g. mono-priced cost estimation models used in the schematic design phase (such as unit, square, cube and building envelope models), resource based models used in the construction phase, models based on functional elements and building operational units. The second one is the untraditional models that is to say, models comprising new techniques and practices; e.g. the experimental models, regression models and simulation models. [Akintoye & Fitzgerald, 2000], [Ashworth, 1988], [Seeley, 1976], [Bledsoe, 1992], [Flanagan&Tate, 1997], [Mann, 1992], [McCaffer et.al., 1984]. [Newton, 1991], [O'Brien, 1994].

Some of the recent works on cost estimation models are as follows. Chan and Park, studied to identify factors that contribute to project cost, to construct a predictive project cost model using the principal component technique and to assess the relative importance of determining factors [Chan and Park, 2005]. Serpell, examined to assess the quality of an estimate through the application of expertise and experience with the help of the knowledge-based assessment model (Serpell, 2004). Oberlender and Trost, presented results of a research effort that developed an estimate scoring system to measure the impact of four determinants on estimate accuracy, who was involved in preparing the estimate; how the estimate was prepared; what was known about the project; and other factors considered while preparing the estimate (Oberlender and Trost, 2001). Trost and Oberlander, studied to establish a model which enables estimators and business managers to objectively evaluate the accuracy of early estimates (Trost and Oberlander, 2003). Ellis et.al., examined to add to the qualitative exploration of Value Management by investigating the attitudes and experiences of Value Management facilitators within major UK cost consultancies (Ellis et.al., 2005). Yu, proposed PIREM (Principal Item Ratios Estimating Method) which integrates several existing conceptual estimating methods including parametric estimating, ratios estimating, and cost significant model with advanced nonlinear mapping techniques, and adopts a scheme that separates unit prices with the quantities of a cost item (Yu, 2006). Lowe et.al., described the development of linear regression models to predict the construction cost of buildings. Liu and Zhu, attempted to identify the critical factors for effective estimation at various stages of typical construction projects and developed a theoretical framework that identifies the critical factors for effective cost estimation during each project phase of a conventional construction project.

Background to computer-aided building cost estimation systems
Building cost estimation process involves tedious repetitive, computational and numerical analysis activities. Computers have been used to help cost estimating almost for 40 years.

The earliest applications were in-house developed software for mainframe computers by some large contractors. Due to the high cost, they were not available to most estimators. In the 1980s PCs became widely used and the cost of computing declined rapidly. A new generation of purpose built cost estimating software emerged. Computer-based estimating programs are good at the data collection, computational, and clerical aspects of estimating. They achieve and retrieve large volumes of resources, cost, and productivity information, perform calculations quickly and accurately, and present results in an organized, neat, and consistent manner. All these virtues are of tremendous help in the high-pressure environment in which most construction estimators often find themselves [Sun & Howard, 2004].

Recent developments in communication and information technologies increased the speed, productivity and accuracy of building cost estimation process and made easy following tasks:

1. Processing electronic bill-of-quantities (BoQ) either directly form digital CAD files or paper-based documents through digitizers.
2. Setting up computer-aided cost databases,
3. Setting up computer-aided cost estimation systems.

Computer-aided cost estimation systems
Computer-aided cost estimation systems can be classified into two groups: systems used in schematic design phases and those used in design development and construction documentation phases.

One of the computer-aided cost estimation systems used in schematic design phases is the integrated CAD and cost estimation packages which have graphical user interfaces for design and drawing working together with cost estimation. The second one is parametric systems in which it is assumed that if the relationship of the design variables and building cost are modeled mathematically through analysis and recommendations can be given using some ratios. The third one is those taking the advantage of recent developments in the artificial intelligence domain and knowledge-based approach.

One of the systems used in design development and construction documentation phases is spreadsheet applications bundled in office automation software (such as Microsoft Excel™) with wide range of built-in function and formulas, what-if analysis, vast graphical reporting facilities. Spreadsheet + add-ins supplies integration and data transfer facilities for widely used CAD, accounting, scheduling and high-level cost estimation packages. In-house cost estimation applications based on expert programming of database management systems (such as Lotus Notes, Oracle) are the other systems used in design development and construction documentation phase. Those are systems that require vast amount of input and have in-house data structure, customized user interfaces and documentation. The third one is the on-the-shelf cost estimation packages. Those are also called as integrated or high-level systems. They are mainly used by general contractors to prepare estimates for bidding, preparing interim payment lists and by owners to evaluate or compare contractors' bids and interim payment lists. Entering BoQs, standard or user defined cost resource databases and reporting facilities are the most important part of those systems.

Factors affecting the choice of cost estimation models

Traditional building construction process is known as design–bid–build in which phases follow one another. In order to use the limited resources in a rational way, it is necessary that cost estimation should be done efficiently in each phase of the process. As the level of details differentiates in each phase of the project, the cost estimation models applicable for each phase shall be different as well. Model can be chosen consistent with the detail level of the decisions in each phase. On the other hand, participants of the building construction process, needs and uses, cost estimation for different purposes. Owner wants to know how much the profit shall be, how much capital is required for the project. The owner tries to estimate the roughest cost rapidly. On the other way, the designer needs the cost estimation to determine which schematic design alternative is the most suitable solution. Finally, the contractor needs more detailed and reliable cost estimation in order to determine the tender price and to manage the cash flow.

A computer-aided building cost estimation model based on functional elements

The BMBS software consists of several building cost analysis and two different building cost estimation models. Some of them are based on traditional cost models, whereas some of them are cost estimation models developed and modified for Turkish construction sector [Tas and Yaman, 2005]. In this paper one of them, the cost estimation model based on functional elements is examined.

The cost estimation model based on functional elements is one of the main modules of the software developed within the framework of the research project. The model is based on building cost estimation in the feasibility and schematic design phase using historical data of the similar projects.

In the background of the model, it is assumed that a building is built from different component groups, in other words functional element groups and each of them fulfils a specific function. Therefore, it is assumed that the total building cost is also the sum of the costs of each functional element group.

Total building cost can be calculated in a number of steps respectively. The first step is dividing a building into its functional elements by means of a classification system. Then, the total quantity of each functional element is measured on the construction documents, in other words technical drawings.

The total quantity of each functional element in the project is multiplied with the historical unit cost of each functional element of the similar projects.
The steps of the model are explained in detail as follows:

1. Project data entry

The first step is entering the project data for which the building cost to be estimated. These are the characteristics of the project and the parameters that should be entered:

- To estimate the building cost,
- To store and retrieve the estimation,
- To modify the estimation stored,
- To make a query among the similar projects stored in the database.

The project data that should be entered are:

- A project number given by the user,
- The local code (or zip code) of the city where the project shall be carried out,
- A short description of the project,
- Owner of the project,
- Function code of the project. It indicates the function of the project, such as residential, educational, commercial building etc. It can be selected simply by the user among the function codes entered within the framework of the research project,
- Total (gross) construction area of the project. If total gross construction area is known exactly the user can enter it directly or if the area is not exactly known it can be entered as a range of estimated values. The unit must be in square meter,
- The date of estimation,
- Number of storey in the project. If number of storey is known exactly the user can enter it directly or if the number of story is not exactly known it can be entered as a range of estimated values,
- Work type code of the project. It indicates the type of the work such as a new building construction, completion of an old project, restoration or renovation. It can be selected simply by the user among the work type codes entered within the framework of the research project,
- The code which indicates the price type and time period (quarter) of unit cost of functional elements, either current market price or public sector price. It is the code that indicates whether the cost calculation shall be made using current market prices or the prices that is annually published by Ministry of Public Works and Resettlement of Turkey. Market prices are updated every month. On the other hand, public sector prices are determined at the beginning of the year and must be updated manually using inflation indices.

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+------------------------------------------------------------------------------+
¦ITU-MF-BMBS                  COST ESTIMATION                  30/04/2007  ¦
+------------------------------------------------------------------------------+
------------------------------PROJECT INFORMATION------------------------------

Project Number      :   1- 1     Local Code : 34
Project Description : SAMPLE
Project Owner       : HAKAN YAMAN
Function Code       : 7          Construction Area (m^2) :  950  [  800.0-1100.0]
Estimation Date     : 08/30/99   Number of Stories      :    4  [  3-  4]
Work Type Code      : 10         Term Code (BB-PF)      : 1  1

FUNCTIONAL ELEMENT       QUANTITY     UNIT PRICE    FUNC.ELEM.COST     TOTAL COST
CODE & DESCRIPTION         (m^2)         (TL)      CONST.AREA (TL/m^2)    (TL)
10-GROUND SLAB     :         0             0               0                  0
21-FLOORS-STAIRS   :         0             0               0                  0
31-EXTERNAL WALLS  :         0             0               0                  0
32-WINDOWS         :         0             0               0                  0
33-EXTERNAL DOORS  :         0             0               0                  0
41-INTERNAL WALLS  :         0             0               0                  0
42-INTERNAL DOORS  :         0             0               0                  0
50-ROOF            :         0             0               0                  0
60-STRUCTURE (%)   :  0

     T O T A L   E S T I M A T E D   B U I L D I N G   C O S T :              0

Enter data or press ESC to end.
```

Figure 1: *Shows the entry screen of the project data.*

2. Quantity entry of each functional element group

The second step is the entry of estimated quantities of each functional element group in the project. Functional elements of a building are divided into nine different groups using “BMBS cost classification system based on functional elements” developed within the framework of the research projects.

The BMBS cost classification system based on functional elements has been developed reviewing similar classification systems, such as BCIS (Building Cost Information System), CEEC (Construction Economist European Community) or CSI UNIFORMAT. The nine building functional element groups of the BMBS cost classification system based on functional elements are as follows:

1 – Slab on ground,
2 – Floors and stairs,
3 – External walls,
4 – Windows,
5 – External doors,
6 – Internal walls,
7 – Internal doors,
8 – Roof,
9 – Superstructure.

The model can be used in two ways according to the detail level of cost data available for the project. In other words, shall the model be used in the schematic design phase or in feasibility phase of the building construction process?

In feasibility phase the user has not sufficient project data, in other words only approximately total construction area and number of storeys is known. In this case the user can use the historical data. The user can make a query among the similar projects in the database using the project data entered previously. The query results in the average quantities of each functional element group of similar projects in the database. The user may modify the quantities given by the query.

In the schematic design phase the user can measure the quantity of functional element groups on the drawings and enter total quantities of each group. This operation should be repeated for each functional element group.
In both cases, the estimated cost of the superstructure (structural elements of the building e.g. columns, beams, foundations etc.) is determined as a percent of the total cost of all functional element groups. A query can be made using the project data entered previously. The user may modify the percent given by the query.

3. Setting the average unit price of each functional element group
As the user enters the quantity of each functional element group a new window is opened. In group headings for each functional element group, the alternatives of functional elements, in other words composite elements are shown and can be selected by the user.

A composite element can be defined as a building component that is a part of a building and fulfils different functions. Each composite element alternative for a functional element group consists of all the layers covering an area of one square meter. An example of one of the floor composite element alternatives is shown in Figure 2. Each layer of a composite element is related to one or more building operational unit.

As shown in Figure 3, the user can easily browse the code no, the definition and the unit cost of each composite element alternative in the database. The user can select more than one alternative, use them together in a functional element group and calculate an average unit price for the group.

For example, assume that the user has a schematic design drawing of a residential project which has 1,000 m^2 floor area. Assume that 200 m^2 of this floor area will be covered with ceramic tile, 400 m^2 with solid wooden parquet and 400 m^2 with wall to wall carpet. Once the user enters 1,000 m^2 as the total quantity of “Floor & Stairs” functional element group, a new window is opened and the floor covering alternatives and their unit cost is shown. The user may select the floor covering alternatives as ceramic tile, solid parquet or carpet according to the project budget. In order to calculate the average unit price of “Floor & Stairs” functional element group, the user should enter the estimated percent of this floor covering alternative in total floor area. In this example, assume that 20% for ceramic tile, 40% for solid parquet and 40% for carpet. Then, the unit price is set by multiplying the unit price of each floor covering alternative with its percent in total floor area. Finally, sum of the unit price of three alternatives gives the average unit price of “Floor & Stairs” functional element group.

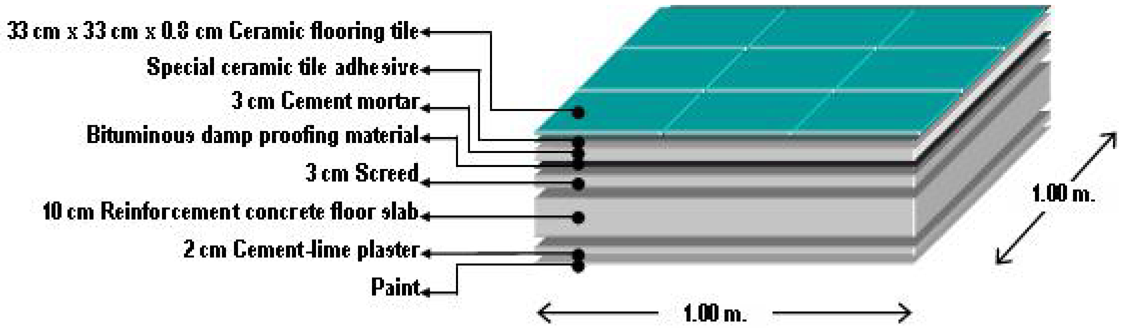

***Figure 2:**. An example of one of the floor slab composite element alternatives.*

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GROUND SLAB

Alt No	Code No	Alternative Description	Price Type	Price 1 (TL/m^2)	Price 2 (TL/m^2)	Percent %
1	10.001	Ceramic tile	1	1,169,028	0	20
2	10.002	Solid wooden parquet	1	1,475,846	0	40
3	10.003	Wall to wall carpet	1	1,414,856	0	40
4						
5						
6						
7						
8						
9						
10						

Unit Price 1,390,086 — Total % 100

Enter data or press ESC to end.

***Figure 3:** The composite element alternatives entry window.*

The composite element alternatives can either be created on the basis of "*Current Prices and Building Operational Unit Price Analysis*" determined by *"Turkish Republic Ministry of Public Works and Resettlement"* or on the basis of unit price analysis developed by the user using current market prices. For each functional element group, the user may either select and use available composite element alternatives stored in the database, or create his own alternatives using his experience and knowledge.

One of the most important issues is updating unit cost of the composite element alternatives in the database due to the inflation. However, the unit cost of the building operational units and composite element alternatives can easily be updated, as the cost calculation system of the software is based on current prices of inputs (i.e. material, equipment and labour unit prices).

4. Estimation of the total building cost

Total building cost is estimated by multiplying total quantity of each functional element group with the average unit price calculated. The estimated cost of each functional element group can be seen on the screen, as shown on Figure 1. It enables the user to make modifications among the composite element alternatives within project budget limits,

It must be noted that the cost of the structural system is not included in the cost estimation process so far. At this point, the user has not only the estimated total cost of each functional element group, but also percent of the structural system historical cost in total building cost of the similar projects. It is the result of the query which is made using the project data entered. The user may also modify the percent given by the query.

By multiplying the percent and the cost of all functional element groups calculated so far, the structural system cost can be estimated.
The final total building cost estimation must be concluded by adding the estimated structural system cost and the cost of all functional element groups.

5. Revision of the total building cost estimation
The model allows the user to make revisions as the result of the first estimation trial is not in the project budget limits. In this case, the user saves the first estimation trial then he may go on the second and the third trials.

The user can modify the project data to enlarge or narrow down the query range of the similar projects stored in the database.

Alternatively the user can save the project data as in the first trial and make some modifications on the composite element alternatives to move around the limits of the project budget. The software has the flexibility to create numerous new alternatives among the existing composite element groups.

Conclusion
It is a well-known fact that up-to-date and reliable databases and information systems that support estimators are needed to make accurate cost estimation for different phases of the building construction process. Recent developments in information and communication technology enable to the development of such kinds of tools. However, the most important matter in cost estimation is the simplicity and applicability of the system to the factual cases. Cost estimation systems must be simple, reliable, flexible and convenient to the nature of the application area.

Several computer–aided cost analysis and two cost estimation systems have been developed for different phases of the building construction process in Istanbul Technical University (ITU). On of them, the building cost estimation model based on functional elements in the feasibility and schematic design phases developed for residential projects is introduced in this paper.

The building cost estimation model based on functional elements helps the user to estimate the total building cost using historical data of the similar projects. Total building cost can be estimated in feasibility or in the schematic design phase depending on the detail level of project data available.

Even in the case of knowing only the total construction area and number of storey of the project the user can estimate approximate total building cost. Even if the user has not sufficient project data, the model allows the user to make a project budget. The average quantities of the functional element groups queried among the similar projects in the database are used for budgeting. If the user has sketches of the project, he can estimate total building cost easily as he measures the quantities of the functional elements in each group on the project.

Furthermore, the user can select and decide which building materials to be used in the project, modify them or create numerous new composite element alternatives. Therefore the model allows the user to make cost planning studies. As the user analyzes the total cost per m^2 of each functional element group, he has feedback even if the budgeted cost is exceeded or not.

As the building materials to be used in the project can be modified, the user can see the total building cost difference between the first trial and the latter one accordingly. The model also allows estimating the most suitable total building cost even in the phase of the schematic design phase, as there is a chance of using more than one composite element alternative for each functional element group.

The software is currently in the testing phase. As the testing phase ends, it is being used for educational purposes. In design process the student will be able to access current market prices of the building operational units and materials selected. Students will also be able to learn not only how total cost is affected by the probable changes made in the project she/he designs, but also how the total cost will change related to the selected building material.

There are some future works that should be made:

- Making use of both public sector and current market prices in the cost estimation process,
- Increasing number of projects stored in the database for more accurate results,
- Estimating costs of different types of projects, such as commercial and educational buildings,
- Calculating the structural functional element percent more precisely,
- Modifying user interfaces using recent developments in the information technologies.
- Integrating BMBS with on-the-shelf building cost estimation software packages widely used in Turkish construction sector.

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Fonksiyonel elemanlara dayalı bina maliyeti tahmin modeli

Son zamanlarda izlenen endüstriyel gelişmenin inşaat sektörüne yansıması ile, bu sektördeki projelerin ölçekleri büyümekte ve projeler gittikçe karmaşıklaşmakta, dolayısıyla projelerin zamanında, istenilen kalite ve maliyet sınırları içerisinde tamamlanması güçleşmektedir. Bina yapım sürecinde karar vermek durumunda olan kişilerin maliyet verilerine istedikleri anda ve istedikleri düzeyde ulaşamamalarının verdiği zorluklardan ötürü verilmesi gereken kararlar gecikebilmekte, bu nedenle hedeflenen maliyet sınırları çoğu kez aşılmaktadır.

Oysa bilinmektedir ki, maliyet planlamasına ne kadar erken başlanırsa, alınan sonuçlar da o denli yararlı olmaktadır. Bina maliyeti tahmini ve hesaplamaları, projenin ilk yatırım kararının verilmesinden başlayarak, şematik (ön) tasarım, tasarım geliştirme ve uygulama projesine kadar uzanan süreç içinde değişik evrelerde farklı modeller yardımıyla yapılmaktadır. Ancak, ön tasarım evresinde, bir projenin maliyetinin gerçeğe en yakın bir biçimde tahmin edilmesi, proje hakkında sahip olunan az miktardaki veri nedeniyle önemli bir sorun oluşturmaktadır.

Bu noktada, inşaat sektörüne yönelik maliyet verilerinin toplanması, saklanması, işlenerek bilgiye dönüştürülmesi, sektörde rol alan özel ve kamu kuruluşları arasında veri ve bilgi iletişiminin sağlanması, bir kez üretilmiş olan bilginin yeni baştan üretilmesini engelleyerek zaman kaybı ve olası yanlışlıkların en aza indirgenmesi gibi amaçlar ile, İstanbul Teknik Üniversitesi Mimarlık Fakültesi'nde "*Türk İnşaat Sektöründe Bilgisayara Dayalı Bir Bina Maliyeti Bilgi Sistemi (BMBS) Geliştirilmesi*" konulu bir araştırma projesi yürütülmüştür. Bu yazıda, söz konusu araştırma projesi kapsamında geliştirilmiş olan bilgisayar destekli iki modelden biri olan **Fonksiyonel Elemanlara Dayalı Bina Maliyeti Tahmin Modeli** tanıtılmaktadır.

Söz konusu araştırma projesi kapsamında geliştirilmiş olan BMBS yazılımı bünyesinde çalışmakta olan, *Fonksiyonel Elemanlara Dayalı Bina Maliyeti Tahmini Modülü*, veri tabanında yer alan ve maliyet tahmini yapılacak olan projeyle aynı türden benzer projelere ait verilerden yararlanarak, ön tasarım evresinde maliyet tahmini yapılması esasına göre çalışmaktadır.

Fonksiyonel elemanlara dayalı bina maliyeti tahmin modülünde, bir binanın, her biri ayrı işlevleri üstlenen farklı yapı bileşeni guruplarından oluştuğu kabulünden hareket edilmektedir. Dolayısıyla, toplam bina inşaat maliyetinin de, her bir fonksiyonel eleman gurubunun maliyetlerinin toplamı olduğu düşünülmektedir. Maliyet tahmini yapılmak istenen bina, araştırma projesi kapsamında geliştirilmiş olan bir sınıflandırma sistemi yardımıyla fonksiyonel eleman guruplarına ayrıştırılmakta, her bir fonksiyonel eleman gurubunda yer alan elemanlara ait miktarlar proje üzerinden ölçülmektedir. Elde edilen her bir elemana ait toplam miktar, fonksiyonel eleman gurubu birim m^2 maliyeti ile çarpılarak, her bir fonksiyonel eleman gurubu maliyeti elde edilmektedir. Buradan da tahmini bina maliyetine ulaşılmaktadır. Bina maliyeti tahmin modelinin uygulama adımları şu şekilde sıralanabilir:

1. Maliyet tahmini yapılacak olan projeye ait ön bilgilerin girilmesi.
   Maliyet tahmini yapılacak olan projeye ait ön bilgiler, kullanıcının tahmini gerçekleştirebilmesi, saklayabilmesi ve daha sonra proje ile ilgili tahmine tekrar ulaşabilmesi ve yazılımın veri tabanında yer alan benzer projeler arasından sorgulama yapabilmesini sağlamak için girilmesi gerekli olan bilgilerdir.

2. Maliyet tahmini yapılacak olan projede yer alan her bir fonksiyonel eleman gurubuna ait miktar bilgilerinin girilmesi.
   Bir binayı oluşturan ana bileşenler bir başka deyişle, fonksiyonel elemanlar, araştırma projesi kapsamında yürütülmüş olan maliyet sınıflandırma ve kodlama çalışmaları sonucunda oluşturulmuş olan, *BMBS fonksiyonel elemanlara dayalı maliyet sınıflandırma sistemi* yardımıyla 9 ana gurupta toplanmıştır. Söz konusu guruplar araştırma projesi kapsamında, dünyada halen geçerli olan, BCIS (Building Cost Information System) ve Avrupa Birliği CEEC (Construction Economist European Community) ve ABD CSI UNIFORMAT gibi benzer sınıflandırma sistemleri incelenerek Türkiye için bir örnek oluşturmak üzere geliştirilmiştir. Fonksiyonel eleman gurupları şunlardır:
   - 10 Alt Kabuk,
   - 21 Ara Döşeme ve Merdivenler,
   - 31 Dış Duvarlar,
   - 32 Pencereler,
   - 33 Dış Kapılar,
   - 41 İç Duvarlar,
   - 42 İç Kapılar,
   - 50 Üst Kabuk,
   - 60 Taşıyıcı İskelet.
3. Maliyet tahmini yapılacak olan projede yer alan her bir fonksiyonel eleman gurubuna ait ortalama birim fiyatın elde edilmesi.
   Maliyet tahmini yapılacak olan projede yer alan her bir fonksiyonel eleman gurubuna ait ortalama miktarlar kullanıcı tarafından girildikten sonra, her bir fonksiyonel eleman gurubunun ortalama birim fiyatının elde edilmesi işlemi başlamaktadır. Bu noktada yazılım, her bir fonksiyonel eleman gurup başlığının yanında, kullanıcıya yeni bir pencere içerisinde, veri tabanında yer alan her bir guruba ait fonksiyonel eleman (kompozit eleman) alternatiflerini sunmaktadır.
4. Projeye ait tahmini inşaat maliyetinin elde edilmesi.
   Her bir fonksiyonel eleman gurubuna ait toplam miktar ve birim fiyatın çarpımı ile tahmini inşaat maliyeti elde edilmektedir. Ayrıca, kullanıcıya bir fikir vermek ve planlanan proje bütçesine göre değişiklikleri yapabilmek üzere, brüt inşaat alanı başına her bir fonksiyonel eleman gurubu tahmini maliyeti de ekranda izlenebilmektedir.
5. Tahmini inşaat maliyetinin revize edilmesi.
   Kullanıcı birinci tahmin denemesi sonucunda elde ettiği toplam inşaat maliyetini, planlanan proje bütçesine göre değerlendirerek revize etme gereksinimi duyabilir. Bu durumda, mevcut tahmini saklayarak, gerekli değişiklikleri yapmak üzere ikinci, gerekirse bir üçüncü tahminde bulunabilir. Kullanıcı, gerekli gördüğü takdirde maliyet tahmini ön bilgilerinde de değişiklikler yaparak, veri tabanındaki benzer projeler arasında yapılan sorgulama alanını genişletip daraltabilir. Ya da maliyet tahmini ön bilgilerini aynen koruyarak, fonksiyonel eleman guruplarını oluşturan alternatiflerde değişiklikler yapmak suretiyle planlanan proje bütçesine en uygun maliyete ulaşana değin bu adımları tekrarlayabilir. Yazılım bu konuda kullanıcıya, mevcut alternatifler arasından sonsuz seçenekler sunma açısından esneklik sağlamaktadır.

Maliyet tahmini yapılacak binaya ait eldeki verilerin ayrıntısına bağlı olarak farklı düzeylerde maliyet tahmini yapmak mümkün olabilmektedir. Kullanıcının elinde maliyet tahmini yapılacak projeye ait sadece *tahmini brüt inşaat alanı* ve *tahmini kat sayısı* gibi, çok kısıtlı veri olması durumunda bile yazılım, ön bilgilerde girilmiş olan verilere bağlı olarak, veri tabanında yer alan ve maliyet tahmini yapılacak projeye benzer projeler arasında yapacağı sorgulama sonucu elde edeceği fonksiyonel eleman gurubuna ait ortalama miktar değerleri yardımı ile maliyet tahmini yapabilmektedir. Eğer kullanıcının elinde maliyet tahmini yapılacak projeye ait bir *avan proje* mevcut ise, bu durumda da, kullanıcı, her bir fonksiyonel eleman gurubunda yer alan elemanlara ait miktar değerlerini projesi üzerinden ölçerek toplam bina maliyeti tahmini değerine ulaşabilmektedir.

Ayrıca yazılım, her bir fonksiyonel eleman gurup başlığının yanında, veri tabanında yer alan her bir guruba ait kompozit eleman alternatiflerini sunarak, kullanıcıya kullanacağı malzemeleri seçme, değiştirme veya kendi isteği doğrultusunda sonsuz sayıda yeni alternatifler yaratma olanağını da sunmaktadır. Kullanıcı her alternatifin m^2 maliyetini görebildiği için, toplam maliyet hedeflerinin aşılması durumunda geri dönüşler yapabilmektedir. Kullanılacak malzemelerde değişiklik yapılması durumunda, sonuç maliyetin nasıl değişeceği kısa zamanda görülebilmektedir. Bunun yanı sıra, her bir fonksiyonel eleman gurubu için birden fazla kompozit eleman alternatifinin birlikte kullanılabilinmesi olanağı ile de, ön tasarım evresinde bile gerçeğe çok yakın olarak maliyet tahmini yapılabilmektedir.

Kullanıcının birinci tahmin denemesi sonucunda elde ettiği toplam inşaat maliyetini, planlanan proje bütçesine göre değerlendirerek revize etme gereksinimi duyması halinde, mevcut tahmini saklayarak, gerekli değişiklikleri yapmak üzere ikinci, gerekirse bir üçüncü tahminde bulunabilmektedir. Kullanıcı, gerekli gördüğü takdirde maliyet tahmini ön bilgilerinde de değişiklikler yaparak, veri tabanındaki benzer projeler arasında yapılan sorgulama alanını genişletip daraltabilmektedir. Ya da maliyet tahmini ön bilgilerini aynen koruyarak, fonksiyonel eleman guruplarını oluşturan alternatiflerde değişiklikler yapmak suretiyle planlanan proje bütçesine en uygun maliyete ulaşana değin bu adımları tekrarlayabilmektedir. Yazılım bu konuda kullanıcıya, mevcut alternatifler arasından sonsuz seçenekler sunma açısından esneklik sağlamaktadır.