J. King Saud Univ., Vol. 18, *Eng. Sci.* (1), pp. 1-17, Riyadh (1426H./2005)

Survey of Procedures Adopted by A/E Firms in Accounting for Design Variables in Early Cost Estimates

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(Received 10 June, 2003; accepted for publication 05 December, 2004)

Abstract. The success or failure of a construction project depends on the reliability of the cost estimates prepared, especially those in the early phase of its development. The objectives of this study were to investigate the early cost estimating techniques and the procedures adopted by A/E firms in accounting for design variables in the early cost estimates they prepare for residential buildings. These were achieved through the administration of a structured questionnaire. Nineteen A/E firms, practicing in the Eastern Province of Saudi Arabia, participated in the survey. The survey results revealed that most of the A/E firms do not utilize specialized software packages in carrying out estimating services, any systematic procedures in accounting for design variables, or any models developed by construction researchers. The consequences of mal-assessment of the cost implications of design variables were also revealed by the study.

Keywords: A/E firms, Design variables, Early cost estimates, Estimating techniques.

Introduction

One of the first questions usually asked by prospective building clients is 'how much will the building cost?' Although the primary purpose of the figure given by the designer is to provide an indication of the probable cost of the facility, it remains fresh in the mind of the client throughout the period leading to the actualization of his idea. The estimates also usually provide the basis for the client's funding arrangements, budgeting and control of the construction costs. History and daily life experiences present scenarios where prediction-based decisions have resulted in fiascoes, especially with respect to building projects where cost and schedule overruns are prevalent. The success of any construction project is measured in terms of delivery at the right time, at the appropriate price and quality standards, and satisfaction provided to the owner. One important influence on the achievement of this success is in the authenticity of the cost estimates prepared by the Architectural-Engineering (A/E) firms during the various phases of any building project, especially during the early phases.

Often the quality of the project design, along with the ability to start construction and complete it on schedule, are dependent on the accuracy of cost estimates made throughout the design phase of a project. Since cost has been identified as one of the measures of function and performance of a building, it should be capable of being "modeled" in order that a design can be evaluated. This will assist in providing greater understanding and possibility of prediction of the effect on the cost of changing the design variables by the A/E firms. The model attempts to represent the significant cost items of a building in a form that will allow analysis and prediction of cost to be undertaken according to changes in such factors as the design variables, construction methods, timing of events, etc. By design variable, we mean any parameter of a building that can be varied between designs while providing the same quality and amount of accommodation. The plan shape, storey height, number of storeys, and circulation space are some of such parameters.

Researchers in the industry have paid very little attention to the issue of design variables in cost estimation. This study is an attempt to explore the practices that are followed by A/E firms in Saudi Arabia in accounting for design variables in the early cost estimates.

Objective of the Study

The principal objectives of this study are to:

1. Investigate the techniques that are used by A/E firms for forecasting the early cost estimates of residential buildings.
2. Investigate the procedures adopted by the A/E firms in accounting for design variables during the preparation of early cost estimates of residential buildings.

This study was limited to only architectural design variables related to residential buildings and the respondents were drawn from the A/E firms practicing in the Eastern Province of Saudi Arabia.

Previous Studies

Kouskoulas and Koehn [1] postulated that the cost of a building is a function of many variables, and suggested that a set of independent variables can be selected to describe a project and define its cost. Such variables should be measurable for each new building project. Kouskoulas and Koehn identified building locality, price index, building type, building height, building quality, and building technology as the independent variables that define the cost.

Brandon [2] identified Plan Shape Index (which represents any plan shape of building to a rectangle having an area and perimeter identical to the building it represents); Number of Storeys; Boundary Coefficient (which represents the extent of the internal divisions of floor area by expressing the perimeter of all rooms as a ratio with the gross floor area); Average Storey Height; Percentage of Glazed Area; and Plan Compactness as the suitable descriptors of building form.

Swaffield and Pasquire [3] identified percentage of glazed wall area; perimeter length; total building height; volume of plant rooms and services cores; and volume of air handled by HVAC systems, as descriptors that may be useful for determining the Mechanical and Electrical (M&E) services cost. The Perimeter to Floor ratio, calculated by dividing the external wall area (inclusive of doors and windows) by the gross floor area is a means of expressing the planning efficiency of a building, and it is influenced by the plan shape, plan size and storey heights.

The plan shape directly conditions the external walls, windows and external doors – which together form the building envelope or enclosing walls. Different building plans can be compared by examining the ratio of the areas of enclosing walls to gross floor area in square meters. Seeley [4] indicated that the lower the perimeter to floor ratio, the more economical the proposal will be. A circular building produces the best wall/floor ratio, but the saving in quantity of wall is usually more than offset by the lowered output, by between 20 to 30% [4].

Ferry and Brandon [5] suggested a multiplier measure to be adopted in adjusting the cost estimate. The multiplier is an efficiency ratio relating the area of external walls to that of the area of enclosed floor area. Perhaps, this is the most widely used of all the efficiency ratios, but it can only be used to compare buildings having similar floor areas and does not have an optimum reference point.

In their research, Seeley [4] and Chaue [6] indicated that Cooke eliminated some of the noticed shortcomings of the previous ratio by introducing a shape efficiency index (JC) which is defined as the ratio of the perimeter of a floor plan to the perimeter of a square floor plan with the same floor area. The larger the value of this index, the more complicated the shape [6].

Researchers in Strathclyde University developed another ratio which is called Plan Compactness Ratio (POP). This measure is defined as the ratio of the perimeter of a circular floor plan (P) to the perimeter of a floor plan with the same area. The smaller the value of the index, the more complicated the shape [6]. In this case, the reference point is the circle (a square would have a POP ratio of 88.6% efficiency and yet it is probably the best cost solution in initial cost terms). Other ratios are developed with different points of reference.

Mass compactness or VOLM ratio uses a hemisphere as the point of reference for considering the compactness of the building in three dimensions. Rectangular index also called Length/Breadth Index (LBI) is defined as the length to breadth ratio of a rectangle with the same area and perimeter as the building. In this index, any right-angled plan shape of building is reduced to a rectangle having the same area and perimeter as the building. Curved walls are dealt with by a weighting system. The advantage here is that the rectangular shape allows a quick mental check for efficiency. The larger the value of the index, the more complicated the shape. It should, however, be borne in mind that all the indices discussed above consider only those elements that comprise the perimeter of the building, or in the case of VOLM, the perimeter and roof. Furthermore, the repercussions of shape on many other major elements are great. For example, wide spans generated by a different plan shape may result in deeper beams, which consequently demand a greater storey height to offer the same headroom, and thus will affect all the vertical elements. These implications require reflecting in any future models.

Chau [6] critically indicated that most of the existing plan shape indices are based on the geometry of the plan without reference to empirical data. He proposed a new approach which involves an empirical estimation of a Box-Cox cost model. His results suggest that it is better to build a regression model that predicts how much floor area can be built with a fixed sum of money than to predict how much money is required to construct one unit of floor space. The flaws of this research, however, include the use of different project types with widely varying characteristics in terms of size, components and specifications. It is also not likely that the analyses of projects of widely differing type, size and qualities would yield reliable results as evidenced in the low coefficients of determination obtained for the shape indices.

Variation in storey heights cause changes in the cost of the building without altering the floor area, and this is one of the factors that make the cubic method of approximate estimating so difficult to operate when there are wide variations in the storey height between the buildings being compared. The main constructional items, which would be affected by a variation in storey height, are walls and partitions, together with their associated finishing and decorations. Constructional costs of buildings rise with increases in their height, but these additional costs can be partly offset by the better utilization of highly priced land and the reduced cost of external circulation works. Private residential blocks are generally best kept low, for reasons of economy, except in very high cost site locations where luxury rents are obtainable. In a similar manner, office developments in tower form are more expensive in cost than low rise, but provided the tower has large gross floor area per floor, the rent obtainable may offset the additional cost.

Tan [7] developed a simple analytic model to show how cost variation with building height is affected by technology, building design, demand, and institutional factors. The model was designed to determine the incremental cost of each floor as building height increases. His model was, however, too simple and does not capture certain institutional realities such as monopolistic pricing and zoning constraints. The model also relies on the unrealistic assumption that unit construction cost rises uniformly with height without capturing the dramatic changes in unit cost as some key thresholds (such as new foundation system or a different crane system) are reached. For the model to produce a more precise estimate, co-variances, about which only little is known, would be required.

Almost every type of building requires some circulation space to provide means of access between its constituent parts, and in prestige buildings spacious entrance halls and corridors add to the impressiveness and dignity of the buildings. As with other parts of the buildings, cost is not the only criterion, which has to be examined – aesthetic and functional qualities are also very important. Circulation space requirements tend to rise with increases in the height of the buildings and it is accordingly well worthwhile to give special consideration to circulation aspects when designing high-rise buildings.

Swaffield and Pasquire [8] postulated that a cost modeling system, which considers the building function, level of services provision, and parameters, which describe the form of the building, would improve the accuracy of early cost advice of building services.

Swaffield and Pasquire [9] in a later study verified that the analysis of M & E services cost in terms of building form descriptors is valid, but that the commonly used gross floor area is not the most appropriate for M & E services cost estimates. They concluded that horizontal distribution volume and internal cube were the most significant variables for M & E services tender cost prediction.

Research Methodology

This section presents the procedures which were followed in achieving the objectives set for this study.

Data collection

Data needed for this study were collected during the fall of 2002 via a structured questionnaire that was developed following a thorough review of related literature to reflect the current practices related to cost estimation in the A/E firms in Saudi Arabia. The questionnaire comprised of a total of 48 questions spread across two sections covering the A/E firm, estimating technique and procedures used in accounting for design variables in early cost estimates. The first part contains 21 questions eliciting general information about the participating A/E firms. To ensure unbiased responses, completion of personal data was made optional. The second section contains 27 questions, which explore the estimating techniques utilized and factors influencing the choice of technique, factors influencing the choice of the design variables, and the procedures used in accounting for them in early cost estimates.

Population and sample

The study population is defined to include all the A/E firms that provide design and/or consultancy services to prospective residential building owners, and practicing in the Eastern Province of Saudi Arabia. A list of 140 registered A/E firms was obtained from the Chamber of Commerce and Industry for the Eastern Province. The list, however, did not classify the practices into the various categories in the construction industry, but telephone enquiry indicated that 30 firms conform to the criteria to be included in the study population. The size of the sample required from the population was determined based on statistical principles for this type of exploratory investigation to reflect a confidence level of 95%. The sample size was determined using the following equations [10]:

$$n_0 = \frac{(p*q)}{V^2} \text{ and} \tag{1}$$

$$n = \frac{n_0}{[1 + n_0/N)]} \tag{2}$$

where n_0 = sample size from an infinite population, p = the proportion of the characteristics being measured in the target population, q= complement of p, i.e. 1-p, V = the maximum standard error allowed, N = the population size, n = the sample size. In order to maximize the sample size n, the value of both p and q are each set at 0.5; the target population N is 30; and to account for more error in qualitative answers of this questionnaire, maximum standard error V is set at 10% or 0.1.

Substituting the values into equations (1) and (2) above, the minimum required sample is calculated to be 13.64. This means that the minimum sample required is 14 from the population.

Prior to the survey proper, a pilot survey was undertaken to detect clarity and adequacy of the questions, choices and space(s) provided. Subsequently, the survey was undertaken and the survey package consisted of a covering letter explaining the purpose of the survey and the questionnaire itself. The questionnaires were initially mailed through postal service, but fax copies were subsequently requested by some firms. After a two-month period and following several telephone contacts, a total of 19 completed responses (representing 63% of the population) were received. This level of response can be regarded as being very good and highly representative of the population since the maximum standard error has been consequently reduced to 7%.

Data analysis

The responses that were received from the survey participants were tabulated and analyzed individually. Simple mathematical techniques such as percentage and average were used in analyzing the data. However, in addition to these techniques, importance, reliability and severity indices were calculated as the case may be, where necessary, to reflect the relative importance or reliability or severity of some of the relevant criteria over others. The indices were calculated as follows [11]:

$$\text{Index} = \left(\frac{\sum_{i=1}^{5} a_i x_i}{5 \sum_{i=1}^{5} x_i} \right) (100\%) \tag{3}$$

where a_i = constant expressing the weight given to i; x_i = variable expressing the frequency of the response for I, i = 1,2,3,4,5 and illustrated as follows:
x_1 = frequency of the "not important/reliable/severe" response and corresponding to $a_1=1$;
x_2 = frequency of "somewhat important/reliable/severe" response and corresponding to $a_2 = 2$;
x_3 = frequency of the "important/reliable/severe" response and corresponding to $a_3 = 3$;
x_4 = frequency of the "very important/reliable/severe" response and corresponding to $a_4=4$;
x_5 = frequency of "extremely important/reliable/severe" response and corresponding to $a_5 = 5$;

The average index for each major criterion is the average of all the indices of the individual criteria within the category.

The importance/reliability/severity indices were grouped to reflect the respondents' ratings as follows: Extremely important/reliable/severe: $80 < I \leq 100$; Very important/reliable/severe: $60 < I \leq 80$; Important/reliable/severe: $40 < I \leq 60$; Somewhat important/reliable/severe: $20 < I \leq 40$; and Not important/reliable/severe: $0 < I \leq 20$.

Results and Analysis

In this section, the results of the study are discussed. The characteristics of the respondents, the techniques they use in preparing early cost estimates, the factors affecting their decision on the type of selected technique, the factors they consider whenever they decide on design variables, and procedures for accounting for such design variables are presented.

Characteristics of the participating contractors

This section presents the characteristics of the participating A/E firms, the age, size, experience, category, specialization, technology use, and capacity of firm.

The key informants who provided the requested information were in the top management of the participating firms. The majority (90%) of the key informants are owners/general managers and engineering managers. The results indicated that the respondents have substantial experiences in their profession. They all have been working for their firms for between 9 and 34 years, with an average of 18 years. The fact that at least 95% of the respondents have long experience was reflected in the level of completeness, consistency and precision of the information provided, and provides further validity for the survey results. The survey results also showed that almost 90% of the firms have been in construction business for over 10 years.

The sizes of the participating A/E firms have been classified in terms of number of employees, and the results showed that most of the firms (over 70%) have less than 100 employees and the distribution shows a correlation with the number of estimating personnel at a ratio of 10:1. The estimating personnel in the participating firms are experienced, with an average of over 10 years experience in estimating.

All the firms that participated in this survey reported that they undertake both design and consultancy services. The composition of the projects handled by the firms indicate that of the total, 38% are industrial projects, 28% are residential, 26% are commercial and 8% are highway projects. All the firms work on residential projects with the average values less than five million Saudi riyals (3.75 Saudi riyals = 1 USD). The categories of residential clients identified include government (20%), private (55%), and semi-government sectors (25%).

The survey results also showed that 84% of the firms do not use any specialized software to perform cost-estimating services. This result is surprising, especially at this age of information technology. The software packages commonly used by the firms using specialized packages include Estimate I and Caesar I, which are not one of the famous packages such as Timberline. The average length of usage was reported to be five years and each of the three firms using specialized packages provided a level of satisfaction of for on a scale of five, which gives a reliability index of eighty. This indicates that the users have found the packages to be very reliable.

Preparation of early cost estimates and design variables

This section presents the reported practices of contractors in managing construction equipment from acquisition to retirement of the equipment.

Preparation of early cost estimates and estimating techniques

Although all the participating firms indicated that they perform cost consultancy services on residential buildings, the survey shows that only 10 firms (53%) prepare early cost estimates. This means that the other 47% only perform cost consultancy at later stages of the project. The common estimating technique used for preparing early cost estimates is provided in Table 1. These commonly used estimating techniques all rely on data from previously completed projects. It seems that A/E firms in Saudi Arabia have no preference toward an estimating method. This may be interpreted by speculating that A/E firms in Saudi Arabia may have little interest in preparing cost estimates for projects they design.

Table 1. Summary of estimating techniques used in preparing early cost estimates

Technique (1)	Frequency (2)	Percent (3)	Cumulative frequency (4)	Cumulative percent (5)
Prevailing cost per square meter	3	30	3	30
Approximate quantities method	2	20	5	50
Database of similar projects	3	30	8	80
Unit rate (time and work)	2	20	10	100

Factors that affect the choice of early cost estimating technique

The participating A/E firms were asked to assess the importance of many factors potentially affecting their decision in selecting an early cost estimating technique. The importance indices, shown in Table 2, were calculated to reflect the relative importance of the factors. The table shows that the most important factor in deciding the estimating technique to be used is the size of the project, while the least important factor is the number of bidders. This distribution follows the estimating techniques that are in common use which tend to rely on data from previously completed similar projects. Thus, the reason why factors either directly related to the characteristics of the project or the owner have more impact on the choice of estimating technique. Three firms have also suggested that both Value Engineering and Constructability are extremely important factors. The participating A/E firms were also asked to rate the reliability of the estimating technique they use in preparing early cost estimates for residential buildings. This rating was based on the comparison between the estimates prepared by the firms in previous projects and the tender prices for the same projects. The rating was transformed into reliability index and the results are given in Table 3.

Table 2. Factors that affect the choice of estimating technique

Factors (1)	Extremely important (2)	Very important (3)	Important (4)	Somewhat important (5)	Not important (6)	Importance index (7)	Rank (8)
Size of the project	16	3	0	0	0	96.84	1
Client (owner)	9	4	6	0	0	83.16	3
Project type	9	3	7	0	0	82.11	4
Experience of estimator	6	8	5	0	0	81.05	6
Information available	13	6	0	0	0	93.68	2
Time available	8	4	7	0	0	81.05	5
Construction method	6	5	7	0	0	78.89	7
Design variables	8	1	10	0	0	77.89	8
Expected number of bidders	4	4	3	4	4	60.00	9

Table 3. Reliability of estimating technique

Factors (1)	Extremely reliable (2)	Very reliable (3)	Reliable (4)	Somewhat reliable (5)	Not reliable (6)	Reliability index (7)
Reliability of estimating technique	5	5	9	0	0	75.76

The reliability level of the estimating technique used by the firms in preparing early cost estimates is "very reliable". While it was shown that the factors which reveal the project characteristics have the greatest impact on the choice of estimating technique, the highest reliability is not attained probably because design variables, which affect project characteristics more than any factor, are not given adequate attention.

Factors that impact decision on design variables of residential building designs

The participating A/E firms were requested to indicate the impact level of the identified factors on decisions relating to each design variable. The importance indices were calculated to reflect the relative importance of the factors. Table 4 presents the importance indices and ranking of each of the factors.

Table 4. Factors that impact the decision on design variables

Factors (1)	Extremely important (2)	Very important (3)	Important (4)	Somewhat important (5)	Not important (6)	Importance index (7)	Rank (8)
Plan Shape							
Shape of the plot	5	10	1	3	0	77.89	1
Functional requirements	8	1	1	9	0	68.42	2
Intended use	6	2	4	7	0	67.37	3
Total number of storeys							
Cost of land	13	2	3	1	0	88.42	1
Prestige	4	5	4	6	0	67.37	3
Planning laws	10	1	2	5	1	74.74	2
Average storey height							
Intended use	11	2	2	4	0	81.05	1
Environmental considerations	6	1	9	3	0	70.53	2
Type of A/C system	4	2	7	6	2	60	3
Amount of circulation area							
Expected traffic	7	7	2	2	1	77.89	1
Safety	6	4	5	4	0	72.63	2
Amount of circulation area							
Expected traffic	7	7	2	2	1	77.89	1
Safety	6	4	5	4	0	72.63	2
Building codes	4	8	4	2	1	72.63	3
Percentage of exterior wall area to be glazed							
Functional requirements	7	2	3	3	4	65.26	3
Building codes	1	11	5	1	1	70.53	2

Owner's wish	14	1	3	1	0	89.47	1

The results indicated that the majority of the A/E firms believe that the shape of plot has a significant importance in determining the plan shape and, consequently, the price of the project. The A/E firms are divided on the importance of the functional requirements and the intended use of the project for determining the plan shape. It seems that A/E firms have the means for furnishing designs that will satisfy the owner requirements with the proper plan shape.

The A/E firms indicated that the cost of the land and the zoning regulations are extremely important for deciding on the number of stories for a proposed building. The results coincide with the logic that an investor would desire to maximize the utilization of his resources. It is very interesting to notice that one participant indicated that the zoning regulation had no importance as to the number of stories of a project.

The results indicated that the intended use of the facility dictates the average storey height, not the type of the Air Conditioning (A/C) system. It seems that the notion that using a centralized air-conditioning system would require higher ceiling to accommodate ducts is challenged. A/E firms may use practical solutions for using such a system without altering the ceiling height.

As expected the circulation area depends on expected traffic, safety, and building codes. The percentage of glazed exterior wall area is controlled by the owner's requirements. The factors rated to be extremely important happened to be those primarily controlled by the owners and outside the jurisdiction of the consultants. This indicates the strong influence that the owners have over decisions in respect of the design variables and a serious challenge to the designers who are required to offer professional advice to the owners.

Application of constructability as a design tool

The participating A/E firms were asked to rate the importance of the application of constructability as a design tool, and the rating was transformed into importance index and the result is given in Table 5. The importance level for the application of constructability as a design tool is "extremely important". Constructability has obvious benefits, which includes ease of construction in order to minimize waste while maximizing use of site plants and thus productivity, hence the justification for level of importance. These benefits will have the highest value if the constructability is applied in the early stages of the design development when the cost of affecting changes will be minimal.

Table 5. Application of constructability as a design tool

Factors (1)	Extremely important (2)	Very important (3)	Important (4)	Somewhat important (5)	Not important (6)	Importance index (7)
Application of constructability	13	6	0	0	0	93.68

Average percentage for circulation space, glazed area and M and E services

The participating A/E firms were asked to indicate the average allowances they make in residential building designs for circulation space as a percentage of total floor area, glazed area as a percentage of total exterior wall area, and cost of M & E services as a percentage of total building cost. The minimum and maximum values and the standard deviation of the values provided by the firms are reported in Table 6.

These results corroborate the previous findings of Seeley [4], Ferry and Brandon [5], and Ashworth [12].

Table 6. Average percentages for circulation space, glazed area, and M&E services

Variable (1)	Minimum (2)	Maximum (3)	Standard deviation (4)	Average (5)
Circulation space	12	60	15.76	31.68
Glazed area	15	70	15.12	29.21
M&E services cost	15	40	7.60	23.68

Use of specific systematic procedure for accounting for design variables

The survey results indicate that only 47% of the participating A/E firms use systematic procedures in accounting for design variables in the early cost estimates they prepare for residential buildings.

Procedure for accounting for plan shape

Only one firm reported the use of Wall to Floor ratio in accounting for plan shape, while 45% (four firms) reported the use of other plan shape indices, without providing any details as to which indices are being used. The other 44% of the firms indicated that they use neither the existing plan shape indices nor Wall to Floor ratio.

Procedure for accounting for number of storeys and average storey heights

The survey results show that 11% and 89% of the participating firms respectively reported the use of detailed analysis and simple ratio to account for both changes in number of storeys and storey height for residential buildings. Detailed analysis could be cumbersome and time-consuming and may lead to inadequate exploration of all the options that may be available to be able to choose an optimum number of floors. Research findings, such as the one provided by Ferry and Brandon [5] a formula was developed for determining an optimum number of floors that will provide the most economical design. Although the use of a simple ratio may provide a reasonable idea for storeys ranging from one to three, the scenario may drastically change thereafter due to changes in the form of foundation, structural framework, roof, etc. Thus, the application of a simple ratio would provide inaccurate assessment of the plan shape variations.

Procedures for accounting for circulation space

The survey results also indicate that 67% of the participating firms reported the use of detailed analysis, while 33% reported the use of simple ratio to account for circulation space in early cost estimates of residential buildings. Adjustments of circulation space are particularly useful when analyzing the relationship between the gross floor area and the net usable area for commercial apartments for the purpose of determining profitability. The need for systematic procedures in accounting for this variable cannot be over-emphasized because its requirements change with provisions of building codes to fulfill the requirements of the other variables such as safety needs and lift/staircase arising from increase in the number of storeys.

Consequences of mal-assessing cost implications of design variables in early cost estimates

The participating A/E firms were requested to indicate the level of severity of the consequences of both under-assessment and over-assessment of the cost implications of design variables in the early cost estimates prepared for residential buildings. The severity indices were calculated to reflect the relative impact of the outcomes. Table 7 shows the importance indices and ranking of each of the factors.

Table 7. Consequences of mal-assessing cost implications of design variables

Outcome (1)	Extremely severe (2)	Very severe (3)	Severe (4)	Somewhat severe (5)	Not severe (6)	Severity index (7)	Rank (8)
Under-assessment 70.00[a]							
Recommendation of infeasible project	4	6	5	4	0	70.53	2
Project abandonment	2	8	2	7	0	65.26	4
Disappointing expected returns	6	7	2	4	0	75.79	1
Sub-standard quality work	4	5	5	5	0	68.42	3
Over-assessment 75.79[b]							
Loss of owner's confidence on A/E	11	3	2	3	0	83.16	1
Rejection of feasible project	6	4	6	3	0	73.68	2
Lost opportunities	6	3	6	3	1	70.53	3

Based on the classification defined earlier, Table 7 reveals that one factor produces "extremely severe" while the other six factors produce "very severe" consequences of mal-assessing the cost implications of design variables. The table also shows that disappointing returns, and loss of owner's confidence in the designer as the most severe consequences of under-assessing and over-assessing the cost implications of design variables in early cost estimates respectively. Project abandonment and lost future opportunities were also shown to be the least severe consequences of under-assessment and over-assessment respectively. It can also be seen from the average severity indices that the consequences of over-assessment is greater than that of under-assessment.

Importance of applying systematic procedures for assessing design variables

The participating A/E firms were asked to rate the importance of the application of systematic procedures in accounting for design variables in early cost estimates. The benefits to be derived from such an application of systematic procedures include ease of adjustments, feasibility studies, evaluation of alternative options and reliability of estimating technique. The rating is transformed into importance index and the result is given in Table 8.

Table 8. Importance of applying systematic procedures for assessing design variables

Factors (1)	Extremely important (2)	Very important (3)	Important (4)	Somewhat important (5)	Not important (6)	Importance index (7)
Importance of applying systematic procedures	5	14	0	0	0	85.26

The importance level for the application of systematic procedures for accounting for design variables is "extremely important". This shows that the firms have realized the strategic importance of developing or adopting systematic procedures for assessing design variables in order to carry out effective cost consultancy services for the clients.

Reliability of procedures for accounting for design variables

The rating of the reliability of procedures adopted by the participating A/E firms in accounting for design variables in early cost estimates were transformed into reliability indices and shown in Table 9. Even though the result of the preceding section indicates that the importance level for "the application of systematic procedures for accounting for design variables" is "extremely important", the overall reliability of the procedures currently applied by the participating firms is not of equal strength. This may be because most of the participating firms use a simple ratio in accounting for design variables, which leads to haphazard assessment in the event of changes. Thus, improvements over the current practices are needed.

Table 9. Reliability of procedures adopted for accounting for design variables

Factors (1)	Extremely reliable (2)	Very reliable (3)	Reliable (4)	Somewhat reliable (5)	Not reliable (6)	Reliability Index (7)
Reliability of procedures for accounting design variables	3	3	12	1	0	68.42

General comments on ways of improving the accuracy of early cost estimates

Only two firms provided open-ended suggestions on ways of improving the accuracy of early cost estimates prepared for residential building projects. The suggestions are to:

1. Ensure informative clients who should be technically knowledgeable of the nature of his investment/project.
2. Establish an original scope for the work.
3. Maintain good quality while ensuring cost effectiveness
4. Ensure good material selections.

Conclusion

This paper investigates some aspects of the cost estimation functions performed by A/E firms in Saudi Arabia. The study revealed that the majority of the firms are neither taking advantage of the available information technology nor the findings of construction researchers, especially with respect to the procedures adopted for accounting for design variables.

Recommendations

While it is recommended that clients should increase the demand for early cost estimates from the designers, the A/E firms must embrace the use of specialized cost estimating packages in order to enhance productivity and accuracy. The A/E firms are advised to account for changing the design variables in the modified designs by using multipliers which are developed and published in the literature. The A/E firms are advised to use the Wall to Floor ratio to account for the plan shape and its effect on project costs. Finally, the A/E firms are urged to develop customized models and implement the research findings in their practices.

Acknowledgement. The authors thank King Fahd University of Petroleum & Minerals, Dhahran, Saudi Arabia, for supporting this research.

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دراسة الأساليب ا عتمدة لدى شركات ا ندسة ا عمارية لتحديد تأث التغي عناصر التصميم ا ندسي على التكاليف ا بكرة

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(قدِّم للنشر في ٢٠٠٣/٠٦/١٠م؛ وقبل للنشر في ٢٠٠٤/١٢/٠٥م)

ملخص البحث. يتوقف نجاح أو فشل أي مشروع بناء على إمكانية الاعتماد على تقدير تكلفته، خاصة في المراحل الأولى من تطويره. وكان الهدف من هذه الدراسة استقصاء التقنيات والأساليب التي تستخدمها شركات الهندسة المعمارية لتأخذ بعين الاعتبار تأثير التغيير في عناصر التصميم على حسابات التكلفة المبكرة التي تقوم بها بالنسبة للأبنية السكنية. وقد تم تنفيذ هذه المهمة بإجراء استبانة اشتركت فيها ١٩شركة عاملة في المنطقة الشرقية من المملكة العربية السعودية. وقد أظهرت نتائج الاستبانة أن أكثر المؤسسات لا تستخدم برامج حاسوبية متخصصة في عملية تقدير تكلفة خدماتها. وبينت النتائج أيضاً أن هذه المؤسسات لا تستخدم أية طرق نموذجية لأخذ تأثير التغيير في عناصر التصميم بعين الاعتبار، ولا أية نماذج رياضية من تطوير باحثين في مجال البناء. وأظهرت الدراسة كذلك آثار سوء تقدير التكلفة لعناصر تصميم هندسة الأبنية.

كلمات المفتاح: شركات الهندسة المعمارية، عناصر التصميم الهندسي، التقدير المبكر للتكلفة، تقنيات التقدير.