DESIGN FEE VERSUS DESIGN DEFICIENCY

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ABSTRACT: The relationship between the design quality and the design fee is directly dependent upon how the fee is determined, compared to the level of services to be provided. Design deficiency is an error or omission in the drawings and/or the specifications, which results in a facility that will not adequately perform its intended mission. This study is an attempt to determine a statistical model that relates the design fee and design deficiency. Such a model can be used to predict the level of design quality. Data regarding design fee and design deficiency were collected for sixty construction projects in Saudi Arabia. Although the data have a large variation, the developed model shows clearly the decrease of design deficiency as the design fee increases.

INTRODUCTION

The relationship between the design quality and the design fee is directly dependent upon how the fee is determined, compared to the level of services to be provided (DeFraites 1989). Quality of engineering design is essential for obtaining quality in a constructed project. The design should be in accordance with the best current technology and professional practice. Quality design obviously involves more than technical considerations. Owners who are not familiar with the construction process find it difficult to articulate their requirements in a form that enables the designer to devise an optimal solution. As a result, misunderstandings occur which can have a detrimental effect on project quality (Ashford 1989). When the owner has particular requirements, the design professional should thoroughly discuss these with the owner, since there are obvious cost and quality implications. There are several definitions of quality. The ASCE Quality in Constructed Projects manual defines quality as conformance to predetermined requirements. Quality in a constructed project is obtained by conscientious application of a thoroughly planned, quality-assurance program implemented through a quality-control procedure. Not all design quality determinants have an absolute value for measurement but instead a comparative value with the past or with other products. It is also difficult to measure what is desired or expected from a project, since expectations are more difficult to define than objectives (CII 1986; ASCE 1990).

The objective of the study is to relate design deficiency to design fee. In the case of local construction industry, such a relationship can be used to predict the level of design quality and to help in setting regulations governing the minimum design fee. Data regarding the design fee and design deficiency were collected from sixty construction projects in Saudi Arabia.

FEE AND DESIGN DEFICIENCY

Several studies have discussed procedures to measure design quality in construction projects (McGeorge 1988; Lutz et al. 1990; Burati et al. 1992). McGeorge suggested calculating the project cost after completion of construction. Project cost is a good indicator of project quality when compared with identical projects. The approach is simple and convenient. However, it cannot be used during the design process or directly after finishing the design documents, and it does not consider total life-cycle costs. Lutz et al. (1990) defined design deficiency as any deficiency in the drawings and/or the specifications that results in a facility that will not adequately perform its intended mission. Burati et al. (1992) developed a system to evaluate the quality-management activities in both the design and construction phases. The cost of poor quality can then be determined. Burati et al. (1992) collected quality deviation data from nine construction projects. The data were collected after the construction phase of the projects to identify the direct costs associated with the work, including redesign, repair, and replacement. The data indicated that project deviations accounted for an average of 12.4% of the total project costs. Furthermore, design deviations averaged 78% of the total number of deviations, 79% of the total deviation costs, and 9.5% of the total project cost. The construction deviation average was 16% of the total number of deviations, 17% of the total deviations costs, and 2.5% of the total project cost. These values are conservative because they consider only direct costs, but they are indications of the impact of design quality on the project total costs. Other studies (Morgen 1986; Kirby et al. 1988) have identified the three major causes of the contract modifications as follows: (1) Design deficiencies; (2) user requested changes; and (3) unknown site conditions. These studies have also revealed that 56% of all contract modifications are concerned with correcting design deficiencies.

The fee that the design offices charge takes several forms depending on the size of the project to be designed and the type of services delivered, other than the basic design services. Generally, the fee may be broken into several constituents. First is the direct cost that covers the cost of engineering services, securing legal permits, and the cost of materials. Second is the overhead cost that includes the cost of all indirect charges for the design of the project and that is necessary for the operation of the design offices.

Usually one of the following methods is used by design offices to determine the design fee: (1) It can be specified as a lump sum at the time of agreement with the owner; (2) it can be determined as a function of engineering hours; (3) it can be determined in accordance with three phases of design development (e.g., feasibility, preliminary, and detailed); or (4) it can be decided during the agreement negotiation.

Most design deficiencies can be categorized as one of the following three types: (1) Contract document conflict—discrepancies between drawings and specifications; (2) interdisciplinary coordination errors—conflicts or interface problems of a structural, mechanical and electrical nature; and finally, (3) technical compliance discrepancies—nonadherence to the appropriate design guidelines, technical specifications, and building codes (Lutz et al. 1990).

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CASE STUDY

Information pertinent to sixty projects were randomly collected from twenty design offices, three projects per office. In addition, construction related data for the sixty projects was collected from the contractors who constructed the projects. The scope was limited to large building projects. Data were collected through personal interviews. Collected data includes (1) information regarding change orders, such as type, number, cost, and time delay—both owner-originated change orders and design deficiencies; (2) design fee; (3) project cost; and (4) built areas. Data were checked for homogeneity consistency and normality. Information of two projects was deleted due to obvious inconsistency. Tables 1 and 2 show the design fee and project cost statistics, respectively.

One of the approaches used to measure design quality is measuring design deficiency. Design deficiency is considered a major component of design quality. The following assumptions were used in building the relationship between the design fee and design deficiency.

1. The following variables were normalized to the project cost:
   - project design fee
   - change orders
   - design deficiencies
   - owner change order values
2. The change orders include all changes that are issued to correct design deficiencies and to perform owners' changes. Therefore, the cost of change orders per project cost equals the cost of design per project cost plus the cost of owner change order costs per project cost.
3. There are additional costs incurred by the owner due to the time delay that results from correcting design deficiencies. Therefore, the total cost of design deficiency (TCDD) is equal to the sum of direct costs of the design deficiency (DCDD), which the contractor charges for the changes, plus indirect costs of change order (ICCO) resulting from project delayed completion. A simple equation was used to calculate the indirect costs of change orders based on the expected profits if the project was completed on time. Average annual profit was assumed to be equal to 15% of the project cost.

$$\text{ICCO} = \text{Expected Profit } (15\%) \times \text{Project Cost} \times \text{Time Delay (in months)}/12 \quad (1)$$

TABLE 1. Summary Statistics of Design Fee

Design fee statistics (1)	Project cost (%) (2)
Minimum value	0.3
Maximum value	12.5
Average value	2.4
Median value	1.4
Standard deviation	3.47

Note: Number of observations = 58.

TABLE 2. Summary Statistics of Project Cost

Project cost statistics (1)	Cost (U.S. dollars) (2)
Minimum value	133,000
Maximum value	10,400,000
Average value	2,000,000
Median value	907,000
Standard deviation	2,373,000

$$\text{TCDD/Project Cost} = \text{DCDD} + \text{ICCO} \quad (2)$$

Table 3 shows the statistics for the design deficiency. Fig. 1 shows a scatter diagram for the design fee per project cost on the *X*-axis with the total cost of design deficiencies per project cost on the *Y*-axis. General observations on the figure are as follows:

- There is a general pattern that the cost of design deficiency tends to decrease as the design fee increases.
- The minimum design deficiency cost is 0.0% and the maximum design deficiency cost is 21% of the project cost.
- Eighty-three percent of the projects have design fees ranging from 0.3% to 3% of the project cost. These values are considered very low when compared to typical values in the United States.
- The variation of design deficiency cost of offices with the same design fees is high, especially in the low design fee zone. This variation decreases substantially as the design fee increases. For example, where a design fee equals

TABLE 3. Summary Statistics of Design Deficiency

Design deficiency statistics (1)	Project cost (%) (2)
Minimum value	0.0
Maximum value	0.21
Average value	0.059
Median value	0.04
Standard deviation	0.053

Note: Number of observations = 58.

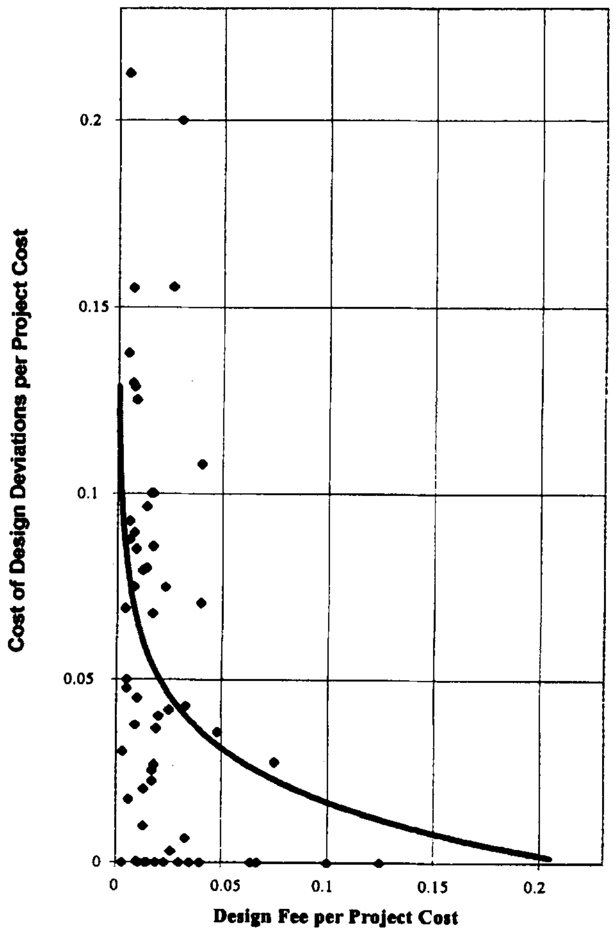

FIG. 1. Relationship between Fee and Design Deficiency

0.4% of the project cost, the design deficiency cost can be as low as 5% or as high as 21% of the project cost.

Using a statistical computer software package, several linear, logarithmic, and polynomial models were tried to build a regression model that fits best the data (Cochran and George 1982). The final model is shown in (3) that describes the TCDD as a function of the project design cost

$$y = -0.003 + 0.0991(1/x) - 0.016(1/x)^3 + 0.0013(1/x)^5 \quad (3)$$

where x = design fee per project cost (thousand of U.S. dollars); and y = correspondent design deficiency cost per project cost (thousand of U.S. dollars). The model has an R^2 value of 85%.

The design deficiency is inversely proportioned with the design fee. As the fee increases it is expected that the design deficiency decreases. Such a trend continues until the marginal change in the design fee has no significant effect in reducing the design deficiency. In real life, the design fee is a function of several components of the design office, such as the experience and credentials of key personnel, the time allotted for design and review, and the cost associated systems. No doubt a good design that fulfills the requirements of the owner, contractor, and regulator agencies requires a lot of effort and resources that will add to the design fee. Quality in design costs money. Owners should be aware that selecting a design professional on the basis of price bidding is counterproductive to producing a quality design. Selecting the proper design firm enhances the project team's ability to provide quality in the constructed project.

The developed model addresses design deficiencies that are discovered during construction and affect construction costs. However, design deficiencies can also affect the operation and maintenance costs over the life of the building. The additional operation and maintenance costs as well as possible occupant lost productivity can exceed costs incurred during construction due to design deficiencies.

CONCLUSIONS

The selection of the design professional is critical in achieving quality in the constructed project. The final selection should not be based on the design fee only. The amount of the design fee depends on the level of professional services provided. The design should be in accordance with the best current technology and best professional practice. In this study a regression model has been developed that relates the design fee to the design deficiency cost. The model can be used, in the case of the local construction industry, to predict the level of design quality. Design deficiency per project cost decreases as the design fee increases; however there is an economic aspect to the relationship. The pursuit of absolute perfection in design is neither economical nor practical.

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APPENDIX. REFERENCES

ASCE. (1990). *Quality in the constructed project: a guide for owners, designers, and constructors*, Vol. 1, ASCE Press, New York, N.Y.

Ashford, J. L. (1989). *The management of quality in construction.* E and FN Spon, London, U.K.

Burati, J. L., Farrington, J. J., and Ledbetter, W. B. (1992). "Causes of quality deviations in design and construction." *J. Constr. Engrg. and Mgmt.*, ASCE, 118(1), 34–46.

CII. (1986). *Constructability, a primer.* Constr. Industry Inst., Austin, Tex.

Cochran, G. W., and George, W. S. (1982). *Statistical methods*, 7th Ed., Iowa State Univ. Press, Ames, Iowa.

DeFraites, A. A. (1989). "Fee versus quality." *J. Profl. Issues in Engrg.*, 115(2), 125–128.

Kirby, J. G., Furry, D. A., and Hiks, D. K. (1988). "Improvements in design review management." *J. Constr. Engrg. and Mgmt.*, ASCE, 114(1), 69–82.

Lutz, J. D., Hancher, D. H., and East, E. W. (1990). "Framework for design-quality-review data-base system." *J. Mgmt. Engrg.*, ASCE, 6(3), 296–311.

McGeorge, J. F. (1988). "Design productivity: a quality problem." *J. Mgmt. Engrg.*, ASCE, 4(4), 350–361.

Morgen, E. T. (1986). *Claims by the Federal Government against its A/E—Guidelines for Improving Practice.* Office for Professional Liability Research, Victor O. Schinner and Co., Washington, D.C.