PERGAMON

International Journal of Project Management 20 (2002) 469–474

INTERNATIONAL JOURNAL OF PROJECT MANAGEMENT

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Selecting the appropriate project delivery method using AHP

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Received 3 October 2000; received in revised form 26 January 2001; accepted 21 March 2001

Abstract

A model using the analytical hierarchy process (AHP) is developed to select the most appropriate project delivery method. Several factors considered to be relevant to the selection decision are used in the ranking of the project delivery methods. Project owners are keen to choose an appropriate project delivery method because it could be a key project success factor. The model developed in this paper is simple to use and allows the owner to consider all decision-relevant factors. It is based on an intuitively appealing methodology, AHP. © 2002 Elsevier Science Ltd and IPMA. All rights reserved.

Keywords: Project delivery; AHP; Design–bid–build; Design–build; Construction management

1. Introduction

This paper deals with selecting the appropriate method of project delivery. The selection is an essential step in defining an overall project delivery strategy. Three project delivery methods are considered in this study: The design–bid–build (DBB) method, the design–bid (DB) method, and the construction management (CM) method. To determine which of these methods is most appropriate, the owner must consider several factors pertinent to the decision. Several studies have discussed these methods and presented the advantages and disadvantages of each. Gordon [1] suggested using judgement to eliminate inappropriate methods. Spink [2] discussed the particular circumstances that make a particular project delivery system suitable; and presented graphical guidelines as an aid to making a selection between the design-bid-build and the design-build methods. Molenaar and Songer [3] developed a web-based selection tool for selecting projects that are appropriate for design-build delivery method.

The analytical hierarchy process (AHP) is a multi-criteria decision-making method developed by Saaty [4]. It has been applied to solve unstructured problems in a variety of decision-making situations, ranging from the simple personal decisions to the complex capital intensive decisions. The application of AHP is carried out in two stages: hierarchic design and evaluation [4]. The design of the hierarchy involves structuring all the problem elements into a hierarchy. At each level, the elements are broken down into components, which constitute the level below. In the evaluation stage, the elements in a level of the hierarchy are compared in pair-wise comparisons with respect to each of the elements in the level directly above. A rating scale of 1 to 9 is used for the pair-wise comparisons. The process of comparison yields a relative ranking of priorities of the elements with respect to the criterion element they were compared against. The final ranking of the elements at the bottom level (the alternatives) is obtained by aggregating the contribution of the elements at all levels to each of the alternatives. The computational procedure is thoroughly discussed in Saaty [5].

Choosing an appropriate method is an essential decision for the owner; yet such a decision can be confounding with the numerous factors that need to be considered. This paper presents an AHP model to determine the appropriate project delivery method. The AHP model developed her is based on several factors that can be grouped under the three major categories of project characteristics, owner's needs, and owner's preferences.

At least two reasons explain the choice of the AHP in this study. First, the ability of the method to incorporate tangible and intangible factors that would otherwise be

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PII: S0263-7863(01)00032-1

difficult to take into consideration; and the second reason is the structure of the hierarchy. The problem is broken down into its constituent parts going down the hierarchy from large elements to small elements. Such a structure clarifies the problem and exhibits the contribution of each of the elements to the final decision.

This paper is organized in several sections. The three project delivery methods are explained in the next section then successively followed by the AHP model, the use of the model, and finally a conclusion.

2. Project delivery methods

The three basic methods are used for this study, DBB, DB, and CM, are described below.

2.1. The DBB method

This is the traditional and most familiar method of project delivery. In this method, the owner contracts with a designer and contractor separately. The designer prepares a design package, including contract documents. The owner submits the package for bidding and selects the best bidder to undertake the construction of the project. Normally, the DBB method is priced by lump sum. The method requires the owner to monitor contractor's activities to assure adherence to contract requirements. The method is known to foster adversarial relationships among the parties involved in the project.

2.2. The DB method

In DB, the owner contracts with a single entity for design and construction. The approach can eliminate the adversarial relationship in DBB because a single entity is responsible for both design and construction. It can also reduce the overall time of project completion and permits the incorporation of constructiblity information during design, but because of the lack of checks and balances, quality assurance can be an issue of concern for the owner. The DB approach is especially successful in cases where the scope is clearly defined, the design is a standard, repetitive design, and the schedule is tight [6].

2.3. The CM method

The construction manager is a consultant hired by the owner to oversee, on his behalf, the process of project development. The method is often used in the case of multiple prime contractors. The CM can fulfill several duties. It can offer constructibility reviews, value engineering studies, construction estimates, and contract packaging. By dividing the project into several contract packages and phasing the packages, the CM can achieve a fast track schedule. During construction, the CM coordinates contractors' activities and control the project. The CM's role during construction can be vital especially in management-intensive situations such as required in fast track and cost plus contracts.

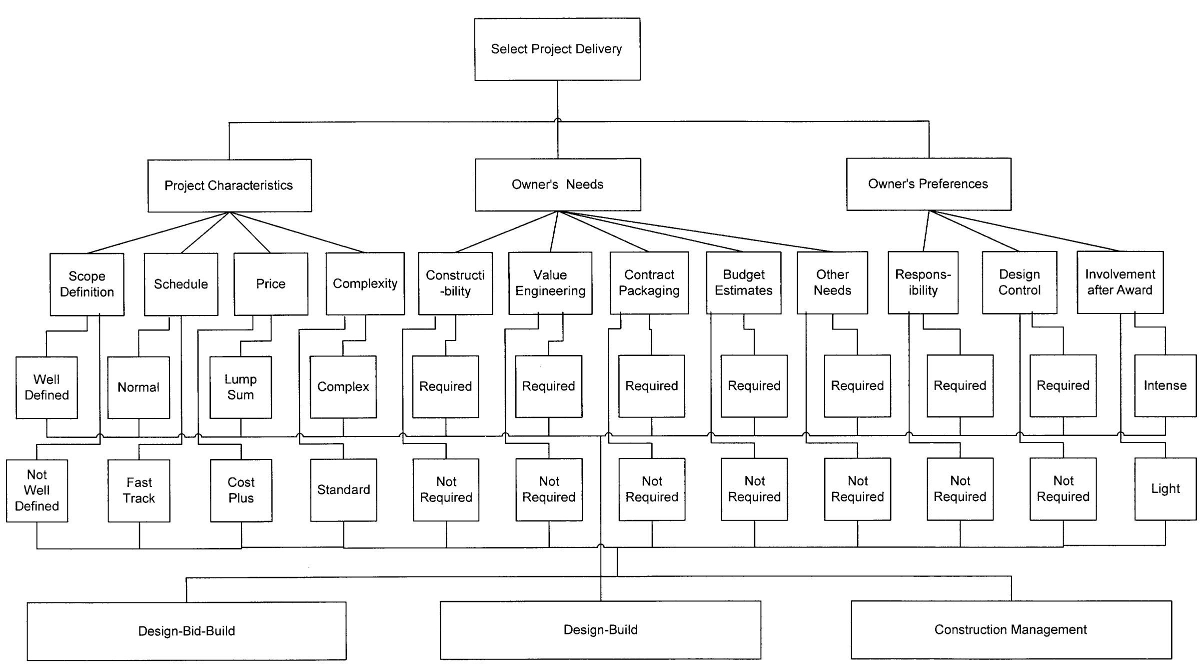

Fig. 1. Hierarchy design for the project delivery method selection model.

3. Development of the AHP model

The design of the AHP hierarchy must satisfy the goal of developing a model that will allow construction projects owners to decide which project delivery method is more appropriate for their particular situation.

The hierarchy developed in this study consists of five levels as shown in Fig. 1. The top level represents the goal of selecting a project delivery method. The last level is represented by the three alternative delivery methods. The objectives of selecting a delivery method is to adequately meet the project and owner requirements as represented by the three major categories of project characteristics, owner's needs, and owner's preferences. Thus, these objectives were assigned to the level just below the top level. The third level constitutes the subcategories of these three major objectives. Under project characteristics the subcategories included are the project scope definition, schedule, complexity, and method of pricing.

The owner's needs vary from project to project and may include such requirements as constructibility studies, value engineering studies, contract packaging, and feasibility studies. The owner's preferences include contract responsibility, design control by owner, and degree of involvement after contract award.

The fourth level contains the actual conditions of the subcategories. The factors in the hierarchy are discussed in the next section.

4. Factors affecting project delivery method selection

Several factors affect the decision to select a project delivery method (PDM). In the model these factors are grouped under three categories: project characteristics, owner's needs, and owner's preferences.

4.1. Project characteristics

4.1.1. Clarity of scope

The clarity of the project scope and requirements of the owner can affect the decision to select a PDM. Generally a DB approach requires a well-defined scope where the project requirements can be determined early in the design process. Other methods are more appropriate if the scope is vague and its definition is evolving.

4.1.2. Schedule

Time is a major constraint in most projects. The owner must determine if a fast track schedule is necessary. In the traditional DBB method, the project duration is lengthy because of the serial sequencing of phases. Fast tracking results in reducing this normal duration and can be achieved by either of the other two methods.

4.1.3. Complexity

Whether a project is a standard, repetitive design or a complex unique design is also a factor in selecting a preferred PDM. Generally a DB is suitable for a standard design. In the case of a complex design DBB may be used. If the owner also requires additional services such as a fast track schedule, the CM method may be the preferred approach.

4.1.4. Contract pricing

Contracts may be priced as lump sum, or cost plus. The DBB and the DB methods may be more suitable under a lump-sum contract, while the CM is generally the preferred method for cost-plus contracts.

4.2. Owner's needs

The owner may have additional requirements and consequently must decide which of the organization types would be better at meeting those requirements. The PDM selection model must be flexible with regards to owner's needs because they may vary from project to project. The model must be able to process varying lists of owner needs. Owner's requirements may include the following:

a. constructibility studies;
b. value engineering studies;
c. contract packaging; and
d. feasibility studies.

4.3. Owner's preferences

4.3.1. Responsibility

Some owners may prefer the characteristic of DB contracts of a single point responsibility. In a DB system, the contractor is responsible for both design and construction errors. However, in such a situation there may be a tendency to cover some of the errors. Hence, other owners may prefer other types of systems which provide for checks and balances between design and construction.

4.3.2. Design control

Owners must determine how much they want to be involved with the design process to influence the final outcome of the design. A high level of involvement may be necessary if the owner wishes to generate a creative design or a special appearance which he has in mind. In such a case, a DBB or a CM approach would be more appropriate. The owner may have limited control of detailed design under a DB approach.

4.3.3. Owner's involvement after award of contract

Owners must determine how much involvement they can afford to offer during the execution of the project.

Some owners may the have the expertise and sufficient available resources to allow for a high degree of involvement. Other owners may not have such capability, or have them but cannot make them available to the project; hence such an owner would prefer to have minimal involvement after contract award. The PDM selected needs to be suitable to the owner's involvement preference.

5. The use of the AHP model

The use of this AHP model requires the owner's project team to discuss and determine the relative importance of each of the elements in the hierarchy. Each element in a level is compared pair-wise with other elements at the same level, with respect to a criterion element at a higher level. The pair-wise comparison is based on a scale of 1 to 9 as per the definition of weights given in Table 1.

Table 1
The AHP comparison scale (based Ref. [4])

Weight	Definition
1	Equal importance
3	Weak importance of one over another
5	Essential or strong importance
7	Very strong importance
9	Absolute importance
2, 4, 6, 8	Intermediate values between the two adjacent judgements
Reciprocals of above	If factor *i* has one of the above numbers assigned to it when compared to factor *j*, then *j* has the reciprocal value when compared with *i*

Table 2
Pair-wise comparisons for the elements at the second level of the hierarchy with respect to the goal at the first level[a]

	PC	ON	OP	Priorities
PC	1	4	6	0.556
ON	1/4	1	3	0.380
OP	1/6	1/3	1	0.064

[a] PC, project characteristics; ON, owner needs; OP, owner preferences.

In Table 2, hypothetical pair-wise comparisons are applied to the second level elements of the model hierarchy. These pair-wise comparisons are done with respect to overall goal of the model: selecting the best delivery method. The owner, in this particular example, assigned the project characteristics a weight of 4 compared with the owner's needs. Thus, the owner considers the 'project characteristics' to be moderately more important than the 'owner needs' when compared to the selection of a PDM. From this matrix, the normalized priority values of the three elements can be computed. The priority values are shown in the last column of Table 2.

In a similar manner, the elements in the third level of the hierarchy are pair-wise compared to their associated factors at the second level. For example, the elements 'scope', 'schedule', 'price', and 'complexity' are compared with respect 'project characteristics'. The comparison values are shown in Table 3 with the priorities listed in the last column.

Thus, by this evaluation procedure, every element receives a normalized priority ranking relative to other associated elements at the same level. The priority values of elements in each matrix are shown in Fig. 2.

Through the aggregation process, the alternatives can be prioritized. The alternative to be selected is the one attaining the highest priority value. In this example, the aggregation results in ranking the PDM as follows:

	Final priorities
DBB	0.27
DB	0.39
CM	0.34

In this case, the DB method should be selected.

6. Conclusion

An AHP model was developed to facilitate the owner's need to evaluate and select an appropriate PDM. The model considers the relevant factors in making the decision. These factors effecting choosing an appropriate

Table 3
Pair-wise comparisons with respect to the project characteristics

	Scope	Schedule	Price	Complexity	Priorities
Scope	1	4	5	1/4	0.316
Schedule	1/4	1	2	1/6	0.111
Price	1/5	1/2	1	1/7	0.072
Complexity	4	6	7	1	0.500

Project Characteristics	
Scope	0.316
Schedule	0.111
Complexity	0.072
Price	0.500

Scope		Schedule		Complexity		Price	
Defined	0.833	Normal	0.75	Standard	0.800	LS	0.833
Vague	0.167	Fast	0.25	Complex	0.200	Cost+	0.167

Owner's Needs	
Cnstructibility	0.228
VE	0.077
Packaging	0.646
Feasibility	0.049

Cnstructibility		VE		Packaging		Feasibility	
Required	0.800	Required	0.833	Required	0.857	Required	0.857
Not	0.200	Not	0.167	Not	0.143	Not	0.143

Owner's Preferences	
Responsibility	0.233
Design Control	0.510
IAA	0.257

Responsibility		Design Control		IAA	
Single	0.8	Required	0.857	Light	0.8
C+B	0.2	Not	0.143	Intense	0.2

Legend: PC =Project Characteristics, ON = Owner Needs, OP = Owner Preferences, VE =Value engineering, Packaging =Preparation of Contract packaging, IAA =Involvement after award of contract, C+B =Checks and balances.

Fig. 2. Priority ranks for all elements in the hierarchy.

PDM were determine from literature review. The AHP hierarchy design required setting up the factors in a hierarchy that properly reflects the process of arriving at the goal of selecting a PDM.

The model is simple to use and the computations can be run using available specialized software or using any spreadsheet program. The AHP hierarchy design and evaluation allow the user to readily determine the relative contribution of each of the factors to the final decision. To use the model the user (owner) need to assess the relative weights he/she wishes to assign to each factor. Thus, the decision reflects the owner's needs and preferences.

Acknowledgement

The author would like to express his appreciation for King Fahd University of Petroleum and Minerals for providing various facilities for conducting this research.

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