# FUNCTIONAL PARAMETER BASED PROJECT DELIVERY METHOD SELECTION DECISION MAKING INDEX

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***Abstract:*** **A project delivery method is the thorough process of assigning the contractual responsibilities for designing and constructing a project. The choice of the suitable delivery method is a key decision that has to be made by owners early in the project lifecycle. The objective of this research is to develop a project delivery system decision making index by identifying the factors and key parameters that have to be considered in such a model. From detailed literature review and expert interviews, total 70 factors and key parameters that affect decision making of PDM selection encountered in a construction project were identified and grouped into 12 categories. A questionnaire survey has been done to determine the most important factors by using Relative Important Index (RII) method with 216 respondents from south Gujarat region. After data analysis, Requirement for within-budget completion, Quality of the completed project, Requirement for on-time completion, Contractor's ability, Owner's goals, and Project type found to be most significant factors. In the final phase weighted-matrix delivery decision approach has been used to construct the decision making index. This index is proposed to be very easy for owners to use, while at the same time providing meaningful results that can be used in making a selection of a suitable project delivery method.**

***Keywords:*** **Project delivery methods, Construction management, Key governing factors, RII, Decision making index.**

## INTRODUCTION

The efficient delivery of construction projects is foundation to the success of the construction industry. To increase the prospect of success, owners must choose the appropriate project delivery systems to match their project needs. Most groups agree that there is no perfect project delivery system. Every project is distinctive and has its own unique set of challenges. Therefore, industry consensus is that every project should be considered on a case-by-case basis to determine the most appropriate project delivery method.

A considerable amount of research has been conducted on the appropriateness of various PDSs, mainly on conventional delivery systems like; Design-Bid-Build, Design-Build and Construction Management at Risk; yet very little, if any, has addressed and evaluated emerging systems like Integrated Project Delivery (IPD) in correlation with traditional PDSs for the construction projects. In this paper we have discussed various PDS available to the owners in India and identified various factors that affect the decision making process of selecting an appropriate PDS for construction projects.

## JUSTIFICATION OF THE STUDY

Due to unstable nature of construction industry, Project Delivery System (PDS) becomes the most crucial strategic decision for an owner before starting a new project. PDS is a set of processes that defines risk and contractual responsibilities of the project participants and provides mechanism for executing the design, construction, operation and maintenance activities of the project. It impacts all phases of the project design and construction, therefore, an appropriately selected PDS enhances the owner's ability to efficiently control the construction processes and accrue financial benefits.

## PROJECT DELIVERY METHODS (PDM)

The existing literature categorizes project delivery methods into various groups, however, in this paper PDM categorization is based on the principles of defining responsibilities, risk sharing mechanism and sequencing of activities. For example, some researchers have considered Construction Management (CM) Agency as separate PDS, but CM Agency particularly does not change the basic roles and risk sharing mechanism between the contracting parties. Therefore, we only considered five major PDS classes for this study i.e., Design-Bid- Build, Design-Build, Construction Management at Risk, Design-Build-Operate-Maintenance with inclusion of Integrated Project Delivery as the fifth class due to its unique role, responsibility and risk sharing structure.

### Design-Bid-Build (DBB)

DBB is the most commonly used traditional PDM, in which the owner enters into two separate contracts; first with a design firm that develops design and second with a construction firm that execute the project based on owner's construction contracts. In DBB owner is responsible for design details and assure accuracy of the design. DBB provides check and balance through firm control over the design and construction process, hence minimize risks, which benefits specialized project.

**Design-Build (DB)**

DB is usually considered effective for large scale projects and has experienced significant growth in the recent years. In DB, the owner is under contract with a single entity for the design and construction of a project. The typical characteristics of DB are; single point of responsibility, overlapping of the design and construction, potential for schedule compression, allowance for preconstruction design services, transfer of design responsibility to contractor and commitment of lump sum fixed price at the beginning of the project.

**Construction Management at Risk (CMR)**

CMR uses the philosophy of integrated processes, wherein the owner first selects a design firm to design the project and then separately hire a construction management (CM) firm who initially acts as the project manager at design stage and takes responsibility as general contractor at construction stage. CM firm usually takes the risk of the construction at a Guaranteed Maximum Price (GMP).

**Design-Build-Operate-Maintain (DBOM)**

In DBOM delivery, a contractor performs the role of operator for the facility in addition to the design and construction of the building. The contractor, usually a joint venture between a design-build firm and an operations firm, holds a single contract with the owner. The term for the O&M of the facility is typically 10-15 years. This contracting arrangement varies greatly from DB and DBB as one entity is contracted in place of three separate entities (the designers, the constructors, and the operators and maintainers).

**Table 1.Comparison of performance of common project delivery systems**

| Parameter | DBB | CM-at-Risk | DB |
|---|---|---|---|
| **Cost** | Ranks lower than others due to trend of intentional under bidding due to problems in design. This leads to change orders and thus increase in total cost of the project. | Guaranteed Maximum price ensures higher cost accuracy. | Perform well on cost front. |
| **Schedule** | Stakeholders take the initial decision deadlines less seriously because changes can be made later. | Performs well on schedule as capable of procuring long lead item early in the project. | Most efficient due to possibility of parallel phasing. |
| **Quality** | Quality of projects delivered through this system is usually good due to presence of independent advisors and the expanded design phase. | Most efficient as Independent construction Professional expertise during design phase help meeting or exceeding quality of project. | Performs well as contractors are on also on board during design but they are not Independent which may affect the project quality. |
| **Administrative Burden** | Administratively burdened due to the need for developing multiple bid packages, issuing them, receiving proposals, evaluating them, negotiating the contracts and overseeing its implementation. | Administratively burdened due to multiple contracts. | Less administrative burden due to lesser contracts and lines of Communication. |
| **Coordination and Teamwork** | Fragmented and does not Promote teamwork. | Early involvement of construction Manager improves coordination. | Promotes coordination and teamwork. |

**Integrated Project Delivery (IPD)**

IPD is an emerging PDS, which tends to address these problems by establishing collaborated work practices. It is defined as a delivery approach that integrates project participants, systems, businesses and practices into a structured process that uses the knowledge and wisdom of all participants to enhance project outcomes, increase value for money, reduce waste, and optimize efficiency through all phases of design and construction (AIA, 2007). ). The basic concept is based on a singular, multi-party agreement between the owner, designer and contractor, with shared project objectives, shared risks and shared rewards. In IPD, owners has the benefit of cost, schedule and program certainty at early stage, while designer and contractor mutually gain or lose profit based on achieving project outcomes rather than individual team.

## METHODOLOGY:

A three-stage research methodology was adopted: First, detailed literature survey and interviews with government engineers, consultants, project managers in the Surat & Navsari were conducted to identify factors affecting the selection of project delivery method for construction projects. Second, a questionnaire methodology was adopted to evaluate and rank these factors according to their influence and significance regarding the selection of project delivery methods. The questionnaire survey was conducted in Surat, Navsari and Valsad city of south Gujarat region with govt. engineers, consultants, contractors and Project Managers.

In the final stage, project delivery system selection decision making index was developed to identify most crucial delivery method for particular project according to their generated index. This index is a new and very useful tool for selection of delivery method based on most significant factors.

## FACTORS AFFECTING SELECTION OF PDS

There are various factors that are essential in making right decisions while selecting PDS. I carried out a comprehensive analysis of relevant available literature and interviews to classify and highlight the most important pertinent factors that affect the decision making process (Table 2). The parameters for project delivery method selection are then classified into twelve broad. The enlisted factors in Table 2 cover most of the decision related issues and are configured to act as customizable specifications for owners to evaluate various PDS for their projects.

**Table 2: Project delivery system (PDS) selection factors**

| Main Factors | Sub Factors | Main Factors | Sub Factors |
|---|---|---|---|
| **Owner's characteristic and objectives** | Experience | **Schedule performance** | Ensure shortest schedule |
| | Requirement for on time completion | | Duration of different phases |
| | Financial ability | | Delivery speed |
| | Requirement for low operational cost | | Control time growth |
| | Requirement for low maintenance cost | | Time certainty |
| | Protect confidentiality | **Cost performance** | Project cost |
| | Acceptable degree for change | | |
| | Preference for using its own resources | | Cost of different phases |
| | Trust towards other parties | | Control cost growth |
| | Owner's construction sophistication | | Minimize expenditure rate |
| | Owner's in-house technical capability | | Cost certainty |
| | owner's controlling role | | Facilitate early cost Estimates |
| | Owners goals | **Quality performance** | Construction quality |
| | Risk management approach | | Rework |
| **Project characteristics** | Project type | | Conformance to specs. |
| | Building construction type | | Level of QC and QA |
| | Project size/nature | **Contractor selection** | Best value procurement |
| | Project complexity | | Prequalification |
| | Field conditions | | Design completion |
| | Project technical uncertainty | **Project team characteristics** | Experience of team members |
| | Project ownership type | | Communication |
| | Ease change Incorporation | | Relationships |
| | familiar project conditions | | Decision making |
| | Capitalize on well defined scope | | Teamwork |
| **Administration** | Degree of agency burden | **Regulatory issues** | Competitive bidding |
| | Promote early procurement | | Stakeholder input |
| **Life cycle issues** | Maintenance | | FTA/EPA Regulation |
| | Life cycle cost | | Local laws |
| | Sustainability | | Labor Unions |
| **External environment** | Markets competitiveness | **External environment** | Protect confidentiality |
| | Contractor's availability | | Weather conditions |
| | Materials availability | | Geological conditions |
| | Technology availability | **Other issues** | Construction claims/dispute |
| | Financial market stability | | Adversarial relationships |

## DATA ANALYSIS & RESULTS

The primary data collected from the first part of the questionnaire was analysed from the perspective of total 216 respondents comprise of Consultant, Project manager, Govt. engineer and Contractor. The responses of them were taken for the analysis with the help of Relative Important Index (RII) method. The top ten factors derived from result are shown below in table.

**Table-3 Top 10 factors from RII method**

| Rank | Factors Affecting PDM Selection | RII |
|---|---|---|
| **1** | Requirement for within-budget completion | 0.900 |
| **2** | Quality of the completed project | 0.894 |
| **3** | Requirement for on-time completion | 0.887 |
| **4** | Contractor's ability | 0.883 |
| **5** | Design and construction quality | 0.881 |
| **6** | Owner's goals | 0.878 |
| **7** | Prequalification | 0.854 |
| **8** | Level of QA and QC | 0.845 |
| **9** | Project type | 0.843 |
| **10** | Maintenance | 0.838 |

In this research, ranking of criteria by various groups was checked as per Spearman's rank correlation coefficient. In order to test the relative agreement between the responses from different groups, the ranks of the calculated RII weights corresponding to the factors of project delivery method selection were analysed using the Spearman's rank correlation method. The values of Spearman's rank co-relation coefficient between various groups were between 0.655 to 0.811. This shows that there is very marginal difference in opinion of experts for ranking of criteria and they all exhibit strongly positive correlation.

## GENERATING PROJECT DELIVERY SYSTEM DECISION INDEX

This proposed index is based on Weighted-Matrix Delivery Decision Approach. It provides a means for clients to further examine and document a project delivery decision for an individual project.

- Each parameter/governing factor under consideration is assigned a weight (wi).
- Relative weight (Wi) is computed from the following equation:

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i}$$

- A decision rating scale (di) for each factor is assigned by dividing the selected weightage of respondent in questionnaire by its respective derived /decided values the result multiplied by 100.

$$d_i = \frac{c_i}{s_i} \times 100$$

$$S_{ii} = W_{i \times d_i}$$

$$PDSDI = \sum S_{ii}$$

**Table 4 Sample Tabular Format of Generating Project Delivery System Decision making Index**

| | $w_i$ | $W_i$ | $c_i$ | $s_i$ | $d_i$ | $S_{ii}$ |
|---|---|---|---|---|---|---|
| **Factor 1** | **Weight of each parameter (Varied between 1 to 5)** | **Relative weight (Depends upon wi)** | **Filled by the Respondents (Varied between 0 to 10)** | **Ideal/optimal value of given governing factor ((0+10)/2)=5** | **Quality rating** | **Sub index of $i^{th}$ parameter** |
| **Factor 2** | | | | | | |
| **Factor 3** | | | | | | |
| **Factor 4** | | | | | | |
| **Factor 5** | | | | | | |
| **Factor 6** | | | | | | |
| **Factor 7** | | | | | | |
| **Factor 8** | | | | | | |
| **Factor 9** | | | | | | |
| **Factor 10** | | | | | | |
| | | | | | **Project Delivery System Decision Index** | **$\sum S_{ii}$** |

## CONCLUSION & RECOMMENDATIONS

Project Delivery System (PDS) becomes the most crucial strategic decision for an owner before starting a new project. Effective analysis of appropriateness of any PDS requires the owner's understanding of the pros and cons of various PDSs, PDS selection methods (PDSSM) and other related factors that affect the decision making process. The preliminary study indicates that the listed factors affecting project delivery method selection must be given adequate consideration while taking decision of new projects. Within budget completion, within time completion, design and construction quality, project type, level of QA and QC, contractor's ability, owner's goals and maintenance are most significant factors for project delivery method. So these factors must be taken consideration. Proposed index is validated with the on-going 10 public projects and results are very satisfactory. This model is proposed to be very easy for owners to use, while at the same time providing meaningful results that can be used in making a selection of a suitable project delivery system.

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