# AC 2011-246: A STUDY OF THE FACTORS CONSTRUCTION TIME FOR PROJECTS IN SOUTH INDIA

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# A Study of the Factors Construction Time for Projects in South India


## Abstract

The purpose of this study is to determine the factors of actual construction time for commercial and residential projects in South India. The data for the study was obtained from some leading architectural and engineering companies in India. The sample size consisted of data for 90 completed construction projects in various locations within the region. Analysis of the data was done using a General Linear Model. The results indicated that actual construction cost and methods of project delivery are major factors that can be used to predict actual construction time of such projects in South India.



**Key words**: Indian Construction Industry, Construction Time, Construction Cost, Construction Delivery Methods, International Construction.


## Introduction

### Construction Industry in India

Indian economy has grown significantly in recent years. With a GDP of $1.237 trillion, it is the 5th largest economy in the world[1]. The development of the Indian economy has made an impact on all sectors of the construction industry. The industry value includes the revenues of companies whose primary activity is the construction of residential, commercial, industrial, and roads and highways. Total construction expenditure of the country in 2007 was $175 billion. It is expected to be $370 billion by the end of 2013[2]. Fast growth of the industry is particularly noticeable in South India, which has emerged as an information technology powerhouse. In order to accommodate the multinational companies and their employees, construction boom in both commercial and residential sectors is sweeping the region.

Sustained growth of the construction sector requires a reasonably good prediction of construction time. It is important for both constructors and owners. The unique characteristics of the construction industry in South India have been reviewed in this study to identify the correlates of construction time for commercial projects.

### Time-cost relationship

Time and cost have been typically used as important criteria for determining project performance globally. Project cost has been identified as a correlate of construction time in many regions of the world[3].

A relationship between completed construction cost and the time taken to complete a construction project was first mathematically established by Bromilow et al.[4]. For the updated model, the authors analyzed the time-cost data for construction projects in Australia. The equation describing the mean construction time as a function of project cost was found to be:

$T = K*C^B$ Eqn. (1)

Where

T = duration of construction period from the date of possession of site to substantial completion

C = completed cost of project, adjusted to constant labor and material prices

K = a constant indicating the general level of time performance

B = a constant describing how the time performance is affected by the size of the construction project measured by its cost.

The model indicates that the duration of project time of a construction project is basically a function of its total cost. It provided a basis for all parties concerned with the construction process to establish a fairly accurate probable duration of a project in days, given the estimated cost of the project. The authors also analyzed the overruns on cost and time that provided a measure on the accuracy of the industry's time and cost prediction.

Several other studies have been performed around the world to make similar predictions for either a specific sector of construction or construction industries, in general. Ireland[5] (1986) replicated the study to predict construction time for high-rise buildings in Australia; Kaka & Price[6] (1991) conducted a similar survey both for buildings and road works in the United Kingdom; Kumaraswamy & Chan[7] (1995) investigated the effect of construction cost on time with particular reference to Hong Kong; Chan[8] (1999) did a similar research for Malaysian construction industry; and Choudhury et al. [9] (2002) conducted a study on health sector construction projects in Bangladesh.

Hoffman et al.[10] (2007) used Bromilow's time-cost model to analyze data collected for 856 facility projects. They, however, included certain other variables such as project location, building type, and delivery method in the model.

All these studies found that the mathematical model developed by Bromilow et al.[4] (1980) holds good for prediction of construction time if the cost of construction is known. This present study is an effort to validate the same model for construction industry in South India, particularly with reference to the commercial sector.

**Project Delivery Methods and Construction Time**

Selection of appropriate delivery system can contribute significantly to the success of a project[11]. Therefore the factors considered for the selection play an important role in determining the success and timely completion of the project. It will be worthwhile to examine the effect of this particular variable on construction time for commercial and residential works in South India,

Like most of the regions of the world, there are basically three different types of project delivery methods used both for commercial and residential construction: (1) design-bid-build, (2) design-build, and (3) construction management.

For design-bid-build, the owner employs an architectural-engineering company to design and provide cost estimates, specifications, and bidding documents for a project. The company helps the owner in the bidding process and selection of a contractor. A separate contract is drawn between the owner and the contractor. The AEC may make periodic supervision of the construction works on an advisory capacity but is not responsible for either quality or timely completion of the works.

For construction management, the owner employs a construction manager along with an architect to serve as the general contractor providing pre-construction and construction services. The construction manager provides design phase consultation in evaluating costs, schedule, implications of alternative design systems and materials during design and serves as a single point of responsibility contracting directly with the subcontractors during construction.

For design-build, a single entity is contracted to provide both design and construction. The team consists of contractor, architect and engineer. The firm contracts directly with the subcontractors and is responsible for delivery of the project. Selection is based on the proposal offering the best value to the owner.

**Hypothesis**

This paper attempts to find the factors that affect the actual construction time in residential and commercial construction in South India. After an extensive review of literature and discussion with professionals involved in this field in India, it is hypothesized that the actual construction time of commercial and residential construction is affected by:

- Actual construction cost and
- Project delivery methods.

**Methodology**

**Data Acquisition**

Data for 90 commercial and residential construction projects were obtained from leading architectural, engineering, and construction management companies in South India. The sample projects were undertaken and completed during last five years. All the projects were constructed by different contractors. The data set contained total construction cost, total construction time, and delivery methods for the projects. The data is shown in Table 1.

Table 1: Construction cost, time, and project delivery methods of sample projects

| Project | Time in Months | Cost in Indian Rs. | Project Delivery Method | Project | Time in Months | Cost in Indian Rs. | Project Delivery Method |
|---|---|---|---|---|---|---|---|
| 1 | 15 | 4876801 | CM | 38 | 16 | 5178542 | DB |
| 2 | 9 | 1302766 | CM | 39 | 11 | 4635675 | DB |
| 3 | 36 | 101231949 | CM | 40 | 11 | 4638956 | DB |
| 4 | 38 | 99931949 | CM | 41 | 10 | 1759694 | DB |
| 5 | 12 | 1905014 | CM | 42 | 14 | 1559694 | DB |
| 6 | 12 | 1779238 | CM | 43 | 13 | 1805014 | DB |
| 7 | 20 | 150579238 | CM | 44 | 16 | 1905014 | DB |
| 8 | 15 | 6016402 | CM | 45 | 12 | 2005014 | DB |
| 9 | 15 | 10019062 | CM | 46 | 12 | 1905014 | DB |
| 10 | 12 | 1045494 | CM | 47 | 15 | 3087657 | DB |
| 11 | 9 | 15870935 | CM | 48 | 15 | 2887657 | DB |
| 12 | 13 | 5389698 | CM | 49 | 15 | 2987657 | DB |
| 13 | 60 | 180276078 | CM | 50 | 18 | 3040838 | DB |
| 14 | 12 | 2191288 | CM | 51 | 18 | 3140837 | DB |
| 15 | 18 | 5075827 | CM | 52 | 13 | 3306047 | DB |
| 16 | 26 | 2899358 | CM | 53 | 13 | 3506048 | DB |
| 17 | 15 | 1844174 | CM | 54 | 15 | 4568805 | DB |
| 18 | 17 | 1546174 | CM | 55 | 15 | 4368805 | DB |
| 19 | 17 | 3204286 | CM | 56 | 18 | 16518640 | DB |
| 20 | 16 | 2303638 | CM | 57 | 9 | 1226969 | DB |
| 21 | 20 | 199235879 | CM | 58 | 9 | 1276969 | DB |
| 22 | 22 | 3506048 | CM | 59 | 51 | 470826397 | DB |
| 23 | 12 | 7496899 | CM | 60 | 30 | 1146523320 | DB |
| 24 | 14 | 3204286 | CM | 61 | 84 | 5510934244 | DBB |
| 25 | 18 | 5609656 | CM | 62 | 16 | 32605776 | DBB |
| 26 | 11 | 1202604 | CM | 63 | 60 | 753319501 | DBB |
| 27 | 28 | 7202941 | CM | 64 | 84 | 884028624 | DBB |
| 28 | 20 | 1245494 | CM | 65 | 84 | 768537564 | DBB |
| 29 | 22 | 1045674 | CM | 66 | 36 | 4743305061 | DBB |
| 30 | 9 | 1456494 | CM | 67 | 48 | 8537681 | DBB |
| 31 | 12 | 1483627 | DB | 68 | 30 | 6990062 | DBB |
| 32 | 24 | 6517491 | DB | 69 | 30 | 6990062 | DBB |
| 33 | 17 | 7960481 | DB | 70 | 72 | 8975417 | DBB |
| 34 | 14 | 16971460 | DB | 71 | 30 | 6261936 | DBB |
| 35 | 14 | 12221460 | DB | 72 | 48 | 9065622 | DBB |
| 36 | 14 | 10221460 | DB | 73 | 48 | 8537681 | DBB |
| 37 | 16 | 5088365 | DB | 74 | 38 | 7131271 | DBB |

Table 1: Continued

| Project | Time in Months | Cost in Indian Rs. | Project Delivery Method | Project | Time in Months | Cost in Indian Rs. | Project Delivery Method |
|---|---|---|---|---|---|---|---|
| 75 | 60 | 9156733 | DBB | 83 | 60 | 8975417 | DBB |
| 76 | 48 | 8623486 | DBB | 84 | 26 | 8537681 | DBB |
| 77 | 50 | 8975417 | DBB | 85 | 15 | 1706577 | DBB |
| 78 | 50 | 8537681 | DBB | 86 | 30 | 5722979 | DBB |
| 79 | 27 | 5498578 | DBB | 87 | 31 | 8285355 | DBB |
| 80 | 42 | 8886111 | DBB | 88 | 38 | 4743305061 | DBB |
| 81 | 54 | 8368624 | DBB | 89 | 30 | 17540096 | DBB |
| 82 | 15 | 3992787 | DBB | 90 | 13 | 4780234 | DBB |

Note: CM = Construction Management, DB = Design-Build, and DBB = Design-Bid-Build.

**Variables**

Actual Construction Time (TIME): It is the actual time measured in months for the completion of a project.

Actual Construction Cost (COST): It is the total cost of a construction project in Indian Rupees (1 Indian Rupee = 0.021 USD).

Natural Logarithm of Actual Construction Time (LNTIME): It is the natural logarithmic value of actual construction time. Literature indicates that relationship, if any, between construction time and construction is not usually linear. In order to fit the data in a linear model, it was necessary to use this variable.

Natural Logarithm of Actual Construction Cost (LNCOST): It is the natural logarithmic value of actual construction cost. Literature indicates that relationship, if any, between construction time and construction is not usually linear. In order to fit the data in a linear model, it was necessary to use this variable.

Project Delivery Method (DELIVERY): It is defined as the method utilized for construction of a project. It was also a class variable categorized into three groups: (1) design-bid-build (2) design-build, and (3) construction management at risk. Two dummy variables were created for project delivery method, design-bid-build (DBB) and design-build (DB). Both these dummy variables were operationalized by assigning a value of 1 when the method was adopted, 0 otherwise.

## Results

### Analysis

The time-cost relationship model developed by Bromilow et al.[4] (1980) was extended to include two additional explanatory variables, change order and category. The model was modified as follows:

$$TIME = K*COST^{\beta 1}*DBB^{\beta 2}*DB^{\beta 3} \quad \text{Eqn. (2)}$$

TIME = duration of construction time months, COST = completed cost of the project in Indian Rupees, K = a constant indicating the general level of time performance for a project, CO = the number of change orders, DBB = project delivery method using design-bid-build, DB = project delivery method using design-build, $\beta_1$ = a constant indicating how the time performance is affected by the size of the construction project measured by its cost, and $\beta_2$ = a constant indicating how the time performance is affected by project delivery method using design-bid-build, and $\beta_3$ = a constant indicating how the time performance is affected by project delivery method using design-build.

The data was analyzed using multiple linear regression technique. This technique was perfectly suitable for this study because it describes the relationship between the dependent variable and multiple independent variables. The analysis was done using Statistical Package for the Social Sciences (SPSS) program.

In order to perform multiple linear regression, the model was re-written as follows by transfoming TIME and COST variables into their natural logarithms:

$$LNTIME = \beta_0 \pm \beta_1 LNCOST \pm \beta_2 DBB \pm \beta_3 DB \pm e \quad \text{Eqn. (3)}$$

Where LNTIME = natural logarithmic value of actual construction time; LNCOST = natural logarithmic value of actual construction cost; DBB = project delivery method using design-bid-build; DB = project delivery method using design-build; $\beta_0$ = intercept; $\beta_1$, $\beta_2$, and $\beta_3$ = regression coefficients; and e = error term.

The results of the analysis are shown in Table 2.

Table 1: Multiple Linear Regression Analysis of LNTIME

| Parameters | | Intercept/Regression Coefficient | t-value | p-value |
|---|---|---|---|---|
| Intercept | | 0.856 | 2.561 | 0.012 |
| LNCOST | | 0.134 | 6.448 | <0.0001 |
| DELIVERY | DBB | -0.094 | -0.980 | 0.330 |
| | DB | -0.661 | -6.661 | <0.0001 |
| F-value of the model = 54.54 (p<0.0001) | | Model $R^2$ = 0.64<br>Adjusted $R^2$ = 0.63 | | |

## Interpretations

The F- value of the model used for multiple regression analysis was found to be statistically significant at less than the 0.0001 level. This provides evidence that a relationship exists between actual construction time and the independent variables used in the model. An important aspect of a statistical procedure that derives model from empirical data is to indicate how well the model predicts results. A widely used measure for the predictive efficacy of a model is its coefficient of determination, or $R^2$ value. If there is a perfect relation between the dependent and independent variables $R^2$ is 1. In case of no relationship between the dependent and independent variables, $R^2$ is 0. Predictive efficacy of this particular model was found to be moderately high with an adjusted $R^2$ of 0.63.

Natural logarithmic value of construction cost was correlated to the natural logarithmic value of actual construction time at a very high level of significance with a p-value of less than 0.0001. Project delivery using design-build method also had a statistically significant effect on construction time at less than the 0.0001 level. The results indicate that, at least for the sample projects, construction time was significantly lower when design-build delivery method was used.

By converting the value of the intercept and assigned values of delivery methods to their exponentials (EXP), the model for estimating actual construction time in South India may be expressed as follows:

$$TIME = 2.354*COST^{\beta 1}*EXP(DBB)^{-0.094}*EXP(DB)^{-0.661} \quad \text{Eqn. (4)}$$

While using the equation, the method(s) not adopted for delivery of construction should be removed.

## Conclusions

The results of the study indicate that the project cost and financing methods have a statistically significant effect on actual time of both commercial and residential projects constructed in South India. Many other studies that have been cited in this paper also provide evidence that all other variables remaining constant, there is a relationship between time taken to complete a construction project and its construction cost. It was not, therefore, surprising to find that construction time of projects in South India is affected by actual construction cost.

Delivery methods play an important role in any project in any part of the world. It was, therefore, not surprising to find that it did make a difference in actual construction time of projects. However, further study with more observations is required to explore the effect of this variable.

The model is useful for graduate students in programs that teach international construction. It is also useful for all parties associated with the construction industry to predict the mean time required for the delivery of a project, when the cost of the project is known. It provides an alternative and logical method for estimating construction time, both by bidders and clients, to supplement the prevailing practice of estimation predominantly on individual experience. The

study will hopefully generate enough interest to do further research for deriving models for time-cost relationships of construction projects in other sectors.

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