

COST EFFECTIVE METHODS IN CONSTRUCTION ENGINEERING

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ABSTRACT

The economic impact of construction cost overrun is a possible loss of the economic justification for the project. The financial impact of a cost overrun results in demand for construction investment credits. Therefore reliable estimates of construction cost are an important aspect to the contemporary construction companies especially during the conceptual phase of lifecycle management. In this paper a cost-effective analysis is done using one of the cost effective construction technique called Rat Trap Bond versus Flemish bond and when estimated with CPWD 2012 schedule of rates it is proved that Low cost techniques such as rat trap bond provides better cost effectiveness as compared to conventional Flemish bond construction method.

KEYWORDS

Cost effective construction, Low cost construction methods, Conceptual Phase construction estimation, Construction cost estimating, comparative estimation analysis

1. INTRODUCTION

In the construction projects, cost and time are the main aspects to be considered in the project management. It is a challenging task for the Project managers to evaluate the plan, take corrective actions and constantly measuring progress (Rajguru and Mahatme, 2016). Overcoming the delay of construction, reducing the time and cost will help obtaining the cost effectiveness (Subramani, Lishitha and Kavitha, 2014). The economic impact of a construction cost overrun is the possible loss of the economic justification for the project. The financial impact of a cost overrun results in demand for construction investment credits. Therefore reliable estimates of construction cost and schedules are important aspects to contemporary construction companies (Stasiak-Betlejewska and Potkany, 2015). Effective cost and time management play an important role to achieve project success in the construction industry. Various cost and time management techniques help to control cost and time overrun in the construction industry (Shanmuganathan and Baskar, 2016).

Cost effectiveness studies and research encompasses methods that determine the cost of construction, which could consider the involvement of more competing technologies and interventions too (Young, Kelly and Holloway, 2013).

Cost-effectiveness analysis is a technique to compare strategies intended to produce the same effect. In its most common form, a new strategy is compared with current practice and is given the equation form as follows (Azimi and Welch, 1998):

Cost-Effectiveness ratio = $\frac{(\text{Cost of New strategy} - \text{Cost of current practice})}{(\text{Effect of new strategy} - \text{Effect of current practice})}$

2. CONSTRUCTION COST ESTIMATING

The purpose of estimating is to determine the forecasting costs required to complete a project in accordance with the contract plan and specifications. The estimator can Conceptual estimate as the name suggests are generally made during the initial stages of a project. It helps reveal whether a project is economically feasible. Once the decision has been made then the estimates may be refined into a detailed design phase. It produces and estimates with reasonable accuracy of providing total costs for a given project (Deshpande, 1999).

The conceptual phase is of strategic importance in the project environment (Abdul-Kadir and Price, 1995). The lifecycle of a construction project includes the conceptual phase, planning and design procurement, construction, operation and maintenance (Ozorhon, Abbott and Aouad , 2016). In the conceptual phase, cost estimate with a reasonable accuracy is required within a limited time period. Various estimation methods for the conceptual phase have been proposed earlier such as simple square foot method, regression analysis, probabilistic estimating, new network, case-based reasoning and fuzzy models etc. In this conceptual phase, cost estimators commonly use analogy-based estimating methods, i.e. an estimator selects a similar one from the past projects and adjusts it based on similarities and differences perceived by the estimator, which also depends on the individual experience or perception. A simple square foot or assembly costs method are also preferred by many cost estimators in the conceptual phase. However when historical data is not available it could lead to estimator's bias which would estimate under budget or over budget. Therefore estimators usually desire to have their estimates compared with the actual costs of past similar projects. Then they prepare a list of quantities and costs in the form of cost breakdown structure. For example, a building is decomposed into work elements whereas unit cost of each element can be assessed and the total cost is the sum of the products of the quantities multiplied by their corresponding unit costs (Kim and Seo, 2011).

3. COST EFFECTIVE BUILDING MATERIALS AND TECHNIQUES

Cost effective building materials has taken off by many builders for new home owners. Construction of low cost housing by using the low cost building materials increases the access to building by low income group people. Low cost housing can be achieved by using low cost materials, economical construction technologies and use of alternate methods of building construction, The profit gained from using such methods can decrease the cost of construction make the low cost housing accessible to all. The use of low cost alternate building materials also prevents the rise of construction due to use of scarce building materials. In the proposed research, the project involves the use of conventional building materials and then determines the total cost reduced by using alternative building construction techniques (Singh and Kumar, 2016). Affordable housing is possible mainly by dealing with effective costing and following sustainable building techniques, which helps in reducing the cost of construction without sacrificing the strength durability and performance. For example, a residential building can be divided into two parts viz. structural and non-structural. As the cost of cement takes major part of total building cost, it can be partially replaced by cement with 30%, 40% and 50% for structural elements. When strength tests such as compressive, split test, flexural test have been calculated, the 40% replacement of fly ash gave required strength for single storey building. For non-structural elements, the low cost materials such as concrete frames, hollow concrete blocks etc can be adopted. It can be concluded that the overall cost can be reduced up to 30% using these construction methods as compared to conventional building cost. It is also found that about

26.11% and 22.68% of building cost can be saved with low cost housing technologies as compared to traditional construction methods (Tam, 2011).

Previous research on low cost housing techniques include: Tam et al. (2011) and Sinha, Mihra, Kumar & Saurabh (2020) in passing. However, the following are some of the low cost techniques discussed by Dharma Raja (2009):

(i) Hollow concrete blocks: Empty solid pieces by and large are made of size 40x20x20cm and will cover a volume of around 11 national braced blocks. The cost reserve funds are on three checks prompting to around 23% sparing in cost. (ii) With Soil cement blocks there will be a sparing cost of 28%. (iii) With concrete door and window frames using M20 concrete, it is assessed that the cost diminution for solid casing will be no less than 31%. (iv) Filler slabs when opted for rooftops and middle of the road floors, it lessen the undesirable dead heap material.

Other cost effective construction techniques include, rat trap bond with 20 percent cost reduction, filler slab roofing with 20 percent reduction, brick on edge lintels with 50% cost reduction and precast sunshades with 10 percent reduction of cost.

4. METHODOLOGY, HYPOTHESIS AND ITS TESTING

The primary function of approximate estimating is to produce a forecast of the future project, before the building has been designed in detail and contract particulars prepared. Estimators have the responsibility of the challenging role of basing the most important business decisions when there is still very little information is available.

The first step is the definition of a general work breakdown structure (WBS) able to properly account for and compare the construction costs of the company projects. Though there are several estimations are done as indicated earlier about different low cost techniques applied at different types of building elements, only one case is presented here in this paper. In the academy, acceptable margins range from + or - 10% to + or - 5%, regardless of the level of detail of the projects and despite the information that can be available (Bettini, Longo, Alcoforado and Maia, 2016). According to Halpin (2004), still in the preliminary phases of design, an error up to 10% would be totally acceptable. But for a fully detailed estimate the percentage of error of any estimation will never be less than 5% (Limmer, 1997).

4.1. Hypothesis Declaration

H01= Rat Trap Bond construction techniques is more cost effective than Flemish Bond construction technique.

H02 = Filler Slab construction technique is more cost effective than convention R. C. C slab.

4.2. Hypothesis Testing

4.2.1.Rat Trap Bond Vs. Flemish Bond:

A comparison of two techniques such as rat trap bond and Flemish bond cost estimation is done to show that Rat trap bond provides more cost effective than Flemish bond cost in a tabular format considering one cubic meter volume of brick work.

(i) Brick work of 23 cm thickness in Rat trap bond using 1:6 cement mortars with cut bricks for the super structure (Rat trap bond method).

Table 1. Estimation of Rat Trap bond for 1m³ brick work

Sl. No.	Item	Qty	Unit	Rate	Amount
1.	Bricks	420	No. s	8	3360.00
2.	Sand	0.2	m ³	2777	555.40
3.	Cement	44	Kg	5.94	261.36
4.	Brick Mason	1.5	Nos	471	706.50
5.	Man	0.75	Nos	377	282.75
6.	Woman	0.2	Nos	377	75.40
7.	Scaffolding				6.25
8.	Add 10% of Labor For the super structure				106.47
	Total				5354.13

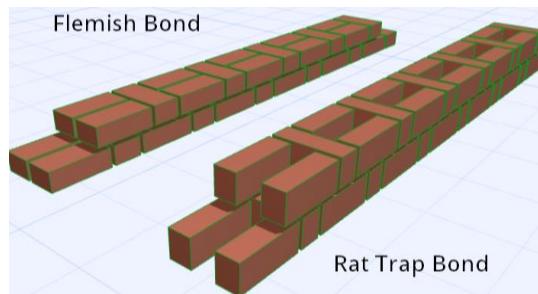


Fig.1: Rat Trap Bond vs. Flemish Bond, (Source: Google Search Image)

ii) Brick work with 23cm thick Flemish bond using 1:6 cement mortars with wire cut bricks for the super structure (conventional method).

Table 2. Estimation of Flemish bond for 1m³ brick work

Sl. No.	Item	Qty	Unit	Rate	Amount
1.	Bricks	460	No. s	8	3680.00
2.	Sand	0.24	m ³	2777	666.48
3.	Cement	58	Kg	5.94	344.52
4.	Brick Mason	0.7	Nos	471	329.70
5.	Man	1	Nos	377	131.95
6.	Woman	1	Nos	377	263.90
7.	Scaffolding				6.25
8.	Add 10% of Labor For the super structure				72.55
	Total				5495.35

The difference in rate comes to 141/m³ (5495-5354). An average of 38m³ of brickwork will be required for a 100m² plinth area of building. For a total of 10000m² of plinth the saving comes to (0.38 x 141 x 10000) = Rs. 5,35,800/-; Where it is seen clearly 5354/ m³ < 5495/m³

Note: The data for the Rat Trap bond is estimated based on the CPWD-Delhi schedule of rates during the year 2021 and the rates of materials and labour are taken from the CPWD-Delhi schedule of rates during the year 2021.

4.2.2.Filler Slab Vs. R. C. C Slab:

People look for attractive houses, more environmental friendly and cheaper but also want more life span and to have roofs over larger space areas (e.g. Halls in houses). Using cost-effective technology not only saves money but also reduce CO₂emissions. When filler slab can be used as an alternative to conventional slab, the cost of construction can reduce up to 25% (Srivastava & Kumar, 2018). The basic principle in a filler slab is that the concrete in the bottom half of the RCC slab is simply considered dead weight and does not take up any compressive loads, but the RCC slab takes up such load. Thus filler in the redundant concrete in tension zone of the slab can be replaced by a suitable lightweight filler material (Sinha, Mishra, Kumar & Saurabh, 2020). Filler slab consists of light weight modest material such as poor quality Mangalore tiles, blocks, coconut shells, glass bottles and so forth. These materials are laid in the steel reinforcement framework (bars of 6mm or 8mm dia.) and cementing is done over them. The Mangalore tiles of size of 23cm x 40 cm and the network size of 33cm x50 cm can be used in the section thickness of 10cm. In specific, RCC filler space of 1:1.5:3 utilizing 20mm broken stone and poor quality Mangalore tiles as filler materials are used.



Fig. 2 Filler (Roof) Slab (Source: Vasista, 2017)

Filler Slab (Roof) Rate Analysis as per CPWD-Delhi Schedule of Rates 2021

Sl. No.	Unit Rate	Item	Qty	Units	Amount
1	8364.20/cum	20mm Metal	0.74	cum	6190
2	1500/cum	Sand	0.37	cum	555
3	6.26/kg	Cement	350	kg	2191
4	784/ day	Mason	1	No.s	784
5	645/day	Man	1	No.s	645
6	645/day	Woman	4	No.s	2580
7	9.5/1 No.	MP Tiles	85	No.s	808
8	48.50/kg	Reinforcement	19.35	kg	939
9	772.1/sqm.	Formwork	10	sqm	7721
10				Total	22413

(Rounded to next Rupee)

Concrete Roof Slab Rate Analysis as per CPWD-Delhi Schedule of Rates 2021

Sl. No.	Unit Rate	Item	Qty	Units	Amount
1	8364.20/cum	20mm Metal	0.9	cum	7528
2	1500/cum	Sand	0.45	cum	675
3	6.26/kg	Cement	432	kg	2191
4	784/ day	Mason	1	No.s	784
5	645/day	Man	1	No.s	645
6	645/day	Woman	4	No.s	2580
7	48.50/kg	Reinforcement	49.77	kg	2414
8	772.1/sqm.	Formwork	10	sqm	7721
9				Total	24538

(Rounded to next Rupee)

The difference in rate comes to $24538 - 22413 = 2125$

As per the estimated records, 12.73 cum of concrete is needed for concrete roof slab for every 100 sqm plinth area of a building. Hence on an average, for a total of 10000sqm of plinth area, the savings comes to $0.1273 \times 2125 \times 10000 = 27,05,125/-$

Reduction in CO₂ emission for a 50 sqm building (Source: Sengupta, 2008)

Sl. No.	Building Materials Required by Conventional Methods	Reduction by using cost effective Construction Technology (Rat-Trap bond, Filler Slab)	Reduction in CO₂ Emission in Kg
1.	Bricks – 20000 No.s	20% i.e. 4000	1440
2.	Cement 60 bags or 3t	20% i.e. 0.6 t	540
3.	Steel – 500 Kg or 0.5 t	25% i.e. 0.125 t	375
Total Reduction in CO ₂ emission		2355 (say 2.4 t)	

5. CONCLUSION

Hence it can be concluded that Rat Trap bond and Filler (Roof) Slab are more cost effective building construction techniques than Flemish bond and Conventional RCC slab construction technique. It means the null hypothesis is accepted

Project managers need to put cost reduction strategies that construction project management imposes in order to achieve success in their projects. A comparative analysis is done on building construction modules through estimation. The cost effectiveness is more evident from comparing low cost house construction techniques with conventional construction techniques.

It is found otherwise that about 22%-26% range of construction cost can be saved using low cost housing techniques as compared to traditional construction methods related to wall and roofing constructions (Tam, 2011).

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