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Construction Cost Estimation Model

Harshil Tyagi

Data Science Engineer, Zupee, Gurugram, Haryana, India

Abstract: The majority of construction businesses today use different models for cost control or material estimation. This estimation is done before the construction begins while the cost control is done during the later period. Therefore, the different options available for cost estimation as well as material estimation may complicate the process. Overestimating and underestimating can also have adverse effects. This application aims to integrate and simplify solutions to all these problems into a single application.

This project aims to develop software that calculates cost and materials used based on blueprints or models of the building; input constraints include the building dimensions or pre-loaded layouts in a library. The project will provide suffice model for estimation for commercial as well as domestic purpose. Considering continuous construction and improvements which are frequent in developing countries like India, the model's application tends to be useful for apartments, malls, condos, houses, studios, shopping complexes and workshops.

Keywords: Construction estimate, raw material cost, building cost, Java.

I. INTRODUCTION

An estimate of construction expenses is a method of forecasting a project's likely costs. Many factors influence project costs, and each factor must be examined, measured, and priced. Contractors must submit a competitive cost estimate for projects built using the design-bid-build (DBB) delivery system. Construction bidding is fiercely competitive, with numerous business contesting for a single project. On a specific pool of jobs, a contractor must be the lowest-qualified bidder while keeping a reasonable profit margin.

The successful estimation of the ultimate cost of a project requires the integration of many variables. These variables can be categorized into either direct field costs or indirect field costs. The indirect field costs are also referred to as general conditions or project overhead costs in building construction. The direct field costs are the material, labour, equipment, or subcontracted items that are permanently and physically integrated into the building. The complexity of an estimate requires organization, estimator's best judgment, complete specialty contractors' (subcontractors') bids, accurate quantity take-offs, and accurate records of completed projects.

Effective cost planning relates the design of construction projects to their cost, so that while taking full account of quality, risks, likely scope changes, utility and appearance, the cost of a project is planned to be within the economic limit of expenditure. This stage in a project life-cycle is particularly crucial as decisions made during the early stages of the development process carry more far-reaching economic consequences than the relatively limited decisions which can be made later in the process. This initial process may also influence the client's decision on whether or not to progress with the project. The cost planning process leads to the generation of a reliable initial project budget that sets up a cost control system to ensure that client's expectations are met. For many clients, completing the project within this initial budget is a paramount determinant of client satisfaction.

II. LITRATURE SURVEY

The contribution of the IT sector to India's GDP stood at 7.7 % in 2016, while the construction industry has contributed an estimated $ 308 billion to the national GDP in 2011-12 (a share of around 19%). In 2014, Steel was the primary culprit for increased construction supply costs. The largest factor influencing this was China's burgeoning economy, which has driven phenomenal growth in their construction and manufacturing needs. China's demand for steel in 2004 increased by 38 million tons; which was equivalent to the total annual steel usage of Mexico and Canada combined. This massive increase in demand, coupled with reduced supplies of raw materials and a weaker American dollar, drove the price for steel up 66% in one six -month period in 2014 and made cost estimating for a wide range of construction projects an ineluctable task. Failing to prepare a reliable cost estimate can have disastrous results. One notorious example was of the Marble Hill nuclear power plant in Indiana. The owner abandoned construction in 1984, seven years after it began. The Public Service Company of Indiana had completed the project only halfway and spent $2.5 billion due to cost overruns.

The practice of construction cost estimating answers those questions. Its origins date back to the 18th century with British quantity surveyors. Since then, estimation techniques have grown considerably in sophistication and complexity. Over past 40 years in construction, one of the best improvements to estimating is the development of construction

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estimating software programs. Understanding cost estimation requires you to have a basic grasp of the construction process. The nine phases a building project undergoes are:

1. **Commissioning a Project**: Commissioning is essentially a verification process that ensures a builder designs, constructs, and delivers a project according to the owner's requirements. It begins early in the construction process and can last until up to a year of occupancy or use.
2. **Determining Requirements**: The first real step in constructing a project is a pre-design phase or planning phase. The pre-design phase involves defining a project's requirements: what its function(s) will be, how much it should cost, where it will be located, and any legal requirements it must comply with.
3. **Forming a Design Team**: An architect is contacted who will then select other specialized consultants to form a design team. Meeting specific design requirements are required by complex projects such as acoustics or housing hazardous materials tend to have more specialized consultants on board to facilitate the design requirements.
4. **Designing the Structure**: A series of designs are created by the architect in this step. Initially, the architect works in conjunction with the ideas of owner to formalize the design and then progressively works closely with the other members of the design team to carve out the structure's design. Designing thus progresses from a schematic design phase. When the architect works with the design consultants to decide on specifics of the construction design a high-level design is presented to the owner for approval.
5. **Bidding Based on the Scope of Work**: Once the construction documents are finalized, they are released to contractors who wish to bid on the project. Along with these bidding documents, they include instructions on how to submit bids, a sample of the contract agreement, and financial and technical requirements for contractors. These documents, which effectively define the scope of the work, are the basis on which contractors prepare their estimates.
6. **Signing the Contract**: This step encompasses the execution of a set of contract documents with the owner. These contracts can follow a number of models, depending on how complete the construction design is and how the owner and contractor bear risks.
7. **Construction**: During the construction phase, the contractor oversees building in accordance with the construction documents. This is the step where profit margin is ensured using cost-control techniques.
8. **Close-Out**: When the builder comes close to finishing a structure, the contractor requests the architect to perform a substantial completion inspection in which the architect verifies the near-complete status of the project.
9. **Completion**: For the final step, a final inspection is performed by the architect. As the structure gets completed according to construction drawings and specifications, the architect will issue a certificate of final completion.

III. REQUIREMENT ANALYSIS

Estimates and techniques

The process of finding an approximation is called estimation, which is a value that is usable for some purpose even if input data may be incomplete, uncertain, or unstable. A cost estimate can not be accurate without a well-defined project plan, it's standard practice to create multiple estimates during the designing phases. This become vividly accurate as the project's level of definition increases. The American Society of Professional Estimators classifies estimates according to a five-level system that becomes increasingly more detailed and reliable. The five levels are:

- Level 1: Order of Magnitude Estimate: Made when project design has not yet gotten under way, you only use an order of magnitude estimate to determine the overall feasibility of a construction.
- Level 2: Schematic Design Estimate: An estimate produced in line with schematic design.
- Level 3: Design Development Estimate: An estimate made during the design development phase.
- Level 4: Construction Document Estimate: An estimate based on the construction drawings and specifications.
- Level 5: Bid Estimate: An estimate prepared by the contractor, based on construction documents. The bid estimate is the basis of the bid price offered to the customer.

Design Estimates

These estimates are prepared during a project's pre-design and design phases. Starting with an order of magnitude estimate, or screening estimate, which are responsible for determining most feasible construction methods and types. Next comes the preliminary estimate, or conceptual estimate, which you base on the schematic design. Following with, detailed estimate or definitive estimate which is based on design development.

Bid Estimates: Contractors prepare bid estimates when bidding to construct the project. Contractors will draw from a number of data points to prepare their estimates, including direct costs, supervision costs, subcontractor quotes, and quantity take-offs.

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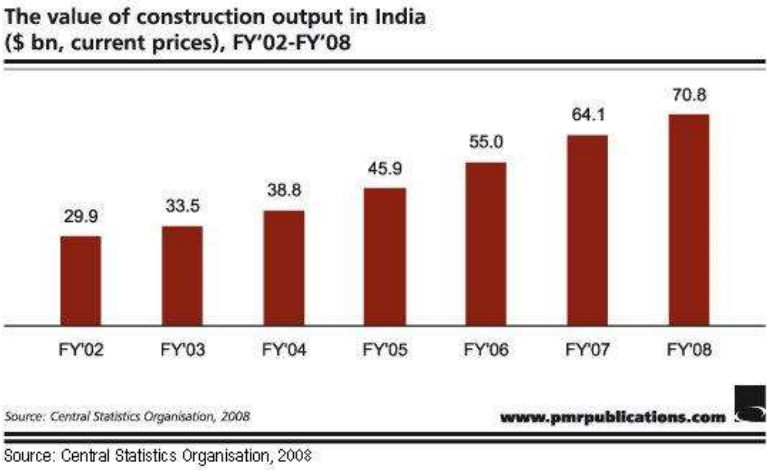
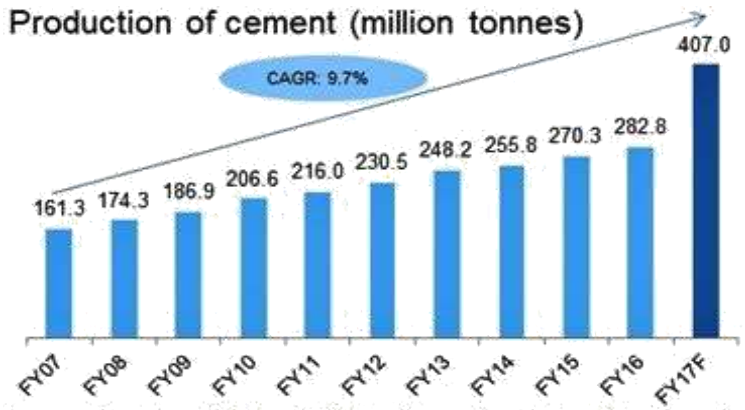
Control Estimates

Prepared after the contractor agreement is signed and before construction gets under way, the control estimate functions as a baseline by which you assess and control actual construction costs. The control estimate also allows contractors to plan ahead to meet upcoming costs and determine the project's cost to completion. Statistics on Indian raw material costs and development is shown using graphs and tables below:



Source: Central Statistics Organisation, 2008

Fig 1: The value of construction output in India



Source: Department of Industrial Policy & Promotion, Office of the Economic Advisor, TechSci Research, F - Forecast, CAGR – Compound Annual Growth Rate

Fig 2: Production of cement

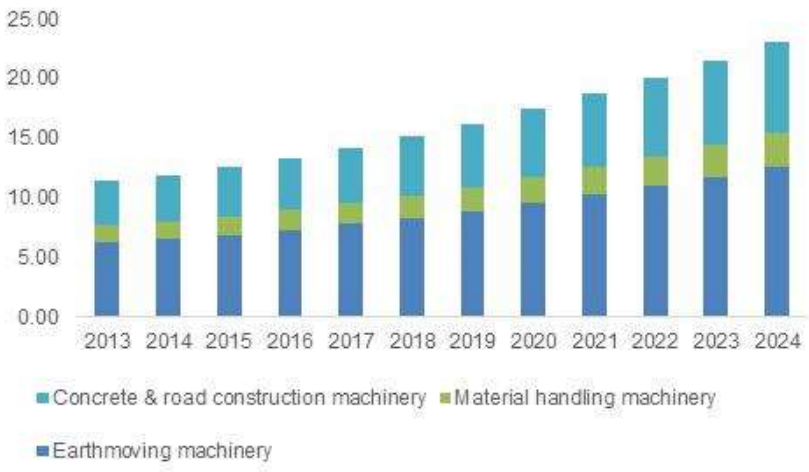


Fig 3: Machinery Used

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Fig 4: No. of Construction Units Sold

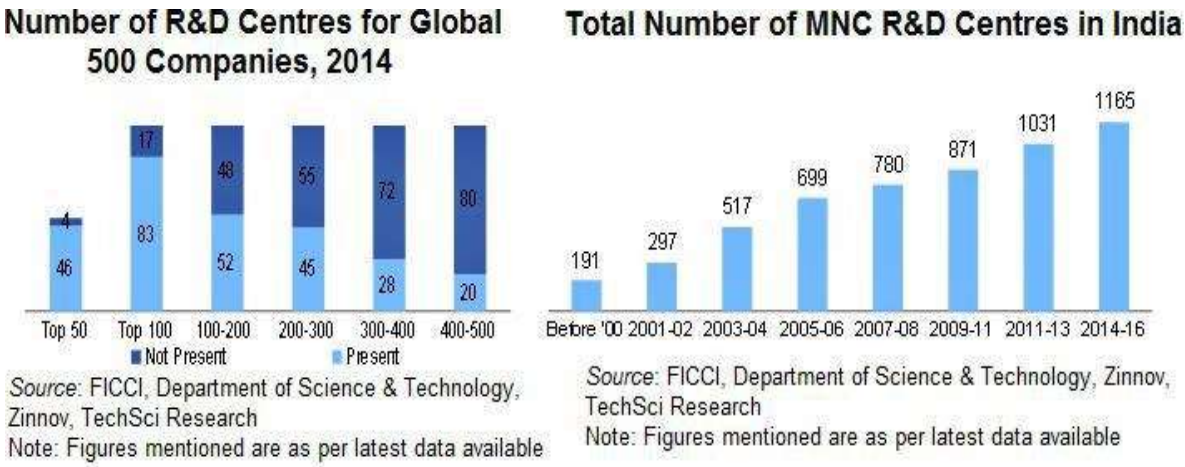

Fig 5: No. of R&D Centre for Companies.

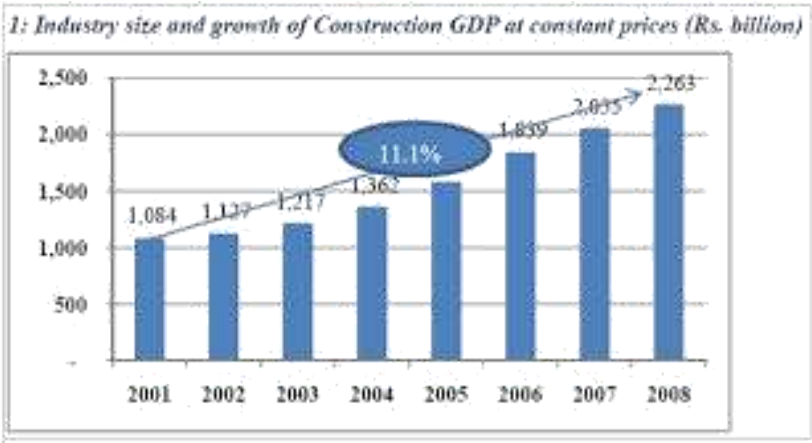

Fig 6: Industry size and growth of Construction GDP

Market Prices Of Some Materials

Formulae Used

- Concrete: Width x Length x Height, divided by 27 = number of yards of concrete needed
- Foundation Masonry Block: 8" high / 16" long / 3/8" mortar normal joint height.
- Roofing: Width x length, divided by 100 = number of squares of shingles needed
- Siding: Width x Height, divided by 100 Square Feet = number of squares of siding needed

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- Carpet: Width of room x length of room, divided by 9 = number of square feet needed for room.
- Wood Siding: Width of board minus distance of lapping = coverage of wood siding per board. The width of area to be sided x height of area to be sided, divided by coverage calculated above = lineal feet of siding you need.
- Brick: bricks = one square feet of coverage. The width of area to be covered x height of area to be covered, divided by 7 = number of bricks needed.
- Elevation_Conversion: Elevation measured in 10ths per foot. 1 of elevation = one foot or 12" equals one foot. Normal measurement 12 inches per foot.
- Convert_Elevation_to_Inches: One Foot of Elevation measurement equals 1.2 inches of normal measurements.
- Board feet = (thickness (in inches) x width (in inches) x length (in inches)) divided by 12 Lineal feet = length only of board.

Brickwork Basics

Cement mortar ratio should be 1:6 for 9" Brickwork and 1:4 41/2" brickwork
Mortar thickness should not be more than 10 mm between the courses and sides of the bricks
Ensure you are using good quality of cement and sand. (Silt Content Test)
Ensure you have all the Civil tools required for the construction.

Brickwork Calculation and Formula

The size of the modular brick is 190 X 90 X 90 (refer the picture)
Mortar Thickness is 10mm
Assume required brickwork volume is 1 cubic meter (m3)
Any brick walls consist of bricks and cement mortar. Calculating the volume of bricks with mortar thickness and then volume of bricks alone.
Volume of 1 brick with mortar = 200 X 100 X 100 (10 mm mortar thickness on all sides) = 0.2 X 0.1 X 0.1
Volume of brick with mortar = 0.002 Cum (m3)
Therefore, Number of bricks required for 1 cubic meter = 1/0.002 = 500 No.s Volume of bricks without mortar
Volume of 1 brick without mortar = 190 X 90 X 90=0.19 X 0.09 X 0.09
Volume of 1 brick without mortar = 0.001539 Cum (m3) Volume of 500 bricks without mortar = 500 X 0.001539 Cum
Volume of bricks without mortar for 1 cum = 0.7695 Cum (m3)
Therefore, Required amount of cement mortar = 1 Cum – Volume of bricks without mortar = 1-0.7695
Required amount of cement mortar = 0.2305 Cum (m3) (Wet Condition)

Note – The above volume is in a wet condition that means we need 0.2305 cement mortar in mixed condition (after adding water). In order to find the dry volume, we need to multiply 33 % as bulkage of sand.

Dry volume of a mortar = 0.2305 cum X 1.33 = 0.306565 cum
We know the mortar ratio is 1:6 (1 part Cement & 6 Part Sand = 7 Part) Required amount Cement quantity in brickwork = 0.306565 X 1/7 X 1440 kg

Cement Calculation and Formulae

Density of cement = 1440 kg. The reason to multiply this density is, the above multiplication will give us only required amount of cement quantity in brickwork as a cubic meter. But we need cement in Kg. Therefore we are multiplying the 1440 kg density of cement to calculate the cement quantity.
Required amount Cement quantity = 63 Kg = 1.26 bags (50 Kg bag)
Required amount of Sand = 0.306565 X 6/7 = 0.26277 Cubic meter (m3)
Therefore, For 1 cum of brickwork, we need

- 500 Numbers of bricks
- 63 kg of cement
- 0.263 m3 of sand.

V. CONCLUSION

This study is aimed at developing a technique for estimating the cost of building projects in India, through developing an application which would help the contracting parties to the construction project to assess the cost involved at the initial stage with the limited information that is available. Demand for new infrastructure is increasing at a healthy but not exorbitant rate, indicating that construction costs will remain constant. Unfortunately, this isn't the case. External influences have resulted in massive inflation for a variety of essential building supplies, raw materials, and services. This reality has made long-term cost forecasts more important and complicated than they've ever been. Most of the infrastructure development sectors moved forward, but not to the required extent of increasing growth rate up to the

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tune of 8 to 10 per cent. With the present emphasis on creating physical infrastructure, massive investment is planned in this sector.

Some other factors that affect the project cost include whether a government or quasi-governmental agency commissions or funds the project, a circumstance which may require additional paperwork and reporting. Some large projects require the completion of a value-engineering review before bidding commences. Value engineering, which examines the function-to-cost ratio of a project, aims at making the design as cost efficient as possible. Finally, all cost estimates add at least a tenth, and sometimes closer to a fifth, of the construction total to account for contingencies. Contingencies are allowances held in reserve for unexpected costs. Construction cost estimating continues to evolve as design, building methods, and materials change.

Some trends that impact cost estimating today which require further research and development can be Building Information Modeling (BIM): A building information model is a digital model of a structure and all its characteristics and dimensions. From the design to the construction, commissioning, and maintenance of a building, all participants can use the model. As such, there's an increasing demand for cost estimating to become an aspect of BIM, though this opinion has not been without challenges. The main criticism of cost estimating in BIM is that cost estimators, with some justification, have less confidence in the level of detail of BIM designs. That lack of specificity can lead to substantial inefficiencies and reworking of estimates.

Apart from that, changes sustaining to introduction of completely new architectural designs or a innovative materials cannot be undermined. Since cost of equipment and materials change on a regular basis. Cost estimating database should be updated automatically from remote resources such as suppliers websites. This would help save time by not having to update individual entries in the cost estimating database. Introduction of GST in Indian markets is a perfect example of the scenario where major cost estimation reform for the model might be required.

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BIOGRAPHY

Harshil Tyagi, B. Tech in Computer Science and Engineering (2015-2019) from SRM Institute of Science and Technology, Chennai, India. Currently working as Data Science Engineer, Zupee, Gurugram, Haryana, India.

