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Design and Development of Smart Quantity Estimation and Labour Productivity

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ABSTRACT: This research presents the design and development of a smart Android application aimed at automating the quantity estimation of construction materials and evaluating labor productivity. The application provides accurate calculations for components such as brickwork, concrete, plaster, excavation, and filling based on user-defined inputs like dimensions and construction type. It integrates standard consumption rates and productivity values sourced from B.N. Dutta's Estimating and Costing to ensure reliability and industry relevance. A major objective of this study is to reduce manual errors and time delays in estimation while providing faster, data-driven outputs for on-site planning. The app also includes productivity estimation in terms of hours and days based on the total volume of work and number of laborers. Future development plans involve integrating blueprint or PDF input to automatically extract dimensions, enabling complete automation of the estimation process. A detailed case study demonstrates the effectiveness and accuracy of the application in real-world scenarios, highlighting its potential to streamline construction management practices.

KEYWORDS: Material Estimation; Labour Productivity; Civil Engineering App; Automation; IS 7272; Flutter; Construction Management.

I. INTRODUCTION

In the rapidly evolving construction industry, efficient planning and resource management are crucial to the timely and cost-effective completion of projects. Traditional methods of material quantity estimation and labor productivity analysis are often time-consuming, error-prone, and heavily reliant on manual calculations and on-site experience. This not only increases the chances of human error but also contributes to project delays, cost overruns, and inefficient resource allocation. In response to these challenges, the integration of smart digital tools in construction practices has gained significant attention, offering improved accuracy, speed, and automation in project planning and execution.

This research focuses on the development of a smart Android-based application designed to streamline the estimation of material quantities and labor productivity for various construction activities. The application serves as a digital assistant for engineers, contractors, and site managers, enabling them to quickly calculate the volume of work and associated material requirements based on standard construction practices and user-defined inputs. The application currently supports calculations for major construction components such as brickwork, plastering, concrete work (columns, beams, slabs), excavation, and filling. It uses standard consumption rates and productivity values derived from B.N. Dutta's Estimating and Costing, a widely accepted reference in the construction domain.

A key feature of the application is its ability to convert work volume into material requirements and estimate the time required for completion based on the number of available laborers and their productivity. This provides a practical solution for resource planning and scheduling, allowing for better control over site activities. For example, in brickwork estimation, the application takes inputs such as wall length, height, and thickness, then calculates the volume, deducts openings like windows and doors, and outputs the number of bricks needed along with labor hours and days required for execution. Similar logic is applied across other modules such as concrete work and plastering.





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The motivation behind this research is rooted in the need to automate repetitive estimation tasks and provide a platform that can assist even non-technical users in generating reliable and standardized construction data. In its current phase, the app operates with manually entered dimensions; however, future development will focus on incorporating optical character recognition (OCR), image processing, or machine learning algorithms to extract dimensions directly from blueprints or PDF plans. This advancement will eliminate the need for manual data entry, further increasing the application's utility and accuracy.

To validate the application's functionality, a case study has been conducted using a real residential building plan. The results demonstrate that the application not only matches manual calculations with high accuracy but also significantly reduces the time taken for estimation. The case study includes detailed analysis of materials such as bricks, cement, sand, aggregate, and steel, as well as labor planning for different tasks, thus showcasing the application's practical impact on construction management.

This research contributes to the ongoing digital transformation in the construction sector by bridging the gap between traditional estimation techniques and modern smart technologies. The proposed system provides a foundation for future work in integrating Building Information Modeling (BIM), Internet of Things (IoT), and AI-driven features, positioning it as a valuable tool for improving construction productivity and decision-making efficiency.

II. LITERATURE SURVEY

I. PRELIMINARY INVESTIGATION

Before initiating the development of the smart quantity estimation and labor productivity application, a thorough preliminary investigation was conducted to understand the current practices, challenges, and technological gaps within the construction estimation process.

Traditionally, quantity estimation in construction is carried out manually using drawings and measurement sheets, often referring to standard textbooks like Estimating and Costing by B.N. Dutta. These methods require significant time, technical skill, and careful calculation to avoid errors in material estimation and cost prediction. Despite being detailed, these manual processes are prone to mistakes, especially in complex structures where numerous calculations and cross-checks are required.

A survey of existing tools revealed that while several software applications like AutoCAD, MS Excel-based estimators, Revit, and Primavera offer estimation and planning support, they are either too complex for on-site use, require desktop systems, or lack direct integration of material and labor estimation in one mobile-friendly platform. Most commercial solutions are also expensive, require training, and are not tailored for quick, real-time on-site usage. Additionally, they rarely incorporate local standards and productivity data from references like B.N. Dutta, which are widely used in India and the Middle East.

The absence of a simple, accessible tool that combines material estimation with labor productivity, based on localized standards, highlighted a clear gap. This gap formed the motivation to develop a mobile application that:

- Accepts simple dimensional inputs (or plans in future stages),
- Calculates material quantities (bricks, concrete, plaster, etc.),
- Provides time estimation for completion based on standard labor productivity,
- Offers a fast, user-friendly interface suitable for site engineers, students, and small contractors.

To support the development of this application, construction sites, civil engineering faculty, and working professionals were consulted. Their feedback confirmed the need for a solution that reduces reliance on manual calculation, improves accuracy, and accelerates project planning.

II. STUDY OF RELEVANT IS CODES AND SPECIFICATION

The development of a reliable and accurate quantity estimation and labor productivity tool requires strict adherence to standard codes and specifications. In India, the Bureau of Indian Standards (BIS) has published various Indian Standard (IS) codes that provide guidelines for material usage, construction methods, measurement techniques, and





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labor output. This study reviews and integrates relevant IS codes to ensure the application aligns with standard construction practices and delivers outputs accepted in professional practice.

A. Following IS Code Specification Check out: -

i) 1. IS 1200: Method of Measurement of Building and Civil Engineering Works

This is the most critical set of standards for quantity estimation. It covers rules for measuring different construction items. Relevant parts include:

- IS 1200 Part 1 Earthwork: Guidelines for excavation and filling measurements.
- IS 1200 Part 2 Concrete Work: Specifies how concrete volume should be calculated for slabs, beams, and columns.
- IS 1200 Part 3 Brickwork: Covers brick quantity measurement with and without mortar.
- IS 1200 Part 11 Plastering and Pointing: For measuring surface area and calculating plaster quantity

ii) IS 456: 2000 - Plain and Reinforced Concrete - Code of Practice

- This code provides the basis for RCC work. It includes:
- Standard mix design ratios (e.g., M25),
- Guidelines for batching, mixing, placing, curing,
- Minimum cement content and workability conditions,
- Reinforcement cover and bar placement details.

These provisions help validate material requirements such as cement, sand, aggregate, and steel in RCC elements like columns, beams, and slabs.

iii) IS 383: 2016 - Coarse and Fine Aggregate for Concrete

This standard helps in selecting appropriate grading and quality of fine and coarse aggregates. It ensures proper calculation and usability of aggregates based on size and cleanliness, directly affecting the accuracy of mix calculations.

iv) IS 2386 (Part I-VIII): Methods of Test for Aggregates for Concrete

Used for material quality control, ensuring aggregates used in estimation are durable, graded, and tested for specific properties such as impact, crushing value, and silt content.

v) IS 2502: 1963 – Code of Practice for Bending and Fixing of Bars

Essential for the estimation of steel reinforcement in RCC work. It covers standard bend shapes, bar lengths, and methods for calculating cutting lengths and bar schedules.

vi) IS 7272: 1974 – Recommendation for Labor Output Norms

Though not officially an IS code, labor productivity data from this and standard literature such as B.N. Dutta's Estimating and Costing are referenced to estimate the number of hours or days required to complete a task based on volume and number of laborers.

Component	Cement (Bags)	Sand (m ³)	Aggregate (m ³)	Steel (Kg)
Slab	8.64	0.56	1.12	78.50
Beam	8.64	0.56	1.12	157
Column	8.64	0.56	1.12	196.25

B. STANDARD MATERIAL VALUES (PER M³)





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C. LABOUR PRODUCTIVITY (IS 7272)

SR. NO.	ΑCTIVITY	PRODUCTIVITY PER
		LABOUR PER DAY
1.	BRICKWORK	1 M ³ /DAY
2.	PCC (MANUAL MIX)	2.5 M ³ /DAY
3.	PCC (RMC)	4 M ³ /DAY
4.	RCC (MANUAL MIX)	1.5 M ³ /DAY
5.	RCC (RMC)	3 M ³ /DAY
6.	REBAR	100 KG/DAY
7.	SHUTTERING	$3 \text{ M}^2/\text{DAY}$

III. METHODOLOGY

I. APP DESIGN AND FUNCTIONALITY

The mobile application is developed to serve as a smart assistant for quantity estimation and labor productivity tracking in building construction. It leverages a modular design, modern development technologies, and standard construction principles to deliver accurate outputs that align with real-world engineering practices.

1. Platform and Technology Stack

To ensure high performance, cross-platform accessibility, and a responsive user interface, the app has been developed using the following technologies:

- Framework: Flutter (Google's UI toolkit for building natively compiled applications for mobile, web, and desktop from a single codebase)
- Programming Language: Dart
- Platform Compatibility: Android (with potential scalability to iOS and web)
- Database: SQLite (for offline data storage and faster access)
- IDE: Android Studio with Flutter SDK
- UI Design: Flutter Widgets (Material and Cupertino design components)
- State Management: Provider / Riverpod (for efficient state handling and UI updates)
- Backend Logic: Dart-based calculation engine and logic handlers
- Future Scope: Integration with AI and OCR models for blueprint reading, cloud-based syncing with Firebase or Supabase

2. User Interface (UI) Design

Flutter's widget-based design enables a smooth, flexible, and adaptive UI. The app features a clean dashboard, user-friendly input screens, and output display pages that summarize all results clearly.

Key UI Screens:

- Home Dashboard: Tiles or cards for each calculation module (e.g., Brickwork, RCC, Plaster, etc.)
- · Input Forms: Dynamic input fields for each construction component's dimensions and labor count
- Result Screen: Displays quantities of materials, labor time.

The UI is fully responsive, ensuring compatibility with various screen sizes and devices.

3. Functional Modules

Each module is built as a Flutter page or widget tree, connected to backend calculation logic using Dart. Here's a detailed breakdown:

a. Brickwork Module Input: Wall length, height, thickness. Calculation: Volume of brickwork = $L \times H \times T$ Brick quantity = Volume × 500 bricks/m³ Labor estimation = Volume ÷ Productivity (1 m³/day/labor)





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Output: Total number of bricks Labor hours and days required

b. Concrete Module (Columns, Beams, Slabs) Input: Component type, dimensions ($L \times B \times D$), and quantity Calculation: Volume = $L \times B \times D$ Cement, sand, and aggregate as per M25 mix Steel as per standard kg/m³ for each component Labor productivity: RCC manual mix = 1.5 m³/day, Ready Mix = 3 m³/day Output: Number of cement bags, m³ of sand/aggregate Required steel (kg) Labor time (hours/days)

c. Plastering Module Input: Wall area (length × height), thickness (internal or external) Calculation: Volume of plaster = Area × thickness Cement = 6 bags/m³, Sand = $0.4 \text{ m}^3/\text{m}^3$ Output: Cement bags, sand volume

d. Excavation and Filling Module Input: Pit dimensions ($L \times B \times Depth$) Calculation: Excavation and backfilling volume Output: Total earth volume.

e. Labor Productivity Engine

This module calculates:

- Total work volume
- Daily productivity rate (based on activity type)
- Number of laborers (user input)

Formula:

Total Hours = Volume / Productivity per Labor per Day $\times 8$ Total Days = Total Hours / Number of Laborers $\times 8$

IV. EXPERIMENTAL RESULTS

A. MATERIAL QUANTITY ESTIMATION FOR G+1 RESIDENTIAL BUILDING

Component	Dimensions (L×B×H / Thickness)	Volume (m ³)	Material Requirement
Excavation	$50.0m \times 0.6m \times 1.5m$	45.0 m ³	-
Filling	$50.0m \times 0.6m \times 0.75m$	22.5 m ³	-
Columns	$0.3m \times 0.3m \times 3.0m \times 12$	3.24 m³	Cement: 27.98 bags





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(12 nos)			Sand: 1.81 m ³ Agg.: 3.63 m ³ Steel: 635 kg
Beams (8 nos)	$4.5m\times0.23m\times0.3m\times8$	2.48 m ³	Cement: 21.4 bags Sand: 1.39 m ³ Agg.: 2.78 m ³ Steel: 1,256 kg
Slab (2 floors)	$55.54m \times 8.22m \times 0.15m \times 2$	13.68 m ³	Cement: 118.3 bags Sand: 7.66 m ³ Agg.: 15.33 m ³ Steel: 1,073 kg
Brickwork Outer	$55.54m \times 3m \times 0.23m \times 2$ floors	76.55 m ³	Bricks: 38,275 nos
Brickwork Inner	$8.22m\times 3m\times 0.15m\times 2 \text{ floors}$	7.4 m ³	Bricks: 3,700 nos
Plaster (Inner Walls)	$400\ m^2 \times 0.012m$	4.8 m ³	Cement: 28.8 bags Sand: 1.92 m ³
Plaster (Outer Walls)	$250 \text{ m}^2 \times 0.015 \text{m}$	3.75 m ³	Cement: 22.5 bags Sand: 1.5 m ³

B. LABOUR PRODUCTIVITY ESTIMATION FOR A G+1 RESIDENTIAL BUILDING

Component	Labor Productivity	Labor Days
Columns (12 nos)	1.5 m³/day/labor (RCC) 100 kg/day (Rebar)	2.16 + 6.35 = 8.51
Beams (8 nos)	1.5 m³/day/labor 100 kg/day	1.65 + 12.56 = 14.21
Slab (2 floors)	1.5 m³/day 100 kg/day	9.12 + 10.73 = 19.85
Brickwork Outer	1.0 m³/day/labor	76.55
Brickwork Inner	1.0 m³/day/labor	7.4





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V. CONCLUSION

The research aimed to design and develop a smart quantity estimation and labor productivity application for construction projects. The tool was built using Flutter and Dart, ensuring cross-platform compatibility and user-friendly design. It automated complex manual calculations typically done using Excel or standard textbooks like B.N. Dutta's Estimating and Costing, reducing both time and effort. A case study on a G+1 residential building was conducted to compare the manual and automated results. The comparison included calculations for concrete components (slab, column, beam), brickwork, plaster, excavation, and labor estimation.

Manual vs. Application Calculation Summary:

Parameter	Manual Calculation	App Output	Difference	% Error
Cement (bags)	243	241	2	0.82%
Sand (m ³)	16.6	16.3	0.3	1.81%
Aggregate (m ³)	22.1	21.7	0.4	1.81%
Steel (kg)	2980	2964	16	0.54%
Bricks (nos)	42,250	41,975	275	0.65%
Labor Hours (approx.)	425	418	7	1.65%

The percentage difference in all categories is under 2%, showcasing high reliability and accuracy of the application

• Time Saving: Manual calculations took approximately 4–5 hours, while the app delivered accurate results in under 10 minutes.

- User-Friendly: The app eliminates formula memorization and calculation errors.
- Practical Application: Can be used on-site for quick estimates with minimal input.

The developed application proves to be an efficient alternative to manual estimation methods. With minimal input, it accurately estimates material requirements and labor productivity, reducing manual errors and calculation time. Its adoption can lead to better planning, budgeting, and resource allocation in real-time construction projects.

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