

**VISVESVARAYA TECHNOLOGICAL UNIVERSITY**  
“JNANA SANGAMA”, BELAGAVI-590018, KARNATAKA



**MINI PROJECT(BCS586)**

SYNOPSIS

ON

**“AI-Driven Sustainable Material Selection and Waste Optimization in Construction”**

Submitted in the partial fulfilment for the award of degree

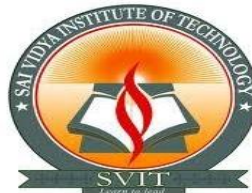
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# **AI-Driven Sustainable Material Selection and Waste Optimization in Construction**

## **1. Introduction:**

### **1.1 Background**

The construction and design industries are among the largest consumers of raw materials globally, accounting for nearly 50% of resource use and generating significant waste. Traditional material selection prioritizes cost and performance but often overlooks sustainability factors, leading to excessive waste and high embodied carbon.

### **1.2 Current Industry Challenges**

Conventional methods lack the ability to balance multiple criteria: such as cost, performance, and sustainability simultaneously. As a result, project managers face inefficiencies in material selection, waste estimation, and lifecycle carbon assessment.

### **1.3 Technology Integration Opportunity**

Recent advances in artificial intelligence and optimization algorithms provide opportunities to revolutionize how materials are chosen, how waste is minimized, and how projects are planned. By embedding these tools into a digital platform, construction professionals can make more data-driven, sustainable, and cost-efficient decisions.

## **2. Problem Statement:**

Material selection and waste management in construction projects are hindered by a lack of intelligent decision-support tools. Current design software fails to:

- Integrate sustainability metrics (e.g., embodied carbon, recyclability).
- Provide predictive waste analysis.
- Balance multi-criteria trade-offs (sustainability, cost, performance).
- Forecast environmental and timeline impacts.

This results in higher costs, environmental harm, and inefficiencies in construction workflows.

### 3. Objectives:

- 1. AI-Powered Material Recommendation:** Develop a multi-criteria decision analysis (MCDA) engine to rank materials by sustainability, cost, and performance.
- 2. Waste Optimization Algorithms:** Implement cutting stock-based algorithms to minimize leftover materials and estimate cost savings.
- 3. Carbon Footprint Calculator:** Estimate embodied carbon from material choices and construction processes.
- 4. Construction Timeline Forecasting:** Provide predictive timelines based on project complexity, materials, and labor factors.
- 5. Circular Economy Integration:** Encourage the use of recyclable and low-carbon materials in project decisions.

### 4. Proposed Methodology:

#### 4.1 AI-Powered Recommendation Engine

Uses weighted scoring models to evaluate materials across sustainability (40%), cost (30%), and performance (30%). Ranks and suggests the top-performing materials for each project type.

#### 4.2 Waste Optimization

Employs First-Fit Decreasing cutting stock algorithm to minimize waste. Calculates potential savings in INR and generates optimized cutting plans.

#### 4.3 Carbon Footprint Calculator

Computes embodied carbon for selected materials. Breaks down contributions by flooring, concrete, tiles, doors, and windows. Adds construction-phase emissions (~15%).

#### 4.4 Timeline Forecasting

Estimates project duration (6–24 months) based on area, floors, and material complexity. Produces a phased schedule (foundation, structure, finishing).

#### 4.5 Integrated Platform (FastAPI + React)

**Backend (FastAPI):** Hosts APIs for recommendations, optimization, carbon calculation, and timeline forecasting.

**Frontend (React):** Provides a user-friendly interface for material selection, analytics dashboards, and project tracking.

### 5. Expected Outcomes:

- Reduction in material waste via algorithmic optimization.
- Transparent visibility of embodied carbon and sustainability scores.
- Balanced decision-making using multi-criteria evaluation.
- Predictive insights into project timelines and costs.
- A digital tool promoting circular economy principles in construction.

### References:

1. Zhang, X. and Liu, Y. – AI-Enhanced Material Selection Framework for Sustainable Construction, Journal of Cleaner Production, Elsevier, 2023.
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