Predicting Concrete Strength

Using regression analysis to support better material decisions,
reduce waste, and cut procurement costs.

R Language   Regression   Hypothesis Testing

Why This Project Matters

Over 18 years of operations, StrataForge accumulated 1,030 mix trials — but
still relied on gut feeling for critical strength decisions.

💰 Cement Overuse
Conservative "safe" mixes inflate material costs by over-specifying cement content.

⚠️ Strength Failures
Occasional failures at 28-day testing require costly rework and delay timelines.

📊 No Predictive Tool
Decisions relied on experience and trial-and-error, not data-driven insight.

🌍 Carbon Targets
Excess cement usage undermines sustainability goals and carbon commitments.

Three Clear Objectives

01 Quantify Influence
Determine how each mix component (cement, slag, water, age, etc.) affects compressive strength using multiple linear regression.

02 Fly Ash Impact
Test whether including fly ash in a mix significantly affects compressive strength using hypothesis testing (Kruskal–Wallis).

03 Prediction Tool
Build a reliable regression model that the batching plant can use to predict strength before pouring — optimising cost and reducing failures.

Data & Approach

The IMF-style rigour applied to concrete: clean data in, validated model out.

1. 1,030 mix trials loaded — entirely numeric, no missing values

2. Columns renamed for clarity (cement, slag, flyAsh, water, etc.)

3. Distributions checked via histograms; outliers assessed with boxplots

4. Correlation matrix identified 4 key predictors: cement, water, superplasticizer, age

5. Log transformation applied to age & superplasticizer to handle skew

6. Forward stepwise regression used to build model iteratively

7. Assumptions tested: linearity, residual independence, normality, homoscedasticity, VIF

The Prediction Formula

```
strength = 23.914
  + 0.0974 × cement
  - 2.545 × ln(superplasticizer)
  - 0.2374 × water
  + 9.759 × ln(age)
  + 0.0683 × slag
```

81.35%
R² EXPLAINED

5/5
ASSUMPTIONS PASSED

<1.5
ALL VIF VALUES

After log-transforming skewed predictors and using forward stepwise selection across 12 candidate models, Model 9 achieved the best balance of explanatory power and statistical validity — all coefficients significant at p < 0.001.
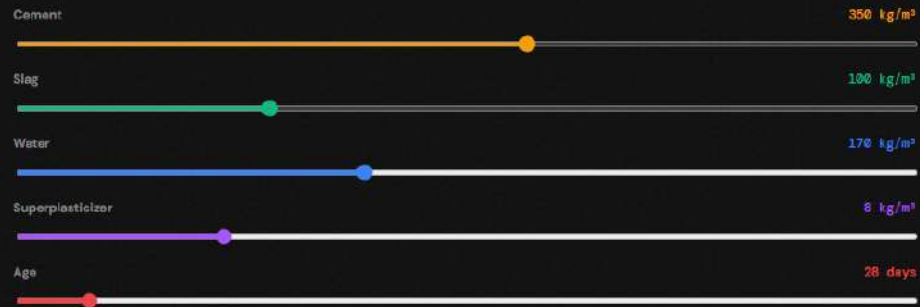
Fly Ash Does Not Reduce Strength

Kruskal-Wallis H_0: μ(no fly ash) = μ(fly ash)

p = 0.2324 → Fail to reject H_0

No significant difference in strength

Kruskal-Wallis H_0: μ(coarse) = μ(fine)

p = 0.3364 → Fail to reject H_0

Concrete category doesn't affect strength

Chi-Square H_0: Category and fly ash are independent

p = 0.9812 → Fail to reject H_0

No association between category & fly ash use

This is a major finding: StrataForge can confidently substitute part of its cement content with fly ash — achieving the same strength while cutting costs and carbon emissions.

Strength Prediction Tool

Cement   350 kg/m³

Slag   100 kg/m³

Water   170 kg/m³

Superplasticizer   8 kg/m³

Age   28 days

PREDICTED STRENGTH

51.7

MPa

VS 400 KG/M³ CEMENT BASELINE

+£6.00 /m³ saved

☑ Meets C25/30 specification

← Prev   ● ● ● ● ● ● ━━ ● ●   Next →

Exemplary Cost Reduction

Consider a typical StrataForge project: a commercial warehouse foundation requiring 2,000 m³ of C30-grade concrete.

BEFORE — CONSERVATIVE MIX

Cement: **400 kg/m³**
Slag: **0 kg**
Cost: **£48.00/m²** cement alone
Total cement cost: **£96,000**

AFTER — MODEL-OPTIMISED MIX

Cement: **310 kg/m³**
Slag: **100 kg/m³**
Cost: **£37.20/m²** cement alone
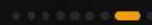Total cement cost: **£74,400**

Saving on this single project

£21,600

22.5%
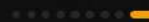COST REDUCTION

~38 MPa
PREDICTED STRENGTH

−180t
CO_2 REDUCED

Data Replaces Guesswork

- Cement and curing age are the strongest drivers of strength

- Fly ash does not reduce performance — use it confidently

- The model captures 81.35% of strength variability

- Potential to save £20k+ per major project through optimised mixes

- Reduced carbon footprint from lower cement dependency

"Engineering Strength from the Ground Up" — now backed by evidence.