# Final Year Design Project Showcase
## Batch-2022
## Year 2026

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| **Department: Civil Engineering (TIEST)**<br>Programme: Bachelor of Engineering in Civil Engineering | |
| **1** | **Project Title**<br><br>Predicting Compressive Strength of Non-Autoclaved Aerated Concrete (NAAC) Using Machine Learning |
| **2** | **Project Idea**<br><br>Non-Autoclaved Aerated Concrete (NAAC) is an emerging lightweight, sustainable construction material characterized by low density, good thermal insulation, and reduced structural dead load. However, predicting its compressive strength is challenging due to complex interactions among mix proportions, aeration mechanisms, curing conditions, and pore structure development. Traditional laboratory testing is time-consuming, resource-intensive, and requires multiple trial mixes. This project aimed to develop a machine learning-based predictive framework to estimate NAAC compressive strength using laboratory-generated experimental data. Three machine learning models (Linear Regression, Random Forest, and XGBoost) were developed and compared. The XGBoost model demonstrated the best prediction accuracy with $R^2 \approx 0.94$, enabling rapid and cost-effective strength estimation without extensive laboratory testing. A user-friendly prediction tool called "NAAC Predictor Pro" was developed for practical engineering applications |
| **3** | **Process**<br><br>**Phase 1: Literature Review & Data Collection**<br>• Reviewed existing literature on NAAC properties and machine learning applications in concrete technology<br>• Collected experimental dataset from published literature (Nguyen, 2026) comprising 91 observations of lightweight foamed concrete<br>• Extracted key material properties: cement content, oven-dry density, water-to-binder ratio, foam volume, and compressive strength results<br>**Phase 2: Experimental Program**<br>• NAAC mix formulations with varying parameters:<br>- Water-cement ratio: 0.50 (constant)<br>- Aluminum powder percentage: 0.05% to 0.20% (6 variations)<br>- Density range: 1340-1850 kg/m³<br>• Specimen preparation: Cube specimens (standard size)<br>• Curing: 28 days in water tank at room temperature<br>• Compressive strength testing using Compression Testing Machine<br>**Phase 3: Machine Learning Model Development**<br>• **Input Parameters:** Density, Water-to-Cement Ratio, Sand-to-Cement Ratio, Aluminum Powder Content<br>• **Output Parameter:** 28-Day Compressive Strength (MPa)<br>• **Models Developed:** |

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| | - Linear Regression (baseline model)<br>- Random Forest (ensemble method)<br>- XGBoost (extreme gradient boosting)<br>• **Data Splitting:** 80% training, 20% testing<br>• **Performance Metrics:** $R^2$, RMSE, MAE, MSE<br>**Phase 4: Software Development**<br>• Developed "NAAC Predictor Pro" - a user-friendly GUI-based prediction tool<br>• Implemented ensemble framework combining Random Forest, XGBoost, and Gradient Boosting Machine<br>• Designed input sliders and output display interface<br>• Integrated performance indicators and mix design recommendations |
| **4** | **Outcome**<br><br>• XGBoost achieved best accuracy ($R^2 \approx 0.94$), outperforming Random Forest ($R^2 \approx 0.89$) and Linear Regression.<br>• Density identified as most influential parameter; higher density = higher strength.<br>• Aluminum powder and w/c ratio also strongly affect strength.<br>**Deliverables:** NAAC Predictor Pro software; validated ML prediction framework**;** feature importance analysis; reduced testing from 28 days to minutes. |
| **5** | **Evidence (Theoretical Basis)**<br><br>**Summary of the Final Year Project:**<br><br>This research presents a novel framework for predicting the compressive strength of Non-Autoclaved Aerated Concrete (NAAC) using machine learning approaches integrated with laboratory-generated experimental data. NAAC is a lightweight, sustainable construction material whose compressive strength prediction is challenging due to complex nonlinear interactions among mix design parameters.<br><br>**Methodology:**<br>• Collected and compiled experimental dataset from published literature (91 observations) comprising mix proportions and compressive strength results<br>• Prepared NAAC specimens with varying parameters: density (1340-1850 kg/m³), aluminum powder percentage (0.05-0.20%), and water-cement ratio<br>• Conducted compressive strength testing after 28 days of curing<br>• Developed and compared three machine learning models: Linear Regression (baseline), Random Forest (ensemble), and XGBoost (gradient boosting)<br><br>**Key Findings:**<br>• Density was identified as the most influential parameter affecting compressive strength—higher density consistently yielded higher strength<br>• Aluminum powder percentage had a decisive role in aeration; increased dosage led to lower density and reduced compressive strength<br>• Water-cement ratio significantly influenced hydration and pore structure; lower ratios resulted in higher compressive strength<br>• XGBoost achieved the best prediction accuracy with $R^2 \approx 0.94$, significantly outperforming Linear Regression and Random Forest |

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| | • Random Forest also demonstrated strong predictive capability ($R^2 \approx 0.89$), confirming ensemble methods are superior for NAAC applications<br><br>**Deliverables:**<br>• A validated machine learning-based prediction framework for NAAC compressive strength<br>• "NAAC Predictor Pro"—a user-friendly software tool with a graphical interface that provides instant 28-day compressive strength predictions based on four input parameters: Density, Water-to-Cement Ratio, Sand-to-Cement Ratio, and Aluminum Powder Content<br>• Feature importance analysis identifying key parameters governing NAAC mechanical behavior<br><br>**Conclusions:**<br>The integration of laboratory testing with machine learning provides a reliable, rapid, and cost-effective approach for NAAC strength prediction. The developed framework reduces experimental effort, optimizes mix design, and enables data-backed decision-making in sustainable construction materials research. The study successfully demonstrates that artificial intelligence can serve as a valuable assistant in concrete technology, reducing the need for extensive trial-and-error experimentation<br>Please provide the summary of the FYP instead of attaching the FYP report. |
| **6** | **Competitive Advantage or Unique Selling Proposition**<br><br>(Cost Reduction, Process improvement, Attainment of any SDG (Sustainable Development Goal), increase of market share or capturing new market or having superior performance over a competitor. In summary, any striking aspect of the project that compels the industry to invest in FYP or purchase it. Some detailed description is required in terms of how, why when what. You can select one or more from the following dropdown and delete the rest of them). Please keep relevant options, delete the rest of them, and correct the sequence |
| **a** | **Attainment of any SDG** (e.g. How it is achieved and why it is necessary for the region)<br><br>**SDGs:** SDG 9 (Innovation), SDG 11 (Sustainable Cities), SDG 12 (Responsible Consumption), SDG 13 (Climate Action). |
| **b** | **Any Environmental Aspect** (e.g. carbon reduction, energy-efficient, etc.)<br>**Environment:**<br><br>Reduces experimental waste, promotes lightweight concrete (lower emissions), minimizes material consumption. |
| **c** | **Cost Reduction of Existing Product**<br><br>**Cost Reduction:** Saves 40-60% testing costs; eliminates trial mixes; reduces material wastage. |
| **d** | **Process Improvement which Leads to Superior Product or Cost Reduction, Efficiency Improvement of the Whole Process** (e.g. What is the issue is current process and what improvement you suggests)<br><br>**Process Improvement:** Reduces mix design time from 28 days to <1 minute; instant predictions using AI/ML. |

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| **e** | **Expanding of Market share** (e.g. how it expand and what is the problem with the current market<br><br>**New Market:** AI-enabled construction solutions; niche market for rapid mix design; addresses small/medium firms without lab facilities. | |
| **f** | **Capture New Market** (e.g. Niche market or unaddressed segment)<br><br>• **Niche Market:** AI/ML-based construction material prediction services<br>• **Unaddressed Segment:** Small to medium construction firms requiring rapid mix design without extensive laboratory facilities<br>• **Target Segment:** Engineering consultancies, construction companies, research institutions, building material suppliers | |
| **g** | **Any Other Aspect** | |
| **7** | **Target Market**<br><br>(Industries, Groups, Individuals, Families, Students, etc) Please provide some detail about the end-user of the product, process, or service<br>Concrete producers, ready-mix plants, construction companies, engineering consultancies, research institutions, housing authorities, QA/QC professionals, mix design engineers, and sustainable building firms. | |
| **8** | **Team Members** (Names along with email address) | Mr. Ammar Mirza (mirza4507554 @cloud.neduet.edu.pk)<br>Mr. Rehan Meo (rehan4501075 @cloud.neduet.edu.pk)<br>Mr. Shahnawaz Halepoto (Shahnawaz4501438 @cloud.neduet.edu.pk) |
| **10** | **Supervisor Name** (along with email address) | **Dr. Abdul Salam Buller**, engr.salam@cloud.neduet.edu.pk |
| **11** | **Video (If any)** | NA |