Design and Proportioning for C-25 concrete using Banana Peels

Subash Thanappan[1], Dimitrios A Karras[2], Aiman Al-Odaini[3]

[1]Lincoln University College, Malaysia; [2]NKUA Athens Greece and Epoka University of Tirhana Albania ; [3]Lincoln University College, Malaysia

Email ID: thanappansubash@gmail.com / (pdf.subash@lincoln.edu.my)

Abstract: This article outlines the design and proportioning used to make C-25 concrete using Banana peels. This methodology is designed not only to measure performance outcomes but also to reveal trends, thresholds, and potential trade-offs associated with BPA usage in structural concrete.

Keywords: Control mix, BPA modified mixes, Mix design, Structural grade concrete, Water-Cement ratio

Introduction

Getting the right mix of concrete is very important because it makes the structure strong and lasts longer. This is important for making sure the project works well. When the mix is balanced properly, the concrete has the strength and stability it needs. If the mix isn't correct, problems can happen, such as the concrete being weak, cracking, or even failing completely. Using the right mix helps create strong, easy-to-work-with concrete and a good overall structure. It's important to use the correct mix ratios for different jobs, like slabs and floors, to get the best results, Kamran Amini et al. (2019), [1]; Anjali Dewangan et al (2025), [2]; Shamsad A & Saeid A (2014), [3].

Materials used

Empire Cement of grade 32.5R was used as the primary binder in this study (ASTM C150, 2020). This type of cement was chosen due to its high early strength, wide availability, and compatibility with admixtures. The cement was stored in a dry, cool environment, free from moisture contamination, to maintain its chemical integrity and reactivity throughout the experimental period.

Fine aggregates used in this study were natural river sand collected from a local place, and they followed the BS 882 (1992) standard. The sand was clean, had good grading, and didn't have any visible dirt or unwanted materials. It had a smooth feel and even particle size, which made it good for mixing with concrete. To make sure it was of high quality, the sand was washed with clean water to remove things like dust, organic materials, and salt, Vasanthi, P et al (2023), [4]. After washing, it was left to dry in the air under normal conditions. Then it was stored in a dry and shady place to keep it clean and stop moisture from building up. The quality of the fine aggregate was very important for getting good workability, bonding, and overall strength in the concrete mix.

Coarse aggregates used in the concrete came from crushed granite, which is known for being strong and lasting. Other studies have also looked into eco-friendly binders (Hunde et al., 2023) [5] and substitutes made with nano-silica (Biratu et al., 2022) [6]. These aggregates had a rough, angular shape, which helped them fit together better inside the concrete, improving its strength and structure. The rough texture also helped the aggregate stick better to the cement paste, which was key for getting the right compressive strength and long-term durability. Before mixing, the aggregates were kept in a dry and clean area to keep their quality.

As suggested by Francis Adjei-Fio, et al (2025), construction industries need to focus on obtaining a sustainable concrete practice [6], [7]. Hence, similar to his concept, Banana Peel Ash (BPA) was made from banana peels that were collected from local fruit markets [8-9].

The peels were left in the sun for several days straight. This natural way of drying kept going until the peels were totally dry and broke easily, showing they had very little moisture and were good for burning. No washing or using machines to dry them was done during this time, so the process stayed cheap and friendly for the environment [8-9].

Once they were dry, the banana peels were burned outside in a safe and controlled way. The burning continued until the peels turned into ash. This method is similar to what was used in some eco-friendly concrete experiments (Srikanth et al., 2022) [10].

The end result, called Banana Peel Ash (BPA), had a grey color and was fine enough to mix with cement. It was kept in sealed containers that protected it from moisture and kept its ability to react before it was added to the concrete mix.

This easy and widely available way of making BPA made it possible to use it as a partial substitute for cement in C-25 concrete. This helped make construction practices eco-friendlier and more encouraged the use of new materials.

Control Mix

The control mix served as the benchmark and contained no Banana Peel Powder Ash (BPA). The conventional mix ratio by weight was as follows:

Cement**:** 1kg

Fine Aggregate (Sand)**:** 1.6kg

Coarse Aggregate (Gravel)**:** 3kg

Water-Cement Ratio**:** 0.56kg

This resulted in a mix ratio of 1:1.6:3 by weight, which is standard for C-25 concrete. The mix was batched using 50 kg of cement as the base unit. Hence the quantity of materials provided is shown in Table 1.

*Table 1.*materials used and its quantity

Material	Quantity (per 50 kg cement)
Cement	50 kg
Fine Aggregate	100 kg
Coarse Aggregate	200 kg
Water	25 liters

For a cube to be casted, the mix ratio is twice the derived mix design. Mix design for a cube is 2:3:6. A total of 24 cubes were casted. Water to cement ratio was obtained by, 0.56x 24 cubes. The quantity of materials used is shown in Table 2.

Table 2. Quantity of materials

Material	Quantity
Cement	48kg
Fine Aggregate	72 kg
Coarse Aggregate	144kg
Water	13.44 liters

Experiments and Results

BPA modified mixes

To investigate the effects of BPA as a partial replacement for cement, three additional mix variants were prepared by replacing cement with BPA at 5%, 10%, and 15% by weight. All other components remained constant to ensure comparability across the mixes. The water-cement ratio was maintained at 0.56 but it was multiplied by the number of cubes casted (24 numbers) to obtain the quantity of water required for the appropriate mixing. Table 3 shows the BPA replacement.

Table 3 BPA modified

Mix	Cement Replacement	Cement (kg)	BPA (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)	Water (liters)
M0	0% BPA (Control)	12.0	0.0	18.0	36.0	3.36
M5	5% BPA	11.4	0.6	18.0	36.0	3.36
M10	10% BPA	10.8	1.2	18.0	36.0	3.36
M15	15% BPA	10.2	1.8	18.0	36.0	3.36

The mix design process was carried out based on the British Standard Method for a target compressive strength of 25 MPa (C-25 grade concrete) BS 882, 1992) [11]. The mix was proportioned by weight using the absolute volume method, ensuring that the final mix meets the strength, workability, and durability requirements. The water-cement ratio was controlled at 0.56 (Mehta & Monteiro, 2014) [12], which is suitable for structural-grade concrete with moderate exposure conditions and margin of safety.

Conclusions

The best qualities of hardened concrete come mostly from the quality of the cement paste. The first step in mixing concrete is choosing the right amount of water compared to the cement and other materials, which affects how strong and long-lasting the concrete will be. The modified mixing proportions would be more helpful for the material quality assessment in addition to laboratory investigations on Slump test and Compressive strength tests.

Acknowledgement

Heartfelt appreciation goes to *KAAF University, Kasoa, Ghana*, for their moral support to utilize the library for literature reviews and to enhance the tests in the laboratory.

References

1. Kamran Amini, Payam V, Halil C, Peter T. Effect of mixture proportions on concrete performance, *Construction and Building Materials*, 212, pp:77-84, 2019. https://doi.org/10.1016/j.conbuildmat.2019.03.294

2. Anjali Dewangan, Pranali Misar, Adity Sahare, Shriniwas Rayadu. Review on Optimization of Concrete Mix Proportion, *International Research Journal of Engineering and Technology (IRJET)*, 12(1), pp:422-427, 2025.
IRJET-V12I163.pdf

3. Shamsad A, Saeid A.A, A Statistical Approach to Optimizing Concrete Mixture Design, *The Scientific World Journal*, Volume 2014, Article ID 561539, 7 pages, 2014.
http://dx.doi.org/10.1155/2014/561539

4. Vasanthi, P., Selvan, S. S., Natrayan, L., & Thanappan, S., Experimental studies on the effect on nano silica modified novel concrete CFST columns, *Materials Research Express*, 10(8), 2023.
https://doi.org/10.1088/2053-1591/aced82

5. Hunde, H., Thanappan, S., & Natrayan, L., Welded tuff as cement replacement material for concrete production – A case study, AIP Conference Proceedings, 2831(1), 2023. https://doi.org/10.1063/5.0164873

6. Biratu, M. K., Thanappan, S., Hailu, H., Nadh, V. S., & Kumar, C. L. M., Nano silica based Teff Straw as an eco-friendly substitute for special concrete, Journal of Nanomaterials, 2022, pp. 1–7, 2022.
https://doi.org/10.1155/2022/7025059

7. Sridhar Jayaprakash, Dhanapal Jegatheeswaran, Pandimani, Sivaramakrishnan Subbaram, Maruthachalam Dhamodharan, Vetturayasudharsanan Ramasamy, Vivek Deivasigamani, Francis

Adjei-Fio. Influence of Granite Powder Waste on the Flexural and Microstructure Morphology Behaviors of Reinforced Concrete Beams with Glass Fiber Reinforced Polymer Bars, *Engineering Reports*, 2025; 7:e70304, pp:1-12, 2025.
https://doi.org/10.1002/eng2.70304

8. Subash Thanappan, Dimitrios A Karras, Aiman Al-Odaini. (2025). Analysis of Biogenic Materials for Self-Compacting Concrete. Journal of Mines, Metals and Fuels, 73(9): 2841-2849; 2025.
https://doi.org/10.18311/jmmf/2025/49686

9. Subash Thanappan, Prof. Dimitrios A Karras, Dr. Aiman Al-Odaini. (2025). Testing on Ingredients for C-25 Self compacting Concrete. *SGS Engineering & Sciences*, VOL. 1 NO .1 (2025): LGPR https://spast.org/index.php/techrep/index

10. Srikanth, S., Krishna, C. B. R., Srikanth, T., Nitesh, K. J. N. S., Nadh, V. S., Kumar, S., & Thanappan, S., Effect of Nano GGBS Volume % on Mechanical Behaviour of High-Performance Sustainable Concrete, Journal of Nanomaterials, 2022, pp. 1–5, 2022.
https://doi.org/10.1155/2022/3742194

11. BS 882, Specification for Aggregates from Natural Sources for Concrete, British Standards Institution, 1992.

12. Mehta, P. K., & Monteiro, P. J. M., Concrete: Microstructure, Properties, and Materials (4th ed.), McGraw-Hill, 2014.