EXPERIMENTAL INVESTIGATION ON PARTIAL REPLACEMENT OF CEMENT BY FLY ASH AND FINE AGGREGATE BY GRANITE FINES ON CONCRETE

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Abstract: The increasing demand for sustainable construction practices has driven the exploration of industrial by-products as substitutes for conventional materials in concrete. This study investigates the partial replacement of cement with fly ash and fine aggregate with granite powder in concrete to assess their impact on mechanical properties, durability, and workability. Fly ash, a pozzolanic material, offers environmental benefits by reducing cement consumption and improving the long-term performance of concrete, while granite powder, a by-product of stone processing, provides a sustainable alternative to natural sand. Concrete specimens were prepared with varying replacement levels of fly ash (5%, 10%, 15%, and 20% by weight of cement) and granite powder (5%, 10%, 15%, and 20% by weight of fine aggregate). These mixes were evaluated for compressive strength, tensile strength, flexural strength, durability, and workability properties. The results demonstrate that optimal replacement levels improve the performance of concrete, achieving comparable or superior mechanical properties and enhanced durability compared to conventional concrete. these materials into concrete production.

Keywords
Fly ash, granite fines, partial replacement, concrete, compressive strength, tensile strength, flexural strength , durability, sustainable construction, workability.

1. Introduction

Concrete is the most widely used construction material due to its strength, durability, and versatility. However, the production of cement, a key component of concrete, contributes significantly to environmental pollution by emitting large amounts of CO_2. To address this issue, researchers have explored the use of supplementary cementitious materials (SCMs) such as fly ash, an industrial byproduct from thermal power plants, as a partial replacement for cement.Similarly, the extraction of natural river sand for fine aggregates in concrete has led to environmental degradation. As an alternative, granite fines, a byproduct of the granite industry, have gained attention for their potential use as a partial replacement for fine aggregates.

1.1 Need and Necessity:

- **Environmental Impact of Cement Production** Cement manufacturing is a major contributor to CO_2 emissions, leading to global warming. Using supplementary cementitious materials like fly ash reduces the carbon footprint.
- **Scarcity of Natural Sand**: Over-extraction of river sand causes environmental degradation, including riverbed depletion and habitat destruction. Alternative materials like granite fines can help conserve natural sand resources.
- **Waste Management**: Fly ash, a byproduct of thermal power plants, is often disposed of in landfills, causing environmental hazards. Granite fines, generated from stone-cutting industries, create disposal challenges.

- **Economic Benefits**: Fly ash and granite fines are industrial byproducts available at a lower cost than traditional materials.

2. Objectives

- To Evaluate the Strength Properties: Assess the compressive strength, split tensile strength, and flexural strength of concrete incorporating fly ash and granite fines. Compare the strength characteristics with conventional concrete.
- To Improve Sustainability in Concrete Production: Reduce the environmental impact by minimizing the use of cement and natural sand. Promote the use of industrial byproducts like fly ash and granite fines as eco-friendly alternatives.
- To Enhance Durability Properties: Analyze the effect of fly ash and granite fines on water absorption, permeability, and chemical resistance of concrete. Study the long-term performance of modified concrete under different curing conditions.
- To Optimize Workability and Mix Design: Examine the effect of fly ash and granite fines on the workability of concrete.

3. Methodology:

3.1 Material selection and its properties

The selection of materials for this study is based on their availability, suitability for concrete production, and potential to enhance the mechanical properties of concrete. The primary materials used in this investigation include cement, fly ash, fine aggregate, granite fines, coarse aggregate, and water.

Material	Test	Observations	IS values
Cement	1.Specific gravity 2.Initial setting time 3.Final setting time 4.Standard consistency	3.13 45 min 480min	3.1-3.16 30 mins 600mins
Fine aggregate	1.Sieve analysis 2.Specific gravity	Zone II 2.61	2.73
Fly ash	1.Sieve analysis 2.Specific gravity	2.66 9.16%of 20mm 97.73%of10mm	2.5-2.7 0.5%-0.6% 0.61%
Granite powder	1.Specific gravity	2.6	2.8
Coarse aggregate	1.Specific gravity	2.6	3.0

Table-3.1.1: Test and observation of material

3.2 Concrete Mix Design

Concrete mix design is the process of selecting suitable materials and determining their relative proportions to achieve the desired strength, durability, and workability of concrete. The design procedure follows the guidelines of IS 10262:2019 (Concrete Mix Proportioning) and IS 456:2000 (Code of Practice for Plain and Reinforced Concrete). The water-cement ratio is chosen based on the required strength, referring to IS 456:2000 (Table 5). Lower water-cement ratios improve strength but reduce workability. Ensure the selected ratio does not exceed the maximum limits specified for durability as per IS 456:2000 (Table 5). Concrete mix design ensures an economical, durable, and strong concrete mix while considering strength, workability, and durability factors. The IS method provides a systematic approach to proportioning materials based on scientific calculations and trial adjustments.

Material	Mix design
Cement	1.1 kg
M-sand	1.20 kg
Coarse aggregate	2.3 kg
Water-cement ratio	0.4

Table-3.2.1: Amount of constituents

3.3 Preparation of Concrete Samples

The preparation of concrete samples involves a systematic procedure to ensure uniformity, strength, and accuracy in testing. By batching, mixing, vibrating, moulding and demoulding, curing.

Fig 3.3.1: Preparation

3.4 Testing and Analysis

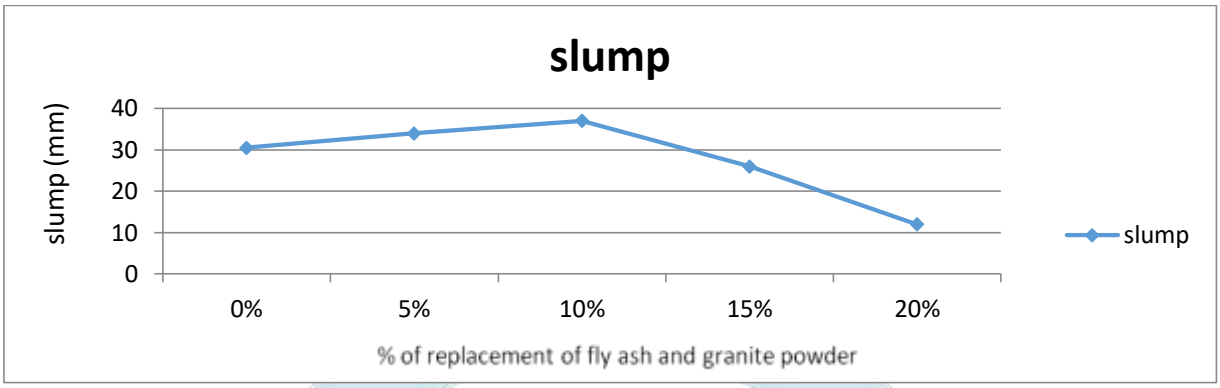
1. Fresh cement :

Slump test : The slump test is a field test used to measure the workability or consistency of fresh concrete. We got true slump in concrete preparation moulding.

Fig 3.4.1: Slump test

Table 3.4.1 : Lab test results of slump test

Sl.No	% of cement	% of fly ash + % of granite	W/C ratio	Slump (mm)
1	100%	0%	0.4	30.5
2	95%	5%	0.4	34
3	90%	10%	0.4	37
4	85%	15%	0.4	26
5	80%	20%	0.4	12



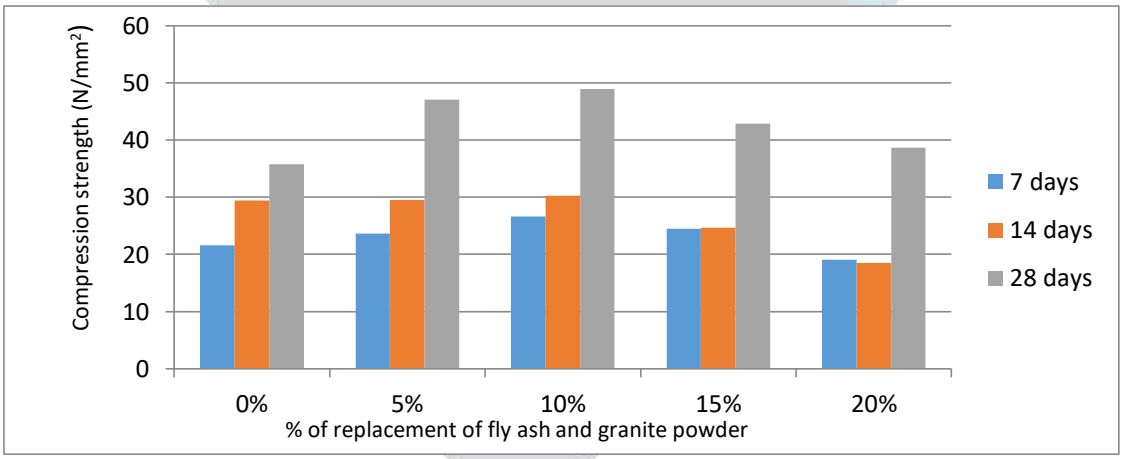
2. Harden Concrete:

1. **Compressive Strength Test :** Tested on concrete cubes.

Table 3.4.2: Lab test results of Compression strength test

Fig 3.4.2 :Compression strength test machine

Percentage%	7 days (N/mm^2)	14 days (N/mm^2)	28 days (N/mm^2)
0%	21.6	29.4	35.8
5%	23.6	29.5	47.06
10%	26.6	30.3	48.9
15%	24.5	24.7	42.9
20%	19.1	18.5	38.7



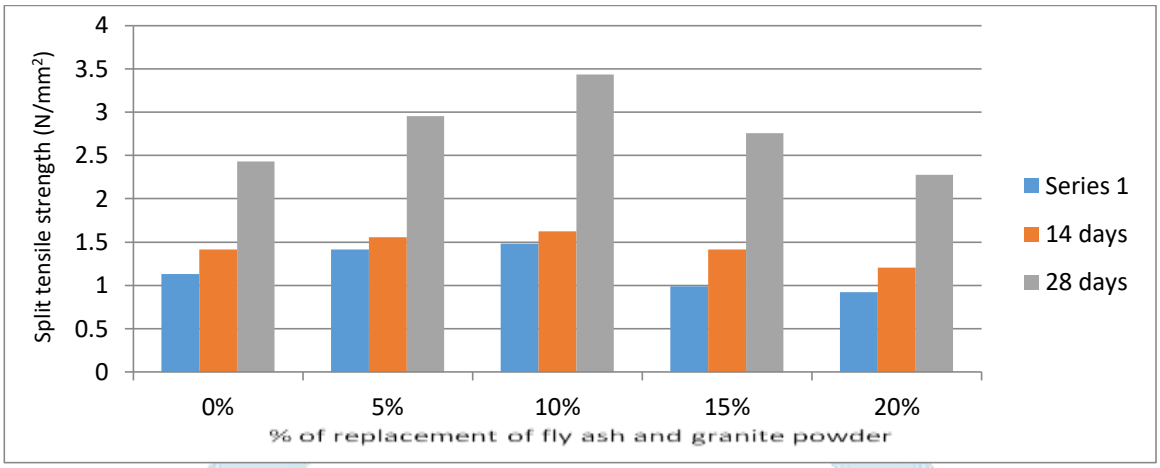
2. **Split tensile Strength test**

Tensile Strength: Split tensile test on cylinders

Table 3.4.3 : Lab test results of Split tensile strength test

Fig 3.4.3 : Split Tensile Strength test machine

Percentage%	7 Days (N/mm^2)	14 days (N/mm^2)	28 days (N/mm^2)
0%	1.13	1.414	2.430
5%	1.414	1.5561	2.951
10%	1.48	1.6269	3.432
15%	0.99	1.414	2.756
20%	0.919	1.202	2.274



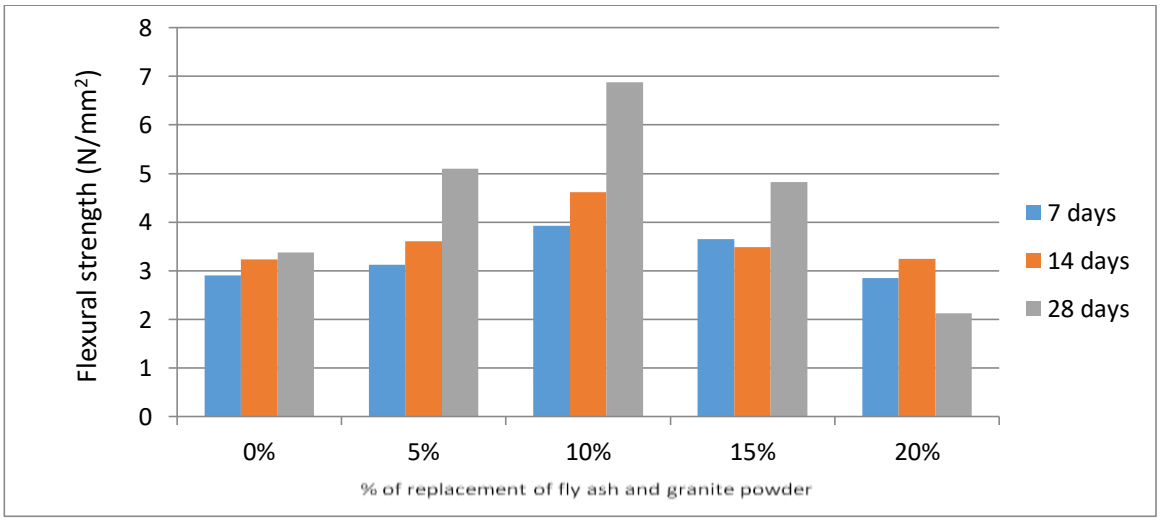
3. Flexural Strength test

Flexural Strength: Flexural test on concrete prisms.

Table 3.4.4 : Lab test results of Flexural tensile strength test

Fig 3.4.4: Flexural Tensile Strength Test Machine

Percentage%	7 days (N/mm^2)	14 days (N/mm^2)	28 days (N/mm^2)
0%	2.90	3.23	3.38
5%	3.12	3.61	5.10
10%	3.93	4.62	6.88
15%	3.65	3.49	4.83
20%	2.85	3.24	2.12



4. Results

- Slump increases with replacement of fly ash and granite powder, at 10% and is comparable to normal concrete, where for 10% there is an 37mm.
- Compressive strength increases with replacement of fly ash and granite powder, at 10% and is comparable to normal concrete.

Sl. No.	Days	Percentage	Peak Load (N/mm^2)
1	7 days	10%	26.6
2	14 days	10%	30.3
3	28 days	10%	47.06

- Split tensile strength got increased at 10% of replacement of cement by fly ash and fine aggregate by granite powder

Sl. No.	Days	Percentage	Break Point (N/mm^2)
1	7 days	10%	1.48
2	14 days	10%	1.6269
3	28 days	10%	3.432

- Flexural strength got increased at 10% of replacement of cement

Sl. No.	Days	Percentage	Break Point (N/mm^2)
1	7 days	10%	3.93
2	14 days	10%	4.62
3	28 days	10%	6.88

- Thus Waste was utilized and makes more environmental friendly.
- Thus granite powder aggregate is the best choice where there are available.

5. Discussion

1. Workability of Concrete

- The addition of fly ash improves the workability of concrete due to its fine and spherical particle shape, which enhances the flow of the mix.
- Granite fines, being coarser than traditional fine aggregates, may reduce workability, requiring adjustments in water-cement ratio or the use of superplasticizers.

2. Strength Characteristics

- **Compressive Strength:** Concrete with fly ash shows lower early strength but gains higher strength over time due to its pozzolanic reaction.

- **Tensile and Flexural Strength:** The replacement of fine aggregates with granite fines may enhance strength properties due to their angular shape, which improves the interlocking of particles.
- **Optimum Replacement:** Experiments usually determine an ideal percentage for replacement (e.g., 20-30% fly ash and 10-20% granite fines) where strength and durability are maximized.

3. Economic and Environmental Benefits

- Fly ash and granite fines are **industrial by-products**, reducing the dependence on natural sand and cement, thus lowering costs.
- The use of these materials contributes to **sustainable construction** by reducing CO_2 emissions from cement production and minimizing waste disposal issues.

6. Conclusion

- The test results show clearly that fly ash and granite powder as partial sand replacement has beneficial effects of Concrete.
- The Granite powder is to be used as partial replacement of the natural sand.
- The use of Granite powder in concrete is beneficial in different manner such as environmental aspects, non- availability of good quality of fine aggregate or rarely availability, strength quality etc. Thus Waste was utilized and makes more environmental friendly.
- Thus granite powder aggregate is the best choice where there are available.

7. References

1. Anupam Ashutosh[1], Amit Kumar[2], Arshad Siddiqui[3], Anil Kumar Yadav[4], Ranoo Sharma[5] (March 2019): “Experimental study on effect of Partial replacement of cement by fly ash and fine aggregate by granite dust powder in concrete”. International Conference on Latest Innovation in Engineering Science and Management. Buddha Institute of Technology, GIDA, Gorakhpur (UP) ISBN: 978-93-87793-80-4

2. Anzar Hamid, & Shameem, M. (2017)**:** "Optimization of fly ash and granite powder proportions for sustainable concrete production." *Journal of Sustainable Construction Materials and Technologies*, 2(2), 45-51. Provides optimized replacement levels for fly ash and granite powder in concrete.
3. Concrete mixes is designed according to the guidelines in IS 10262
4. Concrete Technology : Theory and Practice book by M.S. Shetty
5. Danish Shaikh[1]*, Tahami Patel[2], Maaz Shaikh[3], Tuba Qazi[4], Mandar Mahajan[5] (April 2021): “Partial Replacement of Fine Aggregate with Granite Fines”. International Journal of Recent Advances in Multidisciplinary Topics. Volume 2, Issue 4, ISSN (Online): 2582-7839.

6. Devi, K., & Kannan, K. (2011)**:** "Mechanical properties of high strength concrete using granite powder as fine aggregate." *International Journal of Engineering Science and Technology (IJEST)*, 3(10), 7187-7195. Explores the mechanical properties of concrete with granite powder as a partial replacement for fine aggregate.

7. Kumar, R., & Dhaka, R. (2016): "A Review on Partial Replacement of Cement by Fly Ash and Fine Aggregate by Granite Dust in Concrete" in International Journal of Research in Engineering and Technology (IJRET). Summarizes research on the use of fly ash and granite dust in concrete and their effects on strength and durability.
8. Neville, A. M. (2011). Properties of Concrete. Pearson Education Limited, England. An authoritative text on the properties and behavior of concrete, with insights into durability and mechanical properties.
9. Patel, S., & Shah, B. (2013): "Granite Powder Concrete" in International Journal of Engineering and Advanced Technology (IJEAT), Vol. 2, Issue 3. Explores the use of granite powder as a partial replacement for fine aggregate in concrete.
10. Prerit Saxena, Rishabh[1], Rohit Kumar[1], Neelesh Kumar Singh[2] (May- Jun. 2016): "A Comparative Study on Partial Replacement of Cement With Fly ash & Granite Powder". OSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 13, Issue 3 Ver. V (May- Jun. 2016), PP 86-89.
11. R.Anuradha[1]*, A.Gilbert Immanuel [2] (2017): "Strength Properties of Concrete with Partial Replacement of Cement by Flyash and Fine Aggregate by Granite Powder". International Journal of ChemTech Research CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555. Vol.10 No.8, pp 238-244.
12. Ravi Kumar, S., Ramesh, T., & Aarthi, R. (2018)**:** "Combined effect of fly ash and granite powder on the mechanical properties of concrete." *Materials Today: Proceedings*, 5(1), 2021-2027. Investigates the synergistic effects of fly ash and granite powder on the performance of concrete.
13. Sanjeev Sehga[1], Pratiksha Malviya[2] (Mar-Apr 2019): "Review Paper on Properties of Concrete using Granite Dust and Fly Ash as a Partial Replacement of Fine Aggregate & Cement". International Journal of Trend in Scientific Research and Development (IJTSRD) Volume: 3 | Issue: 3 | Mar-Apr 2019 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470
14. Sheikh Hayath Mahmud*, Md. Maruf Hasan and Liton Chandra Da (February 2024): "Experimental Study on Partial Replacement of Cement with Fly Ash in Concrete Mix Design". The Asian Review of Civil Engineering. ISSN: 2249-6203 (P); 2583-7893 (E) Vol.13 No.1, 2024, pp.1-5.
15. Siddique, R. (2008)**:** *Waste Materials and By-Products in Concrete.* Springer. Comprehensive review of waste materials, including fly ash and granite powder, as replacements in concrete.
16. Vijayalakshmi, M., Sekar, A. S. S., & Ganesh Prabhu, G. (2013)**:** "Strength and durability properties of concrete made with granite industry waste." *Construction and Building Materials*, 46, 1-7. Analyzes the use of granite powder in enhancing the strength and durability of concrete.
17. Y.Yaswanth Kumar* , C.M. Vivek Vardhan, A.Anitha (April 2015): **"**Use of Granite Waste as Partial Substitute to Cement in Concrete". Journal of Engineering Research and Applications ISSN : 2248-9622, Vol. 5, Issue 4.