e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:06/Issue:09/September-2024 Impact Factor- 8.187 www.irjmets.com

PARTIAL REPLACEMENT OF CEMENT BY GLASS POWDER AND FINE AGGREGATES BY PLASTIC PELLETS

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ABSTRACT

The integration of alternative materials like plastic pellets and glass powder into concrete has gained attention due to environmental concerns and the pursuit of sustainable construction practices. This abstract delves into the potential benefits and challenges associated with incorporating these materials into concrete mixtures.

Plastic pellets, derived from recycled plastics, offer a viable solution to reduce plastic waste while enhancing the properties of concrete. Their inclusion can improve the workability, durability, and reduce the density of concrete. Moreover, plastic pellets serve as an alternative to conventional aggregates, thereby conserving natural resources and reducing carbon emissions associated with traditional concrete production.

Similarly, glass powder, obtained from waste glass, presents an environmentally friendly option for enhancing concrete properties. Its incorporation can improve the compressive strength, reduce permeability, and enhance the durability of concrete. Additionally, the use of glass powder aids in reducing the consumption of raw materials and energy during concrete manufacturing processes.

However, challenges such as proper dosage, compatibility with other concrete constituents, and potential adverse effects on long-term performance need to be addressed when incorporating plastic pellets and glass powder into concrete mixtures. Furthermore, the economic feasibility and scalability of production and implementation must be considered to ensure widespread adoption of these sustainable practices.

I. INTRODUCTION

In recent years, there has been a growing interest in exploring alternative materials to enhance the properties and sustainability of concrete. Two such materials that have gained attention are plastic pellets and glass powder. Integrating these materials into concrete mixes offers several benefits, including improved durability, reduced environmental impact, and enhanced performance.

Plastic pellets, often sourced from recycled materials such as plastic bottles or containers, are being used as partial replacements for conventional aggregates in concrete mixes. The incorporation of plastic pellets helps to address the mounting issue of plastic waste by diverting it from landfills and oceans into constructive applications. Plastic pellets in concrete mixes can enhance the ductility and impact resistance of concrete, making it more resilient to cracking and deformation. Furthermore, the use of plastic pellets can reduce the overall weight of concrete structures, making them more economical and easier to handle during construction.

Glass powder, produced from recycled glass cullet, is emerging as a viable supplementary cementations material (SCM) in concrete production. Incorporating glass powder in concrete can help reduce the demand for traditional cement, thus decreasing carbon emissions associated with cement production. The fine particle size of glass powder allows for better packing density within the concrete matrix, resulting in improved mechanical properties and durability. Additionally, the pozzolanic properties of glass powder contribute to the formation of additional calcium silicate hydrates (CSH), which enhance the long-term strength and performance of concrete.

Combining plastic pellets and glass powder in concrete mixes can yield synergistic effects, further enhancing the sustainability and performance of concrete structures. The use of these alternative materials reduces the environmental footprint of concrete production while offering practical solutions to waste management challenges. By promoting circular economy principles, the integration of plastic pellets and glass powder fosters resource efficiency and contributes to the development of more sustainable construction practices.

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II. METHODOLOGY

- **Need of the Present Study:**

The present study is necessitated by the pressing need to address environmental and construction industry challenges. Cement production contributes significantly to greenhouse gas emissions, while plastic and glass waste disposal poses substantial environmental hazards. To mitigate these issues, developing sustainable, eco-friendly concrete alternatives incorporating waste materials is crucial. The construction industry requires improved mechanical properties and reduced costs, and exploring innovative waste management solutions and sustainable materials can contribute significantly. A knowledge gap exists regarding optimal replacement percentages of plastic pellets and glass powder in cement concrete, their effects on workability, strength, and durability, and feasibility in structural applications, necessitating this study to bridge this gap and inform policy decisions, future research, and sustainable construction practices.

- **Objectives:**

The main objectives of this project are:

1. To study the effect of plastic pellets and glass powder on the mechanical properties of cement concrete.
2. To evaluate the compressive strength, workability, and durability of modified concrete with varying percentages of plastic pellets and glass powder.
3. To assess the environmental benefits of using these waste materials in concrete.
4. To compare the performance of conventional concrete with modified concrete in terms of strength and durability.

- **Methodology:**

Using plastic pellets and glass powder in concrete involves several steps and considerations. Here is the methodology for incorporating these materials into concrete:

1. **Material Collection and Preparation**
2. **Concrete Mix Design**
3. **Testing and Characterization**
4. **Preparation of Concrete Mix**
5. **Mixing Process**
6. **Casting and Curing**
7. **Testing and Evaluation**
8. **Analysis and Optimization**
9. **Scale-Up and Implementation**

By following these steps, engineers and researchers can effectively utilize plastic pellets and glass powder to enhance the properties and sustainability of concrete materials.

III. RESULTS AND ANALYSIS

1. TARGET MEAN STRENGTH OF CONCRETE

As per IS -10262 -2009 target mean strength of concrete is given by

$F_m = f_{ck}+1.65\partial$

Where ∂ is standard deviation of samples of cubes strength and fck the characteristic mean strength of concrete which means 95% of cube strength will fall under this strength.

For M30, characteristic mean strength

Target mean strength, f_{ck} =30 + 1.65(5)

= 38.25MPa.

2. Water Cement Ratio = 0.45
3. Estimated water content for 100mm slump

=186 + (6/100)186

=197 Litre.

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4. Cement content =197/0.45
= 437.77 kg/m3 > 320 kg/m3

5. Volume of Coarse aggregates corresponding to 20mm size aggregates and fine aggregates (zone II) for w/c ratio of 0.45
=0.63.

6. Volume of Fine aggregates = 1-0.63
=0.37.

- **MIX CALCULATIONS**

Volume of concrete = $1m^3$.

Volume of cement = (437.77/3.15) (1/1000)

= 0.138 m^3.

Volume of water = (197/1) (1/1000)

=0.197 m^3.

Volume of all-in-aggregates = [1- (0.138 + 0.197)]

= 0.665 m^3.

Mass of coarse aggregates

20mm @60% = 0.665 x 0.60 (2.72 x 0.63 x 1000)

= 688.74 kg.

10mm @40% = 0.665 x 0.40 (2.71 x 0.63 x 1000)

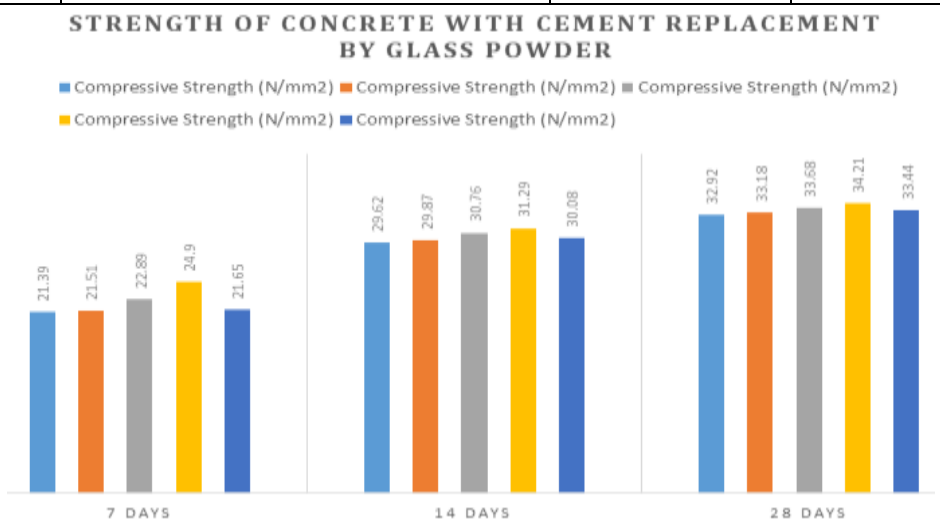
=459.16 kg.

Mass of fine aggregates = 0.665 (2.65 x 0.37 x 1000)

= 674.17 kg.

Strength of concrete with cement replacement by glass powder:

Mix	Sample No.	% Replacement of cement by glass powder	Compressive Strength (N/mm^2)		
			7 days	14 days	28 days
M30	1	05	21.39	29.62	32.92
	2	10	21.51	29.87	33.18
	3	15	22.89	30.76	33.68
	4	**20**	**24.90**	**31.29**	**34.21**
	5	25	21.65	30.08	33.44



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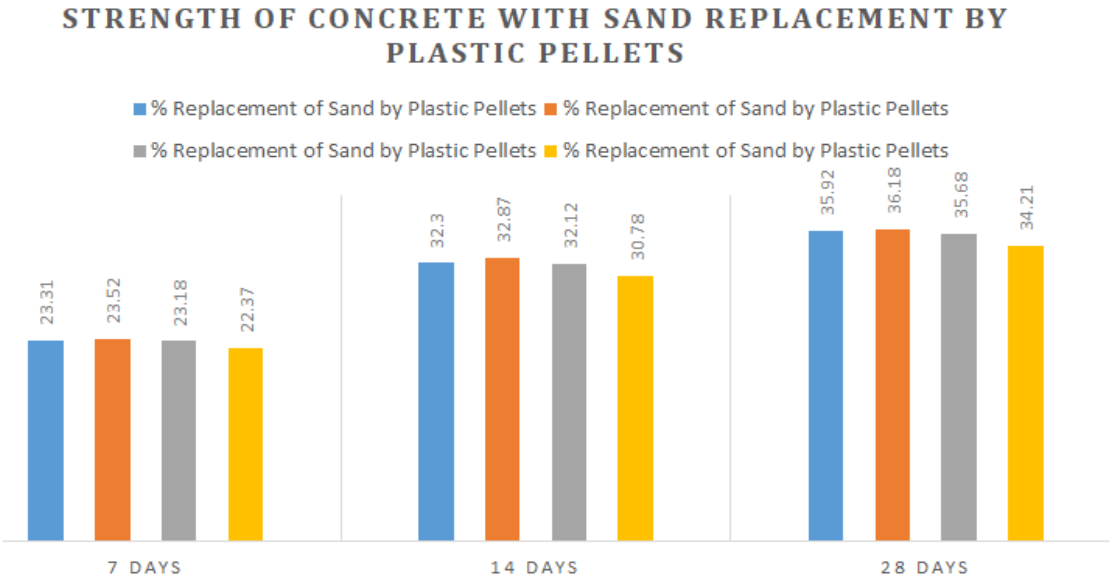
Strength of concrete with sand replacement by plastic pellets:

Mix	Sample No.	% Replacement of Sand by Plastic Pellets	Compressive Strength (N/mm²)		
			7 days	14 days	28 days
M30	1	2.5	23.31	32.30	35.92
	2	**5**	**23.52**	**32.87**	**36.18**
	3	7.5	23.18	32.12	35.68
	4	10	22.37	30.78	34.21



Strength of concrete with combined effect of glass powder and plastic pellets:

Mix	Sample No.	% Replacement of Cement by Glass Powder	% Replacement of Sand by Plastic Pellets	Compressive Strength (N/mm²)		
				7 days	14 days	28 days
M30	1	0	0	24.9	34.52	37.85
	2	15	2.5	23.21	32.13	35.71
	3	15	5	23.51	32.55	36.17
	4	15	7.5	23.27	32.23	35.81
	5	15	10	22.17	30.69	34.11
	6	20	2.5	23.70	32.82	36.47
	7	**20**	**5**	**24.20**	**33.50**	**37.23**
	8	20	7.5	23.84	33.01	36.68
	9	20	10	23.30	32.26	35.85
	10	25	2.5	22.36	30.97	34.41
	11	25	5	23.38	32.37	35.97
	12	25	7.5	22.89	31.70	35.23
	13	25	10	21.81	30.20	33.56

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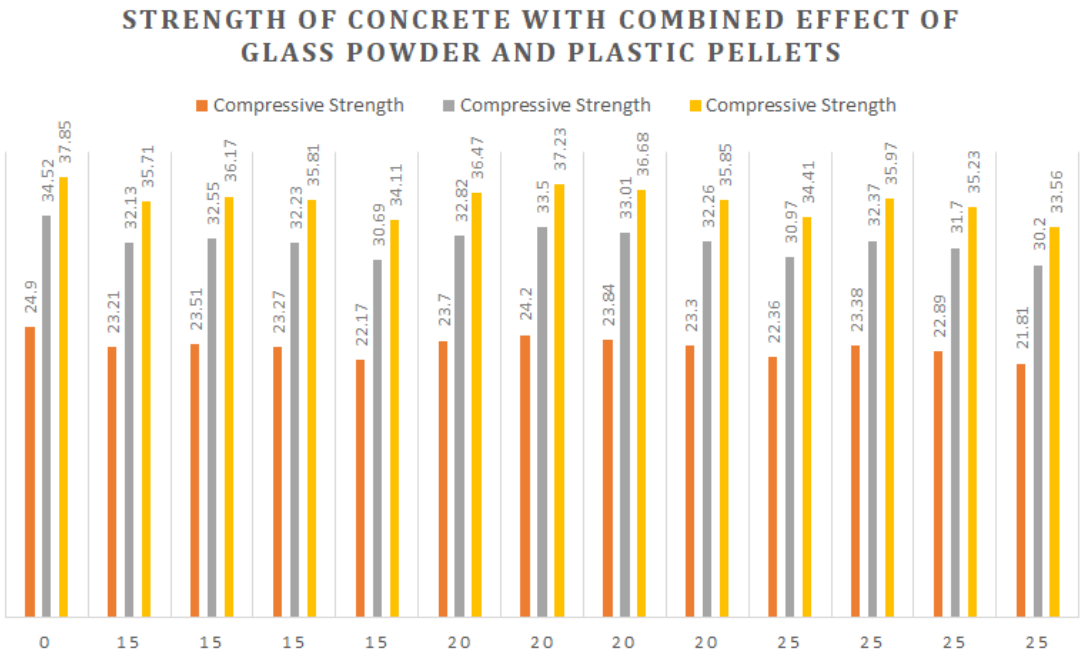
Fig 1: Casting the cubes

Fig 2: Cubes under CTM



IV. CONCLUSION

Following conclusion can be drawn from this experimental study-

1. Optimum strength seen at the 20% replacement of cement by glass powder.
2. In case of plastic pellets, compressive strength increase at the 5 % replacement but further increase of plastic, compressive strength is continuously decreasing.
3. The test results show that the slump value is reduced at higher percentage of glass powder and plastic fiber. But up to 20% glass powder and 5% plastic pellets the slump value is not hampered so much.
4. Optimum strength obtained in case of combine study at 20% glass powder and 5% plastic pellets.
5. The compressive strength obtained from the above case is nearly same to compressive strength of conventional concrete but flexural strength improved by 1.04 to 1.06%.
6. The strength obtained in combine replacement (glass and plastic) is 1to 2 % more as compare to the individual glass powder replacement.
7. Reduce the cost of construction about 10%.
8. Avoid the disposal problem of plastic waste and glass powder.

Considering the strength criteria, the replacement of cement by glass powder and replacement of plastic fiber by sand is feasible. Hence it can be concluded that utilization of waste plastic and waste glass powder in concrete as sand and cement respectively.

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