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STRENGTH STUDIES ON GRAPHENE OXIDE AND METAKAOLIN AS PARTIAL REPLACEMENT OF CEMENT AND QUARRY DUST AS PARTIAL REPALCEMENT OF FINEAGGREGATE IN CONCRETE

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ABSTRACT

Graphene concrete characteristics are modified in this study by replacing some of the cement with metakaolin and some of the fine aggregate with quarry dust. Graphene oxide percentages in cement varied from 0% to 0.03% to 0.06% to 0.09% to 0.12% to 0.15%. In manufacturing, the use of quarry dust as a substitute for river sand in concrete is being investigated. Concrete of grade M20 was made using 0%, 10%, 20%, 30%, and 40%. Metakaolin also replaces cement by 0%, 3%, 6%, 9%, 12%, 15%, and 18%. Compressive and split tensile strength tests should be conducted within 7, 28 days respectively.

***KEYWORDS**: Graphene oxide, Metakaolin, Quarry dust, Compressive strength, Split tensile strength.*

1. INTRODUCTION

Concrete is a composite material made of coarse aggregate joined by a fluid cement that gradually becomes harder. The most common types of concrete are those created with hydraulic cements or lime-based concretes like Portland cement concrete. Cement-based materials are currently the most significant construction materials, and it is quite likely that they will maintain this status in the future.

Quarry dust, a by-product of crushing, is a concentrated material that can be utilised as aggregates for concrete, especially as fine aggregates. When rock is broken into different sizes for quarrying purposes, the dust that results is known as quarry dust and is produced as waste. As a result, it becomes a waste item and contributes to air pollution.

When kaolinite (China clay) is calcined, a highly reactive pozzolana known as metakaolin is created. Although the temperature of manufacture is between 700 and 900 °C as opposed to 1450 °C in the case of cement, it must be treated in a burning process like cement. Therefore, the manufacturing of metakaolin is linked to significant CO2 emissions.

New and possibly greener approaches to building and infrastructure project design are made possible by the use of graphene concrete, mortar, and cement additives. These materials give stronger, more lasting concrete structures. When evaluated using international standard procedures, external testing reveals an increase in the compressive strength and an increase in the tensile strength.

2. OBJECTIVES

1. To optimize the usage of Quarry dust in Fine aggregate.
2. To optimize the usage of Metakaolin and Graphene oxide in concrete.

3. MATERIALS

3.1 Cement:

The cohesive and adhesive properties of cement are enhanced by the presence of water. Such cements are known as hydraulic cements. These mostly consist of clay and limestone-based silicates and aluminates of lime.

3.2 Fine aggregate:

Made up of natural sand or crushed stone, fine aggregate is a crucial component of concrete. The hardened properties of the concrete are significantly influenced by the fine aggregate density quality.

3.3 Coarse aggregate:

Coarse aggregate is defined as material that is maintained over IS Sieve 4.75 mm. According to IS383:1970, the typical maximum size is gradually 10–20 mm.

3.3 Water:

One of the most important elements in building, water is necessary for the preparation of mortar, mixing cement concrete, curing work, and other processes. The strength of the motor and cement concrete in the construction process is directly influenced by the quality of water utilized.

3.4 Quarry Dust:

Quarry dust, a byproduct of the crushing process, is a concentrated material that can be utilised as aggregates, particularly as fine aggregates, in concrete.

3.5 Metakaolin:

To create high-quality cement, metakaolin, a cementitious material, is added. In order to create a white powder of A2Si, kaolin is dried at an appropriate temperature (700-900°C). A few fundamental changes occur when kaolin is heated in the presence of air, and at a temperature of about 600°C, the absence of hydration affects the material's layered structure, causing a transient stage of weak crystalline. Because of its great mobility, metakaolin can be utilised to blend high-quality elite cement and manufacture cementitious materials.

3.6 Graphene oxide:

When heated quickly at fairly high temperatures (between 280 and 300 °C), graphene oxide exfoliates and decomposes, producing finely scattered amorphous carbon.

4. EXPERIMENTAL RESULTS

4.1 Compressive strength:

The 150mm x 150mm x 150mm cube specimens were cast, tested in a compression testing equipment for seven and twenty-eight days while curing the concrete, and then shown in Table.

Table 1: Compressive strength of concrete with Quarry dust as partial replacement of Fine aggregate in concrete

S.No.	% Quarry dust	Compressive Strength, N/mm^2	
		7 Days	28 Days
1	0	19.09	27.64
2	10	20.47	29.72
3	20	21.76	31.81
4	30	23.47	33.29
5	40	22.89	33.13

Table 2: Compressive strength of concrete with Metakaolin as partial replacement of Cement in concrete

S.No.	% Metakaolin	Compressive Strength, N/mm^2	
		7 Days	28 Days
1	0	19.09	27.64
2	3	19.96	29.15
3	6	20.43	29.57
4	9	20.86	30.02
5	12	21.24	30.39
6	15	22.31	31.84
7	18	20.09	29.33

Table 3: Compressive strength of concrete with Graphene Oxide as partial replacement of Cement in concrete

S.No.	% Graphene Oxide	Compressive Strength, N/mm^2	
		7 Days	28 Days
1	0	19.09	27.64
2	0.03	24.36	35.73
3	0.06	26.42	38.27
4	0.09	27.89	40.09
5	0.12	29.16	41.33
6	0.15	27.39	39.15

Table 4: Compressive strength of concrete for combined partial replacement of cement by 15% Metakaolin+0.12% Graphene oxide and fine aggregate by 30% of Quarry Dust

S.No	Combined replacements (%)	Compressive strength, N/mm^2	
		7 days	28 days
1	0	19.09	27.64
2	30%QD+0.12%GO+15%MK	32.31	46.22

4.2 Split tensile strength results

The cylindrical specimens (150 mm in diameter x 300 mm in height) were examined for assessing the split tensile strength at 7 and 28 days. A cylindrical sample is placed horizontally between the loading surface of a compression testing machine, and a load is applied until the cylinder fails along the vertical diameter.

Table 5: Split tensile strength of concrete with Quarry dust as partial replacement of Fine aggregate in concrete

S.No.	% Quarry dust	Split tensile Strength, N/mm^2	
		7 Days	28 Days
1	0	1.84	2.71
2	10	2.06	2.91
3	20	2.28	3.19
4	30	2.41	3.35
5	40	2.26	3.28

Table 6: Split tensile strength of concrete with Metakaolin as partial replacement of Cement in concrete

S.No.	% Metakaolin	Split tensile Strength, N/mm^2	
		7 Days	28 Days
1	0	1.84	2.71
2	3	1.96	2.87
3	6	2.01	2.92
4	9	2.06	2.97
5	12	2.11	3.02
6	15	2.23	3.18
7	18	1.98	2.86

Table 7: Split tensile strength of concrete with Graphene Oxide as partial replacement of Cement in concrete

S.No.	% Graphene Oxide	Split tensile Strength, N/mm^2	
		7 Days	28 Days
1	0	1.84	2.71
2	0.03	2.42	3.53
3	0.06	2.69	3.78
4	0.09	2.76	4.01
5	0.12	2.88	4.12
6	0.15	2.73	3.87

Table 8: Split tensile strength of concrete for combined partial replacement of cement by 15% Metakaolin+0.12% Graphene oxide and fine aggregate by 30% of Quarry Dust

S.No	Combined replacements (%)	Split tensile strength, N/mm^2	
		7 days	28 days
1	0	1.84	2.71
2	30%QD+0.12%GO+15%MK	3.42	4.88

5. CONCLUSION

1. The Normal Concrete Compressive strength result for 7 and 28 days is 19.09 N/mm^2 and 27.64N/mm^2.
2. At 30% replacement of Fine aggregate by Quarry dust the achieved compressive strength of concrete is 23.47N/mm^2 for 7days and 33.29 N/mm^2 for 28days.
3. At 15% replacement of Cement by Metakaolin the achieved compressive strength of concrete is 22.31N/mm^2 for 7days and 31.84 N/mm^2 for 28days.
4. At 0.12% replacement of Cement by Graphene oxide the achieved compressive strength of concrete is 29.16N/mm^2 for 7days and 41.33 N/mm^2 for 28days.
5. Combined replacement of compressive strength of concrete with 30% Quarry dust+15% Metakaolin + 0.12% Graphene oxide the achieved compressive strength of concrete is 32.31N/mm^2 for 7days and 46.22 N/mm^2 for 28days.
6. The Normal Concrete Split tensile strength result for 7 and 28 days is 1.84 N/mm^2 and 2.71N/mm^2.
7. At 30% replacement of Fine aggregate by Quarry dust the achieved Split tensile strength of concrete is 2.41N/mm^2 for 7days and 3.35 N/mm^2 for 28days.
8. At 15% replacement of Cement by Metakaolin the achieved Split tensile strength of concrete is 2.23N/mm^2 for 7days and 3.18N/mm^2 for 28days.
9. At 0.12% replacement of Cement by Graphene oxide the achieved Split tensile strength of concrete is 2.88 N/mm^2 for 7days and 4.12 N/mm^2 for 28days.
10. Combined replacement of Split tensile strength of concrete with 30% Quarry dust+15% Metakaolin + 0.12% Graphene oxide the achieved Split tensile strength of concrete is 3.42N/mm^2 for 7days and 4.88 N/mm^2 for 28days.

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