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MECHANICAL PROPERTIES 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

In this work, the properties of graphene concrete are altered by substituting metakaolin for some of the cement and quarry dust for some of the fine aggregate. Cement included varying amounts of graphene oxide, ranging from 0% to 0.03% to 0.06% to 0.09% to 0.12% to 0.15%. Quarry dust is being researched for usage in manufacturing as a river sand alternative in concrete. 0%, 10%, 20%, 30%, and 40% were used to create concrete of grade M20.Cement is also replaced with metakaolin by amounts of 0%, 3%, 6%, 9%, 12%, 15%, and 18%. Within 7, and 28 days, respectively, compressive, split tensile strength and UPV tests should be performed.

KEYWORDS: Metakaolin, Graphene oxide, Quarry dust, Compressive strength, Split tensile strength and Upv

1. INTRODUCTION

A Fluid cement that gradually grows harder is used to bind coarse aggregate to create the composite material known as concrete. Concrete made using hydraulic cements or lime-based concretes like Portland cement concrete are the most prevalent types. The most important construction materials now are those made of cement, and it is very likely that they will continue to be so in the future.

Quarry dust is created when rocks are crushed to various sizes for quarrying activities. It is a waste product. It consequently ends up in the trash and adds to air pollution.

Metakaolin, a highly reactive pozzolana, is produced during the calcination of kaolinite (China clay). Although it is manufactured at a temperature between 700 and 900 °C as opposed to 1450 °C for cement, it still needs to be burned in the same manner. Therefore, there are large CO2 emissions associated with the production of metakaolin.

The use of graphene concrete, mortar, and cement additives enables new and potentially greener methods of designing infrastructure and building projects. Concrete buildings made of these materials are more durable and stronger. External testing showed an increase in compressive strength and an increase in tensile strength when tested using international standard standards.

2. OBJECTIVES

1. To use quarry dust in fine aggregate as efficiently as possible.

2. To obtain the most efficient use achievable of grapheme oxide and metakaolin in cement.

3. MATERIALS

3.1 Cement:

The addition of water improves the cohesive and adhesive qualities of cement. These cements go by the name of hydraulic cements. Clay, silicates made from limestone, and lime aluminates make up the majority of these.

3.2 Fine aggregate:

Fine aggregate, which is made of natural sand or crushed stone, is an essential part of concrete. The fine aggregate density quality has a considerable impact on the hardened qualities of the concrete.

3.3 Coarse aggregate:

Material that is kept over IS Sieve 4.75 mm is referred to as coarse aggregate. The typical maximum size is gradually 10–20 mm, according to IS383:1970.

3.3 Water:

Water is one of the most crucial building materials because it is required for many activities, including making mortar, mixing cement, curing work and more. The quality of water used has a direct impact on durability of the mortar and cement concrete in construction.

3.4 Quarry Dust:

Quarry dust, a waste material from crushing, is a concentrated material that can be used as aggregates, especially as fine aggregates, in concrete.

3.5 Metakaolin:

Metakaolin, a cementitious substance, is added to cement to produce high-quality cement. Kaolin is dried at the proper temperature (700-900°C) to produce a white A2Si powder. When kaolin is heated in the presence of air, a few essential changes take place. At a temperature of about 600°C, the lack of hydration impairs the material's layered structure, resulting in a brief stage of weak crystalline. Metakaolin can be used to mix premium cement and create cementitious materials because of its excellent mobility.

3.6 Graphene oxide

At relatively high temperatures (between 280 and 300 °C), graphite oxide rapidly exfoliates and decomposes, yielding finely dispersed 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 7 and 28 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		
		28 days	56 days	90 days
1	0	27.64	30.01	32.13
2	10	29.72	32.18	34.73
3	20	31.81	34.43	37.16
4	30	33.29	35.12	38.78
5	40	33.13	36.02	38.54

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

S.No.	% Metakaolin	Compressive Strength, N/mm^2		
		28 days	56 days	90 days
1	0	27.64	30.01	32.13
2	3	29.15	31.67	34.07
3	6	29.57	32.08	34.52
4	9	30.02	32.71	34.94
5	12	30.39	33.04	35.51
6	15	31.84	34.69	37.08
7	18	29.33	31.92	34.09

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		
		28 days	56 days	90 days
1	0	27.64	30.01	32.13
2	0.03	35.73	38.74	41.57
3	0.06	38.27	41.52	44.65
4	0.09	40.09	43.56	46.82
5	0.12	41.33	44.88	48.29
6	0.15	39.15	42.57	45.76

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		
		28 days	56 days	90 days
1	0	27.64	30.01	32.13
2	30%QD+0.12%GO+15%MK	46.22	50.28	54.06

4.2 Split tensile strength results

For determining the split tensile strength at 7 and 28 days, the cylindrical specimens (150 mm in diameter x 300 mm in height) were inspected. A compression testing device's loading surface is surrounded horizontally by a cylindrical sample.

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		
		28 days	56 days	90 days
1	0	2.71	2.94	3.15
2	10	2.91	3.15	3.38
3	20	3.19	3.46	3.72
4	30	3.35	3.64	3.92
5	40	3.28	3.56	3.83

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		
		28 days	56 days	90 days
1	0	2.71	2.94	3.15
2	3	2.87	3.12	3.34
3	6	2.92	3.18	3.42
4	9	2.97	3.21	3.45
5	12	3.02	3.29	3.53
6	15	3.18	3.45	3.76
7	18	2.86	3.09	3.34

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		
		28 days	56 days	90 days
1	0	2.71	2.94	3.15
2	0.03	3.53	3.82	4.12
3	0.06	3.78	4.09	4.45
4	0.09	4.01	4.36	4.67
5	0.12	4.12	4.48	4.86
6	0.15	3.87	4.21	4.52

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		
		28 days	56 days	90 days
1	0	2.71	2.94	3.15
2	30%QD+0.12%GO+15%MK	4.88	5.31	5.74

4.3 Ultrasonic Pulse Velocity Test

The integrity and quality of structural concrete or stone (up to 6 feet thick) are assessed using ultrasonic pulse velocity (UPV) testing, which measures the speed and attenuation of an ultrasonic wave as it flows through the element under test.

Table 9: Ultrasonic pulse velocity of concrete with Quarry dust as a partial replacement for Fine aggregate

Sl.no	% Of Quarry Dust	Pulse velocity (m/sec)	Concrete quality
1	0	4797	Excellent
2	10	5082	Excellent
3	20	5149	Excellent
4	30	5422	Excellent
5	40	4918	Excellent

Table10: Ultrasonic pulse velocity of concrete with Metakaolin as a partial replacement for Cement

Sl.no	% Of Metakaolin	Pulse velocity (m/sec)	Concrete quality
1	0	4797	Excellent
2	3	4850	Excellent
3	6	4963	Excellent
4	9	5014	Excellent
5	12	5116	Excellent
6	15	5218	Excellent
7	18	5009	Excellent

Table11: Ultrasonic pulse velocity of concrete with Graphene oxide as a partial replacement for Cement

Sl.no	% Of Graphene oxide	Pulse velocity (m/sec)	Concrete quality
1	0	4797	Excellent
2	0.03	5224	Excellent
3	0.06	5342	Excellent
4	0.09	5396	Excellent
5	0.12	5449	Excellent
6	0.15	5338	Excellent

Table 12: Ultrasonic pulse velocities 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 (%)	Pulse velocity (m/sec)	Concrete quality
1	0	4797	Excellent
2	30%QD+0.12%GO+15%MK	5782	Excellent

5. CONCLUSION

1. The Normal Concrete Compressive strength result for 28, 56 and 90 days is 27.64, 30.01 and 32.13N/mm^2.
2. At 30% replacement of Fine aggregate by Quarry dust the achieved compressive strength of concrete is for 28, 56 and 90 days is 33.29, 35.12 and 38.78N/mm^2.
3. At 15% replacement of Cement by Metakaolin the achieved compressive strength of concrete is for 28, 56 and 90 days is 31.84,34.69 and 37.08N/mm^2
4. At 0.12% replacement of Cement by Graphene oxide the achieved compressive strength of concrete is for 28, 56 and 90 days is 41.33,44.88and 48.29N/mm^2
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 for 28, 56 and 90 days is 46.22, 50.28 and 54.06N/mm^2
6. The Normal Concrete Split tensile strength result is for 28, 56 and 90 days is 2.71, 2.94 and 3.15N/mm^2
7. 7.At 30% replacement of Fine aggregate by Quarry dust the achieved Split tensile strength of concrete is for 28, 56 and 90 days is 3.35,3.64 and 3.92N/mm^2
8. At 15% replacement of Cement by Metakaolin the achieved Split tensile strength of concrete is for 28, 56 and 90 days is 3.18,3.45 and 3.76N/mm^2.
9. At 0.12% replacement of Cement by Graphene oxide the achieved Split tensile strength of concrete is for 28, 56 and 90 days is 4.12, 4.48 and 4.86N/mm^2.

10. Combined replacement of Split tensile strength of concrete with 30% Quarry dust+15% Metakaolin + 0.12% Graphene oxide the achieved compressive strength of concrete is is for 28, 56 and 90 days is 4.88,5.31 and 5.74N/mm^2.
11. The Normal Concrete Ultrasonic pulse velocity result is for 28 days is 4797m/s.
7.At 30% replacement of Fine aggregate by Quarry dust the achieved Ultrasonic pulse velocity result of concrete is for 28 days is 5422m/s.
11. At 15% replacement of Cement by Metakaolin the achieved Ultrasonic pulse velocity result of concrete is for 28 days is 5218m/s .
12. At 0.12% replacement of Cement by Graphene oxide the achieved Ultrasonic pulse velocity result of concrete is for 28 days is 5449m/s.
13. Combined replacement of Split tensile strength of concrete with 30% Quarry dust+15% Metakaolin + 0.12% Graphene oxide the achieved Ultrasonic pulse velocity result of concrete is for 28 days is 5782m/s.

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