AN EXPERIMENTAL WORK ON CONCRETE BY USAGE OF CALCITE POWDER AND DIATOMITE POWDER AS PARTIAL REPLACEMENT WITH CEMENT

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Abstract: *— Diatomite powder continent amorphous silica and pozzolanic material. Calcite powder is natural form of calcium carbonate. This paper described the procedure and result of a laboratory investigation of mechanical properties carried out on concrete specimen containing diatomite powder and calcite powder as partial replacement of cement in concrete. Preparation of concrete specimens with diatomite powder and calcite powder with different ratio by volume as replacement with cement. Find the best mechanical properties from the replacement of cement with diatomite powder and calcite powder separately and together. Test result indicate that the concrete specimens containing 10% diatomite powder and 10% calcite powder replacement by volume with cement separately and together improve the mechanical properties of the conventional concrete mixture. Indian Standard cube, cylinder and beam are prepared to measure compressive strength after 7days, 14days, and 28days and Split tensile, Flexural strength after 28days of water curing and compare this strength with M30 control mix. The deteriorating effects of Sulphuric acid solution on concrete had been assessed. The standard cube samples of size 150mm x 150mm x 150mm were immersed in Sulphuric acid solutions. The changes in weight and strength of the concrete samples were found after 91 days of immersion.*

Index Terms – Concrete, Calcite powder, Diatomite powder, Compression strength, Flexural strength, Acid attack

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I. INTRODUCTION

The most importance properties of concrete are compressive and flexural strength. The mechanical properties of concrete can be improved with alternative material used for partial replacement of Portland cement in concrete. These materials are more common due to some technical, economic and environmental reasons.

One of this material is diatomaceous rocks. Diatomite refers to the light-colored sedimentary rock that is composed of the remains of one-celled algae known as diatoms. Diatomite is highly siliceous, has a low specific gravity, and is very porous. When diatomite is crushed into a powder, it is normally referred to as diatomaceous earth Diatomite is sedimentary rock of biogenic origin with high natural amorphous silica content. The amorphous silica is mainly in the form of diatom frustules, and secondarily in the form of sponge spicules, silicone-flagellate skeletons and radiolarian cells. This type of SiO_2 can react with $Ca(OH)_2$ and produce calcium silicate hydrates (C-S-H), which are responsible for the development of strength. Diatomite rocks commonly contain carbonate and clay minerals, quartz, feldspars and volcanic glass.it can be used as pozzolanic material for partial replacement of cement in production of concrete. [1][5]

Calcite powder is rock forming mineral with chemical formula with $CaCO_3$. It is extremely common and found throughout the world in sedimentary, metamorphic, and igneous rocks. Calcite is the principal constituent of limestone and marble. These rocks are extremely common and make up a significant portion of Earth's crust. They serve as one of the largest carbon repositories on our planet. Calcite powder is natural form of calcium carbonate with extremely high witness, purity and free flowing in nature. Calcite powder is widely used in plastic as filler, due to its high dispensability, low oil absorption, high impact resistance, smooth surface finish, easy processing and excellent dimensional stability. These materials are easily mixed, transported, and placed in the form of a slurry that will harden into a durable construction material. The properties of calcite make it one of the most widely used minerals. It is used as a construction material Calcite powder is mainly containing calcium carbonate. Mineralogical changes as functions of cement composition and amount of added calcite. Calculations of the specific volume of solids as a function of calcite addition suggest that the space-filling ability of the paste. [2][5]

In this study, the effect of usage of calcite powder and diatomite powder as partial replacement of cement on mechanical properties of concrete mixture measure. It is the aim of this paper to optimize the dosage of diatomite powder and calcite powder separated and together as replacement for cement in production of concrete. The different concrete test series were prepared by replacing calcite powder and diatomite powder separately and together.

II. MATERIALS

2.1 Calcite powder

In the present experimental work, Calcite powder is rock forming mineral, 25-micron size obtained from palanpur. The chemical compositions of calcite powder are showing in table 1.

Table.1 Chemical composition of Calcite powder

SR.NO	Particulars	Units	Results
1	Calcium carbonate as CaO	%	53.48
2	Magnesium oxide as MgO	%	01.02
3	Aluminium oxide as Al_2O_3	%	00.04
4	Ferric Oxide as Fe_2O_3	%	00.28

5	Calcium Carbonate as $CaCO_3$	%	95.50
6	Magnesium Carbonate as MgO_3	%	02.55
7	Silicon Di-Oxide As SiO_2	%	02.30
8	Loss of Ignition	%	43.52

2.2 Diatomite powder

Diatomite refers to the light-colored sedimentary rock that is composed of the remains of one-celled algae known as diatoms. Diatomite is highly siliceous, has a low specific gravity, and is very porous. The diatomite powder is taken size of 325 mesh size. Diatomite is sedimentary rock of biogenic origin with high natural amorphous silica content. The amorphous silica is mainly in the form of diatom frustules, and secondarily in the form of sponge spicules, silicone-flagellate skeletons and radiolarian cells. the chemical composition of diatomite powders showing in Table 2.

Table 2 Chemical composition of Diatomite powder

SR.NO	Particulars	Units	Results
1	SiO_2	%	90
2	Al_2O_3	%	6
3	TiO_2	%	3
4	Fe_2O_3	%	1
5	K_2OMn_2O	%	Traces
6	Combined Moisture	%	5

2.3 Aggregate

Generally, locally available coarse aggregate with combination of 20mm (65%) and 10mm (35%) are used in the present work. Also, natural available river sand of Zone II is used as a fine aggregate.

III. MIX DESIGN AND MIX PROPORTION

Mix design for concrete grade of M-30 has been carried out as per IS-10262:2009 and mix proportion shown in table.

Table.3 Mix proportion for mixes

MIX	Cement (kg)	Calcite powder (%)	Diatomite powder(kg)	Fine Aggregate(kg)	Coarse Aggregate(kg)	Water (kg)
M30	425	0	0	701.76	1145	192
Mix-1	401	18.76	0	701.76	1145	192
Mix-2	401	0	16.75	701.76	1145	192
Mix-3	379.89	18.76	16.75	701.76	1145	192
Mix-4	379.89	37.52	0	701.76	1145	192
Mix-5	379.89	0	33.5	701.76	1145	192
Mix-6	358.78	18.76	33.5	701.76	1145	192
Mix-7	358.78	37.52	16.75	701.76	1145	192
Mix-8	337.65	37.52	33.5	701.76	1145	192

IV. EXPERIMENTAL STUDY AND TEST RESULTS

For compressive strength test, cube specimens of dimensions 150mm x 150mm x150 mm and cylinder specimens of diameter and height 150mm x 300mm were casted, then cubes and cylinder are placed in water for curing after 24 hours of casting. The cubes and cylinders are tested for compressive strength on compressive testing machine after 7day, 14day and 28day. For split tensile test, cylinder specimens of dimeter and height 150mm x 300 mm are casted, then cylinder are placed in water for curing after 24 hours of casting. The cylinder is tested for split tensile strength after 28day. For flexural strength test, Beam specimens of dimension 150mm x 150 mm x 700 mm are casted, then beam is placed in water for curing after 24 hours of casting. The beams are tested for flexural strength after 28day. The durability of concrete is measured for 91 days from casting against acid attack. The Indian standard cubes were immersed for 28 days from casting in water and for remaining days in Sulphuric acid. Here 5% weight of water is replaced by 98% concentrated Sulphuric acid. The changes in weight and strength of the concrete samples were found after 91 days of casting.

Table 4. Test results: Compressive strength(Cube-Cylinder) and Flexural strength(Beam)

Mix	Compressive strength-Cube (N/mm^2)			Compressive strength-Cylinder(N/mm^2)			Flexural strength-Beam(N/mm^2)
	7 Days	14 Days	28 Days	7 Days	14 Days	28 Days	28 Days
M30	25.35	29.03	37.09	21.88	24.25	31.26	3.9
Mix-1	25.97	31.48	38.30	22.34	26.45	32.82	4.4
Mix-2	26.56	32.50	39.51	22.85	27.31	33.84	4.1
Mix-3	26.32	33.94	40.28	21.75	28.63	33.31	4.4
Mix-4	26.70	33.81	40.33	22.59	28.95	34.27	4.8
Mix-5	28.47	35.68	44.25	24.11	30.32	37.65	4.5
Mix-6	26.46	32.04	39.14	22.69	27.47	33.41	4.4

Mix-7	26.88	31.16	38.70	22.78	26.49	32.76	4.6
Mix-8	27.80	34.93	43.68	23.17	29.71	36.44	5.0

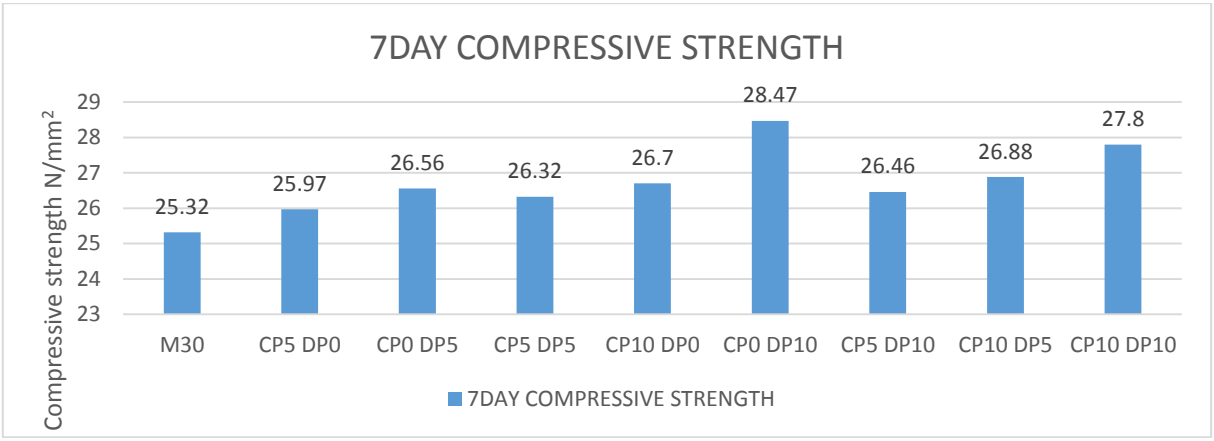

Chart-1 7-day compressive strength (Cube)

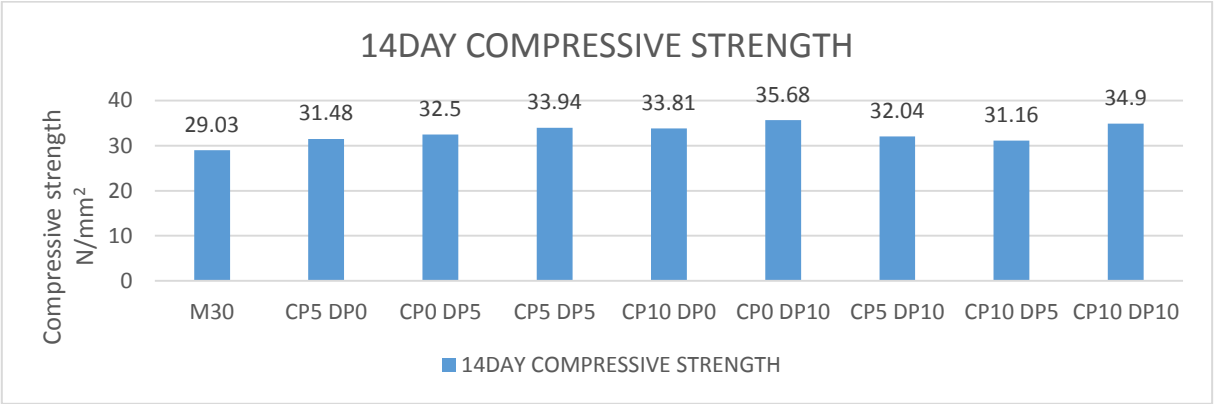

Chart-2 14-day compressive strength (Cube)

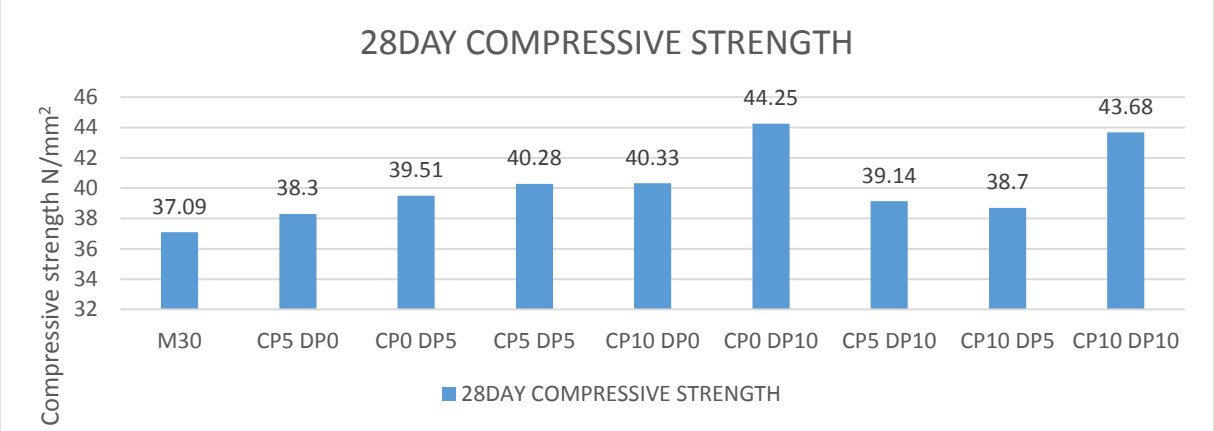

Chart-3 28-day compressive strength (Cube)

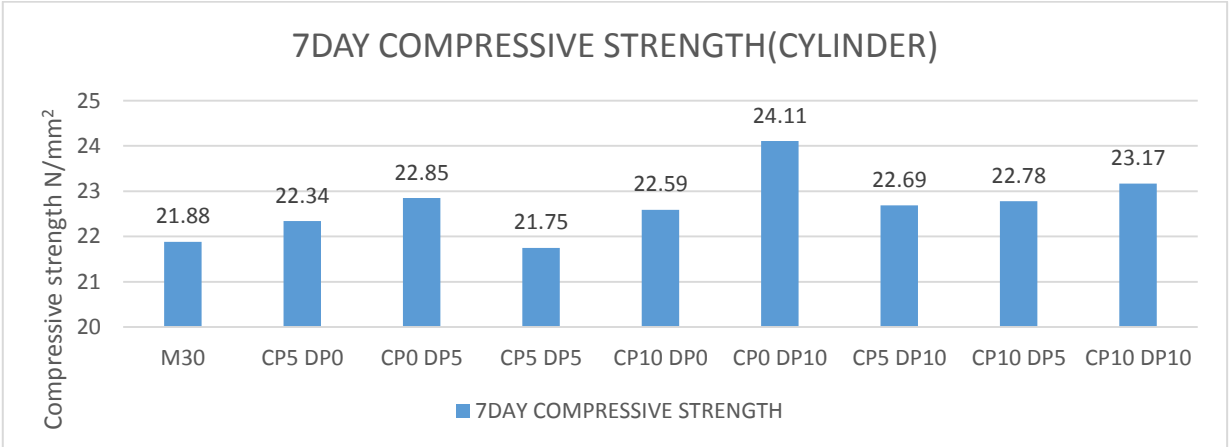

Chart-4 7-day Compressive strength(Cylinder)

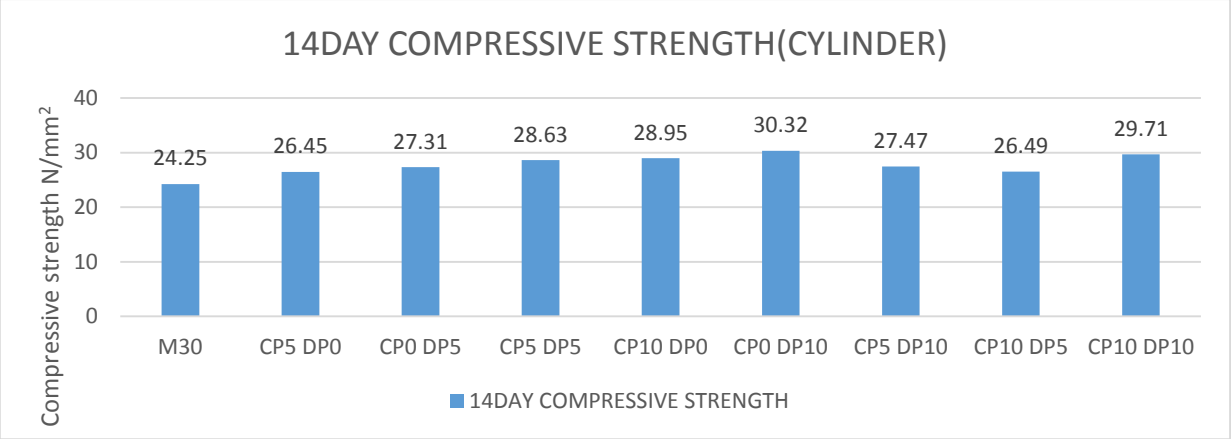

Chart-5 14-day compressive strength(Cylinder)

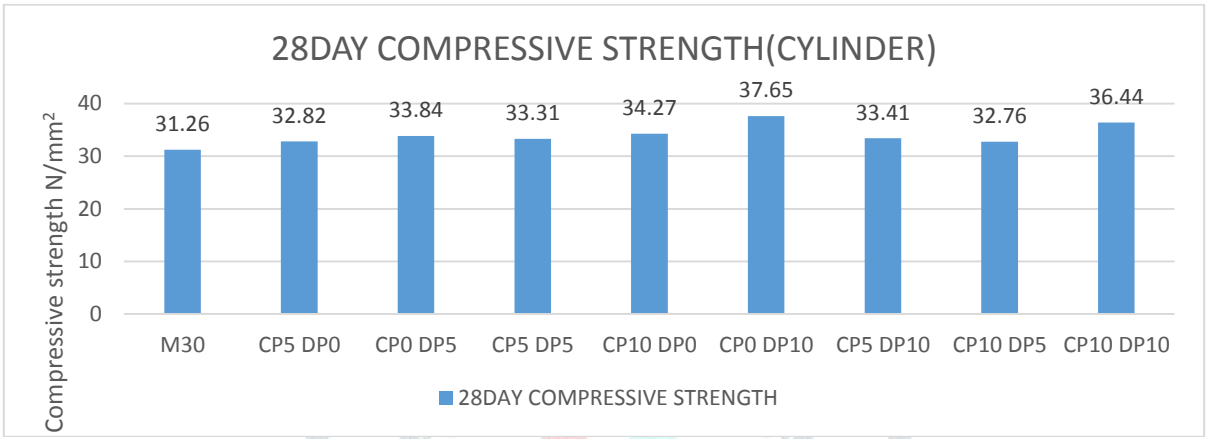

Chart-6 28-day compressive strength(Cylinder)

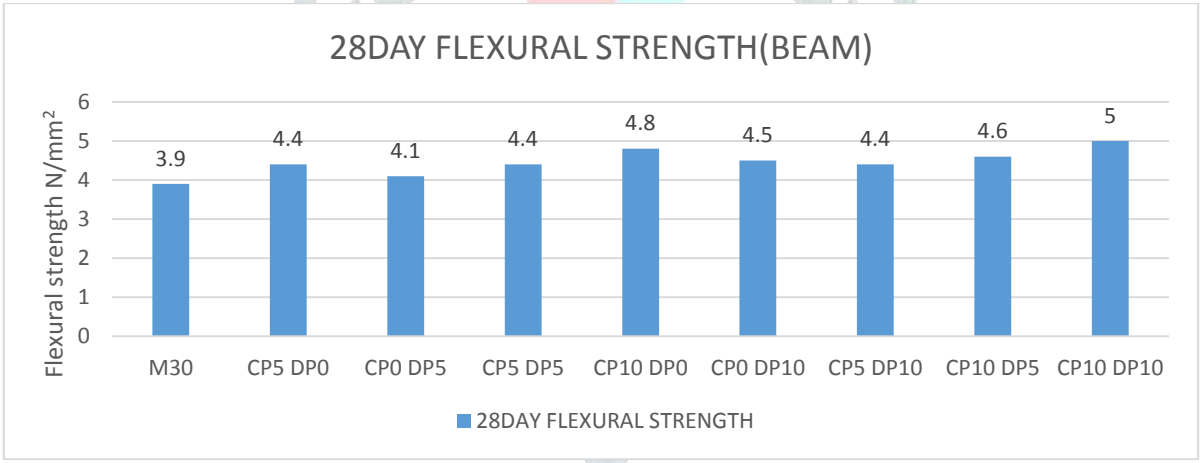

Chart-8 28-days Flexural Strength(BEAM)

Table 5. Test results: Ratio of Cube-Cylinder (Compressive strength) and Split tensile strength

Mix	Ratio of Cube-Cylinder (Compressive strength)			Split tensile strength (N/mm^2)
	7 Days	14 Days	28 Days	28 Days
M1	0.86	0.84	0.84	3.8
M2	0.86	0.84	0.86	4.1
M3	0.86	0.84	0.86	3.7
M4	0.83	0.84	0.83	3.9
M5	0.85	0.86	0.85	4.3
M6	0.85	0.85	0.85	4.1
M7	0.86	0.86	0.85	3.8
M8	0.85	0.85	0.85	4.0
M9	0.83	0.85	0.83	4.4

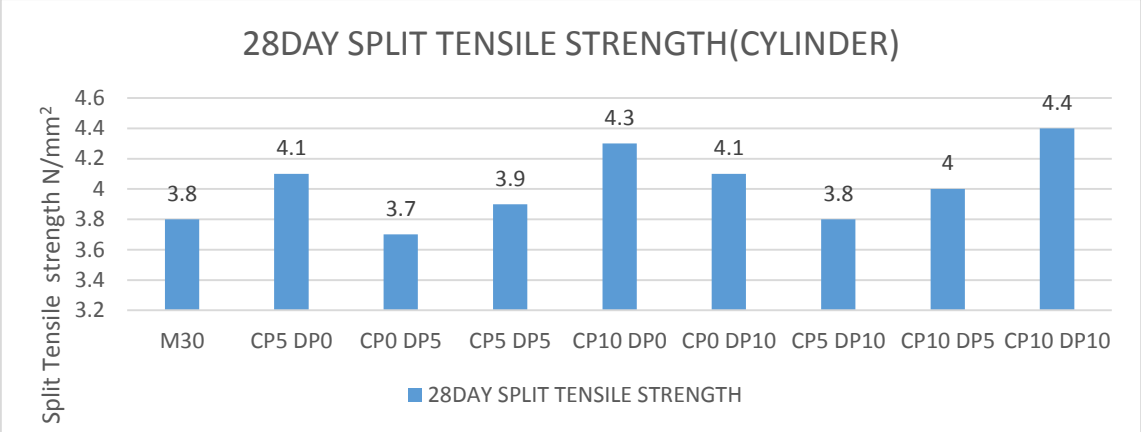

Chart-7 28-day split tensile strength

Table 6. Test results: Durability

Mix	Initial weight	Final Weight	Weight loss (%)	Compressive strength at 56days (N/mm^2)	Compressive strength after 91 days in acid (N/mm^2)	Compressive strength loss (%)
M30	8.659	8.270	4.7	37.09	31.01	16.4
Mix-1	8.579	8.156	5.1	38.30	30.06	21.5
Mix-2	8.572	8.220	4.2	39.51	34.21	13.4
Mix-3	8.586	8.222	4.4	40.28	33.1	17.8
Mix-4	8.580	8.137	5.4	40.33	32.23	20.1
Mix-5	8.602	8.286	3.8	44.25	38.8	12.3
Mix-6	8.596	8.255	4.1	39.14	33.24	15.1
Mix-7	8.592	8.208	4.6	38.70	31.34	19.0
Mix-8	8.566	8.206	4.3	43.68	37.16	14.9

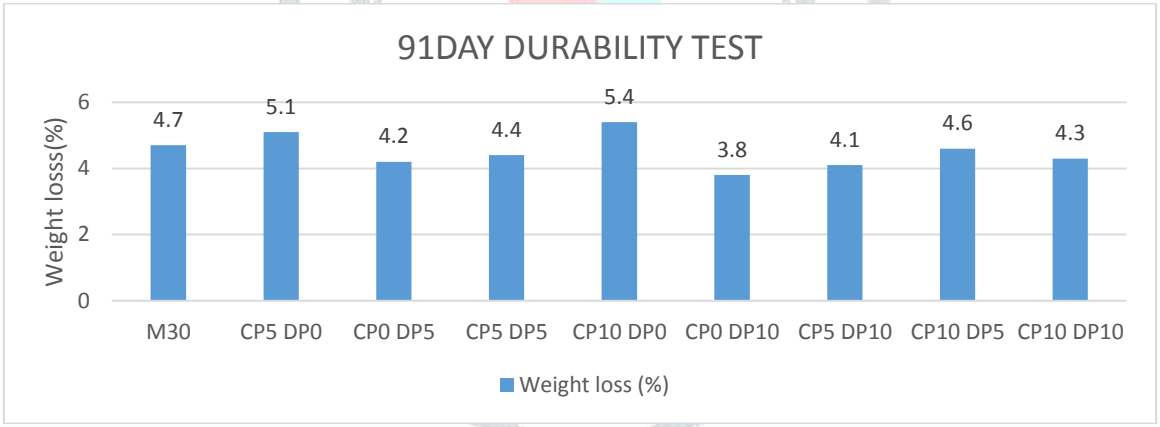

Chart-9 Durability: Weight loss at 91 days

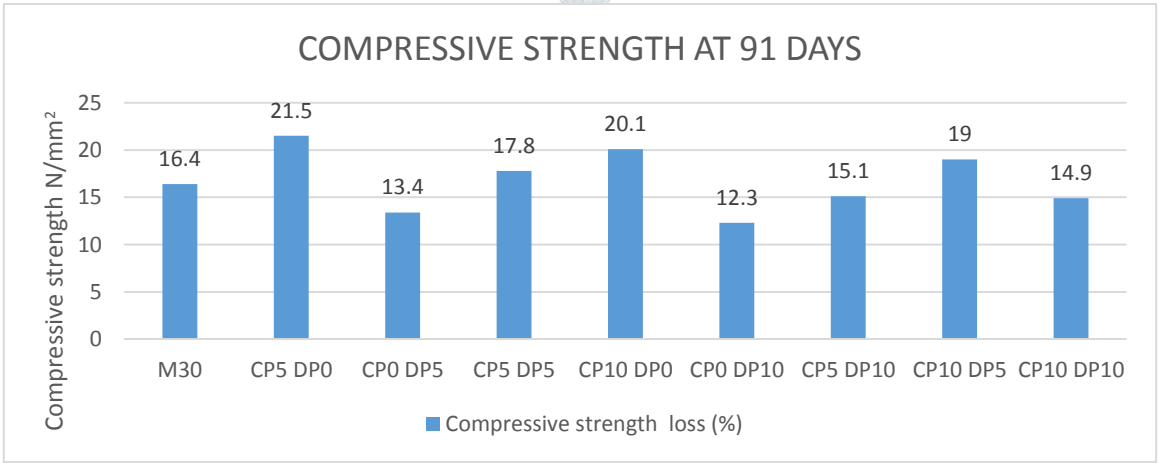

Chart-10 Durability: Compressive strength loss at 91 days

V. CONCLUSION

- Partial replacement of calcite powder and diatomite powder with cement give improvement in mechanical properties. Her, I show some results for mechanical properties.
- With 10% diatomite powder replacement with cement gives maximum compressive strength 44.25 N/mm^2 at 28days for cube specimens which is 19.30% increment to M30 normal mix.
- With 10% diatomite powder replacement with cement gives maximum compressive strength 36.44 N/mm^2 at 28days for cube specimens which is 16.57% increment to M30 normal mix.
- With 10% diatomite powder and 10 % calcite powder replacement with cement gives maximum split tensile strength 4.4 N/mm^2 at 28days for cube specimens which is 12.82% increment to M30 normal mix.
- With 10% diatomite powder and 10 % calcite powder replacement with cement gives maximum flexural strength 5.0 N/mm^2 at 28days for cube specimens which is 28.20% increment to M30 normal mix.
- Because of smaller particles of calcite powder and diatomite powder the packing in concrete became denser which improves properties of concrete. Also The amorphous silica is mainly in the form of diatom frustules, and secondarily in the form of sponge spicules, silicone-flagellate skeletons and radiolarian cells. This type of SiO_2 can react with $Ca(OH)_2$ and produce calcium silicate hydrates (C-S-H), which are responsible for the development of strength.
- Here replacement of OPC by Diatomite powder improves durability of concrete against acid attack.
- For 10% replacement of OPC by Diatomite powder the weight loss is minimum which is 3.8%.
- For 10% replacement of OPC by Diatomite powder the Strength loss is minimum which is 12.3%.
- The improvement in durability is because of improved pore structure of concrete. Here because of smaller particles of Diatomite powder the pores in concrete are reduced hence, the penetration of acid through pores is less compared to normal concrete mix.
- The replacement of 10% calcite powder and 10% diatomite powder with cement give improvement in all mechanical properties.C10D10 mix proportion are given maximum result for all mechanical properties.

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