Evaluation Of Mechanical And Durability Properties Of Concrete Made By Using Dolomite , Fly Ash And Quarry Dust As Partial Replacements Of Cement And Sand

[1] N. Usha Rani, [2] Dr.S.M.V.Narayana
[1] M.Tech.,(PG Scholar), [2]Professor & Head of the Department
DEPARTMENT OF CIVIL ENGINEERING, [2] DEPARTMENT OF CIVIL ENGINEERING
[1] Department Of Civil Engineering,Annamacharya Institute Of Technology & Sciences, Rajampet, Kadapa,
2 Department Of Civil Engineering,Annamacharya Institute Of Technology & Sciences, Rajampet, Kadapa,

Abstract : Incorporation of pozzolanic materials as complementary cementing material, use of different types of industrial by-products or wastes and other suitable materials into concrete to enhance the properties have been carried out by many researchers during the past several decades. In most of the attempts, the supplementary materials and other wastes were used in cement in their micro size or micro form. Recently, the use of these materials in micro form in cement or concrete has gained importance in the field of the concrete technology. In the scenario of the growing production of OPC and the emission of harmful gases into atmosphere during the production of OPC leading to global warming, there is a great need to utilize the indigenous material in cement or concrete to improve the concrete properties for reducing OPC and for sustainable growth of construction field. Dolomite is a common rock forming mineral it is a calcium magnesium carbonate with a chemical component of CaMg(CO3). It is the primary component of the sedimentary rock known as dolostone and the metamorphic rock known as dolomitic marble. Dolomite powder obtained by powderising the sedimentary rock forming mineral dolostone can be used as a replacement material for cement in concrete up to certain percentage. Dolomite powder has some similar characteristics of cement. It may increase the strength of concrete to some extent. Every year about 0.2 million tonnes of fly ash is generated from RTPP located in muddanuru kadapa district. Recently government of Andhra Pradesh has restricted the use of river or natural sand for constructions. In the present study, an attempt is made to investigate the strength of OPC concrete using fly ash, dolomite and the quarry dust. The results revealed that the combination of fly ash and dolomite improve the strength of concrete with partial replacement of sand with quarry dust. The XRD analysis is conducted on dolomite and fly ash for determining their form. The XRD analysis results indicated that the fly ash and dolomite are in form.

1. INTRODUCTION

The demand for building materials like cement, sand and coarse aggregate are increasing rapidly due to increase in growth of population, economy and living standards in India. Cement production in the country is assessed to be 347 million tons per annum and cement production grows by 5% every year. Cement concrete is the most important material for the construction. The quantity of cement in concrete can affect the mechanical and durability properties of concrete. It also contributes to achieve economy, sustainability and can make concrete an eco-friendly material. Production of one tone of OPC requires about 1.5 tons of raw materials, 80 units of electric power. About one ton of CO2 is released into the atmosphere for every tone of production of OPC inorder to reduce the greenhouse gas emissions, to add value to the wastages which are suitable for the use in production of concrete, for sustainability and for making concrete more and more eco-friendly, there is a need to use lesser and lesser OPC and use alternative/ supplementary cementious materials in concrete. Fly ash has been used for the past several decades in the manufacture of concrete. But the use of fly ash in Nano form into the concrete is yet to gain popularity through much research is being done in this direction,

1) Total production of flyash in the world.
2) Total production of flyash in India.
3) The uses of flyash.

One thermal power plant is located at RTPP Muddanuru in kadapa district which produces about 2.2 tones of fly ash every year. Dolomite is a common rock forming mineral having calcium and magnesium carbonates with a chemical composition, CaMg(CO3). It is the primary component of the sedimentary rock known as dolostone and the metamorphic rock known as dolomitic marble. Dolomite powder obtained by pulverising the sedimentary rock forming mineral dolostone can be used as a replacement material for cement in concrete up to certain percentage. In the present investigation 5%, 7.5% and 10% of Dolomite powder is used replacing with cement in concrete. Dolomite powder was collected from Bharathi Minerals located in Dhone town, Kurnool district. Recently, government of Andhra Pradesh has imposed restrictions on the use of natural sand for constructions. In order to keep pace the growth of construction in the state, alternative materials for sand have become inevitable. Smart sand or manufactured sand are proved alternatives for the natural sand in cement concrete production. Quarry Dust which is the waste tailing and residue generated from the crushing of rock stone into

aggregate. Quarry dust can be obtained from the stone crushing industries. This quarry dust is being used for asphalt, substitute for sand, and filling around pipes, sub grade for roads etc. To add value to this waste material, it can be used in concrete in place of fine aggregate. In view of the direct material to be need in concrete, An attempt is made to find out the effects of partial replacement of sand with 25% of quarry dust, 5 to 10% of Dolomite and Fly ash are used in concrete and on the strength or mechanical properties and durability properties of M25 grade concrete are studied. Quarry dust (for partil replacement of sand)Fly Ash and Dolomite as partial replacements to cement are used in concrete..

II LITERATURE SURVEY

This chapter presents the literature on a short review of the terminology and also the past studies on Dolomite powder, Fly ash, Quarry dust and Dolomite along with Fly ash. The available published literature on Dolomite, Quarry dust and Fly ash is reviewed. Kamal M.M, et al (2012) (1)evaluated the bond strength of self compacting concrete mixes containing dolomite powder. Either silica flume or fly ash was used along with dolomite powder to increase the bond strength considerably. The result showed that the bond strength increased as the replacement of Portland cement with dolomite powder increased. All SCC mixes containing dolomite powder up to 30 % yielded bond strength that is adequate for design purpose. The availability of this type of concrete provided unique merits for faster construction. Deepa Balakrishnan S and Paulose K.C (2013) (2) carried out an investigation on the workability and strength charectaristics of self compacting concrete containing fly ash and dolomite powder. They made high volume fly ash self compacting concrete with 12.5 percent, 18.75 percent, 25 percent and 37.5 percent of the cement (by mass) replaced by fly ash and 6.25 percent, 12.5 percent and 25 percent of the cement replaced by the dolomite powder. The test results for acceptance characteristics of self compacting concrete such as slump flow test, J-ring test, V-funnel test and L-box test were presented. The mixes were then tested for the mechanical properties like cube compressive strength at 7th day, 28th day and 90th day, cylinder compressive strength at 28th day, split tensile strength, and flexural strength at 28th day. For all levels of cement replacement, concrete achieved superior performance in the fresh and hardened states when compared with the reference mixture. Bhavin k, et al (2013) (3) presented the details of the investigation carried out on paver blocks made with cement, dolomite block and different percentages of polypropylene fibres. They reported that addition of 0.3% and 0.4% of polypropylene fibres improved the abrasion resistance and flexural strength of paver block.
Salim Barbhuiya (2011) (4) carried out an investigation to explore the possibilities of using dolomite powder for the production of SCC. Test results indicated that it is possible to manufacture SCC using fly ash and dolomite powder. The mix containing fly ash and dolomite powder in the ratio 3:1 was found to satisfy the requirements suggested by the European Federation of Producers and Contractors of Specialist Products for Structures (EFNARC) guidelines for making SCC. Compressive strengths of SCC with 75% fly ash and 25% dolomite powder was found to be satisfactory for structural applications. Chandana Sukesh et al (2013)(5) are made an investigation by replacing fine aggregate with quarry dust. This present work is an attempt to use Quarry Dust as partial replacement for Sand in concrete. Attempts have been made to study the properties of concrete and to investigate some properties of Quarry Dust the suitability of those properties to enable them to be used as partial replacement materials for sand in concrete.

III. OBJECTIVES AND SCOPE OF INVESTIGATION

The concrete manufacturers and construction industry have realized that they need to use available alternate replacement material for cement. At the same time, the increase in usage of concrete result in hundreds of tons of use Fly Ash and Dolomite Powder in palce of cement and quarry dust in place of sand for the production of concrete for the specific purposes.
It has been well established that Fly ash and Dolomite Powder can be used for all structural elements in civil engineering technology. Accordingly, the present investigation aimed at the study of mechanical properties and durability properties of concrete using above materials. Main objectives of the experimental work are mentioned here:

OBJECTIVES OF THE TEST PROGRAM

To find the effect of the Fly ash, Dolomite Powder and quarry dust on the mechanical properties of OPC concrete. To know the behavior of various concrete mixtures with Fly ash and Dolomite Powder under compression at 90 days(30days in normal water curing and 60days curing in acid and in alkaline water). To achieve the above objectives, the experimental work, and the test programs were planned. Total 310 cube specimens and 64 disc specimens were prepared with Fly ash (20%, 40% and 65%) and Dolomite (5%, 7.5% and 10%) as replacement to cement and 25% of quarry dust as replacement to fine aggregate i.e., natural sand. The details of each category are described below.

DETAILS OF SPECIMENS

Size of cube specimen: 150mm×150mm×150mm.
RCPT : 100 mm diameter discs with 50mm thick were casted
Grade of concrete : M-25(for details refer Annexure-1)
Water Cement ratio: 0.50
Number of specimens: 342 specimens (288+54) with (5%, 7.5% and10% of Nano dolomite powder, 20%, 40% and 65% of Nano fly ash and Nano dolomite powder + Nano fly ash (5% + 20%, 5% + 40%, 5% + 65%, 7.5% + 20%, 7.5% + 40%, 7.5% + 65%, 10% + 20%, 10% + 40%, 10% + 65%) were casted among which 54 were round discs for RCPT.

MATERIALS USED

The materials were used for the experimental work and methods of the tests conducted in the present investigation are presented. Materials used for present investigation are:

- Cement
- Fine aggregate
- Quarry dust
- Coarse aggregate
- Water
- Dolomite
- Fly ash
- Chemicals used for curing:
- Hydrochloric Acid (Hcl)
- Sodium Hydroxide (NaOH)

IV EXPERIMENTAL INVESTIGATION

In the present investigation M25 concrete is used. In this experiment cement has been replaced with different percentages of Fly ash by 20%, 40% and 65% and Dolomite Powder by 5%, 7.5% and 10% and combination of both materials and then Fine aggregates is replaced with Quarry dust. For study of various properties Specimens have been casted and tested. Here a constant water-cement ratio of 0.5 has been adopted. The experimental investigation is followed by selection of materials and testing, casting of specimens and curing, and finally testing specimens.

MIX DESIGN OF CONCRETE

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the objectives of producing concrete of certain minimum strength and durability as economically as possible.
To design the concrete mix is not a simple task on account of widely varying properties of the constituent materials will on the condition at the site. To design the concrete mix needs not only knowledge on material properties but also wider knowledge and experience of concreting. Even then the proportion of the materials of the concrete found out at the laboratory requires modifications and readjustments to suit the field conditions. In this present investigation M25 grade of concrete is considered. The mix of concrete is designed as per the guidelines given in IS 10262-2009; the mix proportions are 1: 1.52: 0.508: 3.85 with water cement ratio of 0.50.

MIXING OF CONCRETE

The ingredients of concrete such as cement and fine aggregate is replaced with 25% of quarry dust are mixed, and then Fly ash or Dolomite is added and then thoroughly mixed. After that coarse aggregate is added and mixed. Water is measured exactly, and then adds to the mix properly to get a uniform color, workable consistency of concrete. Properly mixed concrete is used for casting of specimens.

CURING OF SPECIMENS

The concrete which was casted in the moulds has allowed to dry for about 24hours and then the specimens were de-moulded and kept for curing. Marking was done on the specimens to identify the percentage of Dolomite powder, Fly ash and their combination and then the specimens were placed in water tank for curing. All the specimens have been cured for 30days in normal water and then the specimens were taken out of normal water and immersed in the acid water containing Hydrochloric acid (HCL) with pH of 2 at 5% weight of water and Alkaline water having 5% of sodium hydroxide (NaOH) by weight of water for about (The pH of acid water is maintained at 2 and the pH of alkaline water is maintained 3). After 60days of immersion the cubes were taken out of acid water and alkaline water and then tested for its compressive strength.

Fig Curing of specimens in acid water

Fig Curing of specimens in normal water

TESTING OF SPECIMENS

After curing of specimens to the desired age, they were tested for compressive strength, split tensile strength and flexural strength.
Cube Compressive Strength Test The test set up for concrete cube compressive strength test is shown in plate no2. Compression test on cubes is conducted with 2000kN capacity compression testing machine. The machine has a least count of 1kN. The cube was placed in the compression-testing machine and the load on the cube was applied at a constant rate till the failure of the specimen and the corresponding load was noted as ultimate load. Then cube compressive strength of the concrete mix is computed by using standard formula f c= $\frac{P}{A}$ N/mm2. Where, P is the ultimate load in N (Newton).
f c is compressive strength in N/mm2.
A is a cross sectional area of cube in mm2.

Rapid Chloride Permeability Test (RCPT)

In the chloride permeability test, a water-saturated, 50 mm thick, 100 mm diameter concrete specimen is subjected to a 60 v applied DC voltage for 6 hours using the RCPT apparatus. In one reservoir is a 3.0% NaC1 solution and in the other reservoir a 0.3 M NaOH solution were used or filled.The test was conducted as per the procedure prescribed in ASTMC 1202. The total charge passed is determined and this is used to rate the concrete according to the criteria included.

Fig Casting of disc specimens for RCPT

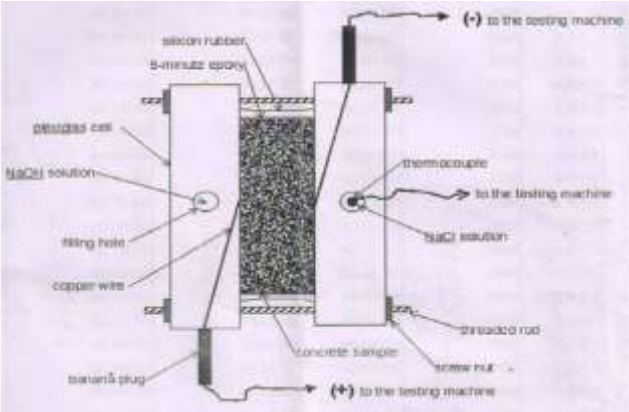

Fig Description of RCPT setup

The specimens were fit in the chamber with the required brass as well as rubber oaring. The record time is set as 30 minutes and also the log time as 6 hours and 30 minutes and the current of 60V is passed continuously. The charge passing through the concrete specimen was recorded at every 30 minutes upto 6 hours and the values were tabulated in table no 4.3.
RCPT ratings (per ASTM C1202):

Table No 4.1 : RCPT ratings

Charge passed (coulombs)	Chloride Ion penetrability
>4000	High
2000-4000	Moderate
1000-2000	Low
100-1000	Very low
‹100	Negligible

Average current flowing through one cell is calculated by,

I = 900 * 2 * I Cumulative coulombs.

ICUMMULATIVE = 900(I0 + 2(I30 + I60 + I90 + I120 + I150 + I180 + I210 + I240 + I270 + I300 + I330)+ I360)

I=900(I0+2(I30+I60+----------+I330)+I360)

Where
I0 = Initial current reading in mA.
I30 = Current reading at 30 minutes in mA.
I60 = Current reading at 60 minutes in mA.
I90 = Current reading at 90 minutes in mA.
I120 = Current reading at 120 minutes in mA.
I150 = Current reading at 150 minutes in mA.
I180 = Current reading at 180 minutes in mA.
I210 = Current reading at 210 minutes in mA.
I240 = Current reading at 240 minutes in mA.
I270 = Current reading at 270 minutes in mA.
I300 = Current reading at 300 minutes in mA.
I330 = Current reading at 330 minutes in mA.
I360 = Current reading at 360 minutes in mA.

Fig. Rapid Chloride Permeability Test setup

Table 4.2: Mix Designations of Concrete used in the Study

SL .No	Mix designations	Proportions of binding material
1	A1, B1, C1, D1,E1	conventional OPC concrete
2	A2	5% replacement of OPC with dolomite powder.
3	A3	7.5% replacement of OPC with dolomite powder.
4	A4	10% replacement of OPC with dolomite powder.
5	B2	20% replacement of OPC with fly ash
6	B3	40% replacement of OPC with fly ash
7	B4	65% replacement of OPC with fly ash
8	C2	20% replacement of cement with fly ash + 5% of dolomite powder.
9	C3	40% replacement of cement with fly ash + 5% of dolomite powder.
10	C4	65% replacement of cement with fly ash + 5% of dolomite powder.
11	D2	20% replacement of cement with fly ash + 7.5% of dolomite powder.
12	D3	40% replacement of cement with fly ash + 7.5% of dolomite powder.
13	D4	65% replacement of cement with fly ash + 7.5% of dolomite powder.
14	E2	20% replacement of cement with fly ash + 10% of dolomite powder.
15	E3	40% replacement of cement with fly ash + 10% of dolomite powder.
16	E4	65% replacement of cement with fly ash + 10% of dolomite powder.

Compressive strength of concrete is considered to be the most valuable and important property of concrete since it gives the overall picture of the concrete quality.

Effect of Dolomite powder and quarry dust on Compressive Strength of Concrete

The compressive strength of M25 grade concrete mixes by replacing OPC with Dolomite powder at 5%, 7.5% and 10% and 25% of sand replaced with quarry dust are investigated and the results of compressive strength of A1, A2,A3 and A4 concrete mixtures tested after 14 days, 28 days, 60 days and 90 days curing in normal water are presented in table. The graphical representation of the compressive strength at 14days, 28days, 60days and 90days are shown in figure.

Table.: Effect of Dolomite Powder on Compressive strength of M25 concrete

Mix Designation	Proportions of Binding Materials	Compressive strength N/mm2			
		14 Days	28 Days	60 Days	90 Days
A1	100% cement + Normal sand	24.40	31.14	33.21	35.20
A2	95% cement+ 5% Dolomite powder+ 25% Quarry dust	23.13	32.40	34.21	35.80
A3	92.5% cement + 7.5% Dolomite powder + 25% quarry dust	24.12	33.57	35.42	36.23
A4	90% cement + 10% Dolomite powder + 25% quarry dust	24.62	34.70	36.00	36.61

%Reduction in strength
40
35
30
25
20
15
10
5
0

Mix Designation	Proportion of binding material	Compressive strength N/mm2			
		14 Days	28 Days	60 Days	90 Days
B1	100% cement + Normal sand	24.40	31.14	33.21	35.20
B2	80% cement+20% Fly ash+25 % quarry dust	23.16	30.15	34.68	37.80
B3	60% Cement+40% Fly ash+ 25% quarry dust	21.74	25.70	28.44	31.41
B4	35% Cement+65% Fly ash+ 25% quarry dust	17.30	19.53	22.80	25.32

Fig no – Effect of Dolomite on concrete.

Effect of Fly Ash on Compressive Strength of Concrete

The compressive strength of M25 grade concrete mix with replacement of OPC by Fly ash at 20%, 40%, and 65% was investigated. The compressive strength of B1, B2, B3, and B4 concrete mixtures at 14days, 28days,60days and 90 days are shown in table.

Table Effect of Fly Ash on Compressive strength of M25 concrete

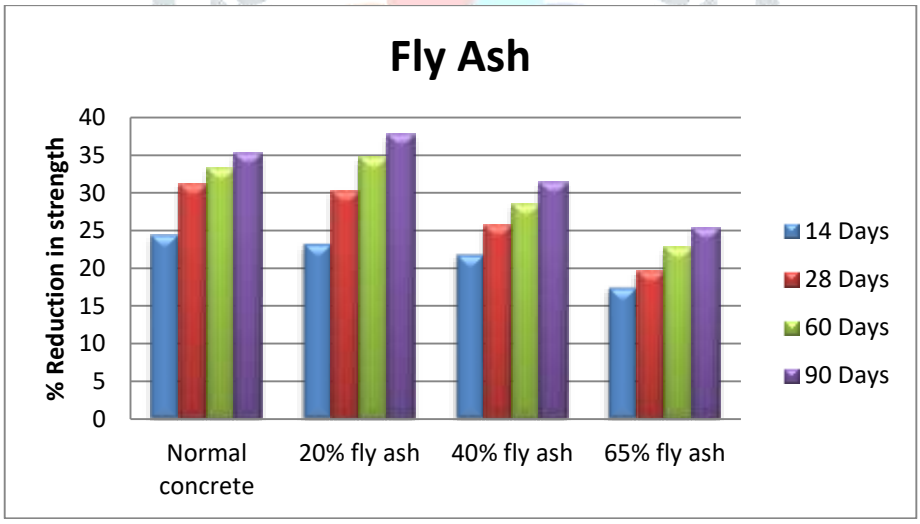

Fig. No . Effect of Fly ash on concrete.

Effect of Fly Ash + Dolomite powder + 25% Quarry dust on Compressive Strength of Concrete:

The compressive strength of M25 grade concrete mix with replacement of OPC by fly ash and dolomite powder with different proportions, 25% of sand is replaced with quarry dust are shown in below tables. The strength variation has shown when different proportions of fly ash i.e., 20%, 40%, 65% and different proportions of dolomite powder i.e., 5%, 7.5% and 10% is combined and replaced with cement and 25% of sand is replaced with quarry dust are investigated.

5.2.3.1 Effect of 20%, 40% And 65% Fly Ash + 5% of Dolomite powder on Compressive Strength of Concrete:

The compressive strength of M25 grade concrete mix with replacement of OPC by 20%, 40% and 65% fly ash + 5% of dolomite powder by replacing with OPC, 25% of sand is replaced with quarry dust are investigated. The results of compressive strength of C1, C2, C3, and C4 concrete mixtures which were allowed to cure in normal water for 14days, 28days, 60days and 90days are shown in table.

Table Effect of the Combination of Dolomite Powder and Fly Ash on Compressive strength of concrete

Mix Designation	Proportion of binding material	Compressive strength N/mm2			
		14 Days	28 Days	60 Days	90 Days
C1	100% cement + Normal sand	24.40	31.14	33.21	35.20
C2	20% fly ash+ 5% Dolomite powder +75%cement+ 25% quarry dust	24.12	33.40	34.70	36.25
C3	40% fly ash + 5% Dolomite powder +55%cement+ 25% quarry dust	23.85	33.40	36.16	37.15
C4	65% fly ash 5% Dolomite powder +30%cement+ 25% quarry dust	20.10	28.4	30.15	32.40

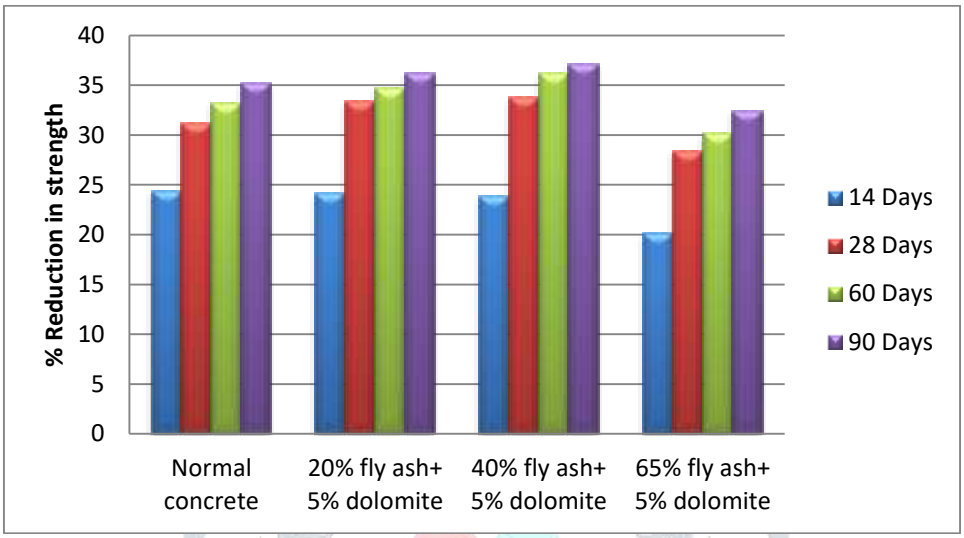

Fig Effect of fly ash + 5% Dolomite powder on concrete.

Effect of 20%, 40% and 65% Fly Ash + 7.5% of Dolomite powder on Compressive Strength of Concrete:

Effect of the combination of dolomite powder and fly ash on chloride permeability:

The increase in replacement of the combination of dolomite powder and fly ash decreases the chloride permeability of concrete. Concrete with 7.5% dolomite powder and 65% of fly ash has shown the least chloride permeability.

Effect of fly ash+dolomite powder on Chloride permeability:

sS.NO	Mix Designation	Proportions of binding material	Charge passed in coulombs (90days)
1	C1	100% cement + Normal sand	1989
2	C2	20% fly ash+ 5% Dolomite powder +75%cement+ 25% quarry dust	1926
3	C3	40% fly ash + 5% Dolomite powder +55%cement+ 25% quarry dust	1816
4	C4	65% fly ash 5% Dolomite powder +30%cement+ 25% quarry dust	1503
5	D1	100% cement + Normal sand	1989
6	D2	20% fly ash+ 7.5% Dolomite powder +72.5%cement+ 25% quarry dust	1863
7	D3	40% fly ash+7.5% Dolomite powder +52.5%cement + 25% quarry dust	1794
8	D4	65% fly ash +7.5% 9Dolomite powder +27.5%cement + 25% quarry dust	1562
9	E1	100% cement + Normal sand	1989
10	E2	20% fly ash+ 10% Dolomite powder +70%cement+ 25% quarry dust	1908
11	E3	40% fly ash+10% Dolomite powder +50%cement + 25% quarry dust	1812

12	E4	65% fly ash +10% Dolomite powder +25%cement + 25% quarry dust	1602

V. CONCLUSION

1) The compressive strength of M25 concrete increases with the replacement of OPC by dolomite powder up to 10%.
2) The replacement of OPC by the combination of dolomite powder and fly ash increases the strengthof M25 concrete at early age.
3) The combination of dolomite powder and fly ash as replacement to OPC increases the acid resistance of concrete.
4) The alkaline resistance of concrete can be improved by using dolomite powder as replacement to OPC.
5) The combination of dolomite powder and fly ash in concrete shows higher acid resistance than fly ash concrete.
6) The chloride permeability increases with the replacement of OPC by dolomite powder.
7) The chloride permeability decreases with the replacement of OPC by the combination of dolomite powder and fly ash. As the percentage of dolomite powder increases in the combination of with dolomite powder and fly ash, the chloride permeability of concrete increases.

SCOPE FOR FUTURE INVESTIGATIONS

The research work on pozzolanic materials is limited. But it promises a suggestion for future studies. Following aspects are considered for future study and investigation. Investigations to find the durability of concrete with fly ash, Dolomite powder and combination of these two can be carried out. Studies on the strength and durability properties of above concretes with super plasticizer can be carried out.

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