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UTILIZATION OF PALM OIL FUEL ASH (POFA), HIGH - VOLUMEULTRAFINEPOFAANDFLYASHINCONCRETE AS PARTIAL REPLACEMENT OF CEMENT

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ABSTRACT: Palm oil fuel ash is a waste material having pozzolanic nature obtained from the palm oil industry. The use of high volume of palm oil fuel ash and the lime seems to offer the best solution to rising cement demands. These two materials not only reduce the green house emission proportionately and results in green concrete, prevent the depletion of natural resources. Additional benefit includes minimization of waste disposal and Reduction in heat of hydration takes place by replacing cement. Palm oil fuel ash is added to the concrete in varying percentages, ranging from 0 to 40%. The compressive strength, flexural strength, splitting tensile strength and ultrasonic pulse velocity, water absorption tests were measured. At all the replacement levels of palm oil fuel ash in concrete the compressive strength is improved, when compared with nominal concrete (P0). A highest compressive strength is observed with P20 (20% palm oil fuel ash) concrete. A similar trend of improvement in flexural strength and splitting tensile strength is observed, when compared with compressive strength. As per IS 13311(part 1): 1992 the UPV values obtained for palm oil fuel ash concrete at 28 days of curing age denotes the excellent quality of concrete. Water absorption values obtained for palm oil fuel ash concrete at 28 days of curing age, denotes the good quality of concrete as per concrete society board (CEB, 1989). The results support the use of palm oil fuel ash as partial replacement of cement up to 40%.

KEY WORDS: Palm Oil Fuel Ash, High Volume Ultrafine Palm Oil Fuel Ash, Fly Ash, Pozzolanic strength index, Compressive strength, Concrete, compressive Strength, Flexural Strength, Split Tensile Strength, Ultrasonic pulse Velocity (UPV).

I. INTRODUCTION

From the past concrete was considered as a widely used construction material. We use concrete structures with interest of development of urban and industrial areas, aggressive marine environments, harmful sub-soil water areas and many other hostile conditions where other materials of construction are found to be uneconomical and durable. Since the use of concrete in recent years have spread to highly harsh and hostile conditions, the earlier impression that concrete is a very durable material is being threatened, particularly on account of premature failures of number of structures.

In the past only strength of concrete was considered in the concrete mix design procedure assuming strength of concrete in all pervading factor for all other desirable properties of concrete including durability. In the recent revision of IS 456: 2000, one of the points discussed, deliberated and revised is the durability aspects of concrete, in line with codes of practice of other countries, which have better experiences in dealing with durability of concrete structures. One of the main reasons for deterioration of concrete in the past is that too much emphasis is placed on concrete strength parameters.

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As a matter of fact advancement in concrete technology has been generally on the strength of concrete. It is now recognized that strength of concrete alone is not sufficient, the degree of harshness of the environment condition to which concrete is exposed over its entire life is equally important. Therefore, both strength and durability have to be considered explicitly at the design state. Hence there is a need to develop relation between concrete strength and durability properties.

Durability of concrete is its resistance to deteriorating agencies to which the concrete may be exposed during its service life. When one deals with the durability aspects of concrete, the chemical attack, which results in loss of weight, cracking of concrete and the consequent deterioration of concrete, becomes an important part of investigation. Ordinary Portland cement concrete usually does not have good resistance to acid attack. The addition of POFA improves the micro structural properties of concrete like porosity, permeability and sorptivity. The reduction of porosity and permeability implies the improvement in chemical attack and corrosion resistance. The experimental investigation of this aspect is to find compressive strength and durability of concrete by partial replacement of cement with quarry dust.

The objective of the present project work is to study the behavior of concrete in partial replacement of cement with palm oil fuel ash in proportions. It includes a brief description of the materials used in the concrete mix, mix proportions, the preparation of the test specimens and the parameters studied. In order to achieve the stated objectives, this study is carried out in different stages. In the initial stage, all the materials and equipment needed must be gathered or checked for availability. Once the characteristics of the materials selected have been studied through appropriate tests, the applicable standards of specification are referred. The properties of hardened concrete are important as it is retained for the remainder of the concrete life. In general, the important properties of hardened concrete are strength and durability.

II. LITERATURE SURVEY

Ali Ergun have studied effects of usage of palm oil fuel ash as partial replacement of cement on the mechanical properties of concrete. . Test results indicated that the concrete specimens containing 10% palm oil fuel ash, 5% WPM and 5% WPM + 10% palm oil fuel ash replacement by weight for cement had the best compressive and flexural strength. The replacement of cement with palm oil fuel and WPM separately or together using super plasticizing admixture could be used to improve mechanical properties.

Felix F. Udoeyo studied properties of sawdust as partial replacement of cement. Before application in concrete, the ash was ground and sieved through a number 425 micron BS sieve. The compressive and spilt tensile strengths of SDA concrete generally decreased with an increase in the percentage of SDA content. However, with between 10 and 20% replacement of OPC by SDA, the reduction in the 28-day compressive and spilt tensile strengths were within the range of 4-25% and 1-4%, respectively.

Felix F.Udoeyo has examined properties of Maize-cob Ash as filler in concrete as partial replacement of cement. The cob was sieved through 600 µm sieve before application in concrete. The compressive and spilt tensile strengths and modulus of rupture decreased with an increase in MCA content. With the exception of samples with a 30% replacement level, attained at least 70% of their 28- day strength at seven-day curing. The results of compressive strength test indicated that up to 10% of MCA could be used as a replacement of OPC.

Noor-ul Amin explained the use of bagasse ash in concrete and its impact on the strength and chloride resistivity. Bagasse is a major by-product of sugar industry, which is utilized in same industry as an energy source for sugar production. Sugarcane contains 25-30% bagasse, whereas industry recovered sugar is about 10%. Up to 20% of high strength Portland cement can be optimally replaced with well burnt bagasse ash without any adverse effect on the desirable properties of concrete. The specific advantage is development of high early strength, reduction in water permeability, and appreciable resistance to chloride permeation and diffusion.

III. MIX DESIGN

Design of M35 as per IS: 10262:2009.

a) Maximum size of aggregate
= 20 mm

b) Degree of workability
= 0.90

c) Degree of workability
= Good

d) Type of exposure
= Mild

Test data for materials:

a) Specific gravity of cement
= 3.13

b) Specific gravity of fine aggregate
= 2.57

c) Specific gravity of coarse aggregate
= 2.7

Design of concrete (M35):

1)Determine the target mean strength f_{ck}'
$=f_{ck}+1.65(S)$
=35+1.65 x 4
=41.6 N/mm²

2) Selection of water –cement ratio (W/C) = 0.4
Max water content = 186kg
(Nominal max size of aggregates 20mm)

3) Cement content from W/C=186/0.4
Cement =465kg

4) Value of all in aggregate
a) Volume of CA in %=0.62
b) Volume of FA in % =1-0.62 =0.38

a) VolumeofCAin%	=	0.62
b)VolumeofFAin%	=	1-0.62=0.38

5) The mix of calculation as per unit volume
e) Volume of cement = (mass of cement /Specific Gravity) x (1/1000)
= (465/3.13) x (1/1000)
=0.148 m³
f) Volume of water = (mass of water /Specific Gravity) x (1/1000)
= (186/1) x (1/1000)

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*=0. 186 m^3
g) Volume of admixture = nil
h) Volume of all in aggregates = (1-0.148-0.186)
=0.666
i) Mass of coarse aggregates = (e' x volume of CA x sp.gravity x 1000)
= (0.666 x 0.62 x 2.7 x 1000)
=1114.88kg
j) Mass of fine aggregates = (e' x volume of FA x sp.gravity x 1000)
= (0.66 x .38 x 2. x 1000)
=683.31kg

Water (Lts)	Cement (Kg/m^3)	Fine aggregate (Kg/m^3)	Coarse aggregate (Kg/m^3)
186	450	660	1078.91
0.4	1	1.46	2.39

Table 1: Design of M35 as per IS: 10262:2009.

Mix Designation	Compressive strength after 7 days	Compressive strength after 28 days
P0	30.42	51.56
P10	32.66	52.22
P20	33.24	55.76
P30	30.08	52.48
P40	27.40	48.10

IV. TEST METHODS

COMPRESSIVE STRENGTH TEST: Compression is a major characteristic property of a concrete. Cube compressive strengths tests on 100mm size cubes at the age of 7days and 28 days were conducted as per IS 516-1959.The compressive test is the most common test conducted on hardened concrete, partially because it is an easy test to perform and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. The compressive strength test specimens were of dimensions 100mm x 100mm x 100mm.

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FLEXURAL STRENGTH TEST: Flexural strength also known as Modulus of Rupture (or) Transverse Rupture Strength (or) Bond Strength is a material property defined as the stress in a material just before it yields in a flexure test.

SPLITTING TENSILE STRENGTH TEST: A method of determining the tensile strength of concrete using a cylinder which splits across the vertical diameter. It is an indirect method of testing tensile strength of concrete.Concrete is a material, which is weak in tension. So, it becomes very important to know tensile strength for concrete used in designing structures. Finding tensile strength for concrete is done by using two methods:

ULTRA SONIC PLUSE VELOCITY TEST: Ultrasonic Pulse Velocity (UPV) is an effective Non-Destructive Testing (NDT) method for quality control of concrete materials, and detecting damages in structural components. The UPV methods have traditionally been used for the quality control of materials, mostly homogeneous materials such as metals and welded connections. With the recent advancement in transducer technology, the test has been widely accepted in testing concrete materials.

WATER ABSORPTION TEST: Concrete has been defined as a composite material obtained using cement, aggregate, water and when necessary chemical and/or mineral additives, placed into moulds of various sizes and shapes and hardened under convenient conditions. Today concrete has been used with an increased strength and durability in connection with the developments in technology in pre-stressed concrete, concrete and reinforced concrete structures.

V. RESULTS

Table. 2: COMPRESSIVE STRENGTH FOR POFA

Mix Designation	Compressive strength after 28 days
P0	47.10
P10	40.55
P20	49.89
P30	52.65

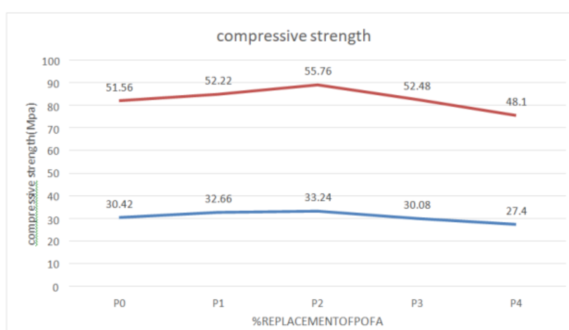

Fig. 1: Compressive Strength (Vs) % Of POFA Replacement

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Table. 3: Compressive strength of the concrete with Ultrafine POFA

Mix Designation	Compressive strength after 7 days	Compressive Strength After 14 Days	Compressive Strength after 28 days
P0	33.2	41.3	48.6
P10	31.6	40.4	52
P20	22.6	38	49.3
P30	20.4	30.6	39.5
P40	18	27.5	34.4

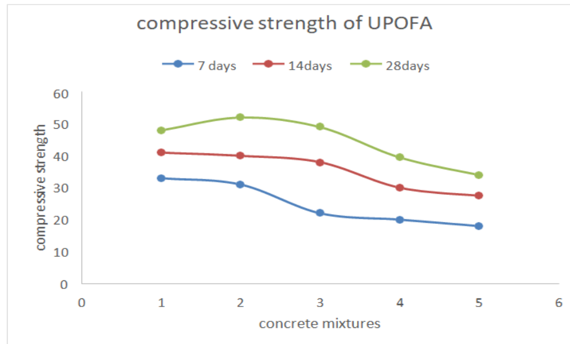

Fig. 2: Compressive Strength vs ultrafine POFA%

Table. 4: Compressive results of concrete with fly ash

Mix Designation	Compressive strengthafter28 days
P0	47.10
P10	40.55
P20	49.89
P30	52.65

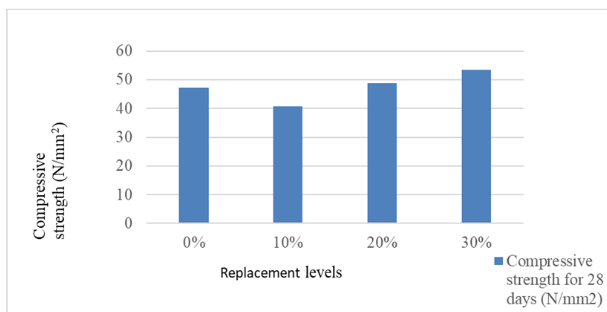

Fig. 3: Compressive strength vs Fly Ash%

Table. 5: Flexural strength for various percentages of palm oil fuel ash

Mix designation	Flexural strength (MPa)
	At28days
P0	5.35
P10	5.63

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P20	5.72
P30	5.53
P40	5.37

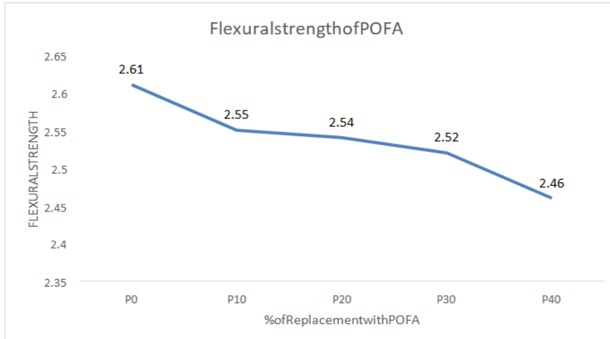

Fig. 4: flexural strength (vs) % of replacement of POFA

Table. 6: Flexural Strength of the Ultra fine palm oil fuel ash(UPOFA)

Mix designation	Flexural strength (MPa)
	At 28days
P0	5.42
P10	5.83
P20	5.86
P30	5.47
P40	5.21

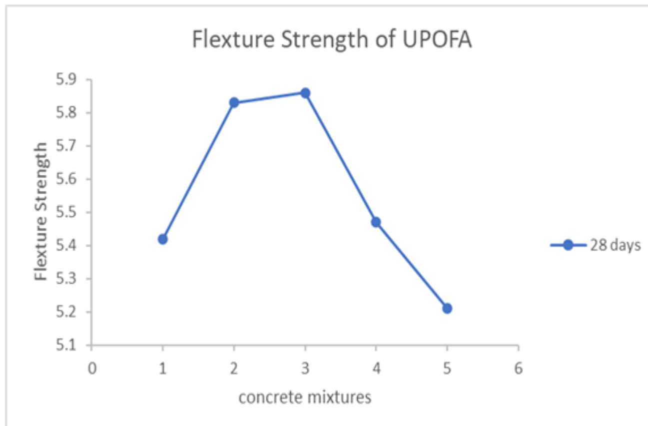

Fig. 5: flexural strength Vs % of replacement of Ultra fine POFA

Table. 7: Flexural strength values of the FlyAsh

Mix designation	Flexural strength (MPa)
	At28days
P0	4.47
P10	4.62
P20	5.13
P30	4.40
P40	4.26

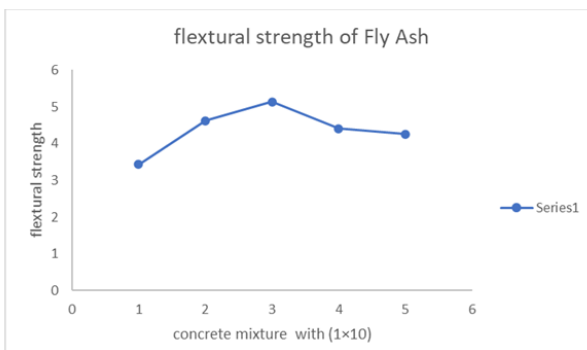

Fig. 6: flexural strength vs the % of Fly ash

Table. 8: Splitting tensile strength for various percentages of POFA

Mix designation	Splitting tensile strength (MPa) At 28 days
P	3.92
P10	4.14
P20	4.21
P30	4.18
P40	4.12

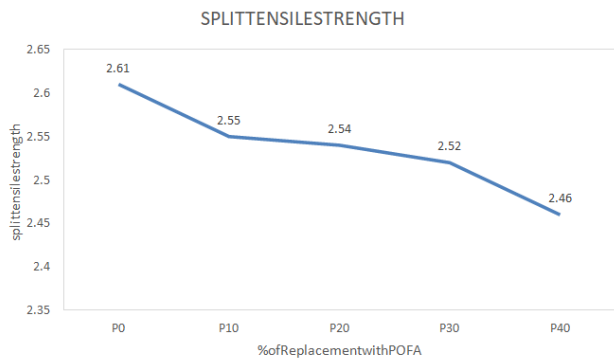

Fig. 7: split tensile strength (vs) % of replacement of POFA

Table. 9: Split Tensile Strength results for Ultrafine POFA

Mix designation	Splitting tensile strength (MPa) At28days
P0	4.46
P10	6.23
P20	6.89
P30	6.59
P40	5.43

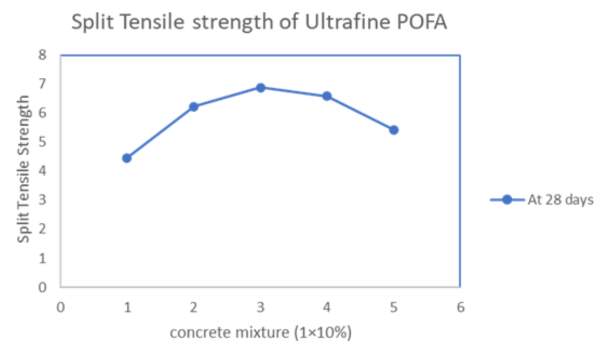

Fig. 8: Split Tensile Strength vs the concrete mixture % of UPOFA

Table. 10: split tensile strength results of fly ash

Mix designation	Splitting tensile Strength (MPa) At28days
P	2.26
P10	2.82
P20	2.64
P30	2
P40	1.55

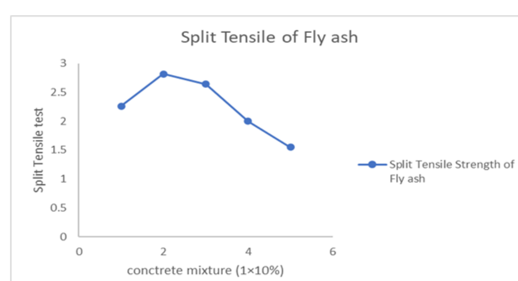

Fig. 9: concrete mixture vs % of fly ash

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Table. 11: Ultrasonic Pulse Velocity (UPV) for POFA

Mix Designation	Ultrasonic Pulse Velocity (Km/s)
	At28days
P0	4.74
P10	4.8
P20	4.9
P30	4.78
P40	4.62

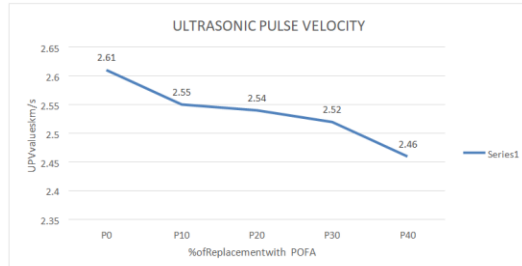

Fig. 10: UPV values (vs) % replacement of POFA

Table. 12: UPV with the % of ultra fine POFA

Mix Designation	Ultrasonic Pulse Velocity(Km/s)
	At28days
P0	0
P10	3.512
P20	3.541
P30	3.515
P40	3.323

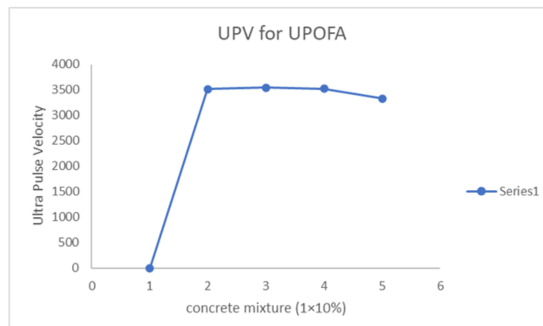

Fig. 11: UPV vs the concrete mixture with UPOF%

Table. 13: UPV results for the Fly Ash

Mix Designation	Ultrasonic Pulse Velocity (Km/s)for
	For28days
P0	4.62
P10	5.10
P20	5.67
P30	4.32

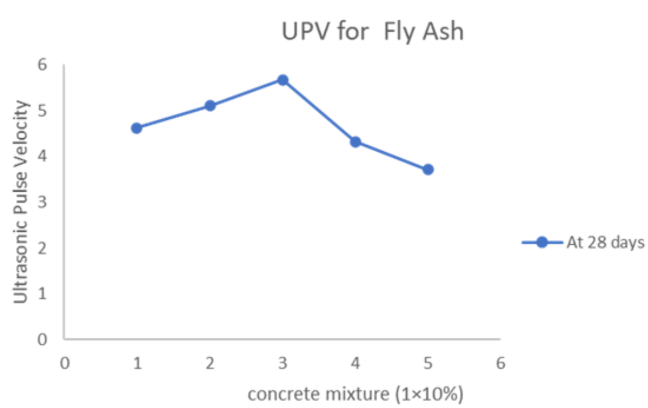

Fig. 12: concrete mixture vs % of the Fly ash

Table. 14: Water absorption at 105°C for POFA

Mix designation	Water absorption at 105oC
	28Days
P0	2.61
P10	2.55
P20	2.54
P30	2.52
P40	2.46

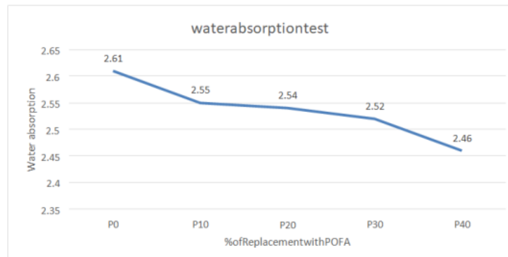

Fig. 13: water absorption (vs) % replacement of POFA

Table. 15: Water Absorption test at 105°C for UPOFA

Mix designation	Water absorption at 105°C
	28Days
P0	2.61
P10	15.12
P20	19.4
P30	20.2
P40	21.23

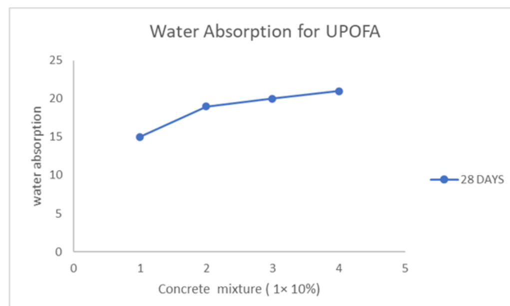

Fig. 14: water absorption vs the UPOFA%

Table. 16: Water absorption results for the Fly Ash

Mix designation	Water absorption at 105°C
	28Days
P0	4.72
P10	17.23
P20	20.63
P30	23.12
P40	25.66

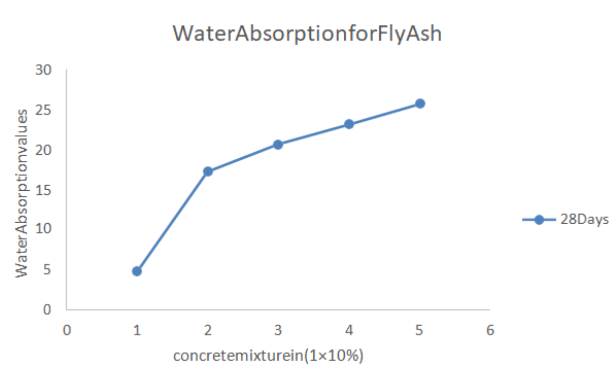

Fig. 15: water absorption vs the % of Fly Ash

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VI. CONCLUSION

Compressive strength of P20 concrete is relatively high when compared with control concrete and satisfying the strength requirements as perIS516:1959. The flexural strength of P20 concrete is relatively high when compared with control concrete and satisfying the strength requirements as per IS 456:2000. The splitting tensile strength of P20 concrete is relatively high when compared with control concrete and satisfying the strength requirements as per IS 456:2000. The UPV ofP20 concrete is relatively high when compared with control concrete. The water absorption results of control mix and palm oil fuel ash concrete at105 oC is 2.61.

For the Palm Oil Fuel Ash(POFA),
Compressive strength-8.14
Flexural Strength -6.9
SplitTensileStrength–7.39
UPV -3.37
Water absorption -5.74
For the High volume Ultrafine Palm Oil Fuel Ash(UPOFA),
Compressive strength–11.23
Flexural Strength -8.9
SplitTensileStrength–6.80
UPV -1.22
Water absorption -11.21 For the Fly Ash,
Compressive strength– 52.65
Flexural Strength -5.02
Split Tensile Strength–3.24
UPV -5.67
Water absorption - 25.66

Among all the tests studied well with help of the materials which are partially replaced with the cement with Palm Oil Fuel Ash (POFA), High Volume of Ultra fine Palm Oil Fuel Ash (UPOFA) and Fly Ash with the percentages of about 0%, 10%, 20%, 30%and 40%. From all these materials FLY ASH will be the better material that shows those the better results, because of it' shigh strength and probability factors.

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