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Study on Strength Properties of Pervious Concrete by Partial Replacement of Cement with Fly Ash

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Abstract: Pervious concrete is a concrete containing little or no fine aggregate; it consists of coarse aggregate and cement paste. It seems pervious concrete would be a natural choice for use in structural applications in this age of 'green building'. It consumes less raw material than normal concrete (no sand), it provides superior insulation values when used in walls, and through the direct drainage of rainwater, it helps recharge groundwater in pavement applications. Due to increase in construction and demolition activities all over the world, the waste concrete after the destruction is not used for any purpose which leads to loss of economy of the country. India is a developing country where urbanization is increasing rapidly which in turn leading to increase of drainage facilities. Pervious concrete helps to allow the water flow into the ground due to interconnected pores. Natural aggregate is becoming scarce, production and shipment is becoming more difficult. In order to overcome this problem, there is need to find a by-product, which can be used to replace the aggregate in conventional concrete mix.

Keywords: Pervious Concrete, Partial Replacement, Fly Ash, Cement, Compressive Strength,

I. INTRODUCTION

A. Pervious Concrete

Pervious concrete is a composite material consisting of coarse aggregate, cement and water. The aggregate is usually of a single size and is bounded jointly in a cement paste. Using sufficient paste to coat and bind the aggregate particles together creates high permeable system with interconnected voids which allows rain water to percolate through the surface and into the ground before it runs-off. We can also say that pervious concrete helps in protecting the surface of the pavement and its environment. This approach reduces storm water run-off volumes and minimizes the pollutants introduced into storm water run-off from surface area sand recharging ground water levels. We can be also provided a perforated pipe to collect it and drains to the required treatment plant. It has been reported that a porous concrete layer over a conventional concrete base is an efficient means of reducing tyre spray and hydroplaning. The desirable properties are: significant noise reduction and drainage; acceptable strength and stiffness; adequate surface properties with respect to traffic safety such as skid resistance and sufficient service life; bonding with underlying dense concrete, and costs comparable to those of conventional pavements.

Figure-1.1 water percolating through pervious concrete cube

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B. Applications of Pervious Concrete

Common applications of pervious concrete are parking lots, side walls, pathways, tennis courts, slope stabilization swimming pool decks, green house floors, drains, highway pavements generally, which is not used for concrete pavements for high traffic and heavy wheel loads.

Advantages

1) The Pervious concrete is an innovative building material with many environmental economic, and structural advantages
2) It can be easily installed.
3) Low cost
4) Can be temporary
5) Eliminates costly Drainage systems
6) Can be used for erosion control
7) By using pervious concrete, the property owners and developers can also reduce fees and enhance the bottom line, which commonly provides 20-40 years of service with little or no maintenance.

C. Environmental And Economic Benefits of Pervious Concrete:

There are many environmental benefits of pervious concrete such as retain storm Water, recharge ground water, keep pavement surfaces dry even in wet situation, reduce or no Storm water drainage is required, allow water and air to get to the roots of trees in the area. Remove oil and other pollutions from the that washes off the surface, reduce heat island effect. Allow to claim LEED points to green certificates in US or in Sri Lanka.

II. MATERIALS AND METHODOLOGY

A. Marterial Specification

1) *Cement:* Ordinary Portland cement is the most common type of cement in general use around the world as a basic ingredient of concrete, mortar, stucco, and most non-specialty grout. It is a fine powder produced by heating materials to form clinker. After grinding the clinker, we will add small amounts of remaining ingredients. Many types of cements are available in market. The color of OPC is grey color and by eliminating ferrous oxide during manufacturing process of cement we will get white cement also. Ordinary Portland cement of 43 grade of brand name ultra tech company, available in the local market was used for the investigation. The cement thus procured was tested for physical requirements in accordance with IS: 4031-1988 and for chemical requirement in accordance IS: 4032-1988. The physical properties of the Cement are listed in table - 3.1.

Table-3.1 Properties of Cement

Sl. No.	Properties	Tests Results	IS 4031-1998
1.	Specific gravity	3.15	
2.	Fineness of cement	9%	=<10%
3.	Normal consistency	0.31	
4.	Initial setting time	40 min	Minimum of 30min
5.	Final setting time	300 min	Maximum of 600min
6.	Compressive strength		
	7 Days Strength	38.14 Mpa	
	28 Days Strength	48.20 Mpa	Minimum of 43 Mpa

2) *Coarse Aggregate:* Crushed aggregates of size 20 - 12.5mm, 12.5 - 4.5mm produced from local crushing plants were used. The aggregate exclusively passing through 20mm and 12.5mm sieve size and retained on 12.5mm and 4.5mm sieve is selected. The aggregates were tested for their physical requirements such as gradation, fineness modulus, specific gravity and bulk density in accordance with IS: 2386-1963.

3) *Fine Aggregate:* Sand is a natural granular material which is mainly composed of finely divided rocky material and mineral particles. The most common constituent of sand is silica (silicon dioxide, or SiO_2), usually in the form of quartz, because of its chemical inertness and considerable hardness, is the most common weathering resistant mineral. Hence it is used as fine aggregate in concrete. River sand locally available in the market was used in the investigation. The aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity in accordance with IS: 2386-1963.The sand was surface dried before use.

Table-3.3 Properties of Fine aggregates

Specific Gravity of Fine Aggregate	2.65
Fineness modulus	3.1%

4) *Flyash:* Ash produced in small dark flecks by the burning of powdered coal or other material and carried into the air. Fly ash can be used as prime material in many cement-based products, such as poured concrete, concrete blocks, and brick.one of the most common uses of fly ash is in Portland cement concrete pavement.
5) *Water:* Potable water fit for drinking is required to be used in the concrete and it should have pH value ranges between 6 to 9.

B. Test On Material Used

1) Cement

a) Specific Gravity of Cement (Is: 4031-1988)

- *Aim:* To determine the specific gravity of cement.
- *Apparatus:* Cement, kerosene, weighing balance, specific gravity bottle.
- *Significance:* Specific gravity is defined as the ratio between the weights of a given volume of cement and Weight of an equal volume of water.
- *Procedure*

➢ Clean and dry the specific gravity bottle and weight noted as W1 grams.
➢ Fill approximate 1/3 of bottle with cement and weighed it again and noted as W2 grams.
➢ Fill the bottle with kerosene and weighed it again and noted as W3 grams.
➢ Empty the bottle, clean it and filled with kerosene and weighed again W4 Grams.
➢ Finally empty the bottle again clean it, fill it water and weight as W5 grams.

- Observation and calculation:

Table-3.4 Observation of Specific Gravity of Cement

Sl. No.	Observation	Weight in grams
1.	Weight of empty specific bottle+ lid (W1)	51 Grams
2.	Weight of bottle + water (W2)	158 Grams
3.	Weight of bottle +cement +kerosene (W3)	135 Grams
4.	Weight of bottle + kerosene (W4)	160 Grams
5.	Weight of bottle +1/3 of cement (W5)	97 Grams

Specific gravity of kerosene (GK)	= (W3-W1)/(W2-W1)
	= 0.785
Specific gravity of cement	= (W5-W1)/((W5-W1) - (W4-W3)) × GK
	= 3.15

- *Results:* Specific gravity of cement is 3.15
- *IS Specification:* The specific gravity of cement typically ranges from 3.10 to 3.25.
- *Inference:* The specific gravity of cement is 3.15 is obtained in accordance with specification.

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b) Fineness of Cement (Is: 4031-1988)

- *Aim:* To determine the fineness of cement by using sieve analysis method.
- *Apparatus:* IS sieve number 9 (90µ sieve), weighing balance, pan and cover.
- *Significance:* The degree of fineness of cement is a measurement of the mean size of the grains in the Cement
- *Procedure*

➢ Weigh accurately 100grams of cement on a plate and transfer to clean dry, 15 sieve Number 9 breaks of their lumps.

➢ Holding the sieve and pan in both hands sieve with gentle with respect to motion unit most of the fine material as passed through and the residue looks fairly clean. This usually Requires 10 minutes of sieving.

➢ The shrinkage and cracking of cement will increase with increase in fineness of cement This is a disadvantage of fineness of cement.

➢ Weight residue on the sieve and calculates % of fineness of cement.

- *Tabular column*

Table-3.5 The Fineness of Cement

Sl. No.	Weight of Cement Taken (W1) In Grams	Weight of Residues Retained (W2) In Grams	% Fineness (W2/W1) × 100	Fineness of cement
1.	100	9	9	9
2.	100	9	9	

- *Result:* The fineness of cement of cement is 9.
- *IS Specification:* According IS specification the fineness of cement varies from 1 - 10%. The fineness of Given cement is 9. Hence, it is in accordance with is specification.

c) Standard Consistency of Cement (Is: 4031-1988)

- *Aim:* To determine the standard consistency of cement by vicat apparatus.
- *Apparatus:* VICAT apparatus with Vicat plunger, vicat needle, vicat mould, trowel, measuring jar, weighing Balance, stop watch.
- *Significance:* The standard consistency of a cement paste is defined as that consistency which will permit a Vicat plunger having 10mm diameter and 50mm length to penetrate to a depth of 5-7mm from the bottom of the mould.
- *Procedure*

➢ The standard consistency of cement paste which permits vicat plunger to penetrate to a Depth of 5 to 7mm from the bottom of the mould.

➢ Take above 400 grams of cement passing through is 90-micron sieve and prepare the Paste of cement passing with weight quantity of water (26% by the weight of cement) Taking care that the time for mixing between 3 to 5 minutes the mixing time is counted from the time of adding water to the dry cement until commencing to fill the mould.

➢ Fill the vicat mould resisting upon non-porous plate after completely filling the mould Then smooth the surface of the paste by the single movement of trowel making it level with the top of the mould may be slightly shaken to expel air.

➢ Place the test block in the mould with the non-porous resting plate under the rod attached with the plunger, lower the plunger gently to touch the surface and fitly weight released and allowing it to sink into the paste.

➢ Prepare the trial paste with varying percentage of water and test as described about until the amount of water necessary for making up the standard consistency into a paste.

- *Tabular Column*

Table-3.6 Standard Consistency of Cement

Sl. no	Brand of cement	Grade of cement	Weight of cement in 'grams'	%of water added by weight	Penetration of needle 'mm'
1.	Ultra-tech	43	300	24	36
2.			300	26	32.5
3.			300	28	25
4.			300	30	14
5.			300	31	07

- *Results:* Standard consistency of cement is 31%.
- *IS Specification:* According to is specification consistency of cement varies from 25 to 35%.
- *Inference:* As per is specification consistency of cement varies from 25 - 35%. The standard consistency of given cement is 30%. Hence, it is in accordance with is specification.

d) Initial And Final Setting Time of Cement (Is: 4031-1988)

- *Aim:* To determine the initial setting time of cement by vicat apparatus.
- *Apparatus:* Vicat apparatus with vicat needle, vicat mould, trowel, measuring jar, weighing balance, stop Watch.
- *Significance:* The period of elapsing between the time when water is added to cement and the time that Which needle falls on the test block above 5mm from the bottom of the mould is known as Initial setting time.
- *Procedure*

➢ Prepare a need cement mortar by mixing a cement mortar by mixing a cement with (0.85p) where. P= standard Consistency as found before the mixing tie kept between 3 to 5 minutes start the stop watch at the time when the water is added to the cement.
➢ Fill the vicat and smooth of the surface of the paste making it level with the top of the Mould the cement block thus prepares known as a test block.
➢ For the determination of initial setting time place the test block confined the mould and Resting on non-porous plate under the rod attached with needle-b cover the needle in Contact with the surface repeat this procedure until the needle falls to above 5mm measures from the bottom. The period elapsing between the time when water is added to cement and the time which needle falls to appears the test block above 5mm is known as initial setting Time.
➢ To determine the final setting time, replace the needle b with needle c.
➢ The cement is considered finally set when needle fails to leave its impression on the surface of the test block.

- *Tabular Column*

Table-3.7 Initial Setting Time and Final Setting Time of Cement

Sl. No	Time in Minute	Penetration of Needle (mm)	Final Setting Time
1	5	0	220
2	10	2	246
3	15	3	260
4	20	4	288
5	25	4	300
6	30	5.5	
7	31	6	

- *Results:* Initial setting time of cement is 31 minutes and final setting time of cement is 300 minutes
- *IS Specification:* The initial setting time of cement should be minimum 30 minutes and final setting time of Cement should be maximum of 600 minutes as per is specification.

2) Coarse Aggregate

a) Specific Gravity of Coarse Aggregate (Is: 2386-1963)

- *Aim:* To determine the specific gravity of the coarse aggregate using pycnometer bottle.
- *Apparatus:* Pycnometer bottle, weighing balance, water, coarse aggregate.
- *Significance:* Specific gravity is defined as the ratio between the weight of a given volume of aggregate and Weight of an equal volume of water.
- *Procedure*

➢ Clean and dry the pycnometer bottle.
➢ Take the empty weight of pycnometer bottle as w1 grams.
➢ Take about a sample in pycnometer 1/3 of the bottle and weight as w2 grams.
➢ Add water to the bottle containing sample the bubbles inside the bottle is removed by Inverting the bottle by shaking and fill the water up to its full and take weight as w3 grams.
➢ Remove the water and sample from the bottle and fill the bottle with water and take the Weight as w4 grams.

Calculate the specific gravity by using the formula.

G = (W2-W1) / ((W3-W4) (W2-W1))

- *Observation And Calculation*

Table-3.8 Observation of Specific Gravity of Coarse Aggregate

Sl. No.	Observation	Weight In 'Grams'
1.	Weight of empty pycnometer (W1)	638
2.	Weight of pycnometer+1/3 volume of C.A.(W2)	1271
3.	Weight of pycnometer+ coarse aggregate water(W3)	1881
4.	Weight of pycnometer water(W4)	1483

Specific gravity, G	= (W2-W1) /((W3-W4) - (W2-W1))
	= (1271-638)/((1271-638)-(1881-1483))
	= 2.7

- *Result:* Specific gravity of coarse aggregate is 2.7.
- *IS Specification:* The specific gravity of coarse aggregate typically ranges from 2.6 to 2.9 as per is Specification
- *Inference:* Specific gravity of given sample of coarse aggregate is 2.7. Hence, it is in accordance with is Specification.

b) Flakiness Index of Coarse Aggregate (Is: 2386-1963)

- *Aim:* To determine the flakiness index of the coarse aggregate using metal thickness gauge.
- *Apparatus:* Balance. Sieve. Metal thickness gauge, coarse aggregate.
- *Significance:* The flakiness index of an aggregate sample is found by separating the flaky particles and Expressing the mass as a percentage of the mass of the sample tested
- *Procedure*

➢ The Sample Is Sieved Through IS Sieve Specified in Table Shown Below.
➢ A Minimum Of 200 Pieces of Each Fraction Is Taken and Weighed.
➢ In Order to Separate Flaky Materials, Each Fraction Is Then Gauged Individually for Thickness On a thickness gauge.
➢ The total amount of flaky material passing the thickness gauge is weighed to an accuracy Of 0.1% of the weight of sample.
➢ Weight of coarse aggregate taken (w) = 5000 grams
➢ The flakiness index on an aggregate is = (Total Weight Passing Flakiness Gauge X100) / total weight of test sample

- *Observation And Calculation*

Table-3.9 Flakiness Index of Coarse Aggregate

Sl. No	Size of Aggregate Passing Through 'mm'	Retained On 'mm'	Thickness Gauge Slot 'mm'	Mass of Aggregate Passing Through Slot 'mm'
1	63	50	33.9	0
2	50	40	27	0
3	40	31.5	19.5	0
4	31.5	25	16.96	0
5	25	20	13.5	5
6	20	16	10.8	149
7	16	12.5	8.55	117
8	12.5	10	6.75	108
9	10	6.3	4.89	1
				W2 = 380 g

Flakiness index	= (w2/w1) ×100
	= (380/5000) × 100
	= 7.6%

- *Result:* Flakiness index of coarse aggregate is 7.6%.
- *IS Specification:* The flakiness index of coarse aggregate typically should not be greater than 30% as per is Specification.

c) Elongation Index of Coarse Aggregate (Is: 2386-1963)

- *Aim:* To determine the flakiness index of the coarse aggregate using metal thickness gauge.
- *Apparatus:* Balance, sieve, metal length gauge, coarse aggregate.
- *Significance:* The elongation index of an aggregate is the percentage by weight of particles whose greatest Dimension (length) is greater than nine-fifths (1.8times) their mean dimension.
- *Procedure*
  - The sample is sieved through is sieve
  - A minimum of 200 pieces of each fraction is taken and weighed.
  - In order to separate elongated materials, each fraction is then gauged individually for Length in the length gauge,
  - The pieces of aggregate from each fraction tested which could not pass through the Specified gauge.
  - The total amount of elongated material retained by the length gauge is weighed to an Accuracy of 0.1% of the weight of sample.
  - Weight of coarse aggregate taken (W1) = 5000 grams
- *Observation And Calculation*

Table-3.10 Elongation Index of Coarse Aggregate

Sl. No	Size of Aggregate Passing Through 'mm'	Retained On 'mm'	Length gauge Slot 'mm'	Mass of Aggregate Obtained on Slot 'grams'
1	50	40	81	235
2	40	31.5	64.35	237
3	31.5	25	50.85	0
4	25	20	40.5	60
5	20	16	32.4	93
6	16	12.5	25.65	149
7	12.5	10	20.25	64
8	10	6.3	14.67	46
				W2 = 884 g

Elongation index	= (w2/w1) ×100
	= (884/5000) × 100
	= 17.68%

- *Result:* Elongation index of coarse aggregate is 17.68%
- *IS Specification:* Elongation index of coarse aggregate typically should not be greater than 30% as per is Specification.
- *Inference:* Elongation index of given sample of coarse aggregate is 17.68%. Hence, it is in accordance with is specification.

3) Fine Aggregate

a) Specific Gravity of Fine Aggregate (Is: 2386-1963)

- *Aim:* To determine the specific gravity of the fine aggregate using pycnometer bottle
- *Apparatus:* Pycnometer bottle, weighing balance, water, and sand.
- *Significance:* Specific gravity is defined as the ratio between the weight of a given volume of aggregate and Weight of an equal volume of water.
- *Procedure*

➢ Clean and dry the pycnometer bottle.
➢ Take the empty weight of pycnometer bottle as w1 grams.
➢ Take about a sample in pycnometer 1/3 of the bottle and weight as w2 grams.
➢ Add water to the bottle containing sample the bubbles inside the bottle is removed by Inverting the bottle by shaking and fill the water up to its full and take weight as w3 grams.
➢ Remove the water and sample from the bottle and fill the bottle with water and take the Weight as w4 grams.

- *Observation And Calculation*

Table-3.11 Observation of Specific Gravity of Fine Aggregate.

Sl. No	Observation	Weight in Grams
1	Weight of Empty Pycnometer(W1)	619
2	Weight of Pycnometer+1/3 Of Its Volume of Fine Aggregate(W2)	1007
3	Weight of Pycnometer +Sand +Water(W3)	1727
4	Weight of Pycnometer+ Water(W4)	1485

Specific gravity	= (W2-W1) / ((W3-W4) -(W2-W1))
	= (1007-619)/ ((1007-619) -(1727-1485))
	= 2.65

- *Result:* Specific gravity of fine aggregate is 2.65
- *IS Specification:* Specific gravity of line aggregate typically ranges from 2.6 to 2.9 as per is specification.

b) Sieve Analysis for Fine Aggregate (Is: 2386-1963)

- *Aim:* To determine the size of grains, present in the soil sample and their distribution and fineness Modulus
- *Apparatus:* Set of IS sieves ranging from 4.75mm to 150 microns, weighing balance, sand.
- *Procedure*

➢ A dry sand sample weighing above 1000 grams is taken
➢ A set of is sieves are arranged in the order of 3 mesh openings. 4.75mm. 2.36mm.1.18mm, 600 microns, 300 microns, 150 microns, and pan such 4.75mm is at the top and pan is at the bottom.
➢ The material is placed in the sieves, and then the whole assembly is properly shaken for 5- 10 mins
➢ Assembly is taken out and weight of sand particle retain in each sieve are recorded
➢ Then the required data is calculated.

- *Tabular Column*

Table-3.12 Sieve Analysis of Fine Aggregate

Sl. No.	Sieve Size	Weight of Sand Retained in Sieve in Grams	Cumulative Weight Retained in Grams	% Cumulative Weight Retained	% Finer	Grading Zone 2
1	4.75mm	93	9.3	9.3	90.7	90-100
2	2.36mm	42	4.2	13.5	86.5	75-100
3	1.18mm	120	12	25.5	72.5	55-90
4	600micron	290	29	54.5	41.5	35-59
5	300micron	242	24.2	78.7	15.3	8-30
6	150micron	105	10.5	89.2	4.8	0-10
7	Pan	48	4.8	94	0	

Fineness modulus	= cumulative % retained / 100
	= 364.7 /100
	= 3.64%

- *Result:* The fineness modulus of given sample of fine aggregate is 3.64%.

C. Mix Design

The mix design procedure adopted for preparation of concrete according to as per IS 10262-2019.. The strength is mainly influenced by water cement ratio, and is almost independent of the other parameters the properties of concrete compressive strength is influenced by the properties of aggregate in addition to that of water cement ratio.

Table-3.13 Stipulations for Proportioning

Sl. No.	Items	Data
1.	Different Size of Coarse Aggregate	20-12.5mm
2.	Specific Gravity of Cement	3.15
3.	Specific Gravity of Fine Aggregate	2.65
4.	Specific Gravity of Coarse Aggregate	2.7
5.	Type of Cement	OPC 43 grade

Figure-3.1 Material During Mixing of Concrete

1) *Mix design for m20 grade pervious concrete with 0% Replacement of cement with fly ash and with 0% fine aggregate*
   a) Volume of voids =15% (Constant for All Mix Design)
   b) Weight of cement =350 kg/m³
   c) Water cement ratio =0.35 (according to referred journals)
   d) Volume of cement = (weight/specific gravity) × (1/1000)
      =(350/3.15)*(1/1000)
      =0.111 m³
   e) Volume of water = (weight × water cement ratio)
      =(350*0.35)
      =122.5 liters
   f) Volume of void ratio =0.15 m³
   g) Volume of all in aggregate =1-(0.111+0.1225+0.15)
      =0.61 m³
   h) Weight of coarse aggregate = (volume of all in aggregate ×specific gravity of aggregate×1000
      0.61*2.7*1000
      =1664 kg/m³
   i) Weight of fine aggregate = 0 kg (as percent replacement is 0%)
   j) proportions

= C	FA	CA	WATER
1	1.02	1.9	0.35

2) *Mix design for m20 grade pervious concrete with5% Replacement of cement with flyash and with 5% fine aggregate*
   a) Volume of voids =15% (Constant for All Mix Design)
   b) Weight of cement =350 kg/m³
   c) Water cement ratio =0.35 (according to referred journals)
   d) Volume of cement = (weight/specific gravity) × (1/1000)
      =(350/3.15)*(1/1000) = 0.111m³
   e) Volume of water = (weight × water cement ratio)
      = (350*0.35)
      =122.5liters
   f) Volume of void ratio = 0.15m³
   g) Volume of all in aggregate =1-(0.111+0.1225+0.15)
      =0.61 m³
   h) Weight of coarse aggregate = (volume of all in aggregate ×specific gravity of aggregate×1000
      =0.61*2.7*1000)
      = 1664kg/m³
   i) Final Weight of fine aggregate
   j) Final Weight of coarse aggregate proportions= 5% of coarse aggregate
      =83.2
      =83.2kg/m³
      =1664-83.2
      =1580.8 kg/m³

= C	FA	CA	WATER
1	**1.02**	**1.9**	**0.35**

3) Mix Design for M20 Grade Pervious Concrete with 15% Replacement of Cement with Flyash and With 15% Fine Aggregate.

a) Volume of voids =15% (Constant for All Mix Design)
b) Weight of cement =350 kg/m³
c) Water cement ratio =0.35 (according to referred journals)
d) Volume of cement = (weight/specific gravity) × (1/1000)
=(350/3.15)*(1/1000)
=0.111 m³
e) Volume of water = (weight × water cement ratio)
=(350*0.35)
=122.5 liters
f) Volume of void ratio = 0.15m³
g) Final Weight of coarse aggregate
h) Proportions

Table -3.14 Mix Proportion for pervious concrete 1:1.02:1.9

SL No	Cement Kg\cube	W\C Ratio	Fine Aggregate Kg\cube	Coarse Aggregate Kg\cube	Fly ash Kg\cube	Water Kg\cube
1	2.27	0.35	0	4.5	0	6.13
2	2.02	0.35	0.3	4.7	0.29	6.13
3	1.7	0.35	0.6	4.9	0.58	6.13
4	1.5	0.35	0.9	5.2	0.88	6.13

D. Test On Pervious Concrete

1) Compressive Strength on Cubes of Pervious Concrete

a) Procedure

- Prepare a specimen of size 150 × 150 × 150 mm from water when such as natural process time and wipe out excess water from the surface.
- Clean the bearing surface of the testing machine.
- Place the specimen within the machine in such a fashion that the load shall be applied to the other sides of the cube forged.
- Align the specimen centrally on the bottom plate of the machine.
- Rotate the movable portion gently by hand so it touches the highest surface of the specimen.
- Apply the load step by step while not shock and incessantly.

Record the utmost load and note any uncommon options within the form of failure. COMPRESSIVE STRENGTH = (LOAD / AREA) N/mm²

Figure-3.2 Compressive Testing Machine

2) Permeability Test

a) Apparatus

- It consists of two water tank, one upper and another bottom water tank. Bottom water tank is attached welded to the middle portion of apparatus.
- Top water tank is 170mm in diameter and 150mm in height.
- Bottom water tank is 50mm in height and 270mm in diameter.
- Cylinder specimen is placed inside the middle portion of the apparatus and it is 160mm in height and 170mm in diameter.

b) Procedure

- Permeability is calculated for the cylinders of size 150mm diameter and 150mm height.
- After the min curing period the cylinders are taken out and placed into the apparatus.
- After placing the specimen, the cap is bolted the water tank pipe is connected to the cap pipe hole.
- Both the valve of top water tank and bottom tank are opened.
- Water is filled into the top water and allowed to pass through the pervious concrete cylinder.
- When the reached the mark of 4.4 cm marked from the bottom of the top water tank, the start the stopwatch and note down the time required for emptying of top water tank.

- Put all the values in formula and find out the permeability in cm/sec

Figure-3.3 Permeability Apparatus

K = (Q × L) / (T × H × A) cm/sec

Where, K = co-efficient of permeability

Q = Total Quantity of Flow in A Time Interval =1000 cm^3

L= Length of Specimen = 15cm

T= Time Taken by The Known Amount of Flow

H= Difference in The Water Levels of The Overhead and Bottom Tank =4.4 cm

A=Total Cross-Sectional Area of The Sample. **=176.71 cm^2**

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III. MATERIALS AND METHODOLOGY

A. Compressive Strength (Is: 516-1959)

The results are obtained by testing the total 72 specimens, 36 specimens for 7days and 36 specimens for 28 days are given in below tables.

Table-4.1 Compressive Strength of Pervious Concrete After 7 Days

Size of coarse aggregate in 'mm'	% Replacement by Cement withFly ash	Failure Load(KN)	Compressive strength (N/mm²)	Average Compressive strength (N/mm²)
20-12.5	0	225	10	9.12
		215	9.55	
		200	8.88	
	5	220	9.77	10.51
		230	10.22	
		260	11.55	
	10	250	11.11	11.78
		265	11.78	
		280	12.44	
	15	280	12.44	10.67
		240	10.56	
		200	8.88	

10% Replacement of cement with Fly ash gives Maximum compressive strength of pervious concrete after 7 days 10.67KN\mm^2.

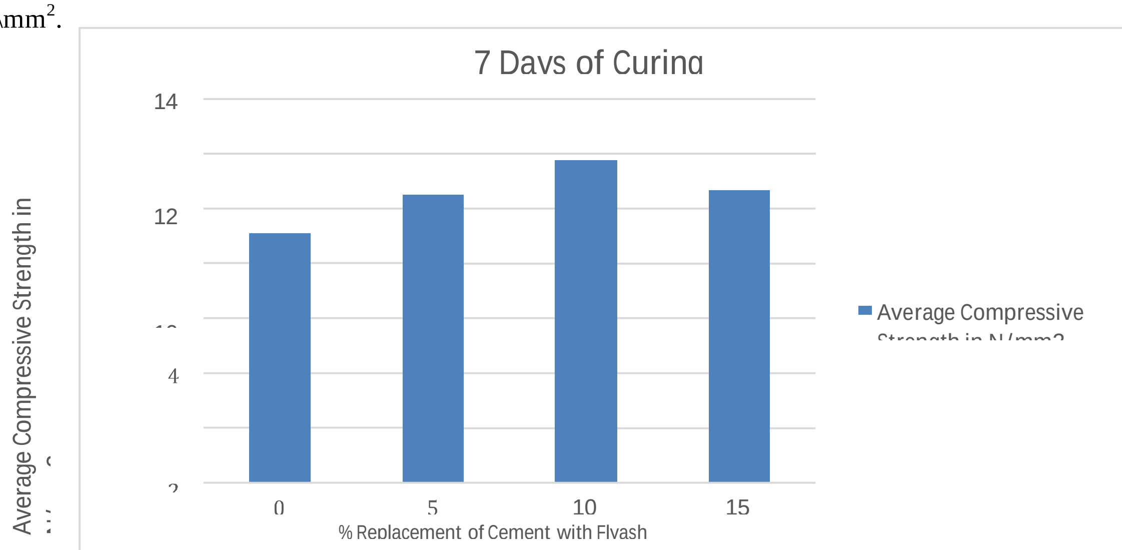

Figure-4.1 Graph of Compressive Strength of Pervious Concrete cube After 7 Days ofcuring.

Experimental observation establishes that the compressive strength of **10%** replacement of cement with gives highest compressive strength Compared to other two mixes. Highest alone compressive strength is given by **10%** replacement of Cement with Fly ash with 10% additionof Fine aggregate.

Table-4.2 Compressive Strength of Pervious Concrete After 28 Day

Size of coarse aggregate in 'mm'	% Replacement by Cement with Fly ash	Failure Load (KN)	Compressive strength (N/mm²)	Average Compressive strength (N/mm²)
20-12.5	0	285	12.66	12.88
		260	11.55	
		325	14.44	
	5	285	12.66	14.6
		480	21.33	
		225	16	
	10	250	11.11	12.37
		420	18.66	
		165	7.33	
	15	400	17.77	16.37
		330	14.66	
		375	16.66	

15% Replacement of cement with Fly ash gives maximum Compressive Strength of PerviousConcrete for 28 days. 16.37N/mm^2.

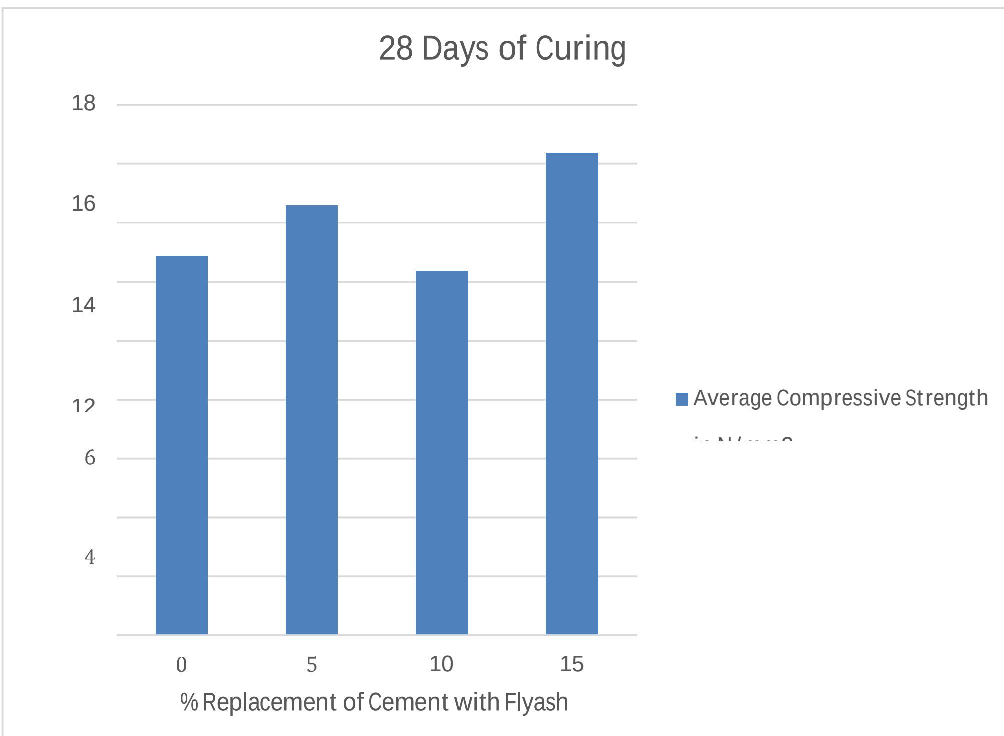

Figure-4.2 Graph of Compressive Strength of Pervious Concrete cube After 7 Days of curing.

Experimental observation establishes that the compressive strength of **10%** replacement of cement with gives highest compressive strength Compared to other two mixes. Highest alone compressive strength is given by **10%** replacement of Cement with Fly ash with 10% additionof Fine aggregate.

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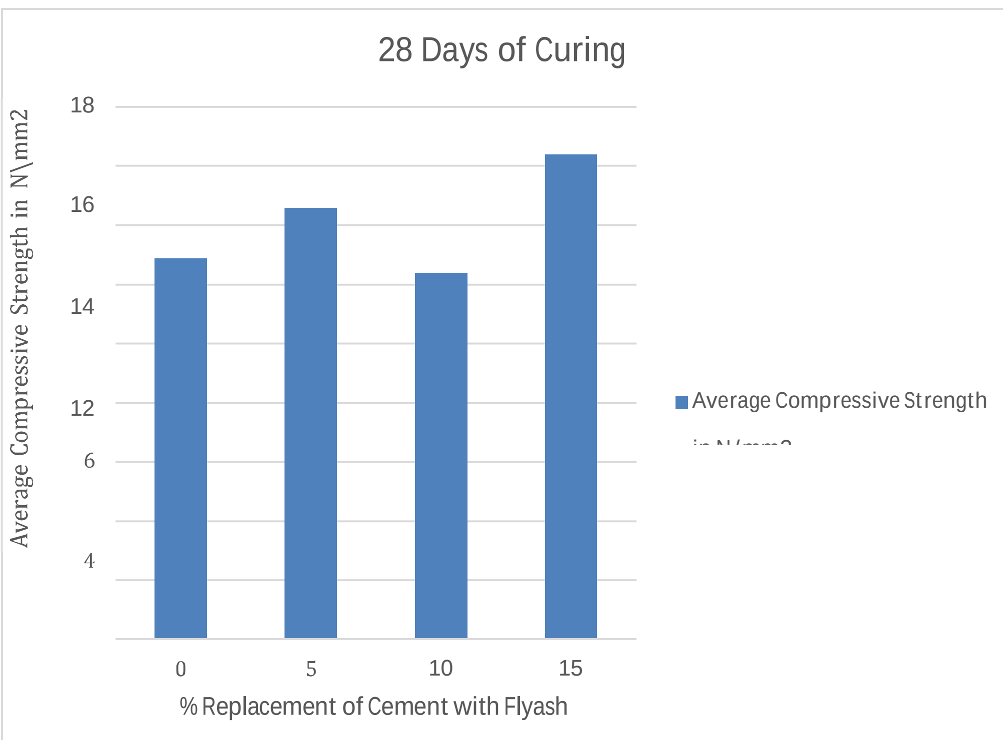

Figure-4.2 Graph of Compressive Strength of Pervious Concrete cube After 28 Days of curing.

Experimental observation establishes that the compressive strength of **15%** replacement of cement with gives highest compressive strength Compared to other two mixes. Highest alone compressive strength is given by **15%** replacement of Cement with Fly ash with 15% additionof Fine aggregate.

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B. Permeability Test

These results are obtained by testing the total 12-cube specimens of 150mm height,150mm width and 150mm depth for pervious concrete of different size coarse aggregate with different % replacement by fine aggregate and the results are tabulation in the table below:

Table-4.3 Permeability of Pervious Concrete (20-12.5mm)

Sl. No.	Size of Coarse Aggregatein 'mm'	% Replacement of Cement with Fly ash	Time 'Sec'	PermeabilityIn 'cm/Sec'
1	20-12.5	0	47	0.408
		5	50	0.384
		10	55	0.348
		15	59	0.325

It has been observed that coefficient of permeability is indirectly proportional to the compressive strength.**20-12.5mm** cube specimen with 0% replacement by fine aggregate have the **Highest** co efficient of permeability and **12.5-4.5mm** cube specimen with **15%** replacement by fine aggregate have the **Lowest** co efficient of permeability.

C. Cost Analysis

Table-4.4 Cost Analysis of Pervious Concrete

Sl. No.	Cement Content Kg/m³	Size of AggregateIn 'mm'	Water In 'liters'	Coarse aggregate		Fine Aggregate		Cost analysis 'Rupees'
				%	Kg/m³	%	Kg/m³	
1.	350	20-12.5	122.5	100	1664	0	0	3490
				100	1664	5	83.2	3560
				100	1664	10	166.4	3630
				100	1664	15	249.6	3700

1) The Highest cost of pervious concrete is 3700 per cubic meter for 15 replacement of fine Aggregate.
2) Pervious concrete reduces the cost 15-20% compared to Normal Concrete.

IV. CONCLUSION

Pervious concrete is a cost-effective and environmentally friendly solution to support sustainable construction. Pervious concrete is the brightest star in the green building movements, according to past research history. If we can do research to improve its basic properties then it has much bright future for its application in India. Whereas the fly ash, a waste generated by thermal power plants is as such a big environmental concern. The problems related with the safe management and dumping of fly ash has turned into a major test to environmentalists and scientists. This study focuses on partial replacement of cement with different percentages of fly ash without compromising with the change in compressive strength of pervious concrete. The replacement of 5% and 10% concrete with fly ash shows good ultimate compressive strength where as the replacement of 15% of cement with fly ash shows slight decrease in ultimate compressive strength of pervious concrete.

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