AN EXPERIMENTAL STUDY ON PROPERTIES OF PERVIOUS CONCRETE

R.VIGNESH KUMAR*, G.VIVEK KUMAR*, V.VINEET*, MS.F.S.FREIDA**

**Final year B.E civil students*
K.C.G College of Technology Karapakkam
Chennai India
***Assistant professor civil department*
K.C.G College of Technology Karapakkam
Chennai India

ABSTRACT:

Pervious concrete is a special high porosity concrete used for flatwork applications that allows water from precipitation and other source to pass through there by Reducing the Runoff from a site and Recharging Ground Water Levels. Compressive Strength, Tensile Strength and infiltration test are included in properties of Pervious Concrete. This paper mainly focuses on the Compressive Strength and tensile Strength of pervious concrete. Experimental methodology and results has been discussed for both these properties of pervious concrete. The pervious concrete has a low compressive strength to increase the compressive strength fly ash is added and the strength of the concrete is increased and investigation is be carried out at a regular interval of 7,14 and 28 days at a concrete mix proportion is 1:4.5 and with the addition of fly ash of 20% and 30%. The infiltration test is also conducted to measure the water infiltration rate.

KEYWORD: *pervious concrete, compressive strength, tensile strength, infiltration test, Fly ash.*

INTRODUCTION:

Concrete is a homogeneous mixture of cement, Aggregate (fine aggregate and coarse aggregate) and water. Now a days, special concrete is more preferred in the construction industry. Some of the special concretes are pervious concrete, transparent concrete, high volume fly ash concrete, self-compacted and curing concrete because of their special properties which is better compared to conventional concrete. Pervious Concrete is a special type of concrete in which no fine aggregates are used and gravel has been used in place of the coarse aggregate. Pervious Concrete is also called as “no-fines” concrete. Compressive strength and tensile strength of pervious concrete does depend primarily on the porosity, it is also affected by aggregate / gravel size, shape and gradation.

FIGURE 1

LITERATURE REVIEW

The environmental benefits of pervious concrete include the removal of pollutants from surface run-off and replenishment of ground water sources. Tennis, Lemming, and Akers stated that pervious concrete traps fluids such as oil and anti-freeze from automobiles, inhibiting them from flowing into nearby water sources during rainstorms. Although pervious concrete is not usually used for roadways that convey high traffic volume, its surface can improve safety during rainstorms by eliminating ponding, spraying, and risk of hydroplaning. Pervious concrete could have compressive and tensile strengths ranging from 500 to 4,000 psi and 150 to 550 psi, respectively (Tennis et al., 2004). Whereas traditional concrete has compressive strength and tensile strength ranging from 3,500 to 5,000 psi and 350 to 600 psi, respectively. However, it is possible to attain a stronger pervious concrete with the addition of admixtures and fiber (Amde et al., 2013).

In February 2013, the State of Maryland examined various mixes to develop high quality pervious concrete for the State's specification. The research was conducted using material from recent projects in the State of Maryland with the primary focus on specific admixtures that could be used to enhance the performance of pervious concrete. The admixtures used were cellulose fiber, a delayed set modifier, and a viscosity modifier. Samples of the pervious concrete were tested for density, void content, compressive strength, split tensile strength, permeability, freeze-thaw durability, and abrasion resistance. Fully saturated, 50% saturated, 0% saturated, and dry hard-freeze tests were investigated for freeze-thaw durability. The mixes with cellulose fiber resulted in significant increases in resistance to freeze-thaw activities. The cellulose fiber in the mixture bonded the cement and course aggregates thereby improving the tensile strength of the pervious concrete. In addition, the delay set modifier admixture was determined to increase the compressive strength which was attributed to lower water cement ratio. Finally, the viscosity modifying admixture created a more workable and easier to mould mix. Its effect on strength and durability, however, was determined to be minimal (Amde et al., 2013).

In 2007, a study conducted in Florida investigated the compressive strength and permeable characteristics of pervious concrete. The study revealed that the strength of pervious concrete not only relies on the compressive strength, but the soil strata below it. In addition, the researchers compared the compressive strength of conventional concrete and pervious concrete.

The results of the analyses showed that pervious concrete has lower compressive strength than conventional concrete. The researchers concluded that pervious concrete can only support light traffic loadings. The authors determined that the following factors affect the strength and permeability of Pervious concrete: compaction, aggregate size, water cement-ratio, and aggregate cement ratio. The tests were conducted in a laboratory with varied concrete mixtures and cylinders. The outcome of the experiment validated the fact that permeable concrete has lower compressive strength than conventional concrete (Chopra et al., 2007)

MIX DESIGN:

Pervious Concrete is a mixture of Cement, Coarse Aggregate / Gravel and Water. No Fine Aggregates are used for making pervious concrete. Pervious Concrete has been casted concrete mix proportion such as 1:4.5 with 19.05 mm gravel size with OPC 53 Grade Cement.

TABLE1 PHYSICAL PROPERTIES OF ORDINARY PORTLAND CEMENT 53 GRADE (OPC)

PROPERTY	VALUE FOR OPC CEMENT	IS RECOMMENDATION
SPECIFIC GRAVITY	3.15	3.10 – 3.15
CONSISTENCY (%)	28%	30 – 35%
INITIAL SETTLING TIME (MIN)	35 MIN	30 $minimum\ min$
FINAL SETTLING TIME (MIN)	178 MIN	600 maximum min
COMPRESSIVE STRENGTH AT 7 DAYS	38.49 N/mm^2	43 N/mm^2
COMPRESSIVE STRENGTH AT 28 DAYS	52.31 N/mm^2	53 N/mm^2

TABLE2 CHEMICAL COMPOSITIONS OF ORDINARY PORTLAND CEMENT 53 GRADE (OPC)

OXIDE	CONTENT (%) IN OPC
Lime CaO	60-67
Silica SiO2	17-25
Alumina Al2O3	3-8
Iron Oxide Fe2O3	0.5-0.6
Magnesia Mo.	0.5-4
Alkaline K2O, Na2O	0.3-1.2
Sulfates SO3	1.0-3.0

WATER CEMENT RATIO:

The w/cm is an important consideration for maintaining strength and the void structure of the concrete. A high w/cm reduces the adhesion of the paste to the aggregate and causes the paste to flow

and fill the voids even when lightly compacted. A low w/cm will tend to cause balling in the mixer and prevent an even distribution of materials. Experience has shown a range of 0.35 to 0.45 will provide the best aggregate coating and paste stability. Higher values of w/cm should only be used if the concrete is lightly tamped or compacted.

A. Testing of Fresh Pervious Concrete

1)Workability: A number of different methods are available for measuring the workability of fresh concrete, but none of them is wholly satisfactory. Each test measures only a particular aspect of it and there is really no method which measures the workability of concrete in its totality. However, by checking and controlling the uniformity of the workability it is easier to ensure a uniform quality of concrete and hence uniform strength for a particular job. In the present work, following test were performed to find the workability.

a) The Slump Test:

b) The Compaction Factor Test

c) The Flow Test

TABLE 3: WORKABILITY OF VARIOUS MIX

MIX	SLUMP CONE TEST(mm)	COMPACTION FACTOR TEST	FLOW TABLE TEST(%)
Pervious concrete	160	0.75	82.12
Pervious concrete with fly ash 30%	175	0.70	80.85
Pervious concrete with fly ash 20% and glass fiber 0.5%	150	0.73	81.27

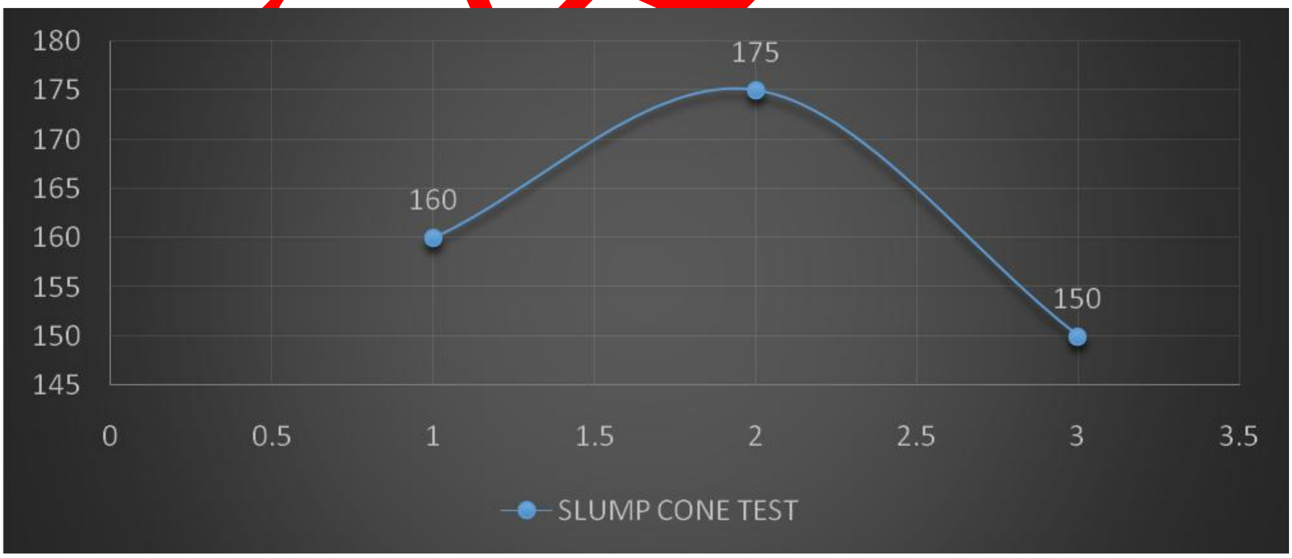

FIGURE 2: SLUMP CONE TEST

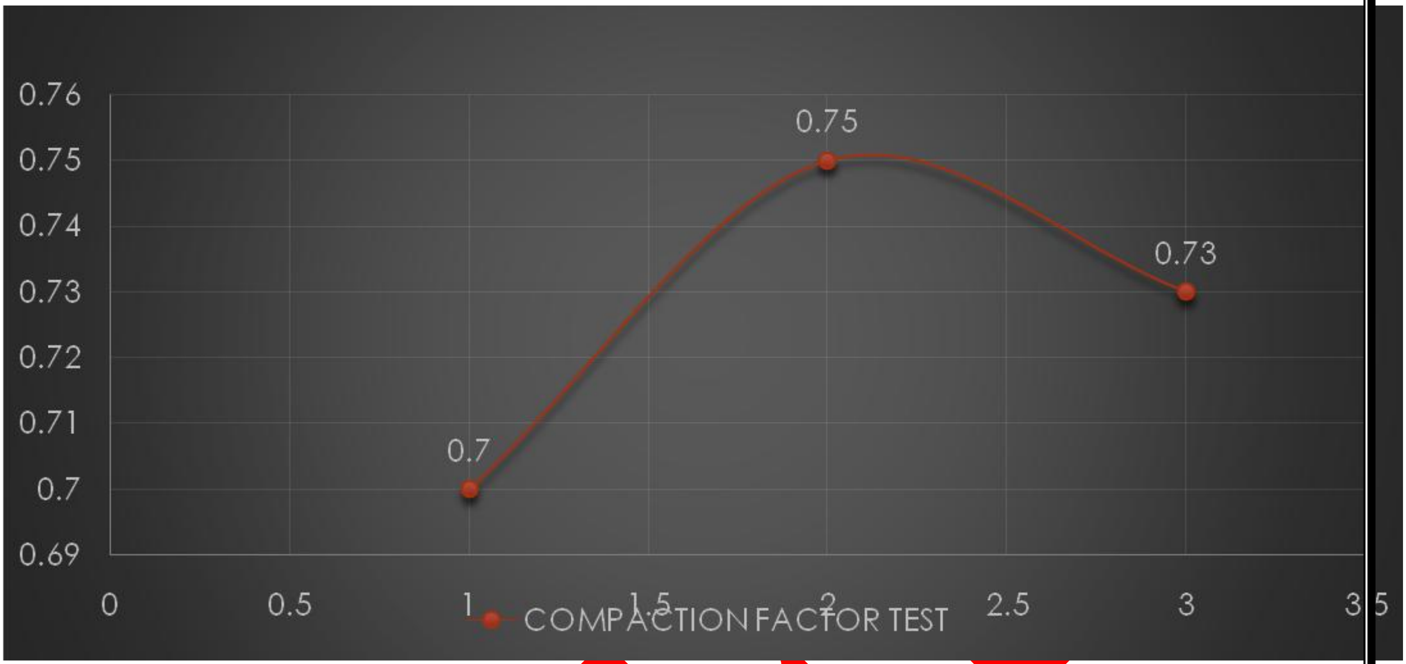

FIGURE 3:COMPACTION FACTOR TEST

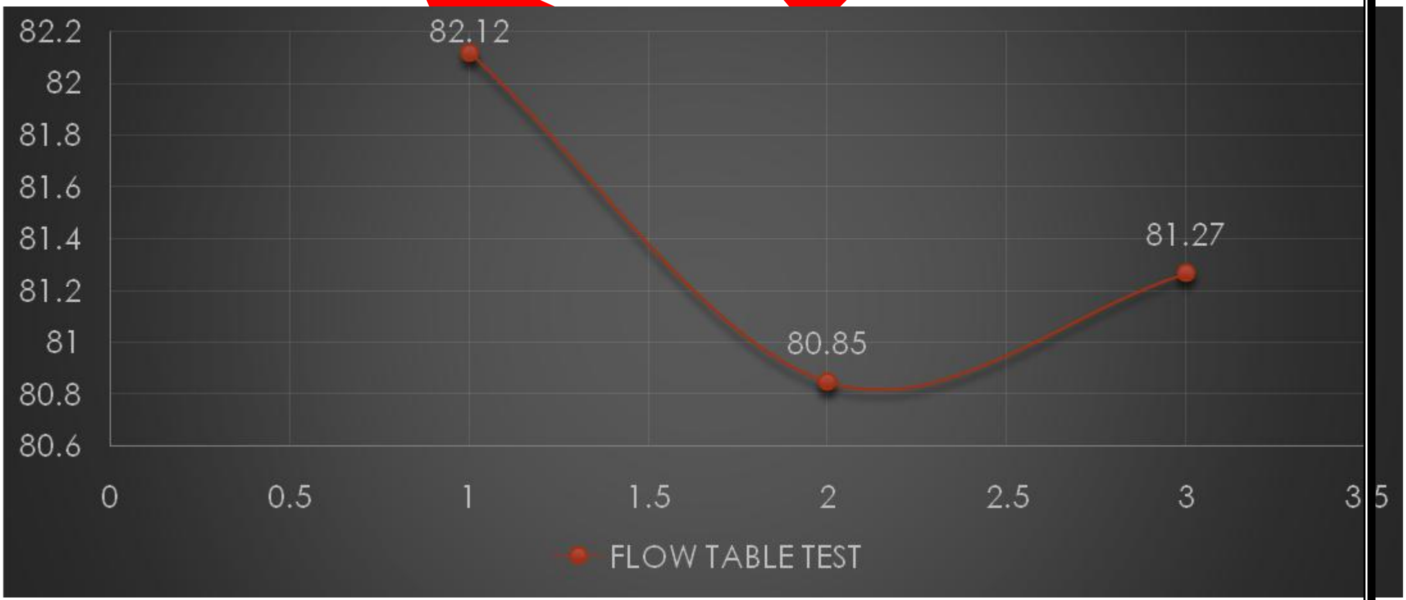

FIGURE 4: FLOW TABLE TEST

SAMPLING PREPARATION PROCEDURE:

The cylinder and cube samples were made and cured in accordance with ASTM C192 Standard Practice for Making and Curing Concrete Test Specimen in the Laboratory. The samples were cast using the following methods:

1) Self-Consolidating (SC): also referred to as self- compacting. The cylinder was completely filled and struck and capped under pressure.

2) Standard Rodding (SR): samples were prepared in two lifts and compacted 25 times with a tamping rod. The samples were also tapped on the sides slightly after the first and last rodding.

3) Proctor Hammer (PH): samples were placed into cylinders in two lifts and compacted with 25 times of the standard Proctor Hammer.

The specimens were cured in a standard moisture curing chamber, until the day of testing. A minimum of 5 samples were prepared for each mix, of which two were used for tensile strength tests and 3 used for compressive strength.

COMPRESSIVE STRENGTH TEST:

The aim of the test is to determine the compressive strength of pervious concrete. The test was carried out in accordance with ACI522R-10.The cubes were tested for compressive strength at specify ages of 7, 14 and 28 days of curing. The compressive strength of pervious concrete is calculated. thus

COMPRESSIVE STRENGTH= $\frac{CRUSHING\ LOAD\ (KN)}{AREA\ OF\ CUBE\ (m^2)}$

FIGURE 5:FAILURE OF CUBE COMPRESSIVE STRENGTH

TABLE 4: COMPRESSIVE STRENGTH OF PERVIOUS CONCRETE

AGE (DAYS)	WATER/CEMENT RATIO	AGGREGATE/CEMENT RATIO	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)
7	0.4	4.5:1	9.78
14	0.4	4.5:1	18.66
28	0.4	4.5:1	30

TABLE 5:COMPRESSIVE STRENGTH OF PERVIOUS CONCRETE WITH FLY ASH 30

AGE (DAYS)	WATER/CEMENT RATIO	AGGREGATE/CEMENT RATIO	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)
7	0.4	4.5:1	6
14	0.4	4.5:1	12
28	0.4	4.5:1	20

TABLE 6: COMPRESSIVE STRENGTH OF PERVIOUS CONCRETE WITH FLY ASH 20% AND GLASS FBIER 0.5%

AGE (DAYS)	WATER/CEMENT RATIO	AGGREGATE/CEMENT RATIO	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)
7	0.4	4.5:1	12
14	0.4	4.5:1	19
28	0.4	4.5:1	35

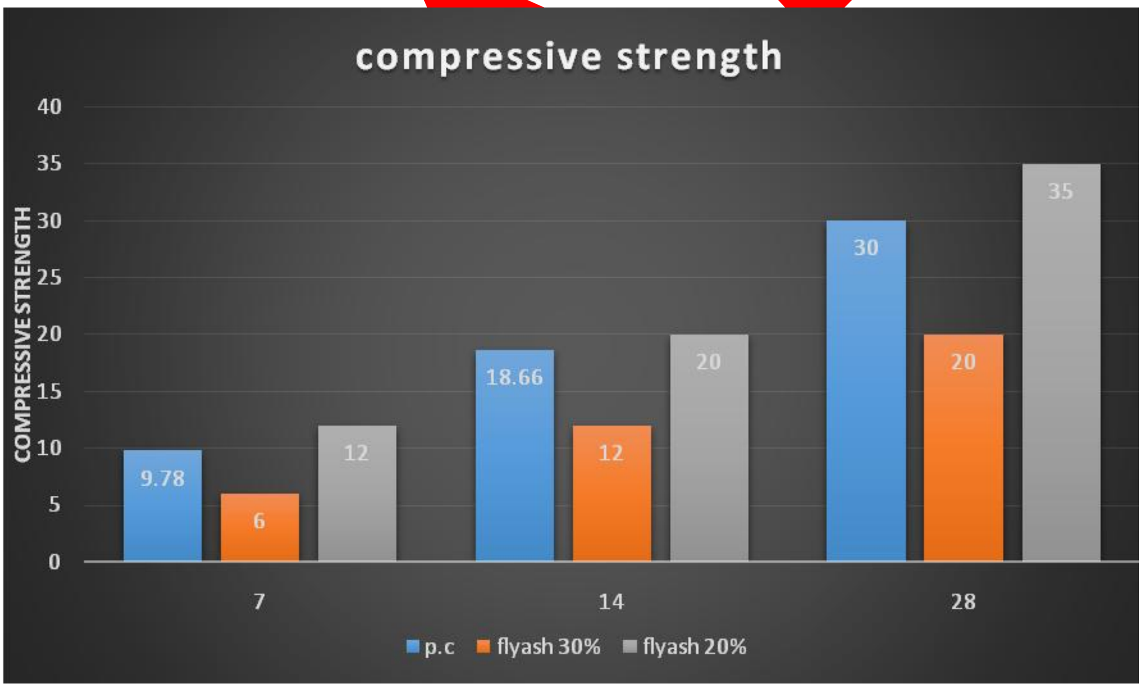

FIGURE 6: COMPRESSIVE STRENGTH TEST

SPLIT TENSILE TEST:

Specimens when received dry shall be kept in water for 24 h before they are taken for testing. Unless other conditions are required for specific laboratory investigation specimen shall be tested immediately on removal from the water whilst they are still wet. Surface water and grit shall be wiped off the specimens and any projecting fins removed from the surfaces which are to be in contact with the packing strips. Thus the tensile strength is calculated from formula

$$TENSILE\ STRENGTH = \frac{2P}{3.14dl}$$

TABLE 7: SPLIT TENSILE STRENGTH OF PERVIOUS CONCRETE

AGE (DAYS)	WATER/CEMENT RATIO	AGGREGATE/CEMENT RATIO	AVERAGE SPLIT TENSILE STRENGTH ($/mm^2$)
7	0.4	4.5:1	1.4
14	0.4	4.5:1	2.05
28	0.4	4.5:1	2.8

TABLE 8: SPLIT TENSILE STRENGTH OF PERVIOUS CONCRETE WITH FLY ASH 30%

AGE (DAYS)	WATER/CEMENT RATIO	AGGREGATE/CEMENT RATIO	AVERAGE SPLIT TENSILE STRENGTH ($/mm^2$)
7	0.4	4.5:1	0.7
14	0.4	4.5:1	1.2
28	0.4	4.5:1	2

TABLE 9: SPLIT TENSILE STRENGTH OF PERVIOUS CONCRETE WITH FLY ASH 20%

AGE (DAYS)	WATER/CEMENT RATIO	AGGREGATE/CEMENT RATIO	AVERAGE SPLIT TENSILE STRENGTH ($/mm^2$)
7	0.4	4.5:1	1.8
14	0.4	4.5:1	2.4
28	0.4	4.5:1	3.1

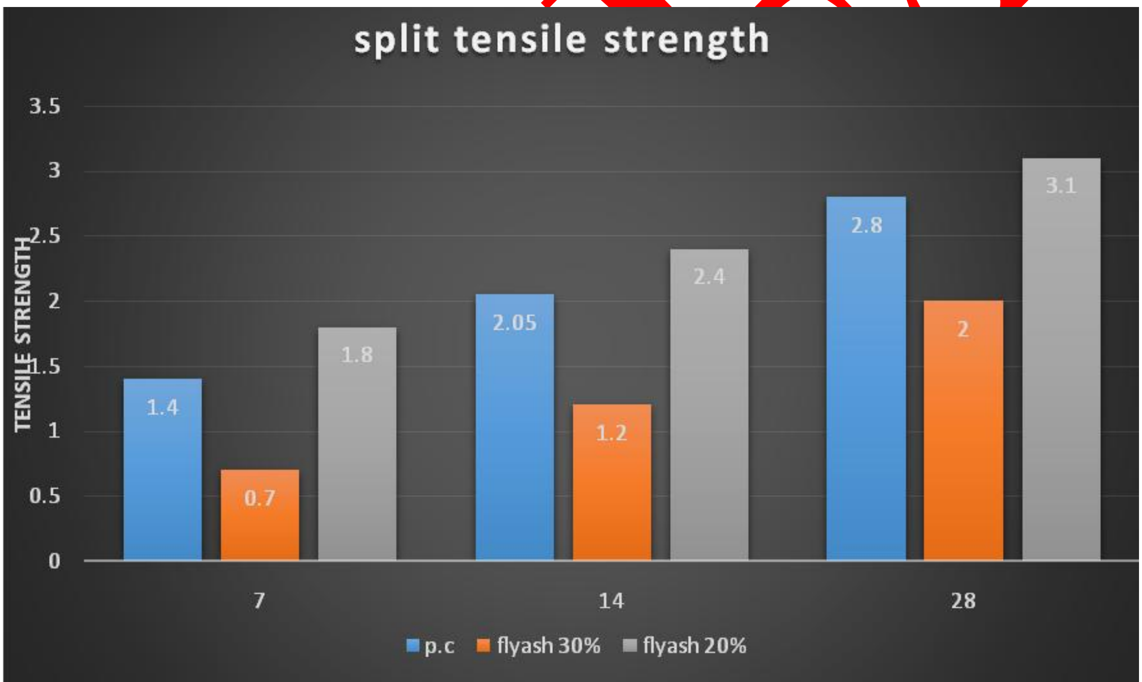

FIGURE 7: SPLIT TENSILE STRENGTH TEST

COST COMPARISON:

TABLE 10: COST COMPARISM BETWEEN PERVIOUS CONCRETE, CONVENTIAL CONCRETE AND PERVIOUS CONCRETE WITH FLY ASH

COST COMPARISM OF CONVENTIAL M20 GRADE CONCRETE AND PERVIOUS CONCRETE						
MATERIAL	**NORMAL CONCRETE OF M20 GRADE**	**RUPEES /cu .ft**	**Pervious concrete**	**RUPEES /cu .ft**	**P.C WITH FLY ASH**	**RUPEES /cu .ft**
CEMENT (380 RS / 50 KG)	100 kg	760	100 kg	760	100 kg	760
FINE AGGREGATE (1200/100 cu.ft)	162 kg	300	NIL	NIL	NIL	NIL
COARSE AGGREGATE (1000/ 60 cu.ft)	320 kg	295	500 kg	525	500 kg	525
Fly ash(2 Rs / 1 kg)	NIL		NIL		15 kg	30
Total		1400		1285		1315

CONCLUSION:

The strength of the pervious concrete cannot be increased by using fly ash 30% but when fly ash of 20% is used the strength of the pervious concrete is increased considerably.

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