

Experimental Investigation on Pervious Concrete Using Special Admixtures

T. Dharshini Priya ¹, S. B. Miruthula ²

¹B.E Civil Engineering, Vel Tech,

²B.E Civil Engineering, Vel Tech,

Abstract-Pervious concrete made from uniform graded material consisting of Portland Pozzolana Cement aggregate, Admixtures and Water. Because pervious concrete contains little or no fine aggregates such as sand, it is sometimes referred to as “no fines” concrete. It is a special type of concrete having a high void content of about 30%, and is becoming popular nowadays due to its potential of reduce water runoff of the drainage systems which can provide a water flow around 0.34cm/second. In this project, detailed various literature has been under taken to fully understand the properties and applications of pervious concrete. An alternate has been made to develop a mix of pervious concrete and compare with that of the conventional concrete. Totally two different mix proportions were used in this project with replacement of cement with 25% GGBS and 2% of poly vinyl alcohol. The strength properties of hardened concrete include compressive strength of cube, split tensile strength of cylinder, flexural strength of prism, load deflection behaviour of beam for various mix proportions have been studied. Based on the results of the experimental study, some important conclusions have been drawn.

Key word -GGBS; Poly Vinyl Alcohol; Super plasticizer; Pervious pavement

I. INTRODUCTION

1.1 GENERAL

Concrete is a construction material composed of cement, commonly Portland cement as well as other cementations materials such as fly ash and slag cement, coarse aggregate, fine aggregate, fine aggregate such as sand, water, and chemical admixtures. Both the fine and coarse aggregate bind together with the fluid cement that hardens over time. Most concrete used are lime based concrete such as Portland cement concrete or concretes made with other hydraulic cements.

1.2 PERVIOUS CONCRETE

Pervious concrete is a special type of concrete with a high porosity used for concrete Flatwork applications that allows water from precipitation and other sources to pass through it, thereby reducing the runoff from a site and recharging ground water levels. The void content can range from 18 to 35% with compressive strengths of 400 to 4000psi. The infiltration rate of pervious concrete will fall into the range of 2 to 18 gallons per minute per square foot (80 to 720 litres per minute per square meter). Typically pervious concrete has little to no fine aggregate interconnectivity of the voids. There are a number of alternate names for porous concrete including permeable concrete, porous pavement and pervious concrete. All of the names basically mean the same thing which is porous concrete is a form of concrete which is permeable.

1.3 USES OF PERVIOUS CONCRETE

Some of the uses of pervious concrete are listed below,

- Pervious concrete is traditionally used in parking areas, areas with light traffic, pedestrian walkways, and greenhouses.
- Pervious concrete is an important application for sustainable construction.
- Porous concrete is concrete which is designed to have many voids to trap water and allow it to penetrate through the concrete to the ground below. This concrete does not use fine aggregates in the mixture that is why it has more voids than conventional concrete.
- It is very suitable for people who are concerned about runoff into the ocean.

- Portland cement and water that allows for rapid infiltration of water overlays a stone aggregate reservoir.
- The water- permeating ,water –draining, and water- retaining performances of this porous concrete have been utilized in road pavement, sidewalks, parks and building extension, as well as for plant bedding and permeable gutters.
- Porous concrete pavement can potentially infiltrate storm water at source which will allow the oils from cars and trucks to biodegrade safely, improve driving safety, reduce traffic noise and also reduce urban temperatures. There had been numerous studies throughout others country on porous concrete and their application like road pavement, fishing bank and even for sidewalks.

1.4 ADVANTAGES OF PERVIOUS CONCRETE

The followings are some of the advantage of pervious concrete,

- Porous concrete can help route storm runoff and rain directly into the soil where it can nourish gardens and flow down into the water table.
- It also can be made with recycled materials including recycled concrete rubble and recycling aggregates.
- It an ecologically friendly and aesthetically pleasing building material.
- We totally eliminate the use of fine aggregates in porous concrete.

II. LITERATURE REVIEW

2.1 GENERAL

The literatures were collected on the previous investigation based pervious concrete and their admixtures. Experimental investigation of pervious concrete with special admixtures was investigated.

2.2 LITERATURE VIEW

1. Karthik H.Obla(2010) Investigated that Pervious concrete is a special high porosity concrete used for flatwork application that allows water from precipitation and other sources to pass through, thereby reducing the runoff from a site and recharging ground water levels. Its void content ranges from 18 to 35% with compressive strengths 28 to 281 kg/cm². The Pervious concrete will fall into the range 80 to 720 per minute per square meter. Typically, Pervious concrete has little or no fine aggregate and just enough cementitious paste to coat the coarse aggregate particles while preserving the interconnectivity of the voids.

2. Baoshan huang(2009) studied the balance between permeability and strength properties of polymer – modified pervious concrete(PMPC). In addition to latex, natural sand and fiber were included to enhance the strength properties of pervious concrete. The test results indicate that it was possible to produce pervious concrete mixture with acceptable permeability and strength through the combination of latex and sand, pervious concrete has been increasingly used to reduce the amount of runoff water and improve the water quality near pavements and parking lots. However, due to the significantly reduced strength associated with the high porosity, pervious concrete mixtures currently cannot be used in highway pavement structures. A laboratory experiment was conducted in this study to improve the strength properties of pervious concrete through the incorporation of latex polymer.

3. Ming-Ju Lee, Ming-Gin Lee, Yishuo Huang, and Chia-Liang Chiang in “Purification Study of Pervious Concrete Pavement studied by capturing storm water and allowing it to seep into the ground, pervious concrete is instrumental in recharging groundwater, reducing storm water runoff, and meeting U.S . Environmental Protection Agency storm water regulations. In this research, water quality and pollutants leached from pervious concrete pavement was investigated. This project mainly aims to study the pervious concrete pavement by pollutants such as acid rain, sea water or waste lubricating oil. The results show that pollutant and water purification of pervious concrete pavement both significantly improved in the acid rain, sea water or waste motor oil test. A diluted sulphuric acid solution (PH value 2) after the pervious concrete pavement system could significantly enhance its PH value to 6.5 above. This study demonstrates that implementing pervious concrete pavement is valuable for road design and hydrologic consideration. Two test has been seen here

1. Strength and water Penetration Testing.
2. Pervious Pavement Test Box and Water pollutant test variables
4. Jaehun Ahn, Jinwoo Jung, Seungbae Kim and Shin-In Han

“ X-RAY IMAGE ANALYSIS OF POROSITY OF PERVIOUS CONCRETES” studied the use of permeable pavement is one of the most promising tools to control runoff and water quality , therefore enabling low impact development(LID), along with several other benefits. The porosity of the permeable pavement is the most important property of the pavement in current state of the practice. In this article, the porosity of a pervious concrete sample made in laboratory was evaluated by two approaches: measuring weights and X-ray image analysis. Two different imaging apparatus, 2D and 3D, were used to construct cross-sectional planar images of a cylindrical pervious concrete sample. It was found that the porosity estimate from 2D X-ray was close to the results with measuring weights, but that of 3D X-ray was rather larger under X-ray imaging configuration and image analysis technique used. The viability of using X-ray images to evaluate the pore characteristics of permeable pavement, and future applications are dealt.

5. Tanvir Hossain, Md. Abdus Salam, Nohiuddin Abdul Kader in “Pervious Concrete Using Brick Chips as Coarse Aggregate: An Experimental Study”

Here brick aggregate is used in producing normal strength or even high strength concrete. However, there is hardly any literature of producing pervious concrete using brick chips as coarse aggregate. This paper describes an experimental investigation carried on pervious concrete made of brick chips and also sheds light on the engineering properties of this new product. The properties of pervious concrete such as strength, permeability and void ratio were investigated. Different sizes of aggregate were used here. Stone aggregates were also used here for comparison purposes. Relationships among various parameters, i.e. Strength, void ratio, aggregate size, permeability for two different pervious concrete are also presented here. It can be seen that pervious concrete made of brick chips performs well in respect of permeability. However, the strength of this concrete is lower than that of the stone aggregate concrete.

6. Ajamu, S.O., A.A. Jimoh, J.R. Oluremi in “Evaluation of Structural Performance of Pervious Concrete in Construction”

The permeability and strength of pervious concrete depends on the particle sizes and proportions of the constituent materials of which the concrete is made of. In this paper, structural property and permeability of pervious concrete made with different coarse aggregate sizes is presented. For the different aggregate/cement ratio used in this study, coarse aggregate size 9.375mm has higher compressive strength values compared to those made from 18.75mm aggregate size while 18.75mm aggregate size had higher permeability value compared to that of 9.38mm.

III. METHODOLOGY

3.1 OBJECTIVE

The main objective of the project is to investigate the experimental investigation of pervious concrete with special admixtures.

In this project, a brief literature review has been carried out on pervious concrete, GGBS and Polyvinyl alcohol.

3.1.1 WORK TO BE DONE

- Detailed Literature Survey was carried out on pervious concrete and their behaviour with admixtures.
- Experimental investigation of concrete by various concentration of admixtures.
- Comparing the results of pervious concrete with the pervious concrete with admixtures.

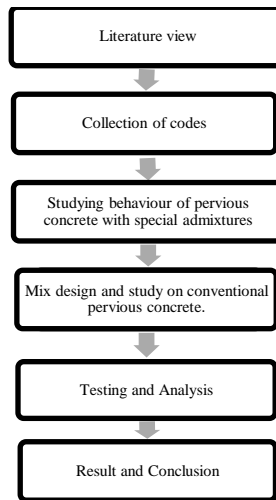


Fig 3.1 Flow Chart For Methodology

3.3 Collection of Materials

In this chapter various materials which were used in project are explained along with its properties and method of conducting the test was discussed in detail.

MATERIALS USED

- Aggregate
- Coarse aggregate (20mm).
- Cement
- Ground Granulated blast slag(GGBS)
- Polyvinyl chlorides

3.3.1 Aggregates

The aggregates are the main components of the concrete which greatly varies the strength, density and other properties of concrete

Coarse Aggregate

Coarse aggregates are widely used in construction applications. They are generally categorized as rock larger than a standard No. 4 sieve (3/16 inches) and less than 2 inches. Usually available coarse aggregates having the maximum size of 20mm were used in this project.



Fig 3.2 Coarse Aggregate



Fig 3.3 Ordinary Portland Cement

3.3.2 Ordinary Portland Cement

OPC is the general purpose cement used in concrete constructions. OPC is a compound of lime (CaO), silica (SiO₂), alumina (Al₂O₃), iron (Fe₂O₃) and sulfur trioxide (SO₃). Magnesium (MgO) is present in small quantities as an impurity associated with limestone.

3.3.3 GGBS:

Ground-granulated blast-furnace slag (GGBS or GGBFS) is obtained by quenching molten iron slag (a by-product of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder.

3.3.3 Poly(Vinyl Alcohol) :

Poly(vinyl alcohol) (PVOH, PVA, or PVAL) is a water-soluble synthetic polymer. It has the idealized formula $[\text{CH}_2\text{CH}(\text{OH})]_n$. It is used in papermaking, textiles, and a variety of coatings. It is white (colourless) and odourless. It is sometimes supplied as beads or as solutions in water.

3.4 Testing Of Materials

Test on aggregates

- i. Water absorption
- ii. Specific Gravity Test

Test on cement

- i. Consistency Test
- ii. Initial and Final Setting Time Test
- iii. Specific gravity

Test on concrete

- i. Slump cone test
- ii. Compaction factor test

3.4.1 Test on Aggregates

Aggregate plays an important role in pavement construction. Aggregates influence, to a great extent, the load transfer capability of pavements. Hence it is essential that they should be thoroughly tested before using for construction.

i. Water Absorption Test

This test helps to determine the water absorption of coarse aggregates as per IS: 2386 (Part III) – 1963. For this test a sample not less than 2000g should be used.

Apparatus used

- Wire basket – perforated, electroplated or plastic coated with wire hangers for suspending it from the balance,
- Water-tight basket,
Dry soft absorbent cloth – 75cm x 45cm (2 nos.), Shallow tray of minimum 650 sq.cm area, Air-tight container of a capacity similar to the basket and Oven.

PROCEDURE TO DETERMINE WATER ABSORPTION OF AGGREGATES:

- i) The sample should be thoroughly washed to remove finer particles and dust, drained and then placed in the wire basket and immersed in distilled water at a temperature between 22 and 32°C.
- ii) After immersion, the entrapped air should be removed by lifting the basket and allowing it to drop 25 times in 25 seconds. The basket and sample should remain immersed for a period of 24 + ½ hrs afterwards.
- iii) The basket and aggregates should then be removed from the water, allowed to drain for a few minutes, after which the aggregates should be gently emptied from the basket on to one of the dry clothes and gently surface-dried with the cloth, transferring it to a second dry cloth when the first would remove no further moisture. The aggregates should be spread on the second cloth and exposed to the atmosphere away from direct sunlight till it appears to be completely surface-dry. The aggregates should be weighed (Weight 'A').
- iv) The aggregates should then be placed in an oven at a temperature of 100 to 110°C for 24hrs. It should then be removed from the oven, cooled and weighed (Weight 'B').

RESULTS:

$$\text{Water absorption} = [(A - B)/B] \times 100\% \\ = 1.21\%$$

ii. Specific gravity test

Specific gravity is the ratio of the density of a substance to the density of a reference substance; equivalently, it is the ratio of the mass of a substance to the mass of a reference substance for the same given volume. Specific gravity test was carried out by using Pycnometer.

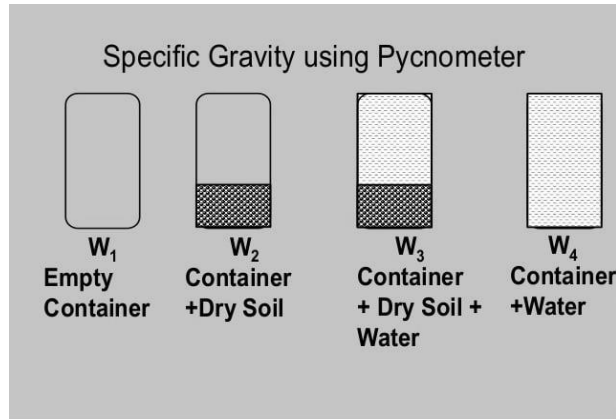


Fig 3.4 Specific Gravity Test

Specific gravity of coarse aggregate

- Empty weight of pycnometer (w_1) = 0.607 kg
- Weight of sand (C.A)+ Water (w_2) = 1.155 kg
- Weight of pycnometer+ water +(C.A) (w_3) =1.840 kg
- Weight of pycnometer +water (w_4) = 1.493 kg

$$\begin{aligned} \text{Specific gravity } G &= \frac{(w_2 - w_1)}{(w_2 - w_1) - (w_3 - w_4)} \times \text{sp. gravity of water} \\ &= \frac{(1.155 - 0.607)}{(1.155 - 0.607) - (1.840 - 1.493)} \times 1 \\ &= 2.72 \end{aligned}$$



Fig 3.5 Test made on pycnometer

3.4.2 Test on Cement

Quality tests on cements at construction site (also called field tests on cement) are carried to know the quality of cement supplied at site. It gives some idea about cement quality based on colour, touch and feel and other tests.

Consistency test

This test was carried out to determine the quantity of water required to produce a cement paste of standard consistency. Consistency test was determined by using Vicat apparatus.

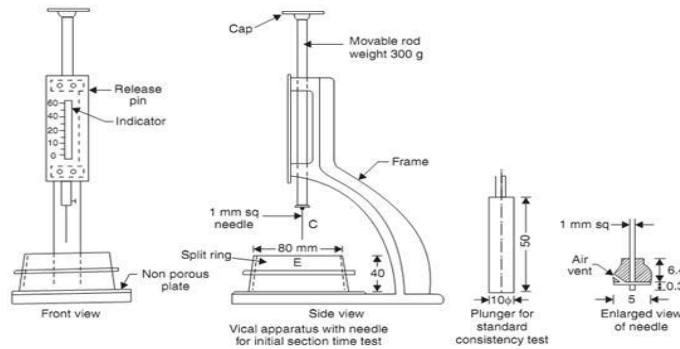


Fig 3.6 Consistency test

Procedure for consistency test

- 1) The mould and the non porous plate are washed, cleaned and dried
- 2) 400g of the given sample of cement is kept on the non porous plate
- 3) 30% water by weight of cement is added very care fully to dry cement and mixed thoroughly to get a neat cement paste. care should be taken that the time of gauging is not less than 3 minutes and not more than 5 minutes. the gauging time shall be counted from the time of adding water to the dry cement until commencing to fill the mould
- 4) The vicat mould is placed on the non porous plate and is filled with the prepared cement paste with trowel, the surface is smoothed is level with the mould
- 5) By shaking mould slightly any air from the sample is expelled.
- 6) The non porous plate and mould are placed under the plunger.
- 7) The plunger is gently levelled to touch the surface of paste and then the indicator is adjusted to show zero reading.
- 8) The plunger is released quickly and allowed to penetrate in to the paste .
- 9) When the plunger comes to rest, the reading on the index scale is noted .
- 10) Several trial pastes are prepared with varying percentages of water and the test is conducted until the needle penetrated 5mm-7mm above the bottom of the mould.

RESULT:

Found standard or normal consistency of cement = 29.5%

Specific gravity of cement

Empty weight of crucible (w₁) = 29.90g

Weight of crucible + cement (w₂) = 47.77g

Weight of crucible + cement + kerosene (w₃) = 80.49g

Weight of crucible + kerosene (w₄) = 67.36g

Specific gravity of kerosene ranges from 0.79 to 0.84.

Take specific gravity of kerosin as 0.82.

$$\begin{aligned}
 \text{Specific gravity } G &= \frac{(w_2 - w_1)}{(w_2 - w_1) - (w_3 - w_4)} \times \text{Sp. gravity of kerosin} \\
 &= \frac{(47.77 - 29.90)}{(47.77 - 29.90) - (80.49 - 67.36)} \times 0.82 \\
 &= 3.15
 \end{aligned}$$



Fig 3.7 Specific gravity of cement

NOTE: Specific gravity of cement always should be less than 10%

Setting time test of cement

Initial setting time is that time period between the time water is added to cement and time at which 1 mm square section needle fails to penetrate the cement paste, placed in the Vicat's mould 5 mm to 7 mm from the bottom of the mould.

Final setting time is that time period between the time water is added to cement and the time at which 1 mm needle makes an impression on the paste in the mould but 5 mm attachment does not make any impression.



Fig 3.8 Vicat apparatus

APPARATUS:

- Vicat apparatus
- Balance
- Measuring cylinder
- Stop watch

PROCEDURE

(A) TEST BLOCK PREPARATION

1. Before commencing setting time test, do the consistency test to obtain the water required to give the paste normal consistency (P).
2. Take 400 g of cement and prepare a neat cement paste with 0.85P of water by weight of cement.
3. Gauge time is kept between 3 to 5 minutes. Start the stop watch at the instant when the water is added to the cement. Record this time (t_1).
4. Fill the Vicat mould, resting on a glass plate, with the cement paste gauged as above. Fill the mould completely and smooth off the surface of the paste making it level with the top of the mould. The cement block thus prepared is called test block.

(B) INITIAL SETTING TIME

1. Place the test block confined in the mould and resting on the non-porous plate, under the rod bearing the needle.
2. Lower the needle gently until it comes in contact with the surface of test block and quick release, allowing it to penetrate into the test block.
3. In the beginning the needle completely pierces the test block. Repeat this procedure i.e. quickly releasing the needle after every 2 minutes till the needle fails to pierce the block for about 5 mm measured from the bottom of the mould. Note this time (t_2).

(C) FINAL SETTING TIME

1. For determining the final setting time, replace the needle of the Vicat's apparatus by the needle with an annular attachment.
2. The cement is considered finally set when upon applying the final setting needle gently to the surface of the test block; the needle makes an impression thereon, while the attachment fails to do so. Record this time (t_3).

RESULTS:

Initial setting time = 4.2mins

Final setting time = 4.95mins

3.5 MIX DESIGN

A-1 Stimulations for proportioning:

- Grade designation:M40
- Type of cement : OPC53 grade confirming to IS-8112
- Maximum nominal aggregate size : 20mm
- Minimum cement content : 320 kg/m³
- Maximum water cement ratio : 0.34
- Workability : 100mm (Slump)
- Exposure condition : Severe
- Degree of supervision : Good
- Type of aggregate : Crushed angular aggregate
- Maximum cement content (OPC) : 400 kg/m³
- Chemical admixture type : Super plasticiser confirming to IS-9103

A-2 Test data for materials:

- Cement used : OPC43 grade confirming to IS-8112
- Specific gravity of cement : 3.15
- Specific gravity of water : 1.00
- Superplasticizers used : Polycarboxylate up to 2%
- Bonding Admixture :Poly vinyl alcohol 2%
- Specific gravity of 20mm aggregate : 2.71
- Water absorption of Coarse aggregate : 1.21%

Free surface moisture of Coarse and fine aggregate : nil

A-3 Target strength for mix proportion:

$$F_{CK} = F_{CK} + 1.65s : 48.25\text{N/mm}^2 \text{ (S=Standard deviation)}$$

F'_{ck} is the target average compressive strength at 28th day

F_{CK} is the characteristic compressive strength at 28th day

From the table 1 of IS10262:2009,s value for M40 is 5N/mm²

A-4 Selection of water- cement ratio:

From the table 5 of IS:456-2000,

Max w-c ratio : 0.34

Assume w-c ratio : $0.30 < 0.45$, hence ok.

A-5 Selection of water content:

From the table 2 IS 10262-2009,

For 20mm, max water content : 186litres

Estimated water content for 100mm slump : $186 + \frac{6}{100} \times 186 = 197$ litres

Super plasticizer used as per IS:9103 water content reduced to 30% : 197×0.70

Water content : 140litres

A-6 Calculation of cement:

Cement content = Max. Water content /w/c ratio

$$= 140 / 0.30$$

$$= 466.66 \text{ kg/m}^3$$

A-7 Proportion of volume of coarse aggregate & fine aggregate:

Vol. of C.A = 0.61 m^3 Zone 1 (20mm) IS 10262

Fine aggregates = Nil

Vol. of C.A = $0.61 - (0.61 \times 1/100)$

$$= 0.59 \text{ m}^3.$$

A-8 Mix calculations:

a) Volume of concrete = 1.00 m^3

b) Volume of cement = $[390/3.15] \times [1/1000] = 0.117 \text{ m}^3$

c) Volume of water = $[197/1] \times [1/1000] = 0.197 \text{ m}^3$

d) Volume of admixtures used = 0.006 m^3

e) Volume of all aggregate = a - [b+c] = $1 - [0.117 + 0.197] = 0.68 \text{ m}^3$

Mass of coarse aggregate in kg = Volume of coarse aggregates x volume of all aggregates x sp.gravity of CA = $0.59 \times 0.68 \times 2.71 \times 1000 = 1140 \text{ kg}$

Mass of admixtures used in kg = Volume of admixtures x Sp.Gravity of admixture x 1000 = $0.006 \times 1.15 \times 1000 = 7 \text{ kg}$

MIXDESIGN(M40)

TABLE 1: MIX DESIGN FOR NORMAL AND MIXED PERVIOUS CONCRETE

MATERIAL	CEMENT	COARSE AGGREGATE	SP	WATER
QUANTITY (kg/m ³)	466.66	1140	7	140
PROPORTIONS	1	2.44	0.015	0.30

CONVENTIONAL AND MIXED PERVIOUS CONCRETE

TABLE 2: PERCENTAGE USE OF THE ADMIXTURES IN PERVIOUS CONCRETE

MATERIAL	CEMENT	COARSE AGGREGATE	GGBS	PVA	WATER	SUPER PLASTICIZER
CONVENTIONAL PERVIOUS CONCRETE	100%	100%	NIL	NIL	100%	NIL
MIXED PROPORTIONS CONCRETE	73%	100%	25%	2%	71%	2%

3.6 TEST ON FRESH CONCRETE

3.6.1. Slump cone (workability test)

Slump test is used to determine the workability of fresh concrete. Slump test as per IS:1199-1959 is followed.

a) Apparatus required

- Slump cone
- Tamping rod
- Metallic sheet

b) Procedure

1. The internal surface of the mould is thoroughly cleaned and freed from superfluous moisture and adherence of any old set concrete before commencing the test.
2. The mould is placed on a smooth, horizontal rigid and non – absorbent surface.
3. The mould is then filled in four layers each approximately $\frac{1}{4}$ of the height of the mould.
4. Each layer is tamped 25 times rod taking care to distribute the strokes evenly over the cross section. After the top layer has been rodded, the concrete is struck off level with a trowel and tamping rod.
5. The mould is removed from the concrete immediately by raising it slowly and carefully in a vertical direction.
6. This allows the concrete to subside. This subsidence is referred to as slump of concrete.
7. The difference in level between the height of the mould and that of the highest point of the subsided concrete is measured. This difference in height in mm is taken as slump of concrete.
8. The pattern of slump indicates the characteristics of concrete in addition to the slump value. If the concrete slumps evenly it is called true slump. If one half of the cone slides down, it is called shear slump.

TABLE 3: SLUMP VALUE OF PERVIOUS CONCRETE

SL.NO	CONCRETE MIX	SLUMP VALUE(cm)
1	Conventional pervious concrete	8
2	Mixed pervious concrete	6

3.6.2 Compaction Factor Test

Compaction factor of fresh concrete is done to determine the workability of fresh concrete by compaction factor test as per IS: 1199-1959.

a) Apparatus required

Compaction factor test apparatus.

b) Procedure

1. The sample of concrete to be tested is placed in the upper hopper up to the brim. The trap-door is opened so that the concrete falls into the lower hopper.
2. Then the trap-door of the lower hopper is opened and the concrete is allowed to fall in to the cylinder. In the case of a dry-mix, it is likely that the concrete may not fall on opening the trap-door
3. In such a case, a slight poking by a rod may be required to set the concrete in motion. The excess concrete remaining above the top level of the cylinder is then cut off with the help of plane blades.
4. The outside of the cylinder is wiped clean. The concrete is filled up exactly up to the top level of the cylinder.
5. It is weighed to the nearest 10 grams. This weight is known as “ weight of partially compacted concrete”
6. The cylinder is emptied and then refilled with the concrete from the same sample in layers approximately 5cm deep. The layers are heavily rammed or preferably vibrated so as to obtain full compaction. The top surface of the fully compacted concrete is then carefully struck off level with the top of the cylinder and weighed to the nearest 10 gm. This weight is known as “weight of fully compacted concrete”

$$\text{The compaction factor} = \frac{\text{Weight of partially compacted concrete}}{\text{Weight of fully compacted concrete}}$$

TABLE 4: COMPACTION FACTOR

SL.NO	CONCRETE MIX	Compaction factor (%)
1	Conventional pervious concrete	86
2	Mixed pervious concrete	88

3.7 PREPARATION OF CONCRETE

Concrete is a mixture of cement, coarse aggregates, fine aggregates and water in certain proportions. The preparation of concrete is done after following specific standard procedures to ensure optimum quality. The main steps used for the manufacturing of concrete are explained as followed:

3.7.1 Proportioning

The process of relative proportions of cement, sand, coarse aggregate and water, so as to obtain a concrete of desired quality is known as the proportioning of concrete.

3.7.2 Batching

It is the process of measuring concrete mix ingredients either by volume or by mass and introducing them into the mixture. Traditionally batching is done by volume but most specifications require that batching be done by mass rather than volume.

Types of batching

- Weight batching
- Volume batching

3.7.3 Mixing

After precise batching all the ingredients of concrete are thoroughly mixed until the concrete of uniform color and required consistency is obtained. Mixing of concrete may be done manually or mechanically.

Manual (or) Hand Mixing

Manual mixing is adopted for small construction activities. Concrete is less efficient and requires more cement than that required in machine mixing to obtain the same strength.



Fig 3.9 Hand mixing

Machine Mixing



Fig 3.10 Machine mixing

Machine mixing is adopted for general construction works. In this method batch mixers or continuous mixers are used. Batch mixers are either with tilting drum or with non-tilting drum and are available in various capacities. Batch mixers with tilting drum are most commonly used. For general works 10/7 or ¼ cubic yard capacity mixers are used. 10/7 means 10 cubic feet of dry material.

3.7.4 Placing

Before placing the concrete, the formwork and reinforcement should be checked to make sure that they are clean and free of any detritus, such as ends of tying wire. The fresh concrete should be deposited as close as possible to its final position. Care should be taken when discharging concrete from skips to avoid dislodging the reinforcement or over filling the formwork.



Fig 3.11 Placing of concrete

3.7.5 Compacting

The process of consolidating the concrete after correct placement is known as compaction of concrete. Compaction is an essential step that should not be neglected because the presence of air bubbles or voids in the concrete considerably reduces its strength. 5% air voids in concrete may reduce its strength up to 30%. Compaction may be manual or by mechanical means.



Fig 3.12 Compacting of concrete

3.7.6 Finishing

After the jointing the concrete, it should be floated with a wood or metal hand float or with a finishing machine using float blades. This embeds aggregate particles just beneath the surface; removes slight imperfections, humps, and voids and compacts the mortar at the surface in preparation for additional finishing operations.



Fig 3.13 Finishing of concrete

3.7.7 Curing

Curing of concrete is defined as the process of maintaining the moisture and temperature conditions of concrete for hydration reaction to normally so that concrete develops hardened properties over time. After the concrete is placed, the concrete increases in strength very quickly for a period of 3-7 days. Concrete which is moist cured for 7 days is about 50% stronger than the uncured concrete.



Fig 3.14 Curing of concrete

3.8 Hardened Concrete Testing

The hardened concrete testing is used to determine the strength of the concrete.

3.8.1 Compression strength test

The specimen is tested by compression test machine after 7 days, 14 days and 28 days curing. Load should be applied gradually at the rate of 140kg/cm^2 per minute till specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

a) Apparatus required

- Moulds for the test cubes
- Tamping rods.

b) Procedure

1. Calculate the material required for preparing the concrete of given proportions.
2. Mix them thoroughly in mechanical mixer until uniform colour of concrete is obtained
3. Pour concrete in the oiled with a medium viscosity oil. Fill concrete in cube moulds in two layers each of approximately 75mm and ramming each layer with 35 blows evenly distributed over the surface of layer.
4. Fill the moulds in 2 layers each of approximately 50mm deep and ramming each layer heavily.
5. Struck off concrete flush with the top of the moulds.
6. Immediately after being made, they should be covered with wet mats.
7. Specimens are removed from the moulds after 24hrs and cured in water 28 days.
8. After 24hrs of casting, cylinder specimens are capped by neat cement paste 35 percent water content on capping apparatus. After 24 hours the specimens are immersed into water for final curing.
9. Compression tests of cube and cylinder specimens are made as soon as practicable after removal from curing pit. Test-specimen during the period of their removal from the curing pit and till testing, are kept moist by a wet blanket covering and tested in a moist condition.
10. Place the specimen centrally on the location marks of the compression testing machine and load is applied continuously, uniformly and without shock.
11. Also note the type of failure and appearance cracks



Fig 3.15 After Testing on loading frame

CALCLATION:

COMPRESSIVE STRENGTH:

Cube area= 150*150mm²
 Load= 182.94KN
 Strength=Load/Area
 =184.94*10³/22500
 =8.13N/mm²

TABLE :5 COMPRESSIVE STRENGTH OF CONCRETE

CONCRETE MIX	7 days		STRENGTH (N/mm ²)	14 days		STRENGTH (N/mm ²)
	LOAD	N/mm ²		LOAD	N/mm ²	
CONVENTIONAL PERVIOUS CONCRETE	182.94	8.13	8.25	291.82	2.97	13.12
	189.42	8.42		292.50	13	
	184.73	8.21		301.72	13.41	
MIXED PERVIOUS CONCRETE	289.10	12.84	13.05	445.50	198	20.78
	293.24	13.12		433.30	19.26	
	297.31	13.2		490.00	21.78	

3.8.2 Flexural Test

Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced d concrete beam or slab to resist failure in bending. It is measured by loading 6 inch * 6 inch concrete beam with a span length of at least three times the depth.

a) Apparatus required

- Prism mould
- Compression testing machine

b) Procedure

1. Test specimens are stored in water at a temperature of 24°C to 30°C for 48 hours before testing. They are tested immediately on removal from the water whilst they are still wet condition.
2. The dimension of each specimen should be noted before testing.
3. The bearing surface of the supporting and loading rollers is wiped and clean, and any loose sand or other material removed from the surfaces of the specimen where they are to make contact with the rollers.
4. The specimen is then placed in the machine in such manner that the load is applied to the upper most surface as cast in the mould
5. The axis of specimen is carefully aligned with the axis of the loading device. No packing is used between the bearing surfaces of the specimen and rollers.
6. The load is applied without shock and increasing continuously at a rate of the specimen. The rate of loading is 4kN/min for the 15cm specimen and 18 kN /min for the 10cm specimen.
7. The load is increased until the specimen fails and the maximum load applied to the specimen during the test is recorded.



Fig 3.16 Flexural Testing made on loading frame

CALCULATION:

FLEXUTURAL STRENGTH:

$$\begin{aligned} \text{Modulus of Rupture (MR)} &= PL / (bd^2) \\ \text{Strength} &= \text{Load} / \text{Area} \\ &= 25.64 * 600 / (100 * 200)^2 \\ &= 3.82 \text{ N/mm}^2 \end{aligned}$$

d-depth of beam, p-load, l- length,b-width.

TABLE:6 FLEXURAL STRENGTH OF CONCRETE

CONCRETE MIX	7 days		STRENGTH (N/mm ²)	14 days		STRENGTH (N/mm ²)
	LOAD	N/mm ²		LOAD	N/mm ²	
CONVENTIONAL CONCRETE	25.64	3.82	4.06	34.73	5.21	5.05
	30	4.5		30.40	4.56	
	25.83	3.875		35.86	5.36	
MIXED PERVIOUS CONCRETE	45.2	6.78	6.21	48.93	7.34	8.25
	41.6	6.25		55	8.25	
	37.33	5.6		56.66	8.5	

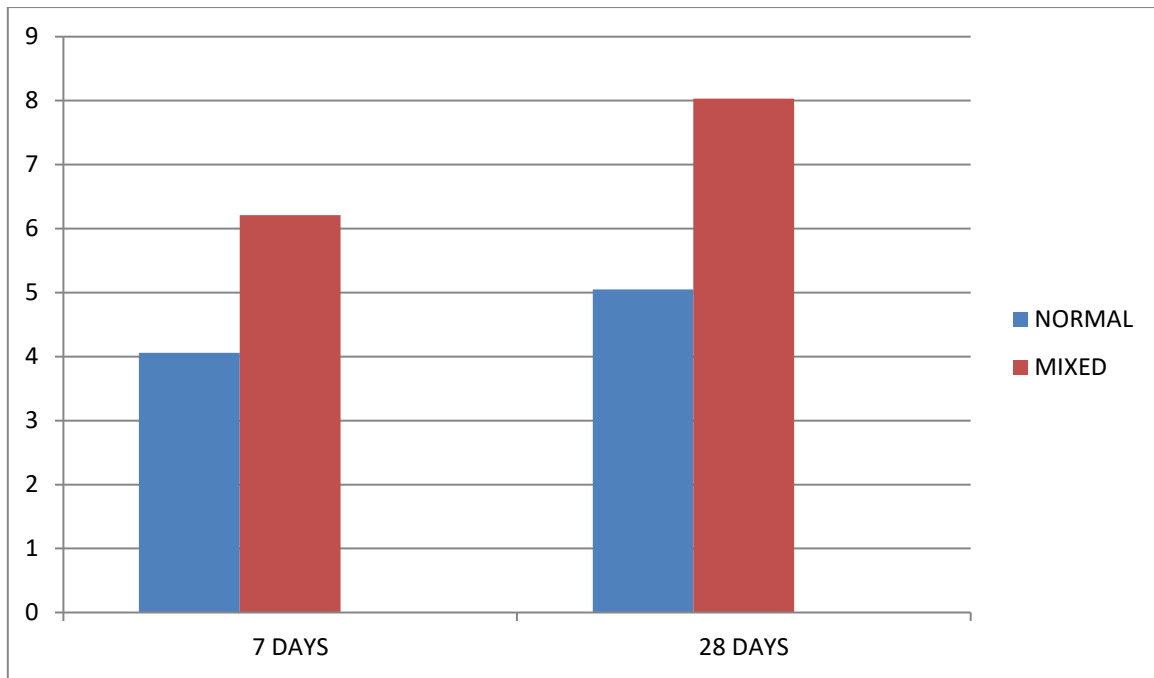


Fig 3.17 Graph plotted for flexural strength

3.8.3 Split tensile test

The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete.

The concrete is very weak in tensile due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may cracks.

a) Apparatus required

- Cylinder mould
- Compression testing machine.

b) Procedure

1. Take the wet specimen from water after curing
2. Wipe out water from the surface of specimen
3. Draw diametrical lines on the two ends of the specimen to ensure that they are on the same axial place
4. Note the weight and dimension of the specimen
5. Set the compression testing machine for the required range.
6. Keep are plywood strip on the lower plate and place the specimen
7. Align the specimen so that the lines marked on the ends are vertical and centered over the bottom plate
8. Place the other plywood strip above the specimen
9. Bring down the upper plate to touch the plywood strip.
10. Apply the load continuously without shock at a rate of approximately 14-21kg/cm²/min
11. Note down the breaking load (P).



Fig 3.18 Split tensile strength test

3.9 CALCULATION:

3.9.1 SPLIT TENSILE STRENGTH:

Cylinder area=

Load = 47.5kN

Strength =Load/Area

=47.5/(*75²)

= 2.98N/mm²

TABLE : 7: SPLIT-TENSILE STRENGTH OF CONCRETE

CONCRETE MIX	7 days		STRENGTH (N/mm2)	14 days		STRENGTH (N/mm2)
	LOAD	N/mm2		LOAD	N/mm2	
CONVENTIONAL PERVIOUS CONCRETE	47.5	2.68	2.98	63.79	3.61	3.27
	53	2.99		53.89	2.75	
	58.20	3.29		60.96	3.45	
MIXED PERVIOUS CONCRETE	62.02	3.51	3.32	76.34	4.32	4.58
	59.02	3.34		82.17	4.65	
	60	3.37		84.46	4.78	



Fig 3.19 Cubes,Cylinders and beam after curing

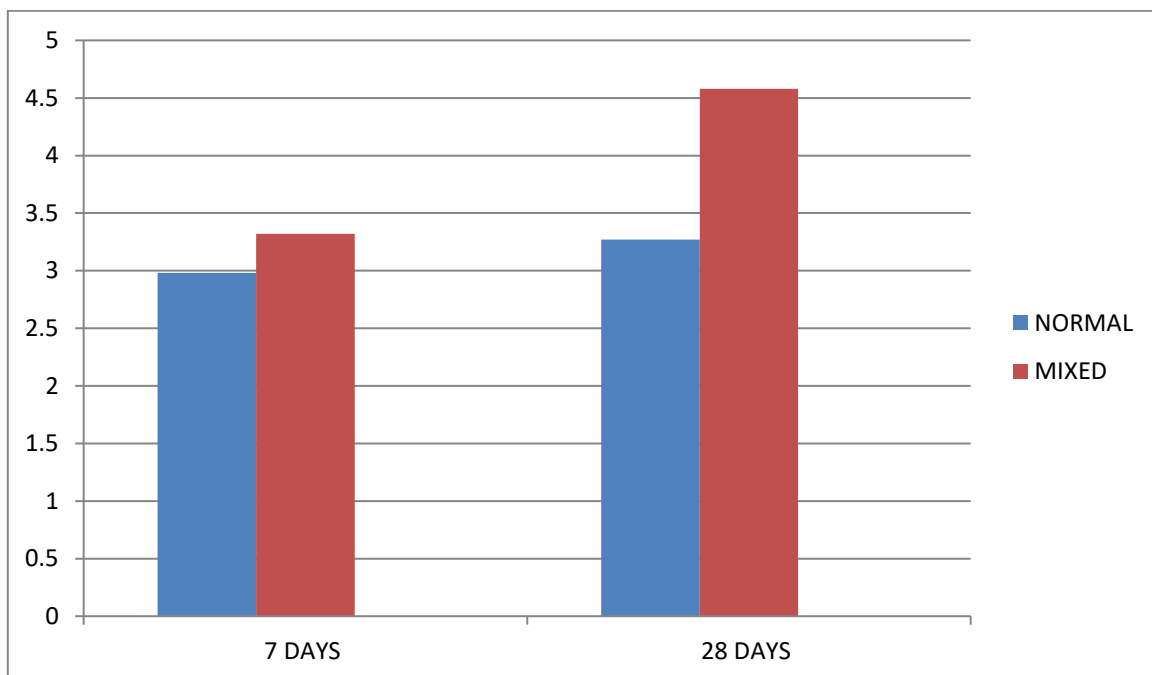


Fig 3.20 Graph plotted for split tensile strength test

IV. RESULTS AND CONCLUSION

4.1 General

The pervious concrete which when tested by adding the admixtures gives desirable values in certain parameters which is discussed below. Based on the values and after testing in various aspects, the values are compared normal pervious concrete and the admixtures mixed pervious concrete.

The Pervious concrete in current scenario is the urgent need for maintaining the storm water management and to keep the surrounding waste stagnated water free environment. The GGBS and PVA is the two major admixtures which shows results in different variations when mixed with the normal pervious concrete as it differs the percentage in large amount and its is also cheap in range.

Pervious concrete acts a physical barrier to various action of any problems in the road surface. The flexural strength increases the durability and crack formation on the surface of the cracks is totally stopped by this pervious concrete enriched with PVA as the polymer enhances the flexural stability for the road. Also, the Compressive strength and crushing load helps in giving the more stability to the road.

The Durability of the Pervious concrete majorly such as Chemical attack, Carbonation is made here, The test shows the pervious concrete is completely from from the chemical reaction induced in it and it also gives less carbonation as the cement which is major cause of CO₂ is replaced by GGBS. Hence, The two parameters shows the durability of the pavement made from Pervious concrete efficiently up to thirty years with less traffic and manageable road acquisition.

TABLE 7, 8: FINAL RESULTS OF ADMIXTURE USED AND NORMAL PERVIOUS AND PERCENTAGE INCREASE

S.NO	DESCRIPTION	NORMAL PERVIOUS CONCRETE (28 DAYS STRENGTH N/mm ²)	GGBS MIXED PERVIOUS CONCRETE(28 DAYS STRENGTH N/mm ²)	PERCENTAGE INCREASE
1.	COMPRESSIVE STRENGTH	13.12	18.43	40.4%
2.	FLEXURAL STRENGTH	5.05	6.46	28%
3	SPLIT-TENSILE STRENGTH	3.27	3.97	21.45%

S.NO	DESCRIPTION	NORMAL PERVIOUS CONCRETE (28 DAYS STRENGTH N/mm ²)	ADMIXTURE MIXED PERVIOUS CONCRETE(28 DAYS STRENGTH N/mm ²)	PERCENTAGE INCREASE
1.	COMPRESSIVE STRENGTH	13.12	20.28	55%
2.	FLEXURAL STRENGTH	5.05	8.13	61%
3.	SPLIT-TENSILE STRENGTH	3.27	4.58	40%

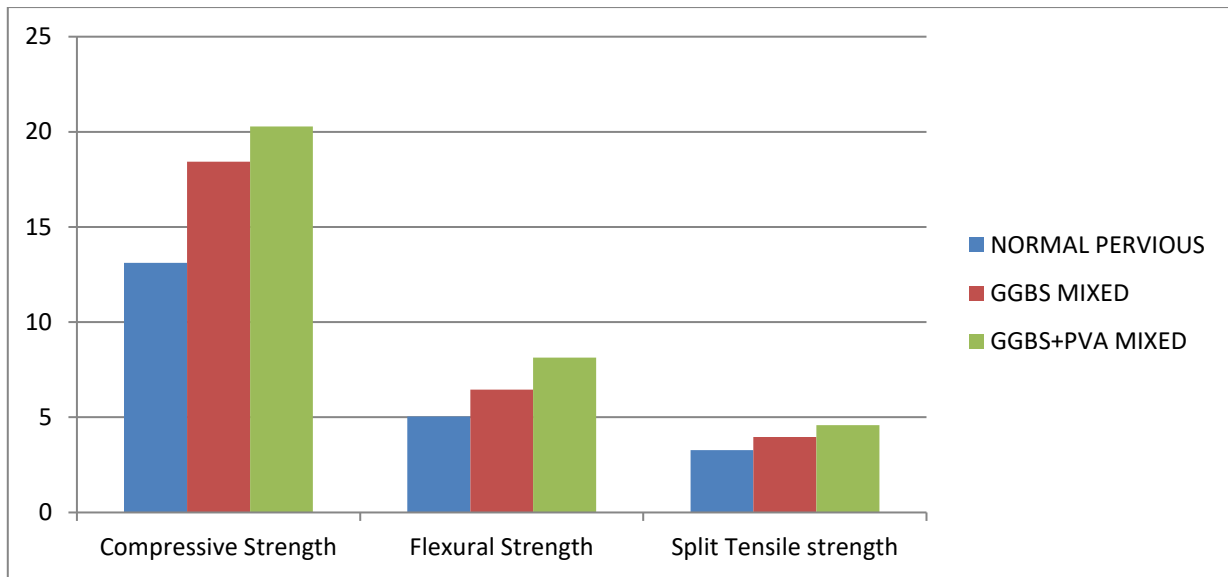


Fig 4.1 Total comparison of strength increase by mixing admixtures

4.2 CONCLUSION

The Compressive strength, Flexural strength, Split tensile strength had increased by adding admixtures such as GGBS (25%) and POLYVINYL ALCOHOL (2%). By using these admixtures the above strengths are increased when compared to Normal Pervious Concrete. The Compressive strength has increased by 55%, Flexural strength has increased by 61%, Split Tensile strength has increased by 40%.

- Achieved greater flexural strength comparing to the normal pervious concrete.
- It also reduces the emission of CO₂ which is produced from the cement because of partial replacement by the GGBS.
- GGBS is the mineral admixtures which increases the compressive strength in certain aspect and PVA which is the chemical admixture increases the flexural strength in pervious concrete by small amounts.
- These can also be used as sound absorbing walls in classrooms, auditorium etc. This can also be used at railway platforms. This will help in reducing water accumulation on railway tracks, parking lots etc .

Scope for further Research

The strength characteristics of pervious concrete can be further studies by taking into account the following parameters:

- By varying the water cement ratio.
- By varying the amount of silica fume and addition of super plasticizers.
- By using some little amount of fine aggregates.
- By using recycled coarse aggregates in the concrete mix as replacement of coarse aggregates.
- Using the super plasticizers in the mixes only by removing silica fume.
- Using different aggregates size and mix ratio

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