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Flexural Strength Behaviour Of Pervious Concrete Towards Conventional Concrete

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Abstract: Pervious concrete is a concrete containing little or no fine aggregate; it consists of coarse aggregate and cement paste. Pervious concrete offers sustainable and environmental benefits for storm water management and urban development. The open void structure of permeable concrete permits wet to maneuver through the pavement structure and into the bottom water while not sterilisation the natural hydrologic cycle." Pervious concrete can be used in low volume, low speed applications in urban and rural settings without creating impermeable space. Therefore it is a low impact development that does not put additional demand on the storm water management system and in some applications will lower the demand on the storm water management system.

Keywords—: pervious concrete, porosity, strength, permeability, mix design, no fine concrete porous concrete.

1. Introduction

The objective of this paper is to review the effects of admixtures on compressive and flexural strength of pervious concrete and provide some guidelines for adopting appropriate concrete admixtures for improving strength. This paper only highlights the admixtures to be included in concrete for improving strength. These structures include not only the pavements but also sidewalks, residential streets, parking areas etc. As the admixtures enhance pervious concrete properties in terms of strength, durability and workability, the end product is also suitable for structures exposed to aggressive environments. High strength pervious concrete are known to have more durable properties for pavements than the conventional concrete. All advantages combined with this pervious concrete have encouraged designers to go in for use of such concretes in various pavements application. Various environmental edges like dominant storm water runoff, restoring groundwater provides, and reducing water and soil pollution became focal points in several jurisdictions.. By creating a permeable surface, storm water is given access to filter through the pavement and underlying soil, provided that the underlying soil is suitable for drainage.

Aims and Objectives

- To investigate the properties of pervious concrete with and without Admixtures
- To compare the flexural strength of pervious concrete of different admixtures with conventional concrete
- To establish an experimental procedure to determine water permeability of pervious concrete and pervious mortar
- To develop pervious mortar suitable for pavement application
- To investigate the performance of a pervious concrete and pervious mortar combinative layers as a pavement system

Pervious concrete

Pervious concrete (no-fines concrete) is a concrete containing little or no fine aggregate. It is a mixture of coarse aggregate, Portland cement and water. It appears pervious concrete would be a natural selection to be used in structural applications during this age of ‘green building. It consumes less amount of 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. It is a special form of concrete with high consistency used for concrete flat work applications that permits water from precipitation and alternative sources to pass directly through, thereby. In recent times, major cities around the world have experienced frequent flooding due to the combination of increased rainfall and reduced in permeable surface areas. With the increasing amount of built infrastructures such as residential and commercial buildings and decreasing permeable unpaved open areas, the storm water runoff is rapidly increased. As a consequence, the drainage system gets overloaded and flash flooding becomes inevitable, thus causing disruption to the road

Transport and flooding of basement car parks and shopping centers. In order to manage the storm water runoff in urban areas, an engineered solution is needed to avoid flash flooding. The use of pervious concrete for the development of secondary roads, parking tons, driveways, walkways and side- walks is increasing all round the world. By capturing a significant amount of storm water and allowing it to seep into the ground, Pervious concrete may be a special kind of concrete with a high proportion of huge sized pores, generally 2–8 millimeter. The typical porosity of pervious concrete ranged from 15 to 30 % and the presence of interconnected large pores system allows the water to flow easily through the pervious concrete. The pervious concrete mixes should meet the specification requirements for permeable concrete pavements. Typical pervious concrete mix consists of 400-500 kg/m3 of binder material, 1500-2200 kg/m^3 of coarse aggregate and water to cement ratio ranged from 0.3to 0.5. The typical 28-day compressive strength ranges from fourteen to thirty three.7mpa, with void ratios starting from fourteen to thirty one the troubles, and porousness constant varies from zero.25 to 6.1 mm/s.It allows. It allows 3-8 gallons (11.34-30.24lts) of water per minute to pass through each square foot.

Previous concrete have reported the influence of water-to-cement ratio, aggregate -to- cement ratio, aggregate sizes, and binder material type on the strengths of pervious concrete. The concrete paste then coats the aggregates and allows water to pass through the concrete slab. Pervious concrete is zero-slump; open graded or poorly graded, Coarse Aggregate.

This project was to investigate the compressive strength as well as flexural strength of pervious concrete with different admixtures and investigate its suitability for secondary roads and low volume pavement construction.

Need for present study

- Operation of pervious concrete pavements for low volume traffic loads
- To determine pervious cement concrete pavement is better than conventional
- Concrete
- Due to scarcity of sand the technologies has to be improved to use pervious
- Concrete
- Natural runoff allows rain water to drain directly to sub base.
- To reduce construction requirements for drainage structures.
- To reduce pollution prevents environmental damage.
- Protects streams and lakes and allow local vegetation to thrive.

2. **Design of pervious concrete mix**

Optimum concrete mix design results from selecting locally available materials that make the fresh concrete peaceable and finish able and that ensure the strength development and other desired properties of hardened concrete as specified by the designer.

Some of the basic concepts that need to be understood for pervious concrete are:

Aggregates should be strong and durable. They need not necessarily be hard and of high strength but need to be compatible, in terms of stiffness and strength, with the cement paste. Generally smaller maximum size coarse aggregate is used for pervious concretes. High strength concrete mixtures will have a high cementations materials content that increases the heat hydration and possibly higher shrinkage leading to the potential for cracking. High strength concrete mixtures generally need to have a low water-cementations materials ratio (w/c). W/c ratios can be in the range of 0.3 to 0.5. These low w/c ratios are only attainable with quite large dosage of high range water reducing admixtures (or super plasticizers). The total cementations material content will be typically around 52 kg/m^3 but not more than about 650 kg/m^3.

Applications of pervious concrete

- Side walks
- Drive ways
- Residential streets
- Light traffic areas
- Path and walk ways
- Watershed and wetlands
- Pedestrian areas
- slope protection
- swimming pool decks
- well linings

Fig.1.1 Applications of pervious concrete at various types of pavements

Sidewalks provided on both sides of streets are generally the preferred pedestrian facility they provide the best degree of comfort for pedestrian and also the presence of sidewalks has been related to raise safety for pedestrians. The uniform vehicle code defines a side walk as that portion of a street between the curb lines, or the lateral lines of a roadway, and the adjacent property lines, intended for use by pedestrians.Parking area pavement fabricated from receptive concrete permits rain to filter through to underlying soil. Receptive concrete may be a mixture of in the main coarse combination, cementing materials and water. The reduced sand content results in a pavement with a high void content, thereby, allowing water to pass freely through it. Overall, permeable concrete will build a vital contribution to achieving a community's property development goals. Malhotra1 mentioned permeable concrete because it relates to applications and properties.

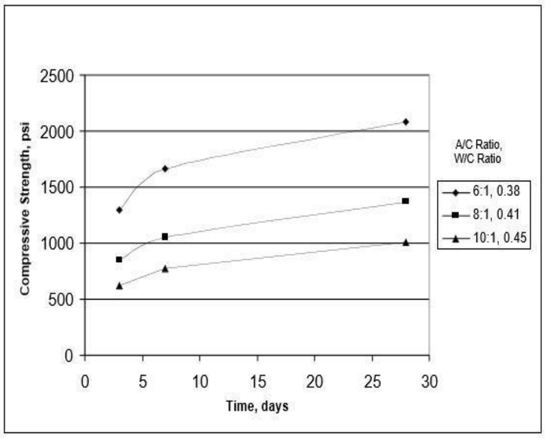
Literature review

In 1976, **V.M. Malhotra[1]** discussed pervious concrete as it relates to applications and properties. He provided details on such properties as consistency, proportions of materials, unit weight, compatibility, and curing in an attempt to maximize permeability in the previous concrete.

Grading	Aggregate Cement Ratio (A/C) by Volume	Unit Weight (lb/ft^3)	Compressive Strength (psi)
A*	8	119.2	1230
		116.8	975
		116	1090
		113.2	815
B**	9	117.6	1040
		113.6	825
		112.4	745
C***	7	117.2	1280
		115.6	1030
		114	1000
		114	950

Table-2.1 Relationship between compressive strength and W/CA/C Ratios(Aggregate size-Gravel)Source: Malhotra, ACI journal,vol.73,issue11,p633
*A/C Ratios are by volume
**W/C Ratios are by weight

Graph-2.1 Compressive strength Vs time



Aggregate Cement Ratio (A/C)*	Water Cement Ratio (W/C)**	Age of Test (days)	Density (lb/ft^3)	Cement (lb/yd^3)	Compressive Strength (psi)
6	0.38	3	125.8	436	1295
		7	125.4	436	1660
		28	124.8	436	2080
8	0.41	3	120	326	850
		7	119.5	326	1055
		28	119.4	326	1365
10	0.45	3	116.7	261	625
		7	116.4	261	780
		28	116.2	261	1015

Table-2.2 Relationship between 28 days compressive strength and grading(Watercontent=0.36)Source: malhothra (1976), AC, journal vol. 73, issue 11, p634

*A = minus 3/4in, plus 3/4in
**B = minus 3/4in, plus 1/2in
***C = minus ½ in, plus 3/8 in

Graph-2.3 a 28 day compressive strength Vs unit weight

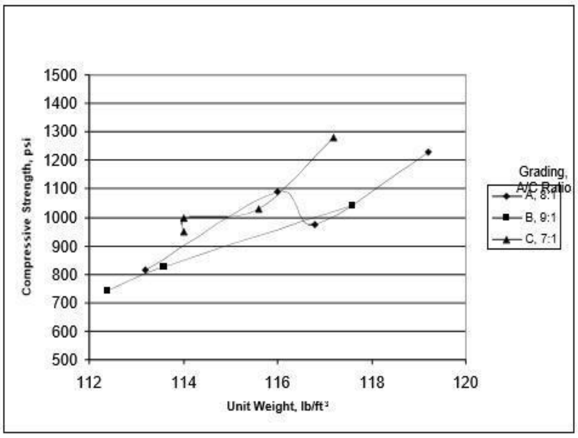


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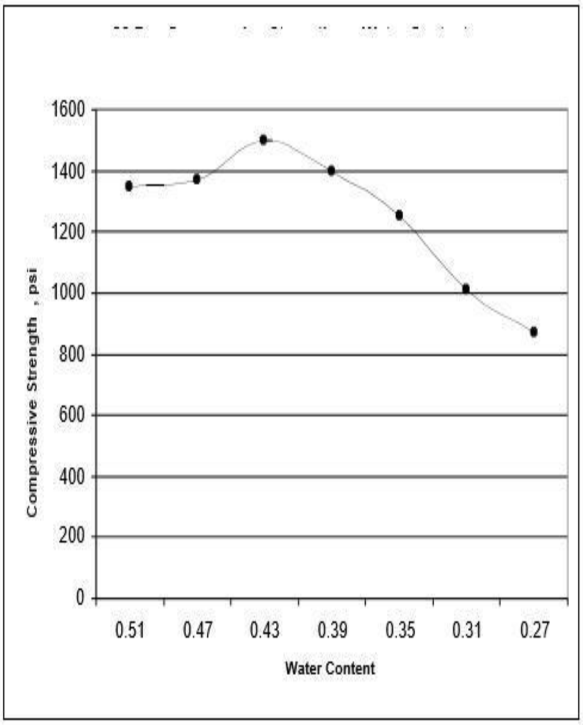
Table-2.3 Relation between 28day compressivestrength and aggregateWater Content= (0.40) Source: malhothra (1976), AC, Journal vol. 73, issue 11, p634

Type of Aggregate	Dry Density (lb/ft^3)	Compressive Strength (psi)
Rounded Quartzite Gravel	115	1250
Irregular Flint Gravel	99	700
Crushed Limestone	114	1000
Crushed Granite	106	1100

In 1988, **Richard Meininger**[2] released results on laboratory experiments he had conducted on pervious concrete. The work was carried out on multiple samples with varying material properties. These properties included water cement ratio, aggregate cement ratio, compaction, and curing time. Results were similar to those found by Malhotra in 1976. Menninger discovered a relationship between the 28 day compressive strength and water content while utilizing aggregate 3/8" in size and an aggregate cement ratio equal to 6. This relationship is seen in Table 2.4 and graph 2.3.

Table-2.4 Relation between 28 day compressive strength and water content(3/8" coarse aggregate-aggregate/cement ratio=6)Source: Menninger (1988),concrete international, vol 10, issue 8, p22

Water Content (by weight)	28 Day Compressive Strength (psi)	Cement (lb/yd^3)	Water (lb/yd^3)	Aggregate (lb/yd^3)	Air (%)	Permeability (in.min)
0.51	1350	440	224	2640	22	5
0.47	1370	430	203	2575	23	4
0.43	1500	430	184	2570	25	10
0.39	1400	425	165	2550	27	30
0.35	1250	415	145	2520	29	40
0.31	1010	410	125	2430	32	51
0.27	870	395	106	2370	33	59



Graph 2.3 A 28 day compressive strength Vs water content

Table-2.5 Relationship between 28day compressive strength and unit weight Source: Menninger (1988), concrete international, vol.10, issue 8, p22

Water Content Ratio (by weight)	Unit Weight (lb/ft^3)	Compressive Strength (psi)	Water Content Ratio (by weight)	Unit Weight (lb/ft^3)	Compressive Strength (psi)
0.34	111	1355	0.31	107.5	975
	110.5	1340		107.5	1050
	112.5	1360		110	1100
	114	1550		112	1395
	120.8	1945		118	1540
	122	2475		120.5	2095

Methodology

In the present proposal it is planned to conduct lab investigation on flexural strength of pervious concrete using different chemical admixtures in and comparing it with the conventional concrete. The main purpose of this investigation is to develop confidence among user agencies in India to use chemical admixtures in a desirable proportion in all civil engineering constructions.

The following tests were conducted on the concrete.

- Compressive strength
- Flexural strength
- Workability
- Type of cracking

The test variables were concrete workability and compressive strength, keeping the size of the specimen same. In the present investigation nine beams and nine cubes of pervious concrete and three beams and three cubes of conventional concrete are prepared. Among the previous three beams and three cubes are of without admixture and remaining six beams and six cubes are casted with different type of admixture. The beams are of standard sizes with dimensions 700mm x 150mm x 150mm. and the cubes of standard dimension 150mm x 150mm x 150mm. These were kept constant for all the specimens. Beams were tested in universal testing machine and Cubes were tested in the compression testing machine of maximum capacity of 2000kN.

Table-3.1 specimens casted for testing

Specimen	Conventional Concrete	Pervious concrete		
		Withot admixture	Conplast sp337	Conplast sp430
Beams	**3**	**3**	**3**	**3**
Cubes	**9**	**9**	**9**	**9**

Test of materials:

In the present investigation the following materials were used.

- 53 grade BIRLA cement conforming to IS: 12269-1987
- coarse aggregate conforming to IS: 383 – 1970

Admixtures:

1) High performance Super plasticizing Admixture ***CONPLAST SP430*** Conforming to IS: 9103 – 1999.
2) High performance Super plasticizing Admixture ***CONPLAST SP337*** Conforming to IS: 9103 – 1999.

Cement

Cement is a binding material, which is the combination of two raw materials called calcareous and argillaceous materials. Birla–53 grade ordinary Portland cement conforming to IS: 12269-1987were used in concrete. The physical properties of the cement are listed in Table – 3.1.

Table -3.2Physical Properties of Birla 53 grade cement

S.no	Properties	Test Results	IS: 12269-1997
1	Normal consistency	29.70%	
2	Initial setting time	130min	Minimum of 30 Min
3	Final setting time	195min	Maximum of 600 Min
4	Specific gravity	3.15	
5	Compressive strength		
	(a) 3 days strength	42.3mpa	Minimum of 27mpa
	(b) 7 days strength	51.6mpa	Minimum of 37mpa
	(c) 28 days strength	71.3mpa	Minimum of 53mpa

Aggregates

A crushed granite rock with a maximum size of 12 mm was used as a coarse aggregate. The Individual term absorption of the aggregates are given in table 3.1.

The impact strength of aggregate is 12.42%

The abrasion test value is 4%

Sieve analysis=1000gms

Aperature size of sieve(mm)	**Weight of soil retained(gm)**	**% retained**	**Cumulative retained**	**% finer(N)**
4.75	79	7.9	7.9	92.1
2.36	98	9.8	19.7	82.3
1.70	286	28.6	46.3	83.7
1.18	130	13.0	59.3	40.7
600microns	176	17.6	76.9	23.1
300microns	184	18.4	95.3	4.7
90microns	41	4.1	99.4	0.6

Water

Potable water was used for mixing and curing of concrete cubes.

Admixtures

Admixtures is defined as a material, other than cement, water and aggregates that is used as an ingredient of concrete and is added to the batch immediately before or during mixing. Additive is a material which is added at the time of grinding cement clinker at the cement factory. Admixtures are chemicals which are added to concrete at the mixing stage to modify some of the properties of the mix. Admixtures ought to ne'er be thought to be a substitute permanently combine style, smart skill, or use of excellent materials. In these conditions standard concrete might fail to exhibit the desired quality performance or sturdiness.. In these conditions ordinary concrete may fail to exhibit the required quality performance or durability. In such cases, admixtures are used to modify the properties of ordinary concrete so as to make it more suitable for any situation.Until about 1930 additives and admixtures though used, were not considered as important part of concrete technology. Since then, there has been an increase in the use of admixtures. Though the use of admixtures and additives is being frowned upon or scorned by some technologists, there are many on the contrary, who highly commend and foster the use and Development of admixtures because it imparts several fascinating characteristics and result economy in concrete construction. It ought to be remembered, however, that admixtures aren't any substitute permanently concreting practices.. It should be remembered, however, that admixtures are no substitute for good concreting practices.

The history of admixtures is as old as the history of concrete. It embraces a awfully huge field, however very little form of admixtures known as water reducers or high vary water reducers, usually referred as plasticizers and super plasticizers, area unit of recent interest. Plasticizers were not manufactured in India and them to be imported, and hence costly. In the simplest case, Portland cement concrete is a three-component mixture of water, Portland cement, and coarse aggregate. Additional components, such as chemical admixtures (plasticizers, super plasticizers) may be added to the basic mixture to enhance certain properties of the fresh or hardened concrete. High-performance concrete mixtures, which may be required to meet several performance criteria (e.g., compressive strength, permeability) Admixtures are natural or manufactured chemicals which are added to the concrete before or during mixing. The most often used admixtures are Plasticizers and super plasticizers. Admixtures are used to give special properties to fresh or hardened concrete. Admixtures may enhance the durability, workability or strength characteristics of a given

Concrete mixture. Admixtures square measure accustomed provide special properties to contemporary or hardened concrete. Admixtures could enhance the sturdiness, workability or strength characteristics of a given concrete mixture.

By consulting admixture suppliers, selection is appropriate as per the application. Admixtures ar evaluated for compatibility with cementations material, construction practices, and job specifications. Admixtures ar usually classified in to 2 types.

Types of admixtures

Admixtures are normally categorized in to two types:

- Chemical admixtures
- Mineral admixtures

Chemical admixtures

Chemical admixtures are the ingredients in concrete other than portland cement, water, and aggregate that are added to the mix immediately before or during mixing. Producers use admixtures primarily to scale back the value of concrete construction; to switch the properties of hardened concrete; to confirm the standard of concrete throughout mix, transporting, placing, and to overcome certain emergencies during concrete operations.Successful use of admixtures depends on the use of appropriate methods of batching and concreting most admixtures ar equipped in ready-to-use liquid kind and ar supplementary to the concrete at the plant or at the jobsite. Certain admixtures, such as pigments, expansive agents, and pumping aids are used only in extremely small amounts and are usually batched by hand from premeasured containers.

The effectiveness of associate admixture depends on many factors including: sort and quantity of cement, water content, combination time, slump, and temperatures of the concrete and air. Sometimes, effects similar to those achieved through the addition of admixtures can be achieved by altering the concrete mixture-reducing the water-cement ratio, adding additional cement, using a different type of cement, or changing the aggregate and aggregate gradation.

Admixtures are classed according to function. There are five distinct classes of chemical admixtures:

1) Air-entraining,
2) Water-reducing,
3) Retarding,
4) Accelerating, and
5) lasticizers (super plasticizers).

All other varieties of admixtures fall into the specialty category whose functions include corrosion inhibition, Shrinkage reduction, alkali-silica reactivity reduction, workability enhancement, bonding, damp proofing, and coloring. Air-entraining admixtures, Air-entraining Admixtures, that square measure wont to on purpose place microscopic air bubbles into the concrete, square measure mentioned a lot of totally in Air-Entrained Concrete.

Water-reducing admixtures usually reduce the required water content for a concrete mixture by about 5 to 10 percent. Consequently, concrete containing a water-reducing admixture wants less water to succeed in a needed slump than untreated concrete. The treated concrete will have a lower water-cement quantitative relation. The treated concrete can have a lower water-cement ratio. This usually indicates that a higher strength concrete can be produced without increasing the amount of cement. Recent advancements in admixture technology have diode to the event of mid-range water reducers.These admixtures reduce water content by at least 8 percent and tend to be more stable over a wider range of temperatures. Mid-range water reducers offer a lot of consistent setting times than customary water reducers.

Retarding admixtures, which slow the setting rate of concrete, are used to counteract the accelerating effect of hot weather on concrete setting. High temperatures typically cause associate degree enhanced rate of hardening that makes inserting and finishing tough. Retarders keep concrete feasible throughout placement and delay the initial set of concrete. Most retarders also function as water reducers and may entrain some air in concrete.

Accelerating admixtures increase the rate of early strength development, reduce the time required for proper curing and protection, and speed up the start of finishing operations. Accelerating admixtures are especially useful for modifying the properties of concrete in cold weather.

Super plasticizers, also known as plasticizers or high-range water reducers (HRWR), reduce water content by 12 to 30 percent and can be added to concrete with a low-to-normal slump and water-cement ratio to make high-slump flowing concrete. Flowing concrete is a highly fluid but workable concrete that can be placed with little or no vibration or compaction. The effect of super plasticizers lasts only 30 to 60 minutes, depending on the brand and dosage rate, and is followed by a rapid loss in workability. As a result of the slump loss, super plasticizers are usually added to concrete at the jobsite.

Corrosion-inhibiting admixtures constitute the specialty admixture class and area unit wont to slow corrosion of reinforcing steel in concrete**.** Corrosion inhibitors can be used as a defensive strategy for concrete structures, such as marine facilities, highway

Bridges, and parking garages, that will be exposed to high concentrations of chloride. Other specialty admixtures include shrinkage-reducing admixtures and alkali-silica reactivity inhibitors. The shrinkage reducers are used to control drying shrinkage and minimize cracking, while ASR inhibitors control durability problems associated with alkali-silica reactivity.

Description of admixture used

The chemical admixtures which we used in this present project are explained in as detailed.

High performance Super plasticizing Admixture ConplastSP-430.

- ConplastSP-430 is based on Sulphonated Napthalene polymers and supplied as a brown liquid instantly dispersible in water.
- ConplastSP-430 has been specially developed to relinquish high water reductions up to twenty fifth while not loss of workability or to provide prime quality concrete of reduced porousness.
- It manufacture high workability concrete requiring very little or no vibration throughout inserting.
- It provides high earlier strength for formed concrete with the advantage of upper water reduction ability.”
- It provides high earlier strength for precast concrete with the advantage of higher water reduction ability.
- It can be used with all types of cement except high alumina cement.
- Conplastsp-430 is directly added into the mix at the same time as the gauging water. Reduce water dosages for required consistency.

Compressive strength

Early strength is increased up to 20% if water reduction is taken advantage of. Generally, there is improvement in strength up to 20% depending up on w/c ratio and other mix parameters.

Properties

Supply form	:	liquid
Color	:	brown
Specific gravity	:	1.220 to 1.225 at 30^{0}C
Chloride content	:	nil

Dosage recommended

The optimum dose is best determined by website trials with the concrete combine that allows the consequences of workability, strength gain or cement reduction to be measured. Site trials with ConplastSP430 should always be compared with mix containing no admixture. So, the rate of addition is in generally the range of **0.5 to 2 liters /100kg** of cement.

High Performance Super plasticizing Admixture ConplastSP-337

ConplastSP337 is based on a blend of specially selected organic polymer. It is supplied as at dark brown liquid, instantly dispersible water .ConplastSP337 disperses the cement particles effectively in the concrete mix and hence exposes a large surface area to the hydration process. This result is employed either to extend the strength or to provide high workability concrete or cut back cement content of concrete or to retard the setting time of concrete.

Properties

Supply form	:	liquid
Color	:	dark brown
Specific gravity	:	1.20 at 27^{0}C
Chloride content	:	nil

Dosage recommended

The optimum dosage is best determined by site trials with the concrete mix which enables the effects of workability, strength gain or cement reduction to be measured. Site trials with ConplastSP337 should always be compared with mix containing no admixture. So, the rate of

Addition is in generally the range of **0.5to 2 liters /100kg** of cement.

Mix design for present investigation

Table-3.3Mix Proportions

S.no	Targeted strength (MPa)	Mix Propo rtions	w/c Ratio
1.	Convention al concrete	1:1.5:3	0.5
2.	Pervious concrete	1:3	0.35

Mixing

Mixing of concrete was done by using hand. All the ingredients of concrete were weigh- batched according to the mix proportions. The order of mixing the ingredients of concrete was first, cement, coarse aggregates and finally water with admixture or without admixture. The materials must be thoroughly mixed to obtain a good mix. As the water/cement ratio is very low for pervious concrete the mixing is done very fast and thoroughly and placed as quickly as possible to avoid loss of moisture from the mix.

Fig 3.1 Mixing of pervious concrete in laboratory

Fig 3.2 Beam mould of size 700mm x 150mm x 150mm

Fig 3.3 Casting d tamping of concrete

Casting

After getting a mix, the moulds must be taken and apply Greece to the inner surface of the mould for getting cubes easily. Concrete is poured in each mould by three layers. Each layer is to be tamped 25 times by using tamping rod, and then finally keep the mould on

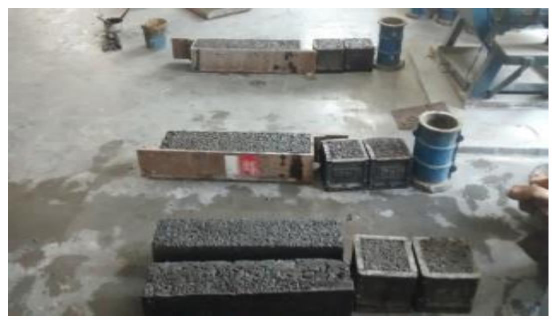


Fig 3.4 Beams and cubes after casting

Curing

The curing must be done immediately after removing the moulds. Normal immersion curing is enough for the cubes and beams. The specimens are marked with admixture numbers for identification purpose.

3.5 Curing of specimen in curing tank in laboratory

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3. TESTING OF SPECIMENS

Flexural strength

Flexural strength is additionally called modulus of rupture, bend strength, or fracture strength, a mechanical parameter for brittle material, is outlined as a material's ability to resist deformation underneath load. 'The flexural strength represents the best stress tough inside the fabric at its moment of rupture. It's measured in terms of stress, here given the image σ. When an object formed of a single material, like a wooden beam or a steel rod, is bent, it experiences a range of stresses across its depth. At the outside of the bend (convex face) the stress will be at its maximum tensile value. These inner and outer edges of the beam or rod square measure called the 'extreme fibers'. Most materials fail under tensile stress before they fail under compressive stress, so the maximum tensile stress value that can be sustained before the beam or rod fails is its flexural strength. The flexural strength is find out using universal testing machine.

Universal testing machine (UTM)

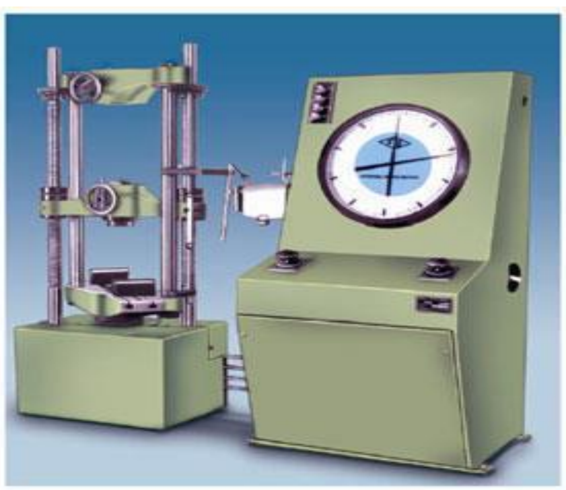


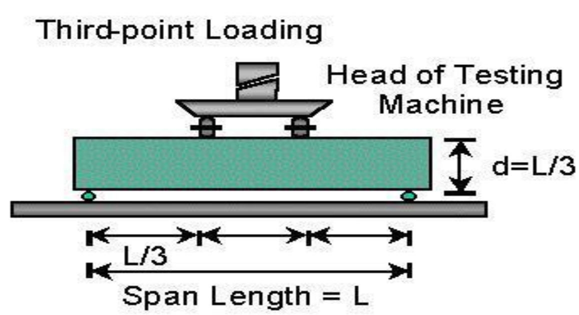
Fig 4.1 Universal testing machine (UTM)

A Universal Testing Machine conjointly called a materials take a look ating machine and may be wont to test the tensile and compressive properties of materials. This type of machines are called Universal Testing Machine because it can perform all the tests like compression, bending, tension etc to examine the material in all mechanical properties. These machines typically have 2 columns however single column varieties also are obtainable. Load cells and extensometers measure the key parameters of force and deformation which can also be presented in graphical mode in case of computer operated machines.. These machines are widely used and would be found in almost all materials testing laboratory. Universal testing machine can be of different types based output required like Computer operated Universal Testing Machine and digitally operated Universal Testing Machine.

Principle of operation: Operation of the machines is by hydraulic transmission system of load from the take a look at specimen to a singly housed load indicator**.**The hydraulic system is ideal since it replaces transmission of load through levers and knife edges, which are prone to wear and damage due to shock on rupture of test pieces.Load is applied by a hydrostatically lubricated ram. Main cylinder pressure is transmitted to the cylinder of the pendulum dynamometer system housed in the control panel. The cylinder of the dynamometer is also of self-lubricating design. The cylinder of the dynamometer is also of self-lubricating design. The load transmitted to the cylinder of the dynamometer is transferred through a lever system to a pendulum. Displacement of the setup actuates the rack and pinion mechanism that operates the load indicator pointer and also the piece of writing recorder. The deflection of the pendulum represents the absolute load applied on the test specimen.Return movement of the setup is effectively damped to soak up energy within the event of abrupt breakage of a specimen.

Loading arrangement

All the beams were tested in the Universal testing machine for 28 days. The loading and specimen web shall be capable of applying third-point loading to the specimen while not eccentricity or force. The fixtures normally used for flexural testing are suitable with the qualification that supporting rollers shall be able to rotate about their axes and shall not be placed in grooves or have other restraints that prevent their free rotation.



It is preferred that all rollers are manufactured from steel and shall have a circular cross section with a diameter of 30 mm ±1 mm. They shall be a minimum of ten metric linear unit longer than the breadth of the check specimen. They shall have clean and swish surfaces, lubricated to make sure free movement. All rollers, including the upper ones, shall be capable of rotating freely about their axes At least one amongll|one amongst one in every of} the lower support rollers shall be capable of being inclined in a plane perpendicular to the longitudinal axis of the take a look at specimen. For the requirements of roller for supports or load; refer to IS 9399.The distance between the centres of the lower supporting rollers (i.e. the span length) shall be set equal to 500 mm. All rollers shall be adjusted to their correct position with all distances having an accuracy of ±1 mm. Load measuring device shall be capable of measuring loads to an accuracy of 10 N.

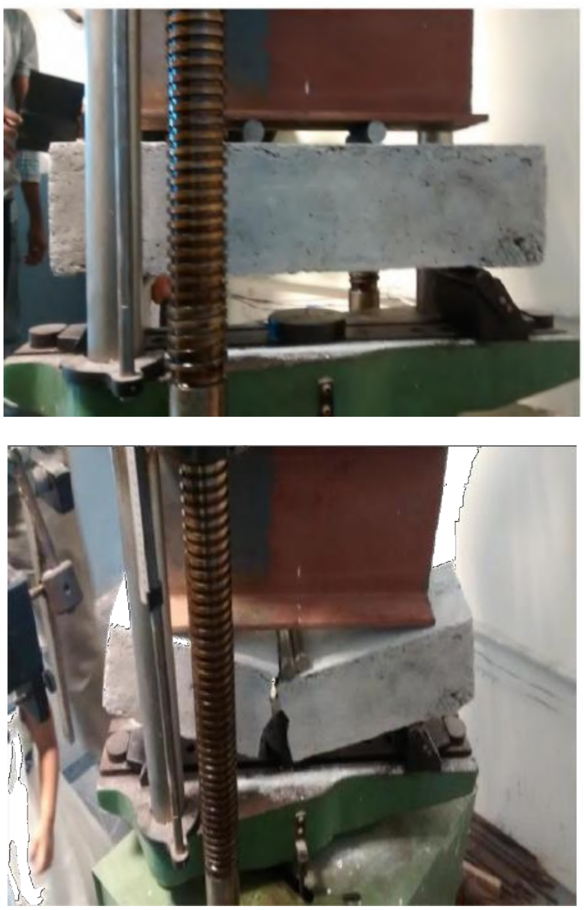


Fig 4.2 Loading and failure of conventional concrete beam

Fig 4.3 Loading and failure of pervious concrete beam without admixture

Fig 4.4 Loading and failure of pervious concrete beam with Conplast SP 337

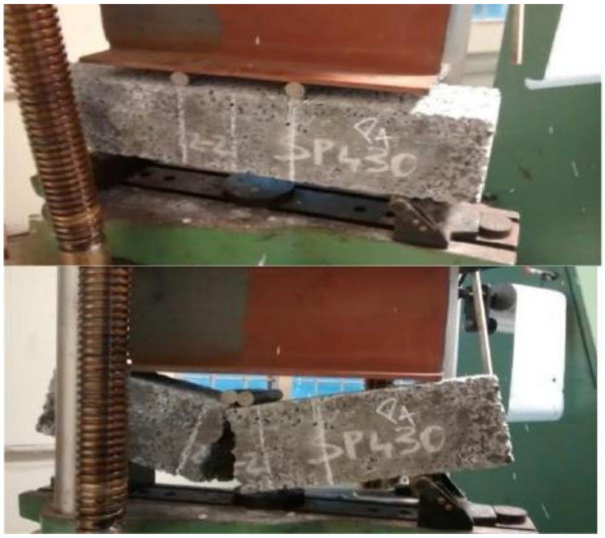


Fig 4.5 Loading and failure of pervious concrete beam with Conplast SP 430

Compressive Strength

Out of the many check applied to the concrete, this can be the utmost necessary which provides an inspiration regarding all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not For cube take a look at 2 forms of specimens either cubes of fifteen cm X fifteen cm X fifteen cm or tencm X ten cm x 10 cm relying upon the. For most of the works cubical moulds of size 15 cm x 15cm x 15 cm are commonly used.This concrete is poured within the mould and tempered properly therefore as to not have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of the specimen should be made even and smooth. This is done by putt cement paste and spreading swimmingly on whole space of specimen.These specimens are tested by compression testing machine aftr 7 days curing or 28 days curing. Load ought to be applied step by step at the speed of a hundred and forty kg/cm2 per minute until the Specimens fails.. Load at the failure divided by area of specimen gives the compressive strength of concrete.

Compressive Strength testing machine

Compression testing machine is designed for test materials under compression bending, transverse and shear loads. Hardness test on metals can also be conducted. There are different types of compressive strength testing machines.

Fig 4.6 Compressive strength Testing Machine (2000KN)

Basic machines have the following components:-**Load Frame**: Load frame is a steel welded structure. It is designed to withstand a few million times of full cycles of loading without any sign of distortion or fatigue. These frames are light in weight. The base carries a fine finished hydraulic ram and the lower platen. The top plate has the spherical seating to take care of any irregularity of the specimen surface or slight misplacement of the specimen from the central position. As a safety precaution front cover is provided, as a protection to the operator while at the same time giving an un-obstructive view of the specimen under test.

Pumping unit: pumping unit is attached on the right hand side of the loading unit. It is a multi plunger pump with booster arrangement .This facility is for fast raising of ram without load. Pump is submerged in the tank and is powered by 1.5 kW electric motor. Operating on 220 volts 50Hz AC supply. (other voltages optional). Power pack gives non-pulsating flow to the hydraulic ram. This ensures smooth loading of the specimen which can be seen by the movement of the load gauge/digital display. The flow of the oil can be precisely controlled by the strain control knob located at a convenient height. With the proper check on the oil, the life of the pumping unit and the hydraulic ram is almost as long as, life of machine. Keeping in view the operators safety regulations, safety features like expanded sheet metal door, overload relief valve is provided as standard in the hydraulic circuit.

Principal of operation: operation of the machines is by hydraulic transmission of load from the test specimen to separately housed load indicator. The hydraulic system is ideal since it replaces transmission of load through levers and knife edges, which are prone to wear and damage due to shock on rupture of test pieces. Load is applied by a hydro-statically lubricated ram. Main cylinder pressure is transmitted to the cylinder of the setup dynamo-meter system housed within the electrical device. The cylinder of the dynamo-meter is additionally of self-lubricating style. The cylinder of the dynamo-meter is also of self-lubricating design. The piston of the dynamo-meter is constantly rotated to eliminate friction. The load transmitted to the cylinder of the dynamo-meter is transferred through a lever system to a pendulum. Displacement of the setup actuates the rack and pinion mechanism that operates the load indicator pointer and also the piece of writing recorder .

Loading arrangement

All the cubes were tested in the compression testing machine for 3 days, 7 days and 28 days. The maximum capacity of the testing machine is 2000 KN. The load was transferred from jack, through a steel circular section. The loading arrangement is as shown in fig. 3.1.For measuring ultimate strength load dial gauges of least count 100kgs were placed behind the compression testing machines.

Fig 4.7 Compressive test on pervious concrete cube.

Observations

Table 4.1 Maximum load at which beams failed

Formulae:

From simple bending equation:

— = — = —

From ,— =—

= * —

= *

i.e = — (= —)

Where,
M=maximum bending moment in N mm I= Moment of inertia in mm4
F= Flexural strength in N/mm²
Z= Sectional modulus in mm³
Y= depth of neutral axis in mm
E= young's modulus in N/mm²
R= radius of curvature in mm

4. RESULTS AND CONCLUSIONS

The test data and results obtained from the tests conducted in the present investigations on 3beams and 9cubes of conventional concrete and 9beams and 27cubes of pervious concrete with different admixtures have been presented in Tables respectively and discussed in this chapter. In this tests, importance has been given to Flexural strength, ultimate compressive strength and cracking. The results of medium strength concrete and high strength concrete are compared with

Adding admixtures in those two types of concrete. Quantities such as flexural strength, compressive strength, cracking have been observed and recorded. Bar charts of flexural strength vs beams and compressive strength *vs* days have been represented in this project. Portland cement is during a type of agglomeration of particles control along by forces. During mixing process the agglomerates break down into fragments and hydration takes place at the surface of fragments. With the appliance of admixtures the hydrating cement on the surface of fragments deflocculates one another and reduces the inter-particle friction. This impact reduced the retention of water between particles.

This effect reduced the retention of water between particles. More workable concrete can be obtained or less water is required for a specified workability. As the inter-particle forces are reduced a more even dispersion of cement particles hence a more even hydration of cement can be achieved with an improvement to the density and strength of concrete.

Flexural strength prediction:

Flexural strength is additionally referred to as modulus of rupture, bend strength, or fracture strength, a mechanical parameter for brittle material, is outlined as a material's ability to resist deformation underneath load. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three point flexural test technique. The beam specimen is of the size 700mm x 150mm x 150mm. the flexural strength of beams tested varied with admixtures used. Pervious concrete with admixtures had more flexural strength than without admixture. For both types of concrete with and without admixtures, beams have been made and flexural strength has been calculated respectively.

Compressive strength prediction:

Compression test is the most common test conducted on hardened concrete, partly 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 cube specimen is of the size 15 x 15 x 15 cm. If the largest nominal size of the aggregates does not exceed 20mm, 12.5mm size cubes may also be used as an alternative. The characteristic compressive strength varies for both medium Strength concrete and high strength concrete. Concrete by using admixtures Flocculates more strength than the medium strength concrete. For both types of concrete with and without Admixtures, cubes has been made and strength is calculated relatively.

Crack pattern

Flexural failure:

There was a sudden failure in beams without admixture. From the experiment it is observed that the beams without admixture failed early than beams with admixture. The failure pattern for some of the beams is shown in figures.

Fig 5.1 Crack and failure pattern of beams

Compression failure:

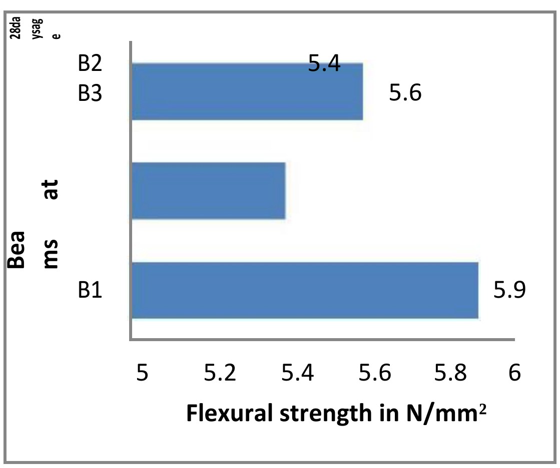
The crack pattern for some of the cubes are shown in fig: . The cracks were found spreading across and inside of the cubes. The cracks were initially minute, but gradually began to increase as the load is increased.

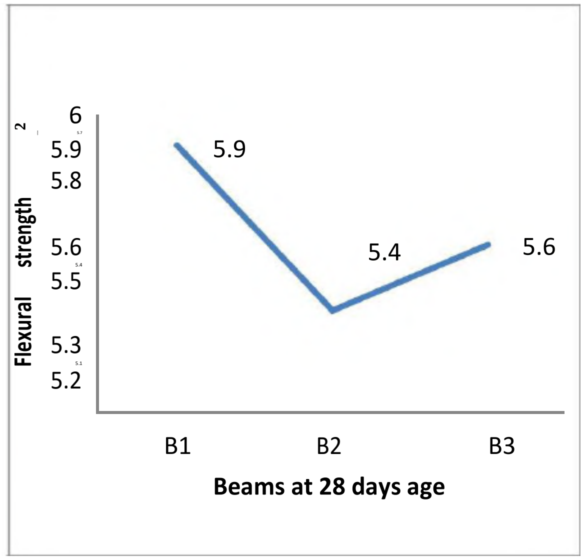
From the experiments it has been observed that the cracks propagated at a relatively faster rate in pervious concrete without admixtures. The cubes with admixtures have more resistance in cracking and also in strength. While doing test more amount of vertical and inclined cracks has been observed.

Fig-5.2 crack pattern of cube

Table: 5.1 Flexural Strength for Conventional Concrete of 20mm and 12.5mm Aggregate with mix proportion (1:1.5:3) w/c Ratio 0.45

Beam no	Age of Concrete Beam(days)	flexural Strength (N/mm^2)
1	28	5.9
2	28	5.4
3	28	5.6

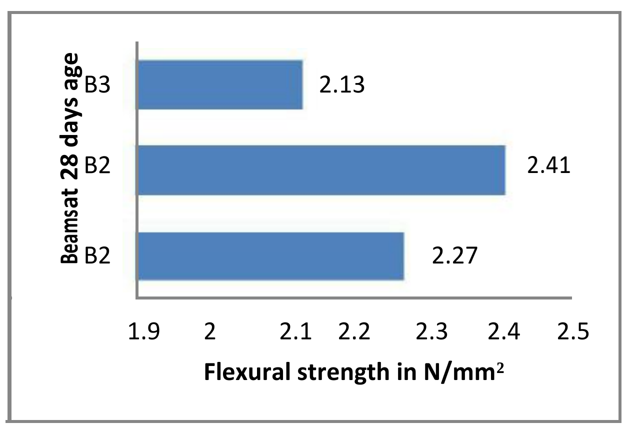


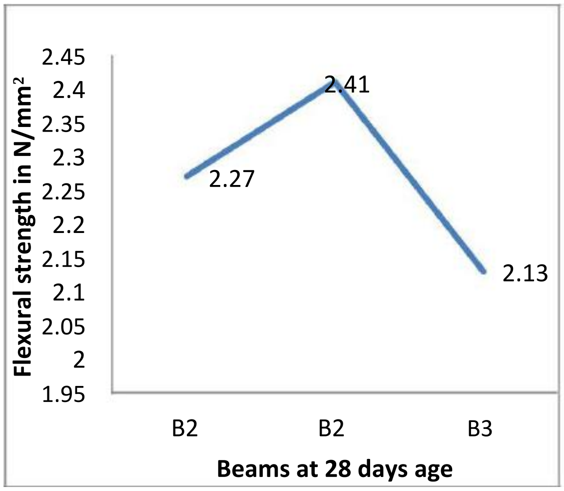


Graph 5.1 Flexural Strength for Conventional Concrete of 20mm and 12.5mm Aggregate

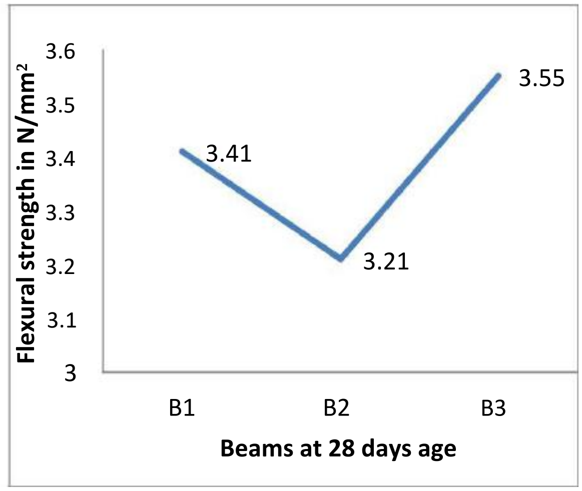
Table: 5.2 Flexural Strength for pervious Concrete with no admixture and 12.5mm Aggregate with mix proportion (1:3) w/c Ratio 0.35

Beam no	Age of Concrete Beam (days)	flexural Strength (N/mm^2)
1	28	2.27
2	28	2.41
3	28	2.13





Graph: 5.2 Flexural Strength for pervious Concrete with no admixture and 12.5mm Aggregate



Graph: 5.3 Flexural strength of pervious concrete with a mix of 0.5% of Conplast SP-430 Admixture

Table: 5.3 Flexural strength of pervious concrete with a mix of 0.5% of Conplast SP-430 Admixture with cement with mix proportion (1:3) w/c Ratio 0.35

Beam no	Age of Concrete Beam (days)	flexural Strength (N/mm²)
1	28	3.41
2	28	3.21
3	28	3.55

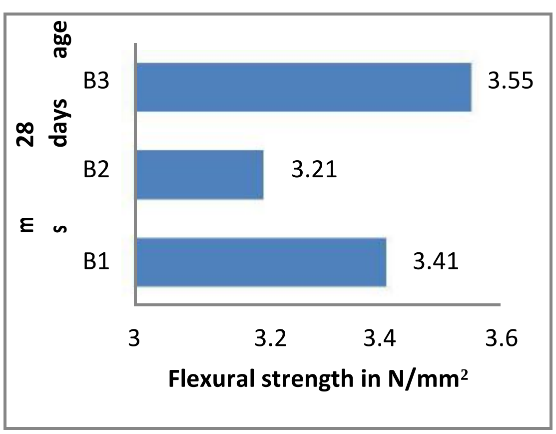
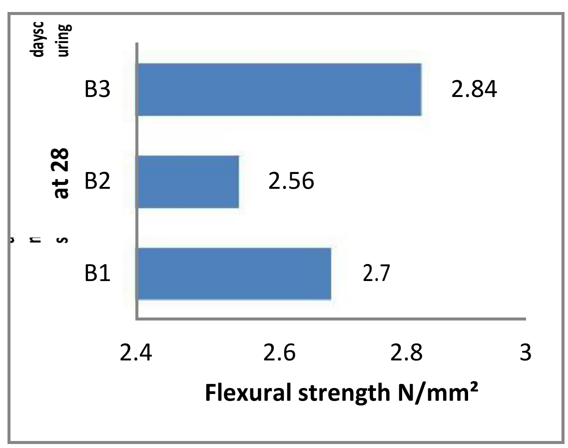
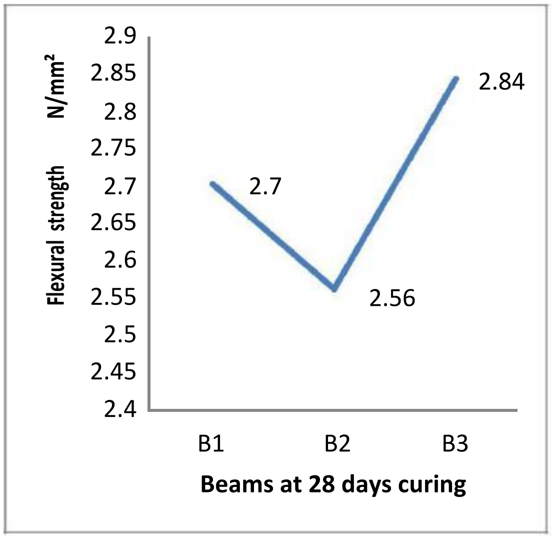


Table: 5.4 Flexural strength of pervious concrete with a mix of 0.5% of Conplast SP-337 Admixture with cement with mix proportion (1:3) w/c Ratio 0.35

Beam no	Age of Concrete Beam (days)	flexural Strength (N/mm²)
1	28	2.7
2	28	2.56
3	28	2.84

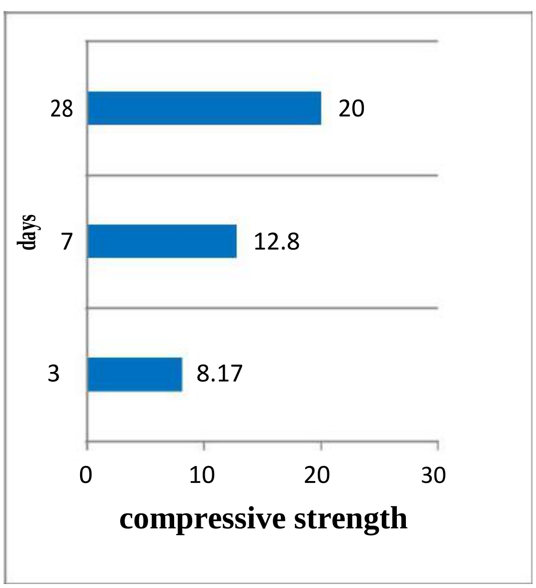


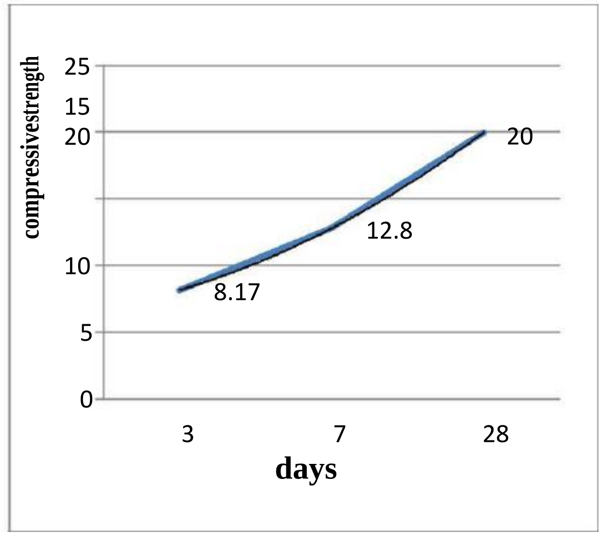


Graph: 5.4 Flexural strength of pervious concrete with a mix of 0.5% of Conplast SP-337 Admixture

Table: 5.5 Compressive Strength for Conventional Pervious Concrete of 12.5mm Aggregate with mix proportion (1:3) w/c Ratio 0.35

S.No	Age of Concrete Cube(days)	Compressive Strength (MPa)
1	3	8.17
2	7	12.8
3	28	20

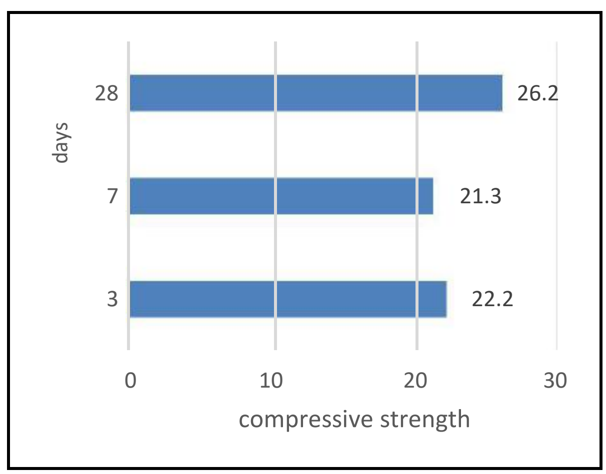


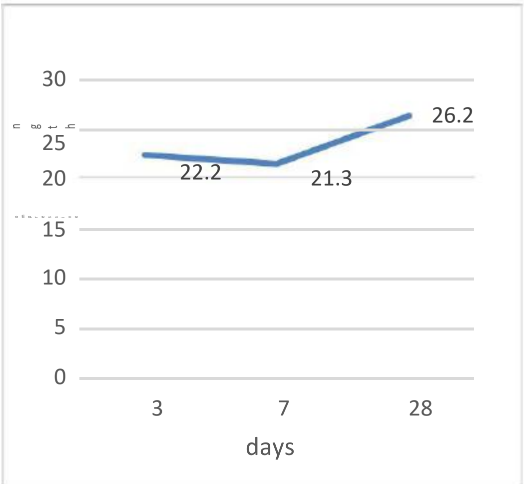


Graph-5.5 Compressive Strength for Conventional Pervious Concrete of 12.5mm Aggregate

Table: 5.6 Compressive strength of pervious concrete with a mix of 0.5% of Conplast SP-430 Admixture with cement with mix proportion (1:3) w/c Ratio 0.35

S.No	Age of Concrete Cube(days)	Compressive Strength (MPa)
1	3	22.2
2	7	21.3
3	28	26.2

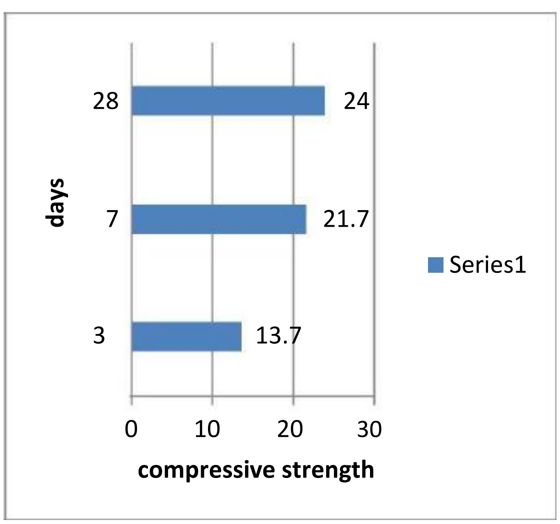


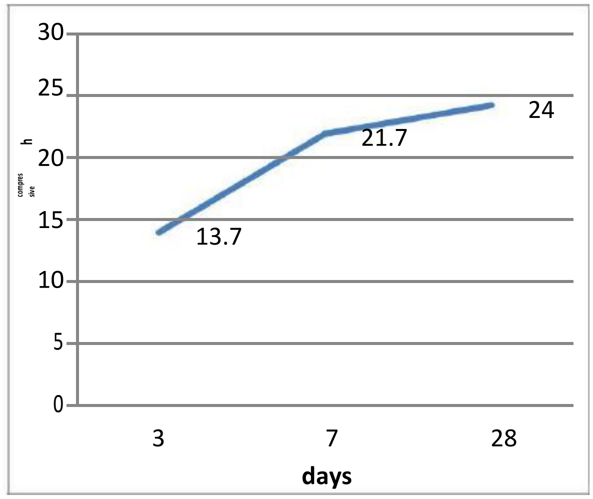


Graph-5.6 Compressive strength of pervious concrete with a mix of 0.5% of Conplast SP-430 Admixture

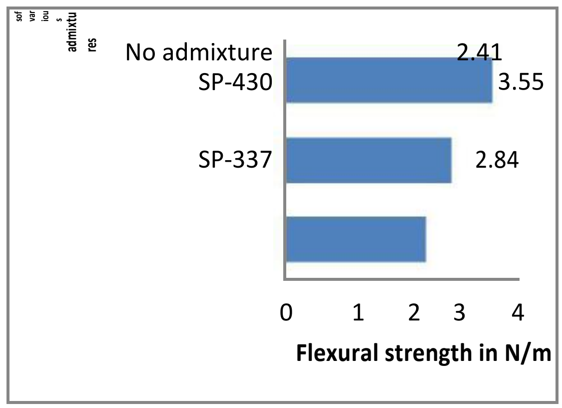
Table: 5.7 Compressive strength of pervious concrete with a mix of 0.5% of Conplast SP-337 Admixture with cement with mix proportion (1:3) w/c Ratio 0.35

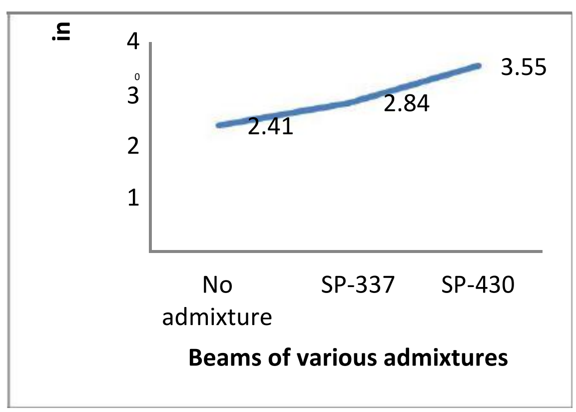
S.No	Age of Concrete Cube(days)	Compressive Strength (MPa)
1	3	13.7
2	7	21.7
3	28	24



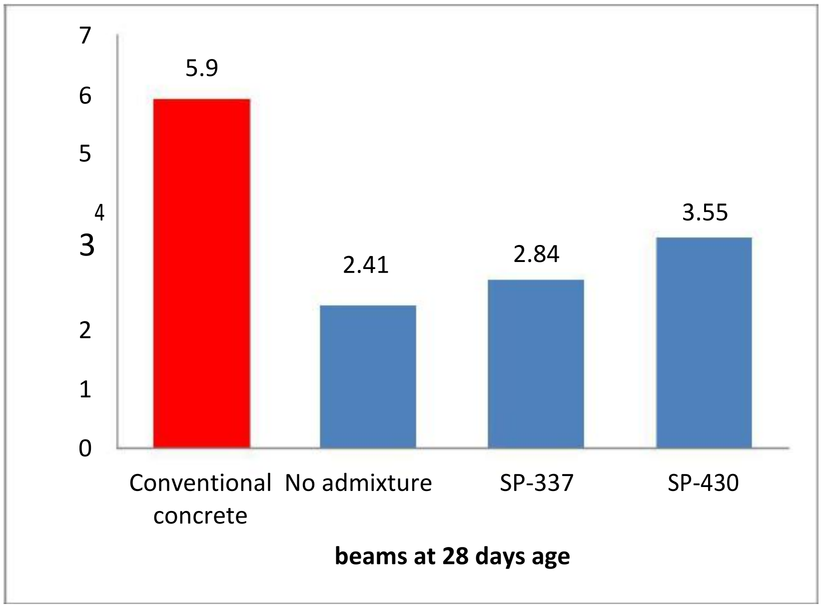


Graph-5.7 Compressive strength of pervious concrete with a mix of 0.5% of Conplast SP-337 Admixture

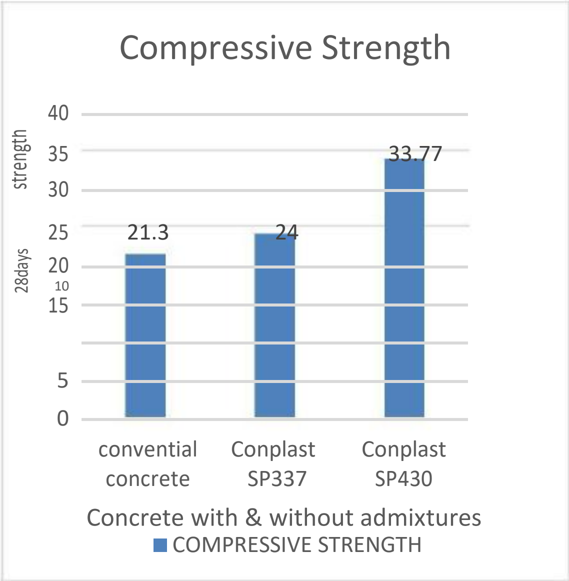




Graph: 5.8 Flexural strength comparison bar chart of pervious concrete with and without admixtures



Graph: 5.9 Flexural strength comparison bar chart of conventional concrete and pervious concrete with and without admixtures



Graph: 5.10 Compressive strength comparison bar chart of pervious concrete with and without admixtures

5. CONCLUSIONS

From this project, the following conclusions can be made.

1. The pervious concrete beam samples tested had the best flexural strength with chemical admixtures. There was a significant difference in flexural strength between samples with and without admixtures cured for 28 days. Conplast SP- 430 has the potential to be used as an effective strength improving super plasticizer. In this study, the Conplast SP-430 produced the best flexural strength of **3.55N/mm²** which is half of the flexural strength of the pervious concrete.
2. The flexural strength which we got for pervious concrete is enough for light weight vehicular loading. So pervious concrete without steel reinforcement is also preferable.
3. Saving in materials as pervious concrete contains no sand and consequently requires considerably less cement, there is a direct saving in materials.
4. The cracks pattern observed in both conventional and pervious concrete are pure flexural cracks.
5. In further work we can impart fibers in the pervious concrete to control maximum flexural cracks and even improve the flexural strength.
6. Finally we recommend pervious concrete for low vehicular loading and by providing fibrous reinforcement we can improve the mechanical properties of pervious concrete.

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