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Mix Design of Green Porous Concrete For Urban Pavements

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Abstract— *Pervious concrete is a type of lightweight concrete that is porous, obtained by detaching sand from the normal concrete mix. therefore, it really is known as a no-fine Concrete. The advantage of this type of concrete are lower density, less cost due to lower cement content and no use of fine aggregate. In this project we have taken two ratios of pervious concrete. One is 1:5 and other is 1:7. We have tested each ratio for 7 days, 14 days and 28 days. Adding fiber reinforcement to the 1:5 ratio average compressive strength increases by 5 percent. Adding fiber reinforcement to the 1:7 average compressive strength increases by 7 percent.*

Keywords: Pervious concrete, Permeable, Compressive strength, Aggregate size, Cement, Mix ratio.

INTRODUCTION

Pervious concrete pavement is a unique and effective means to meet growing environmental demand. By capturing rainwater and allowing it to seep into the ground. It is distinctive due to large volume of voids and high porosity (10–35 %). which permit the running through of precipitation rather than running off. Its constituents include cement, water, the coarse aggregate of desired types, and zero or little fine aggregate with or without admixtures. The mechanical properties of pervious concrete are determined by several factors such as the properties of the paste, the interface between the paste and the aggregate size, water-cement ratio, aggregate-to-cement ratio, void content, unit weight, method of compaction and curing, and mix proportioning. we will use the aggregates of size 20mm. The single size aggregates make a good no fine concrete, which addition to having large voids and hence light in weight, also offers architecturally attractive look. Water to cement ratio should be within 0.27 to 0.5. Portland Pozzolana Cement (PPC) can be used in pervious concrete; also used Recron 3s fiber as an admixture. [2]

THEROTICAL BACKGROUND

Porous concrete was first used in 1800 s in Europe as pavement surfacing and load bearing wall. The initial use of porous concrete was in the United Kingdom in 1852 with the construction of two residential houses and a sea groin. Cost efficiency seems to have been the primary reason for its earliest usage due to the limited amount of cement used. It was not until 1923 when porous concrete surfaced as a viable construction material. This time it was limited to the construction of 2-story homes in areas such as Scotland, Liverpool, London and Manchester. Use of porous concrete in Europe increased steadily, especially in the World War II era. Since porous concrete use less cement than conventional concrete and cement was scare at that time. It seemed that porous concrete was the best material for that period. Porous concrete continued to gain popularity and its use spread to areas such as Venezuela, West Africa, Australia, Russia and the Middle East 2007.

APPLICATION OF PERVIOUS CONCRETE

- Porous concrete has had numerous useful non-pavement applications including buildings, tennis courts, drains & drain tiles, floors in greenhouses, slope stabilization, swimming pools decks, zoo areas etc.

- The majority of porous concrete applications are parking lots, sidewalks, pathways, parks, shoulders, drains, noise barriers, friction course for highway pavements, permeable based under a normal concrete pavement and low volume roads.
- The use of porous concrete in parking lots helped in controlling water runoff in situations where flash flooding frequency occure.
- The reduced runoff eliminates the problems of downstream flooding caused by traditional impervious concrete surface.
- Pervious Concrete as a Road pavement Low-volume pavements Sidewalks and pathways Residential Road sand driveways Parking lots Noise barriers Slope stabilization Hydraulic structures Swimming pool decks Tennis courts
- Because water is allowed to percolate into the ground, nearby vegetation is watered &reduces irrigation needs, groundwater is recharged & storm water runoff is reduced.[1]

ADVANTAGES

- The pervious concrete is an innovative building material with may environmental, economics, and structural advantage.
- The pervious concrete is a recognized as best Management practice by the united stat for its proper utilization.
- For providing first-flush pollution control and storm water management by Environmental Protection Agency (EPA).
- By using porous concrete, the property owner and developers can also reduce the fee and these benefits both.
- Eliminates time consuming and costly storm water detention vaults and piping system.
- Due to the reduced stromwater surface runoff the size and need of the stromwater sewer reduce. They're saving drainage cost. (Shaikh Faizul 2016)

ENVIRONMENTAL BENEFITS

As mentioned earlier, pervious concrete pavement systems provide a valuable storm water management's tool under the requirements of the environmental protection agency. A regulation provides programs and practices to helps control the amount of contaminants in our waterways. Impervious pavements particularly parking lots collect oil, anti-freeze, and other automobile fluids that can be washed onto streams, lakes, and oceans when it rains. Environmental protection agency storm water regulations set limits on the levels of pollutions in our streams and lakes. To meet these regulations, local officials have considered two basic approaches: reduce the overall runoff from an area, and reduce the level of pollution contained in runoff.

SCOPE

Concern has been growing in recent years toward reducing the pollutants in water supplies and the environment. In the 1960s, engineers realized that runoff from developed real-estate had the potential to pollute surface and groundwater supplies. Further, as land is developed, runoff leaves the stein higher rates and volumes, leading to downstream flooding and bank erosion. Pervious concrete pavement reduces the Impact of development by reducing or eliminating storm water runoff rates and protecting water supplies. The need for pervious concrete has grown. It's definitely growing and spreading but it still has a long way to go. The greatest market potential for Green Porous Concrete is parking lots, Parks, road with light traffic, pedestrian walk way, green houses, courtyards, playground, etc. It can also be used as a structural drainage fill behind retaining walls. It is the brightest star in the Green Building movement as it has green grass turf on its surface, that gives aesthetic look and on the same hand helps to reduce the power consumption. [3]

LITRATURE REVIEW

Experimental Investigation of Porous Concrete for Concrete pavement, Sha Shivendra Dubawnt, Dr. Esar Ahmad (2020)

This paper is a study of porous concrete and it has mix Met kaolin admixture; and checked Compression and Tensile strength. Penetrable concrete is an uncommon kind of strong, which includes concrete, coarse aggregates, water and at whatever point required, admixtures and distinctive cementations materials. As there are no fine aggregates used in the strong cross section, the void substance is more which allows the water to travel through its body. Permeable concrete fuses solid, water and if vital, course masses, admixtures and unmistakable cementations constituents. The project involves PPC 53 grade cement. Its consistency 2.93 and Consistency is 31.5%. Initial and final setting time (min) is 34 min and 240 min. The standard kind total for use in pervious cement is commonly squashed stone or waterway rock. Run of the mill sizes are from 10mm to 25mm. Properties of course aggregate density is 1830 kg / m3, specific gravity is 2.78and water absorptions is 1.60%. Use Met kaolin is an admixture utilized as an incomplete substitution of concrete. A solid is expressed to be over the top power concrete if its compressive quality is more than 40Mpa. Met kaolin is prepared by method for calcination of kaolin (clay mineral) at a temperature of 650-800ºC. It has pozzolanic homes. It responds with Ca (OH) 2 one of the through-results of hydration reaction of concrete and impacts in extra C-S-H gel which prompts expanded quality

Experimental Research on Optimization for Performance of Pervious Concrete Jintao Liu, Yang Yang , Liangying XU (2018)

This experiment strength of pervious concrete is relatively lower compared with ordinary concrete because of its porosity. In this paper, three reinforcing agents were used to optimize the Performance of interface area between aggregate and cemented material. Specifically, the contents of FA were weight of cement 10%, 15%, 20% to replace cement; and similarly, the contents of BS were 5%, 8%, 10%; the contents of DLP were 1%, 3%, 5%. The ratio of aggregate (RAB) to binder was optimized for pervious concrete strength by experiment. The permeability coefficient and porosity of pervious concrete increased with the RAB increases. The compression strength of pervious concrete can be improved by adding suitable amount reinforcing agents such as FA, BS, DLP. The test results suggested that the suitable range of FA was10%~15%, the range of BS was around 10%, and the range of DLP was 1%~3%. (2) The permeability coefficient and effective porosity decreases obviously while the amount of FA was greater than 20%, and that of BS greater 8%. (3) The permeability coefficient and porosity of pervious concrete increased with the RAB Increases.

Properties Of PCC Binder pervious Concrete K.S. Elango, V. Revathi (2017)
In this paper focus on study on pervious concrete made with Portland Pozzalona cement (PPC) as a binder. The mix proportions were prepared with different coarse aggregate sizes. The size of coarse aggregate (CA) ranging from 6 mm to 12mm was used in this study. Aggregate to binder ratio and water to binder ratio was considered as 3.3 and 0.35. Properties such as compressive strength, flexural strength and permeability were examined and relationships between aggregate size vs strength parameters, coefficient of permeability, void ratio and density properties of PPC binder pervious concrete were drawn to evaluate the influence of CA sizes in pervious concrete.

Compressive strength, Permeability and Porosity Analysis of Pervious Concrete by Variation of Aggregate and Compacting Method, Nico Sanjaya, Saloma, Hananiah (2020)
In this project compressive strength increases as the amount of fine aggregates increases. The highest percentage change in compressive strength was found in the mixture without fine aggregate which was 46.15% of the mixture with 15% fine aggregate. Permeability decreases as the amount of fine aggregate increases. The highest percentage of permeability changes was found in the mixture without fine aggregate, which is 62.6% of the mixture with 15% fine aggregate. Porosity decreases as the number of fine aggregates increases.

The highest porosity percentage change was found in the mixture with20% fine aggregate which was 87.24% to the mixture with 25% fine aggregate. The highest percentage change in compressive strength was found in the mixture compacted with the standard rodding method which was 10.00% to the mixture compacted by the proctor Hammer method. The highest percentage change in permeability was found in the mixture compacted with the proctor Hammer method which was 25.619% to the mixture compacted by concrete vibrator method. The highest percentage change in porosity was found in the mixture compacted with the standard rodding method which was 10.07% to the mixture compacted with the proctor Hammer method.

Study on the Permeability of Recycled Aggregate Pervious Concrete with Fibers, Chengcheng Wen, Zhanqiao Wang (2020)
The main purpose of this paper is to find out the permeability of porous concrete. In general, larger porosity will increase the permeability coefficient, but will significantly decrease the compressive strength. The effect of water-cement ratio, fiber types, and fiber content on the permeability coefficient porosity, compressive strength, and flexural strength were investigated. The pore tortuosity of the pervious concrete was determined by volumetric analysis and two-dimensional cross-sectional image analysis. the permeability coefficient of the recycled aggregate pervious concrete with PPTF is 7.64 mm/s, which is better than that of CCF and PPF at 5.74 mm/s and 6.01 mm/s, respectively. In this paper, when the amount of PPTF content is 3 kg/m3, the permeability coefficient and strength have relatively balanced results. The flexural strength is the highest at 3.42 MPa, the compressive strength is 21.43 MPa, and the permeability coefficient is 7.64 mm/s.

Pervious Concrete as an Environmental Solution for Pavements Focus on Key Properties, Marek Kovac, Alena Sicakova (2020)
The tested range of w/c ratio caused only very slight differences in strength characteristics of pervious concrete, though practically sufficient values were achieved: 14.5–17.5 MPa of compressive strength and 1.6–2.0 MPa of splitting tensile strength. The strength of the aggregate seems to be a limiting factor in the further strengthening of pervious concrete. This opinion is based on the crack formation that occurs at yield strength of samples. When applying 0.35–0.25 w/c ratio, hydraulic conductivity values ranging from 8.6 to 10.2 mm/s were achieved. The results of strength characteristics found in the presented experiment are promising and open up opportunities for future experimental work focusing on various locally available materials. The achieved values of hydraulic conductivity can be usable in storm-water management of urban areas when applying the pervious concrete for pavements, thus bringing environmental benefit to the lives of people who reside in cities.

A Study on Compressive Strength of Pervious Concrete, **Muhammad Zeeshan (2018)**
This paper presents the end result of the relative learn of different researches, to find out the optimum compressive strength of concrete mix made without fine aggregates. As well as, to look for the aftereffect of aggregate/cement proportion, w/c ratio, and3size of aggregates on the compressive strength of pervious concrete. It absolutely was found that the strength of no-fines concrete is significantly less than that of conventional concrete, but sufficient enough or structural use. The compressive strength generated by 1:6 (cement: coarse aggregates) having a w/c proportion of 0.40 and aggregate size of 9.375mm at 28 days was10.8MPa. Which is greater than the compressive strength of first-class brick(10.297MPa).

Mechanical Properties of Hybrid Synthetic fiber Reinforced elf Consolidating Concrete, Sahar Y. Ghanem , Jonathan Bowling , Zhihui Sun (2021) The test results that the higher the macro fibers in the mixture, the denser the concrete and the less macro fibers in the hybridization, the higher the slump flow. For mixtures with hybrid fibers, the compressive strength decreases with increasing microfiber percent. The combination of macro and microfibers achieved higher tensile strength than the single fiber mixture. The research also found that when compared with concrete reinforced with monofilament polypropylene fibers, concrete reinforced with a collated fibrillated fiber is less flow able with less passing ability, lower compressive and splitting tensile strength. Using hybrid synthetic fiber to reinforce Self-Consolidating Concrete (SCC) shows promising results in this research, more re- search is needed to optimize the hybridization process to achieve the best performance of concrete. Further investigations are necessary to understand their behavior under flexural loading, durability, and shrink- age. To broaden the study scope, more types of fibers and volumes can be studied and the effect of fibers' diameter and length on the SCC properties.

Mechanical Properties of Pressure Moulded Fiber Reinforced Pervious Concrete Pavement Brick, **Bukola Oni, Jun Xia, Mengdi Liu (2020)** This work was directed towards investigating the performance of pressure molded fiber reinforced pervious concrete by determining the mechanical properties and permeability. However, the addition of fibers at a volume fraction of 0.3 % lead to approximately 47 %, 21.5 % and 18.8 % decrease in 28- days compressive strength, and 26 %, 7.3 %, and 17.6 % reduction in tensile splitting strength for specimens containing Kevlar, PVA, and UHMWPE fibers, respectively. When compared with the control group, an optimum 9.5 % increase in the flexural strength shows the effectiveness of the fiber addition. The permeability values range between 0.15 cm/s to 0.39 cm/s, which is proportional to the porosity of the material and satisfactory according to ACI standards. Combining the pressure compaction method and the addition of fibers adversely affects the compressive and splitting tensile strength, while increasing the flexural strength slightly.

Study On Porous Concrete with Coarse Aggregate and Fine Aggregate Mix Proportions, **Dinesh Mangur, Avinashi Patel, Poornima K.B. (2017)** In this project study on porous concrete with adding coarse and fine aggregate and its mix proportion. In the study of porous concrete following material use in this project such as Cement, Normal Aggregate, Fine Aggregate and Water. The methodology consisting of collecting the specified coarse and fine aggregate grouping them according to different standard size like 12 mm passing size of coarse aggregates. Similarly fine aggregate like (4.75-1.18) mm and mixing them in a standard proportion as that of M20 grade concrete of 1:3:0.3 with w/c of 0.3 and specimens were casted of by following standard procedure and properties have been evaluated for the analysis.

METHODOLOGY

MATERIAL USED

In the present investigation the following materials were used:

- Pozzolana Portland Cement of 43 Grade use.
- Fine aggregate and coarse aggregate 20mm used.
- Drinkable Water use.
- Admixture like Recron 3s Fiber.

CEMENT

Pozzolana Portland Cement is the most common type of cement in general use around the world. In this project use BIRLA SHAKTI (PPC) 43 Grade cement. A cement is a binder a substance use for construction that sets, Hardens and adheres to other material to bind them to gather. Concrete is a key to system industry and is used for various purposes and moreover made in various structures. Improvement of amazingly high compressive quality in starting periods helps in early covering. Intense Concrete Feasible for commonsense strong mix structures.

FINE AGGREGATE

Sand is a natural granular material which is mainly composed of finely divided rocky material and mineral particles. The most common constituent of sand is silica (silicon dioxide, orSiO_2), usually in the form of quartz, because of its chemical inertness and considerable hardness, is the most common weathering resistant mineral. Hence It is used as fine aggregate in concrete. River sand locally available in the market was used in the investigation. The aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity. The sand was surface dried before use.

COARSE AGGREGATE

In this project we have use 20mm coarse aggregate. Aggregate can be clarified as1) Normal Weight Aggregate 2) Light Weight aggregate3) Heary Weight aggregat. Light Weight aggregate and heavy Weight aggregat will be discussed elsewhere under appropriate topics. In this Chapter the properties of normal weight aggregate will only be discussed. Normal weight aggregat can be further clarification as natural and artificial aggregates. Natural Natural Artificial Artificial Sand Gravel Crushed Broken Brick Rock Such as Granite. Air-Cooled Slag Quartzite Basalt Sintered Fly Ash Sandstone Bloated Clay Aggregate Can also be Clarified of the size of the aggregate as coarse aggregate and Fine aggregate Aggregate is commonly considered inter filler. Which account for 60 to 80 presents of the Weight of concrete. Maximum size of aggregate affects the Workability and Strength of concrete.

WATER

Water is an important ingredient of Concrete as it actively participates in the chemical reaction with cement.it necessary for us to go into the purity and quality of water. Water is important ingredient of Concrete. since it binds all the materials for giving a proper mix.

ADMIXTURE

In our project we have added special type of admixture such as Recron 3s Fiber. Use 12mm Recron fiber in our project. This fiber use reduces 60-70% Rebound loss. Reduce crack during plastering and hardening stages. 12mm Recron 3s fiber use 1500gm/m3. There is a specific method of mixing the fiber, first soaking it in water for 30 minutes and then mixing it in the concrete so that it is properly mixed everywhere in the concrete. Recron® 3s is a state of art reinforcing material which is used to increase strength.

MIXING OF CONCRETE

In this project we have taken all the material according to weight. we have use Birla Shakti cement 43 grade, and 20mm size of coarse aggregate are use. In the same way that we used use in concret drinkable water. In this concrete we have mixed soaked Recron 3s fiber We mix all this material properly mix in mechanical mixer after mixing remove all material and fill metal cube.

Fig no 1: Mechanical mixer after mixing

PREPARATION MOULD

Generally metal mold are preferred first remove previous material with the help of hammer and to assembly ready for use the dimension and internal phase are required to be accurate within the following limit the assembly the mold for use the join between the sexual of the mode are thinly coated with mold oil and similar coating of mole oil is apply between the contract surface of water of the mold and the best plate in order to ensure that no water scape during the interior surface of the assembly mode is also required to be thinly Coted with moral oil to prevent forever project 150 * 150 * 150 mm cube mod where creeper after applying the oil we are ready for casting then sample wear casted and live for 24 hours for remolding.

Fig no 2: Preparation of mold for casting

COMPACTION OF MOULD

After oiling the steel mold, the concrete material was filled into mold. The concrete was poured into the mold in three layers and tamping each layer by 35 times. The steel road is using is 16mm diameter and 600 mm long. After tamping the concrete mold is placed on the vibration machine to vibrate. When the vibration is completed, concrete mold set for 24 hours. After 24 hours remove from concrete cube.

Fig no 3: Compaction of mold

CURING OF CONCRETE CUBE

After 24 hours specimen are Marked and remove from the mold and unless required for the taste within 24 hour immediately some merge in clean fresh water or saturated lime solutions and keep their until taken out just pure to test the water or solution in which the specimen are some nude every seven day and we maintain at temperature of 27° + - 2 degree The specimen are not to be allowed to become a dry and time of until after remolding the specimen ready for place in curing tank until the day of testing the sample will be cure for a span of 7 days 14 days and 28th days.

TESTING

When their curing period was complete, they were taken out of the water and let it dry for a while. After drying for a while, two types of tests are to be performed on it. The first is Compression test and the second is permeability test. In the compression test, the concrete block was placed on the UTM machine to find out compression strength. In the permeability test the timing of one litter water passing through a concrete cube was measure. Thus, we have taken these two tests on porous concrete in this project.

Fig no 4: Compression test on UTM

Fig no 5: Permeability test

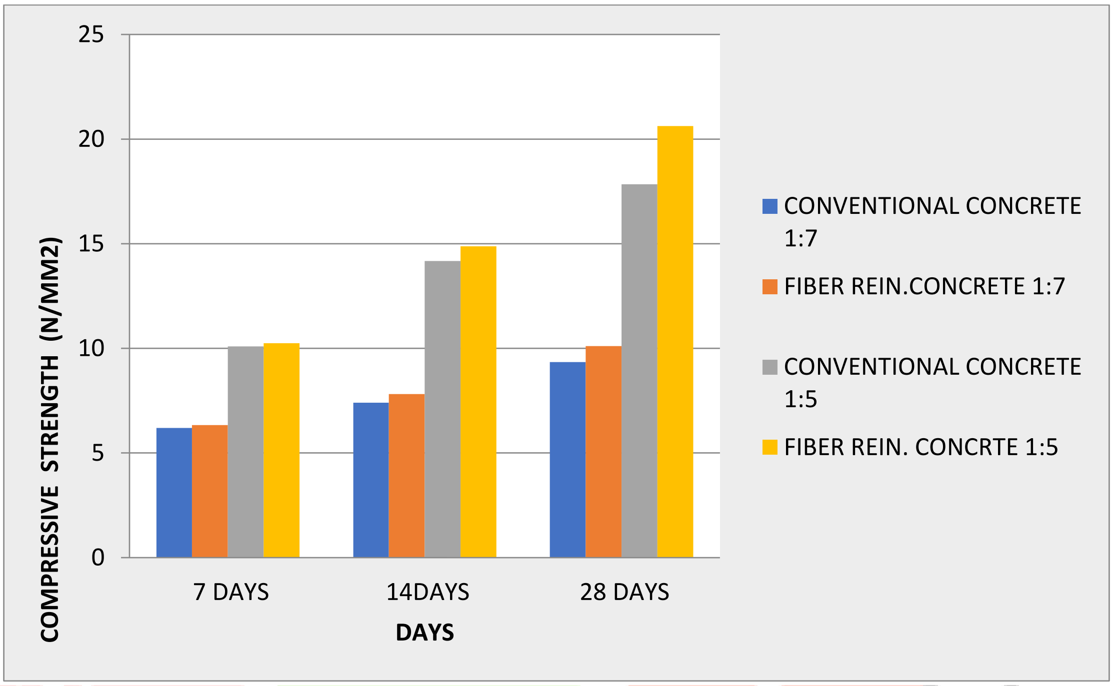
RESULT

COMPRESSIVE STRENGTH TEST

Compression test is the most common test conducted on harder concrete partly because it is an easy taste to perform and partly because most of the desirable characteristics properties of concrete are equitalively related to its compressive strength. The compression test is carried out on specimen's cubicle or cylindrical in shape but it is not common in our country sometime the compression strength of concrete is determine using part of a beam tested the in parts of the beam left intact after failure in flexure and because of the beam is usually of square compression this part of the beam could be used to find out the compressive strength is of the cube size 15 x 15 x 15 cm. In this project we have used 1:5 and 1:7 ratio of concrete. the test concluded every 7 days 14 days and 28 days remove the specimens for curing tank and wipeout access water from surface then put the specimen on the basic plate of the machine movable portion move downward by mechanically so that it is the top surface of the specimen touch moveable part then applied the load low or gradually and continuous apply it is the specimen fails record the maximum load minimum 3 tested at each selected day. These results are obtained by testing the total 36 specimens for 7 days, 14 days and 28 days. Considering the average of test results and that are tabulated in table.

Table 1: Compressive strength of concrete

	CONVENTIONAL CONCRETE		FIBER REINFORCED CONCRTE	
GRADE	1.5	1.7	1.5	1.7
7 DAYS	10.1	6.2	10.24	6.34
14 DAYS	14.18	7.4	14.88	7.82
`28 DAYS	17.85	9.34	20.63	10.11



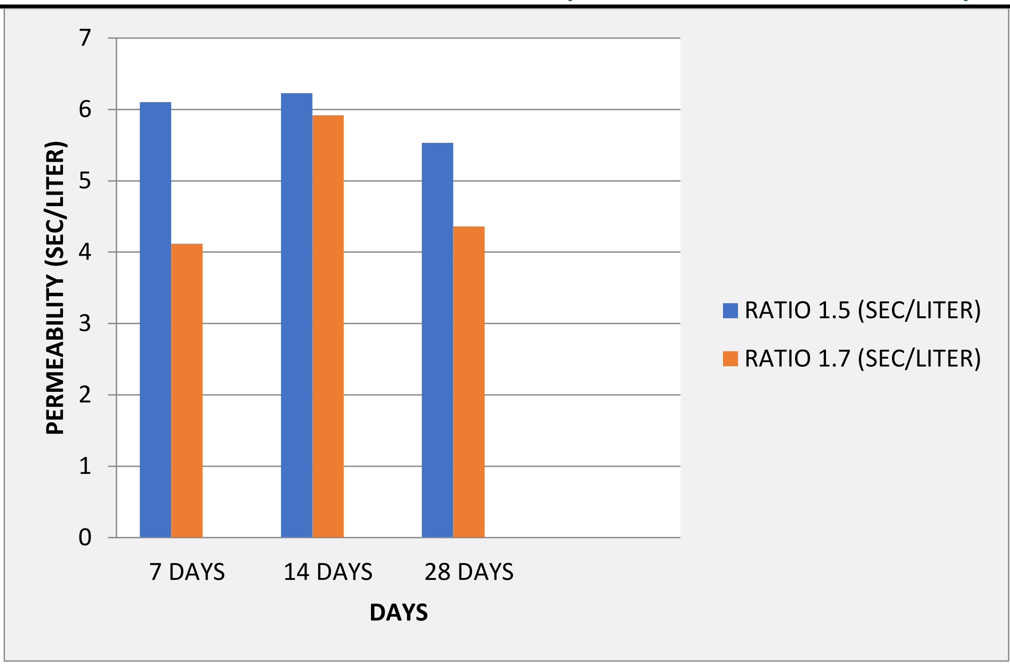
Graph 1: Compressive strength variation of conventional and fiber reinforced concrete

PERMEABILITY TEST

Permeability is the property that governs the rate of flow of fluid into a porous solid. In our project experimental result shows that the aggregate size is large, the porosity is bigger, and the water permeability is better. Mainly because of the coarse gap of the coarse aggregate specimen, under the same condition. The coarse aggregate internal porosity is higher, so that its permeability is higher. These results are obtained by testing the total 18 specimens for conventional and fiber reinforced concrete. Result is tabulated in the table.

Table 2: Permeability of porous concrete

DAYS	RATIO	
	1:5 (Sec/lit)	1:7 (Sec/lit)
7 DAYS	6.01	4.12
14 DAYS	6.23	5.10
28 DAYS	5.58	4.36
Average	5.94	4.52



Graph 2: Permeability variation of 1:5 and 1:7 ratio

CONCLUSION

In This Project We Have Taken Two Ratio of Pervious Concrete That is 1:5 and 1:7 and We have Compared That with Conventional Concrete.

- Adding fiber reinforcement to the 1:5 ratio on the 7 days increases the compressive strength by 3 percent.
- Adding fiber reinforcement to the 1:5 ratio on the 14 days increases the compressive strength by 5 percent.
- Adding fiber reinforcement to the 1:5 ratio on the 28 days increases the compressive strength by 16 percent.
- Adding fiber reinforcement to the 1:7 ratio on the 7 days increases the compressive strength by 3 percent.
- Adding fiber reinforcement to the 1:7 ratio on the 14 days increases the compressive strength by 6 percent.
- Adding fiber reinforcement to the 1:7 ratio on the 28 days increases the compressive strength by 9 percent.

So, we suggest that used admixture in pervious concrete cause it helps to increases compression strength.

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