Study on Pervious Concrete using Different Size of Course Aggregate

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Abstract— Concrete is a widely used structural material consisting essentially of a binder and a mineral filler. Concrete has been the leading material since it was used and is bound to maintain its significant role in the upcoming future due to its durability, adaptability to any shape and size and many other applications. It is a composite material produced by mixing cement, inert matrix of sand and gravel or crushed stone. Pervious concrete is a type of concrete that has a low watercement ratio and contains none of sand. This concrete has a light colour and open-cell structure because of which they do not absorb heat from the sun; they also do not radiate the heat back into the atmosphere, which reduces heating in the environment. Pervious concrete has low installation costs. In addition, it filters the storm water thus reducing the number of pollutants entering the rivers and ponds. Pervious concrete also improves the growth of trees. In the present study the behaviour of pervious concrete has been studied experimentally. Various mix proportions were prepared cement with fly ash (20% by the weight of cement) and 5% of cement replaced by fly ash. Different properties of pervious concrete e.g. compressive strength, permeability test at 7, 14 & 28 days have been studied experimentally.

Keywords: Experimental Study, Pervious Concrete, Different Size, Coarse Aggregate

I. Introduction

A. General:

Urbanization and the resulting increase in urban storm water over the past few decades have led to an increase in runoff and pollution. This increase directly affects the surrounding rivers and streams, with impacts such as increased stream bank erosion, decreased water quality, and decreased base flow as areas become less and less pervious. In recent years, porous concrete pavements have become popular as an effective storm water management device. Porous concrete pavement may be new in some areas in the world. According to Mark et al. porous concrete technology has been used since 1970s in various parts of the United State as an option to complex drainage systems and water retention areas.

Ghafoori and Dutta found in their literature review, the earliest application of porous concrete was in the United Kingdom in the year 1852. The most common application includes driveways, parking lots, sidewalks, streets and also other low traffic volume areas.

B. Pervious Concrete

It is define the term "pervious concrete" typically describes a near-zero-slump, open-graded material consisting of Portland cement, coarse aggregate, little or no fine aggregate, admixtures, and water. It is such a concrete that has high porosity and allows draining freely unlike dense, high strength concrete. Its applications are therefore in conditions where water from precipitation or other sources needs to be drained. The high porosity is achieved by the absence or very low content of fine aggregates. Pervious concrete is also known as no-finesconcrete, gap graded concrete or porous concrete. It essentially consists of cement, coarse aggregate, water and little or no fine aggregate. In normal concrete, the fine aggregates typically fill in the voids between coarse aggregates. But in pervious concrete fine aggregate is non-existent or present in very small amounts. Moreover, there is globally considerable research is being done on pervious concrete that can be used for concrete flatwork applications.

C. Applications of Water Absorption Concrete Road

It is mostly applied in roads with low traffic usage, parking and sidewalks. It can serve as the surface course in such sites. Reports indicate that since 1970 pervious concrete has been utilized as the material for paving in Florida. It has also been applied in permeable drainages in water and power recourses, noise barriers, wall building, systems of thermal storage in greenhouses, decks of swimming pools, sludge beds in sewage treatment plants, bridge tennis courts, embankments and wall lining in water wells. Presently, substantial level of interest has existed regarding the application o pervious concrete in the alleviation of noise from tire-pavement interaction in concrete pavements. Pervious concrete possesses an excellent acoustic absorption capacity because of its extensive porosity. Acoustic absorption takes place in the material when sound waves are transmitted via a series of interconnected pores present in the material.

D. Construction Process

Pervious concrete consists of cement, coarse aggregate and water with no fine aggregates. The addition of a small amount of fly ash will increase the strength. The mixture has a water-to-cement ratio of 0.35 to 0.45 with a void content of 15 to 25 percent. The correct quantity of water in the concrete is critical. A low water to cement ratio will increase the strength of the concrete, but too little water may cause surface failure. A proper water content gives the mixture a wet-metallic appearance. As this concrete is sensitive to water content, the mixture should be field checked.

E. Applications

Although not a new technology, pervious concrete is receiving renewed interest, partly because of federal clean water legislation. The high flow rate of water through a pervious concrete pavement allows rainfall to be captured and to percolate into the ground, reducing storm water runoff, recharging groundwater, supporting sustainable construction, providing a solution for construction that is sensitive to environmental concerns, and helping owners comply with EPA storm water regulations. This unique ability of pervious concrete offers advantages to the environment, public agencies, and building owners by controlling rainwater on-site and addressing storm water runoff issues. This can be of particular interest in urban areas, or where land is very expensive. Depending on local regulations and environment, a pervious concrete pavement and its sub base may provide enough water storage capacity to eliminate the need for retention ponds, swales, and other precipitation runoff containment strategies.

This provides for more efficient land use and is one factor that has led to a renewed interest in pervious concrete. Other applications that take advantage of the high flow rate through pervious concrete include drainage media for hydraulic structures, parking lots, tennis courts, greenhouses, and pervious base layers under heavy-duty pavements. Its high porosity also gives it other useful characteristics: it is thermally insulating (for example, in walls of buildings) and has good acoustical properties (for sound barrier walls).All of these applications take advantage of the benefits of pervious concrete's characteristics. However, to achieve these results, mix design and construction details must be planned and executed with care.

F. Research Objectives

The use of pervious concrete to date has been limited to low volume and low speed traffic areas such as parking lots and sidewalks. These facilities are not typically subjected to high volume and standard wheel loads. Many jurisdictions are now considering the use of pervious concrete on low volume roads such as residential streets and alleys.

- To study about properties of Pervious concrete.
- Creating an eco-friendly pavement.
- To provide a sustainable environment.
- Result analysis in the strength and permeability.

It is an important application for sustainable construction and is one of the techniques used for ground water recharge. Pervious concrete naturally filters water from rainfall or storm and can reduce pollutant loads entering into streams, ponds and rivers. So in this way it helps in ground water recharge. It also reduces the bad impact of urbanization on trees. A pervious concrete ground surface allows the transfer of water and air to root systems allowing trees to flourish. Pervious concrete demonstrate the following advantages, benefiting the environment.

1) Decreasing flooding possibilities, especially in urban areas.
2) Recharging the groundwater level.
3) Reducing puddles on the road.
4) Improving water quality through percolation.
5) Sound absorption.
6) Heat absorption.
7) Supporting vegetation growth.

G. Advantages

- Environmental - reduced storm water runoff, recharge groundwater, efficient land use by reducing the need for retention ponds.
- Economic - the management effort made in preventing excess runoff during heavy rainfall is prevented. Reduces cost to maintain large detention ponds.
- Safety - increased safety for drivers, improves driving in wet weather conditions, reduces night time glare and lessens the risk of hydroplaning
- Reduced Surface Temperatures, Minimizes the Urban Heat Island Effect
- Extended Pavement Life Due to Well Drained Base and Reduced Freeze-Thaw
- Less Lighting Needed Due to Highly Reflective Pavement Surface.

H. Limitations

The following are the limitations of the pervious concrete pavement:

- Proper Soil Stabilization and Erosion Control are required to Prevent Clogging
- Quality Control for Material Production and Installation are Essential for Success.

II. METHODOLOGY

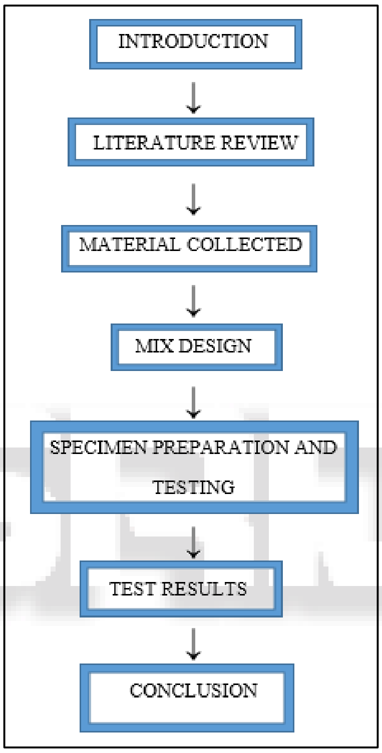


Fig. 1: Shows the methodology adopted in this study.

III. MATERIALS PROPERTIES

A. Cement

The cement used was ordinary Portland cement 43 (OPC 43).All properties of cement were determined by referring IS 10262 - 2009. The specific gravity of cement is 3.15. The initial and final setting times were found as 85 minutes and 585 minutes respectively. Standard consistency of cement was 28%.

B. Coarse Aggregate 20mm Size Aggregates

The coarse aggregates with size of 20mm were tested and the specific gravity value of 2.78 and fineness modulus of 7 was found out and water absorption is 0.85%. Aggregates were available from local sources.

- Specific Gravity
- Bulk Density
- Surface Moisture
- Water Absorption
- Fineness Modulus

C. Water

The water used for experiments was potable water. Water used for mixing and curing shall be clean and free from injurious amounts of Oils, Acids, Alkalis, Salts, Sugar, Organic materials Potable water is generally considered satisfactory for mixing concrete Mixing and curing with sea water shall not be permitted. The pH value shall not be less than 6.

IV. MIX DESIGN STIPULATIONS

- Grade Designation M-30
- Type of cement O.P.C-43grade
- Sp. Gravity Cement 3.15
- Sp. Gravity Coarse Aggregate 2.8

A. Mix proportion

Cement = 0.157 m^3
Water = 0.197 m^3
Coarse Aggregate = 0.621 m^3
W-C ratio = 0.35
Ratio = C : S : A : F
= 1 : 0 : 2.55 : 0.055
Fly Ash = 0.025 m^3

V. TESTING PROCEDURE

A. Compressive Strength

Test The main aim is to determine the compressive strength of concrete specimen. The test specimens, cubical in shape of size 150x150x150 mm are used. Compression tests are conducted at 7, 14, 28 days of the casting of specimens. Specimens cured in the water where tested immediately on removal from water and while they are still in wet condition. The load applied 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. Compression test is carried out on specimens cubical in shape. Sometimes, the compression strength of concrete is determined using parts of beam tested in flexure.

The maximum load applied to the specimen until a failure recorded. Then based on the load value the compressive strength of the concrete specimen calculated as follows. Compressive strength=ultimate load/contact area of the cube

B. Permeability Test on Concrete.

The permeability of concrete to liquids, ions and gases is of direct relevance to both durable concrete and to leak resistant concrete for containment. Analytical models used to predict the age at which corrosion of the reinforcement will be initiated require a detailed knowledge of the transport mechanisms involved and the permeability of the concrete. Some specifications for projects in extreme environments (e.g. the Middle East) or requiring very long lives (e.g. railway tunnels) have specified permeability criteria, based on some form of analytical durability model, to be verified by testing the supplied concrete or precast concrete elements. A simple permeability test could form part of the quality assurance (QA) scheme for any precast concrete element, to check on the variability of standard units.

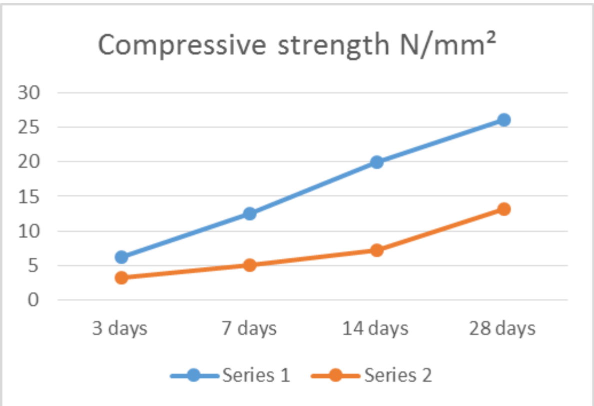
VI. TESTING RESULT

A. Compressive Strength of Cube

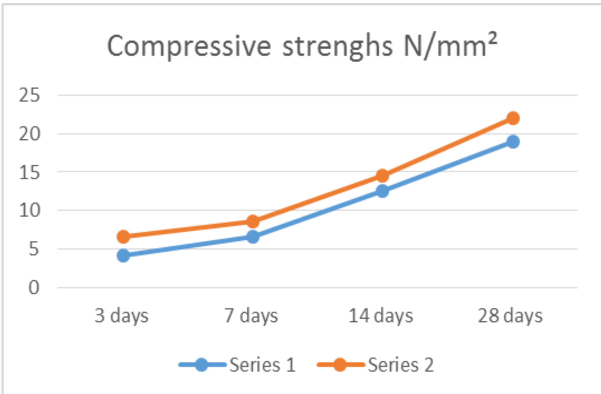
For M30 Grade of Concrete and for three different types of cubes with different sizes of aggregate (viz. 10mm, 20mm, 10+20mm) test results were compared and the results are tabulated in table No.6.1. The day wise comparison of strength is shown in Fig. 6.2 and Fig 6.3.

Sr.No.	Type of concrete	Casting	Results (Compressive strength in N/mm²)			
			3 days	7 days	14 days	28 days
1.	Conventional concrete	Completed	6.23N/mm²	12.6 N/mm²	19.9 N/mm²	26 Nmm²
2.	Pervious concrete Coarse pervious concrete	Completed	3.19 N/mm²	5.06 N/mm²	7.3 N/mm²	13.2 N/mm²
	Medium pervious concrete	Completed	4.2 N/mm²	6.17N/mm²	12.6 N/mm²	19 N/mm²
	Fine pervious concrete	Completed	6.67 N/mm²	8.67N/mm²	14.5 N/mm²	22 N/mm²

Table 6.1:



Series 1= conventional concrete cube
Series 2= Pervious concrete cube of 20 mm
Fig. 6.2:



Series 1 = Pervious concrete of 20mm and 10 mm
Series2 = Pervious concrete of 10 mm
Fig. 6.3:

B. Porosity of Pervious Concrete

The porosity of the pervious concrete layer is the dominant variable of the system, affecting durability, hydraulic and mechanical properties this study provides a method for correlating the surface infiltration rate of newly placed pervious concrete layer and its estimated porosity.

Sr. No.	Types of cubes	Date of casting	No. of cubes	Porosity
1.	Conventional cubes	8/02/2019	7	0%
2.	Pervious cubes with 10mm aggregate	9/02/2019	9	50%
3.	Pervious cubes with 10+20mm aggregate	9/03/2019	9	65%
4.	Pervious cubes with 20mm aggregate	11/02/2019	9	90%

VII. Conclusion

This project deals with strength parameters and percentage porosity of pervious concrete for different sizes of aggregate viz. 10mm, 20mm and 10+20mm. Pervious concrete does not contains fine aggregate, which affects the strength and porosity of pervious concrete. Finer the size of coarse aggregate strength will be more but the porosity will decrease. And coarser the size of coarse aggregate porosity will be more but ultimately its strength gets decreased. It aims at finding out most probably suitable size of aggregate is to be adopted to get maximum strength and porosity. A comparative study of different research work for suitable type and size of aggregate is obtained. In this project M30 Grade of Concrete comparison had been established between three different types of cubes with different sizes of aggregate.

Following are the comparative conclusion of our project:

- Pervious concrete helps the water to infiltrate into ground increasing ground water discharge and maintaining stability of ground water level
- Cities with pervious concrete pavements would be safer for traffic, be cleaner and less pollution, thus more environmental friendly then the impervious pavement
- Pervious concrete advantages are major over its disadvantages. Thus it can be used in areas as mentioned earlier which would be more beneficial.
- From research it can be concluded that the pervious the concrete containing finer
- coarse aggregate gives more strength i.e. 12.8 N/mm² foe 3 days.
- The W/C and aggregate size had an effect on porosity and strength.

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