VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"Jnana Sangama", Belgaum-590 014

A Dissertation Project Report on

"PROPERTIES OF PERVIOUS OUS CONCRETE"

Submitted in partial fulfilment for the award of the degree of

BACHELOR OF ENGINEERING IN

CIVIL ENGINEERING

BY

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CMR INSTITUTE OF TECHNOLOGY

(ITPL MAIN ROAD BENGALURU-560 037)

2019-2020

C.M.R. INSTITUTE OF TECHNOLOGY

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Department of Civil Engineering

Certificate

This is to certify that the project work entitled "PROPERTIES OF PERVIOUS CONCRETE" has been successfully completed by Mr. Bharath Kumar (USN 1CR17CV402),Mr. Darshan N J(USN1CR17CV403),Mr. Nikhil HC(USN 1CR17CV415) and Mr. Vinay B(USN1CR17CV424) bonafide students of CMR Institute of technology in partial fulfilment of the requirement for the award of degree of Bachelor of Engineering in Civil Engineering of the "VISVESVARYA TECHNOLOGICAL UNIVERSITY", Belgaum during the academic year 2019-2020. It is certified that all corrections indicated for internal assessment has been incorporated in the Report. The project report has been approved as it satisfies the academic requirements in respect of project work prescribed for the said Degree.

Mrs. Preeti Jacob	Dr. Asha M Nair	Dr. Sanjay Jain
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Name of the Examiners	External Viva	Signature with date
1.		
2.		

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DECLARATION

We, Mr. Bharath Kumar (USN 1CR17CV402),Mr. Darshan N J(USN1CR17CV403),Mr. Nikhil H C(USN 1CR17CV415) and Mr. Vinay B(USN1CR17CV424) bonafide students of CMR Institute of Technology, Bangalore, hereby declare that dissertation entitled "Study on Properties of Pervious Concrete " has been carried out by us under the guidance of Dr. Asha M Nair (HOD), Mrs. Preeti Jacob (Assistant Professor), Department of Civil Engineering, CMR Institute of Technology, Bangalore, in partial fulfilment of the requirement for the award of degree of Bachelor of Engineering in Civil Engineering of the Visvesvaraya Technological University, Belgaum during the academic year 2019-2020. The work done in this dissertation report is original and it has not been submitted for any other degree in any university.

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ABSTRACT

Pervious concrete is a special type of concrete with high permeability which is used for pervious concrete pavement as an effective green technology that allows the seepage of precipitation through the pavement thereby reducing the storm water runoff and also recharging the groundwater resources. Generally pervious concrete is designed as no-fines concrete as per IS: 12727 – 1989. However the no-fines concrete has poor compressive strength and requires lot of care in its manufacturing, placing and curing. In this project, the compressive strength is increased by narrow gradation of coarse aggregate and reducing the proportion of coarse aggregate in the mix design. In order to increase compressive strength, fly-ash is added. The fly ash also decreases the permeability of concrete. The maximum compressive strength achieved is 17.78 N/mm2 for the mix design 1:0.5:4. The maximum permeability achieved is 0.234mm/s for 1 kg/cm2 pressure intensity and mix proportion 1:0.5:5. This study attempts to optimize the performance of pervious concrete by considering small percentage of fly ash to increase the compressive strength maintaining adequate permeability.

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Abstract

Pervious concrete is a special type of concrete with high permeability which is used for pervious concrete pavement as an effective green technology that allows the seepage of precipitation through the pavement thereby reducing the storm water runoff and also recharging the groundwater resources. Generally pervious concrete is designed as no-fines concrete as per IS: 12727 – 1989. However the no-fines concrete has poor compressive strength and requires lot of care in its manufacturing, placing and curing. In this project, the compressive strength is increased by narrow gradation of coarse aggregate and reducing the proportion of coarse aggregate in the mix design. In order to increase compressive strength, fly-ash is added. The fly ash also decreases the permeability of concrete. The maximum compressive strength achieved is 17.78 N/mm2 for the mix design 1:0.5:4. The maximum permeability achieved is 0.234mm/s for 1 kg/cm2 pressure intensity and mix proportion 1:0.5:5. This study attempts to optimize the performance of pervious concrete by considering small percentage of fly ash to increase the compressive strength maintaining adequate permeability.

CONTENTS

INTRODUCTION

1.1 GENERAL

Pervious concrete is a mixture of gravel or stone, cement, water and little or no sand which creates an open cell structure that allows water and air to pass through it. According to EPA (Environmental Protection Agency's) storm water runoff can send as much as 90% of pollutant suchasoilandotherhydrocarbon.Theabilityofperviousconcretetoallowwaterto flow through itself recharges groundwater and minimizes the extent of pollution and stormwater runoff. Pervious concrete is used to allow stormwater to infiltrate through the pavement and reduce or eliminate the need for additional control structures, such as retention ponds.

Pervious Concrete is a special type of concrete in which no fine aggregates are used and gravel has been used in place of the coarse aggregate. Pervious Concrete is a homogeneous mixture of cement, aggregate / gravel and water. Pervious Concrete is also called as **“no-fines”** concrete. Durability is one of the most important considerations in the design of new structures and when assessing the condition of existing structures. Concrete construction is becoming increasingly complex and the importance of producing structures that are both cost effective and durable has never been higher. The main purpose of durability is about minimizing the rate of deterioration. Durability of Concrete is related to the design process, specification of materials, workmanship, environmental effects, accidents and repairs. In Water Absorption Test cylinders are cured in curing pond for 28 days and weighing it & % water absorption is to be determined. In Durability Test cylinders are first cured in curing pond for 28 days and then after weighing it is again immersed in “Sodium Chloride Solution” for another 28 days

The Durability of Concrete is the resistance of concrete to weathering action, chemical attack, abrasion and other degradation processes. The Water Absorption of Concrete is the procedure that involves drying a specimen to a constant weight, weighing it, immersing it in water for specified amount of time, and weighing it again. The increase in weight as a percentage of the original weight is expressed as its absorption (in percent). The average absorption of the test samples shall not be greater than 5% with no individual unit greater than 7%.

1.2 HISTORY OF POROUSCONCRETE

The initial use of porous concrete was in the United Kingdom in 1852 with the construction of two residential houses and a sea groyne. 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 re 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 concreteuse less cement than conventional concrete and cement was scarce 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 (Wanielista et al. 2007). After World War II, porous concrete became widespread for applications such as cast-in-place load-bearing walls of single and multistory houses and, in some instances in high-rise buildings, prefabricated panels, and steam-cured blocks (Ghafoori et al. 1995). Also applications include walls for two-story houses, load-bearing walls for high-rise buildings (up to 10 stories) and infill panels for high-rise buildings (Tennis et al. 2004).

1.3 ADVANTAGES

1. The rainwater can quickly filter into ground, so the groundwater resources can renew in time. As the pavement is air permeable and water permeable, the soil underneath can be kept wet.
2. The pervious concrete pavement can absorb the noise of vehicles, which creates quiet and comfortable environment.
3. In rainy days, the pervious concrete pavement has no plash on the surface and does not glisten at night. This improves the comfort and safety of drivers.
4. The pervious concrete pavement materials have holes that can cumulate heat. Suchpavement can adjust the temperature and humidity of the Earth's surface and eliminates the phenomenon of hot island in cities.

1.4 DISADVANTAGES

1. Runoff volumes: In a large storm event, the water table below the porous pavement can rise to a higher level preventing the precipitation from being absorbed into the ground. The additional water is stored in the open graded crushed drain rock base and remains until the subgrade can absorb the water. For clay-based soils, or other low to 'non'-draining soils, it is important to increase the depth of the crushed drain rock base to allow additional capacity for the water as it waits to be infiltrated.

2. Pollutant load:Highly contaminated runoff can be generated by some land uses where pollutant concentrations exceed those typically found in stormwater. These "hot spots" include commercial nurseries, recyclingfacilities, fuelingstations, industrial storage,marinas, some outdoor loading facilities, public works yards, hazardous materials generators etc. Since porous pavement is an infiltration practice, it should not be applied at stormwater hot spots due to the potential for groundwater contamination. All contaminated runoff should be prevented from entering municipal storm drain systems by using bestmanagement practices(BMPs) for the specific industry or activity
3. Weight and traffic volumes:Reference sources differ on whether low or medium traffic volumes and weights are appropriate for porous pavements. For example, around truck loading docks and areas of high commercial traffic, porous pavement is sometimes cited as being inappropriate.
4. Climate:Cold climates may present special challenges. Road salt contains chlorides thatcould migrate through the porous pavement into groundwater. Snow plow blades could catch block edges and damage surfaces. Sand cannot be used for snow and ice control on pervious asphalt or concrete because it will plug the pores and reduce permeability.

Performance

Pervious concrete is not difficult to place, but it is different from conventional concrete, and appropriate construction techniques are necessary to ensure its performance. It has a relatively stiff consistency, which dictates its handling and placement requirements. The use of a vibrating screed is important for optimum density and strength. After screeding, the material usually is compacted with a steel pipe roller. There are no bull floats, darbies, trowels, etc. used in finishing pervious concrete, as those tools tend to seal the surface. Joints, if used, may be formed soon after consolidation, or installed using conventional sawing equipment. (However, sawing can induce raveling at the joints.) Some pervious concrete pavements are placed without joints. Curing withplasticsheetingmuststartimmediatelyafterplacementandshouldcontinuefor at least seven days. Careful engineering is required to ensure structural adequacy, hydraulic performance, and minimum clogging potential. More detail on these topics is provided in subsequent sections.

Environmental Benefits

pervious concrete pavement systems provide a valuable stormwater management tool.. Impervious pavements—particularly parking lots—collect oil, antifreeze, and other automobile fluids that can be washed into streams, lakes, and oceans when it rains.By capturing the first flush of rainfall and allowing it to percolate into the ground, soil chemistry and biology are allowed to "treat" the polluted water naturally. Thus, stormwater retention areas may be reduced or eliminated, allowing increased land use. Furthermore, by collecting rainfall and allowing it to infiltrate, groundwater and aquifer recharge is increased, peak water flow through drainage channels is reduced and flooding is minimized.

The light color of concrete pavements absorbs less heat from solar radiation than darker pavements, and the relatively open pore structure of pervious concrete stores less heat, helping to lower heat island effects in urban areas.

Trees planted in parking lots and city sidewalks offer shade and produce a cooling effect in the area, further reducing heat island effects. Pervious concrete pavement is ideal for protecting trees in a paved environment. (Many plants have difficulty growing in areas covered by impervious pavements, sidewalks and landscaping, because air and water have difficulty getting to the roots.) Pervious concrete pavements or sidewalks allow adjacent trees to receive more air and water and still permit full use of the pavement (see fig below). Pervious concrete provides a solution for landscapers and architects who wish to use greenery in parking lots and paved urban areas.

Although high-traffic pavements are not a typical use for pervious concrete, concrete surfaces also can improve safety during rainstorms by eliminating ponding (and glare at night), spraying, and risk of hydroplaning.

1.5 OBJECTIVES

1. The main objective of the project is to develop a strong and durable pervious cement concrete (PCC) mix using different types of fine aggregates with varying the quantity.
2. In addition, to compare the properties of these PCC mixes. So in the present study, two types of fine aggregates are used viz., foundry Sand (FS) and River Sand (RS) are used.
3. The percentage of fine aggregates used in pervious concrete and PCC mix is 0, 10, and 20 per cent. The properties of pervious concrete and PCC mixes were studied for compressive strength, flexural strength, tensional and permeability.
4. To optimize the mix design for target requirements of the given site condition.
5. To study the effect of compressive strength for controlled addition of fine aggregate under constant mix proportion.

1.5 BENEFITS OF PERVIOUSCONCRETE:

1. It reduces the stormwater runoff
2. Eliminates the need for detention ponds and other costly stormwater management practices.
3. Mitigates surface runoff
4. Replenishes the aquifers and water table
5. Allows more efficient land development
6. Prevents water from entering into the stream and also prevents it from being polluted

1.6 APPLICATIONS OF PERVIOUSCONCRETE:

1. Pervious Concrete as a Road pavement
2. Low-volume pavements
3. Sidewalks and pathways
4. Residential roads and driveways
5. Parking lots
6. Noise barriers
7. Slope stabilization
8. Hydraulic structures

9. Swimming pool decks

LITERATURE REVIEW

S.O. Ajamu, A.A. Jimoh, J.R. Oluremi carried out the work on "Evaluation of Structural Performance of Pervious Concrete in Construction". In their study the permeability and strength of pervious concrete depend on the particle sizes and proportions of the constituent materials of which the concrete is made of. In this paper, structural property and permeability of pervious concrete made with different coarse aggregate sizes is presented. For the different aggregate/cement ratio used in this study, coarse aggregate size 9.375 mm has higher compressive strength values compared to those made from 18.75 mm aggregate size while 18.75 mm aggregate size had higher permeability value compared to that of 9.38 mm. The average specific gravity of the two aggregates sizes used was 2.7. Aggregate/cement ratio of 6:1, 8:1 and 10:1 respectively were used to produce three different batches of fresh concrete using 18.75mm aggregate size and same ratios were used for 9.375mm coarse aggregate size to produce another three different batches. In each case, aggregate/cement ratio of 6:1 gave the highest compressive strength compared to other aggregate/cement ratio of 8:1 and 10:1. The highest compressive strength obtained was 8.2N/mm2 and 10.8N/mm2 respectively for 18.75mm and 9.375mm coarse aggregate sizes. These values fall within the values stipulated by ACI 552R-10 (2.8N/mm2-28 N/mm2). It was found that the aggregate/cement ratio of 10:1 produced pervious concrete of higher co-efficient of permeability of 3.12x10-3 cm/sec and 3.89x10-3 cm/sec for aggregate size 9.375mm and 18.75mm respectively.

M. Harsha vardhana Balaji, M.R.Amarnath, R.A.Kavin, S. Jaya pradeep carried out the work on DESIGN OF ECO FRIENDLY PERVIOUS CONCRETE. Pervious concrete is a zero-slump, open graded material consisting of hydraulic cement, coarse aggregate, admixtures and water. Because pervious concrete contains little or no fine aggregates such as sand, it is sometimes referred to as "no-fines" concrete. It is a special type of concrete having a high void content of about 30%, is becoming popular nowadays due to its potential to reduce the runoff to the drainage systems which can provide a water flow rate around 0.34 cm/second. Pervious concrete has a large open pore structure hence less heat storage and faster. Pervious concrete also find its effective application in low loading intensity parking pavements, footpaths, walkways and highways. The pervious concrete is considered as an Environmental Protection Agency (EPA) for providing pollution control, storm management and suitable development. Here, pervious concrete mix is designed without sand and adding silica fume as an admixture using ACI 522R-06 code, the mechanical strength of the concrete is increased to an extent. The aim of the study is to lay the pervious concrete in platform and car parking thus transmitting the water to the underground surface very easily for maintaining the groundwater table even in all the places.

Mr.V. R. Patil Prof. A. K. Gupta Prof. D. B. Desai carried out the work on Use Of Pervious Concrete In Construction Of Pavement For Improving Their Performance in their study cities arebeing covered with building and the air-proof concrete road more and more. In addition, the environment of city is far from natural. Because of the lack of water permeability and air permeability of the common concrete pavement, the rainwater is not filtered underground. Without constant supply of water to the soil, plants are difficult to grow normally. In addition, it is difficult for soil to exchange heat and moisture with air; therefore, the temperature and humidity of the Earth's surface in large cities cannot be adjusted. This brings the phenomenon of hot island in city. At the same time, the plash on the road during a rainy day reduces the safety of traffic of vehicle and foot passenger. The research on pervious pavement materials has begun in developed countries such as the US and Japan since 1980s. Pervious concrete pavement has been used for over 30 years in England and the United States. Pervious concrete is also widely used in Europe and Japan for roadway applications as a surface course to improve skid resistance and reduce traffic noise. However, the strength of the material is relatively low because of its porosity. The compressive strength of the material can only reach about 20 - 30 MPa. Such materials cannot be used as pavement due to low strength. The pervious concrete can only be applied to squares, footpaths, parking lots, and paths in parks. Using selected aggregates, fine mineral, admixtures, organic intensifiers and by adjusting the concrete mix proportion, strength and abrasion resistance can improve the pervious concrete greatly

Dr.R.R.SinghandEr.A.S.Sidhucarriedout the work on Strengthening of Pervious Concrete for HighLoadRoadApplication;aReview.Inthis study pervious concrete has been increasingly used all over the world to reduce the amount of runoff water and improve the water quality near light volume pavements and parking lots, but its use in India is question of concern. However, due to the significantly reduced strength associated with the high porosity, pervious concrete mixtures currently cannot be used in highway pavement structures. This paper provides the review of improving the mechanical properties of pervious concrete through different factors i.e. using additives, using different type and size of aggregates, different w/c ratios; without considerable effect on permeability. This review paper aims at looking for a vision to introduce pervious concrete with optimum Mechanical properties for using in Highways as an alternative for stormwater mitigation and increasing the groundwater level.

MATERIALS AND METHODOLOGY

3.1 Materialsused

3.1.1 Cement

In this experiment 53 grade ordinary Portland cement (OPC) with brand name Zuari was used for all concrete mixes. The cement used was fresh and without any lumps. The testing of cement was done as per IS 8112:1989. The specific gravity of cement was found to be 3.15. The physical properties of cement used are as given in table 3.1.

Table 3.1 Showing the Physical properties of cement

Particulars	Experimental result	As per standard
1.Fineness	268 m^2/kg	225 m^2/kg
2.Soundness		
a) By Le Chatelier mould	1.00 mm	10 mm
b) By Autoclave	0.16	0.8 maximum
3.Setting time (minutes)		

a) Initial set	200 minutes	30 minutes minimum
b) Final set	270 minutes	600 minutes maximum
4.Comp strength (M Pa)		
a) 3 days	34	23 MPa
b) 7 days	44	33 MPa
c) 28 days	58	43 MPa
Temperature during testing	27.81^{0}C	27° C ± 2%

3.1.2 Coarseaggregate

The coarse aggregate used in experimentation were 6.3mm passing and 4.75mm retain and their specific gravity was found to be 2.66.

3.1.3 Flyash

Fly ash has been found to have good pozzolanic property. Pozzolana is siliceous material, which while in itself possessing no cementitious property, in finely divided form and in the presence of water reacts with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties.

The utilization of fly ash as pozzolanic material results in considerable improvements such as a lower heat of hydration, less water requirements, reduced permeability resulting in durable concrete, increases resistance to chemical attack by sulfates and chlorides and reduced risk of alkali-aggregate reactions.

Fly ash particles are generally finer than cement particles and can fill the interstices between them when mixed. This improves the particles packing and reduces the amount of non surface adsorbed water, required to obtain certain workability. In concrete and mortars this is likely to improve the particle packing at the aggregate surface in particular. This interface is known for its porous and permeable character, mainly due to the so called water wall effect, and it improve it fine additions are added.

In order to give proper guidance regarding the quality of fly ash suitable for different applicationspozzolana,theBureauofIndianStandardhaspublish. IS 3912(PART 1):2003 Specifications for pulverized fuel ash Part 1, for use of pozzolana in cement, cement mortar and concrete (second version).

IS 3912 (PART 2):2003 Specifications for pulverized as Part 2, For use as admixture in cementmortar and concrete (second version).

PROPERTIES OF FLY ASH:

The fly ash produced is found to be different power plant, depending on the type and source of coal, operation of the power plant unit as well as ash collection, handling and storage methods. Ash properties may also varies within the same boiler at various times in response to varying demand. The properties of fly ash depend upon the following factors:

1. Types of coal used.
2. The treatment to which coal has been subjected prior to combustion.

3. The method of combustion.
4. Furnace temperature.
5. Amount of air condition.
6. Collection and storage places adopted.
7. Method of disposal.

Its chemical and mineralogical composition and physical and morphological properties as established by various researchers are summarized in the following sections.

Chemical Composition:

The principle constituents in fly ash are silicon dioxide (Sio_2), aluminum Oxide (Al_2o_3),iron oxide (Fe_2o_3) and calcium oxide (Cao) and carbon content. Ash also contains smaller amounts of Mgo, Tio_2, Na_2o and K_2o; an very small quantities of 20 to 50 elements.

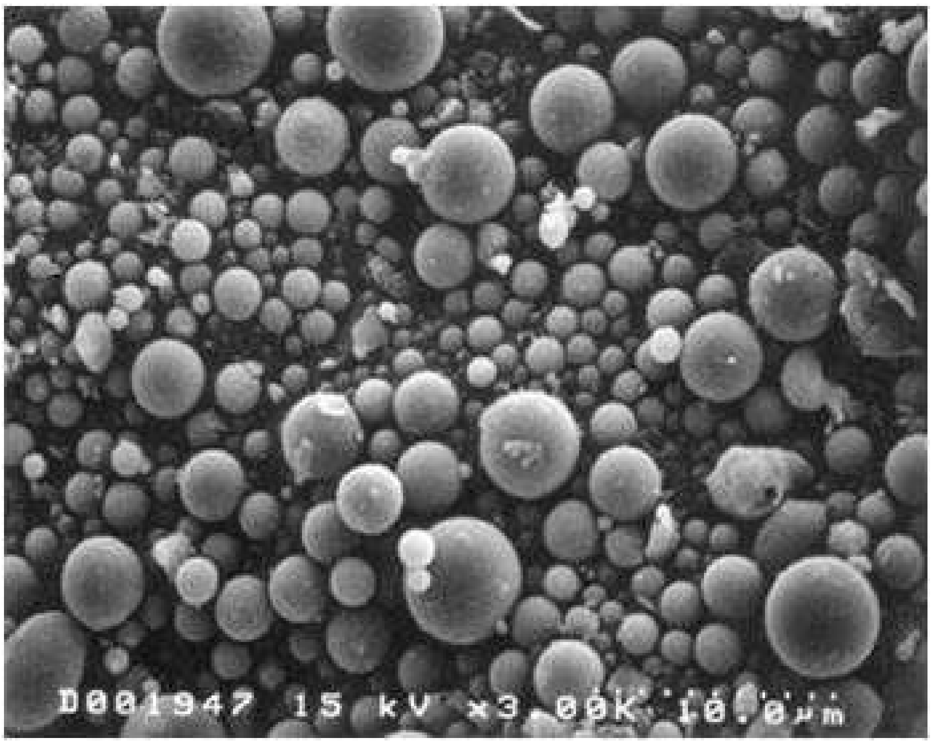
Physical properties:

1: Specific gravity:

For fly ashes specific gravity varies considerably from 1.7 to 2.9unlike soils. The variation of specific gravity from 2.0 to 2.4 from same thermal power plant has been reported. This is because of factors such as changes in boiler load and hence firing conditions, differential settlement in lagoons in lagoon ash, degree of pulverization of coal, design of furnace etc. The specific gravityof fly ash depends considerably upon its iron content, which increases the specific gravity and carbon content of fly ash , which decreases the specific gravity.

2: Colour:

Fly ash spans a colour range of light tan to grey to black. Increased carbon content causes a darker grey-black tone, while increased iron content imparts a tan coloured ash.



Microscopic view

3: Particle size distribution:

Fly ashes,which are disposed off by wet ash disposal system and deposited near the discharge point show more than 50% fine sand range of particles. Fly ashes, which are deposited away from the discharge unit, shown more than 505 silt rang e particles.

Table 4: Range of values for particle sizes (Sridharan, 2000).

MATERIAL	EFFECTIVE	D_{60}	UNIFORMITY	COEFFICIENT

	SIZE D_{10}(mm)	(mm)	COEFFICIEN T	OF CURVATURE
Fly ash	0.0027-0.02	0.036-0.2	13.3-10.0	2.16-0.73
Pond ash	0.014-0.038	0.1-0.2	7.1-5.3	1.20-0.95
Bottom ash	0.08-0.7	0.46-6.4	5.8-9.1	0.83-1.03

4: Fineness:

ASTM C 618-94a (1995) uses the fineness for specifying ash as Class F and C. It specify that not more than 34% of fly ash particles shall retain on 45mm sieve for Class F and C fly ashes. However more information is given by particle size distribution curve, which shows the amount of finer (or coarser) than any particle size over the entire range of sizes. Specific surface area is another very useful measure of fineness.

Increase in properties of concrete using fly ash :

Fly ash contributes to strength and durability:

#. Most people don't realize that durability and strength are not synonymous when talking about concrete. Durability is the ability to maintain integrity and strength over time.Strength is only a measure of the ability to sustain loads at a given point in time.Two concrete mixes with equal cylinder breaks of 4,000 psi at 28 days can vary widely in their permeability, resistance to chemical attack, resistance to cracking and general deterioration over time — all of which are important to durability. Cement normally gains the great majority of its strength within 28 days, thus the reasoning behind specifications normally requiring determination of 28-day strengths as a standard. As lime from cement hydration becomes available (cements tend to vary widely in their reactivity), it reacts with fly ash. Typically, concrete made with fly ash will be slightly lower in strength than straight cement concrete up to 28 days, equal strength at 28 days, and substantially higher strength within a year's time. Conversely, in straight cement concrete, this lime would remain intact and over time it would be susceptible to the effects of weathering and loss of strength and durability.

Fly Ash increases workability:

First, fly ash produces more cementitious paste. It has a lower unit weight, which means that on a pound for pound basis, fly ash contributes roughly 30% more volume of cementitious material per pound versus cement. The greater the percentage of fly ash "ball bearings" in the paste, the better lubricated the aggregates are and the better concrete flows. Second, fly ash reduces the amount of water needed to produce a given slump. The spherical shape of fly ash particles and its dispersive ability provide water-reducing characteristics similar to a water reducing admixture. Typically, water demand of a concrete mix with fly ash is reduced by 2% to 10%, depending on a number of factors including the amount used and class of fly ash. Third, fly ash reduces the amount of sand needed in the mix to produce workability. Because fly ash creates more paste, and by its shape and dispersive action makes the paste more "slippery", the amount of sand proportioned into the mix can be reduced. Since sand has a much greater surface area than larger aggregates and therefore requires more paste, reducing the sand means the paste available can more efficiently coat the surface area of the aggregates that remain.

#. Evidence of the contribution .y ash makes to workability includes:

#. Lightweight concrete including .y ash is much easier to pump.

#. Finishers notice the “creamier” texture when working. They also see reduced “bug holes” and segregation

#. when stripping forms. Slip form pavers eliminate rock pockets and voids in an otherwise harsh, no-slump

#. paving mix.

Fly ash reduces heat of hydration in concrete :

The hydration of cement is an exothermic reaction. Heat is generated very quickly, causing the concrete temperature to rise and accelerating the setting time and strength gainof the concrete. For most concrete installations, the heat generation is not detrimental to its long-term strength and durability. However, many applications exist where the rapid heatgain of cement increases the chances of thermal cracking, leading to reduced concrete strength and durability. In these applications, replacing large percentages of cement with fly ash (fly ash generates only 15 to 35 percent as much heat as compared to cement at early ages) can reduce the damaging effects of thermal cracking. While the first structures to apply this concept in earnest were hydroelectric dams built in the 1930s and 1940s with40% to 50% cement replacement, warm weather concreting and the risk of thermal cracking is a problem that exists today for all concrete. Warm weather will naturally raise the temperature of concrete aggregates, which make up the majority of the mass in concrete. This natural heating of the aggregates, coupled with solar heating at the construction site, can cause even thin concrete slabs to suffer the damaging effects of thermal cracking, along with finishing difficulties caused by rapid uncontrolled setting. Replacing 20% to 35% ofthe cement for “everyday” concrete in warm conditions will help reduce thermal cracking and provide the time needed to obtain the desired finish.

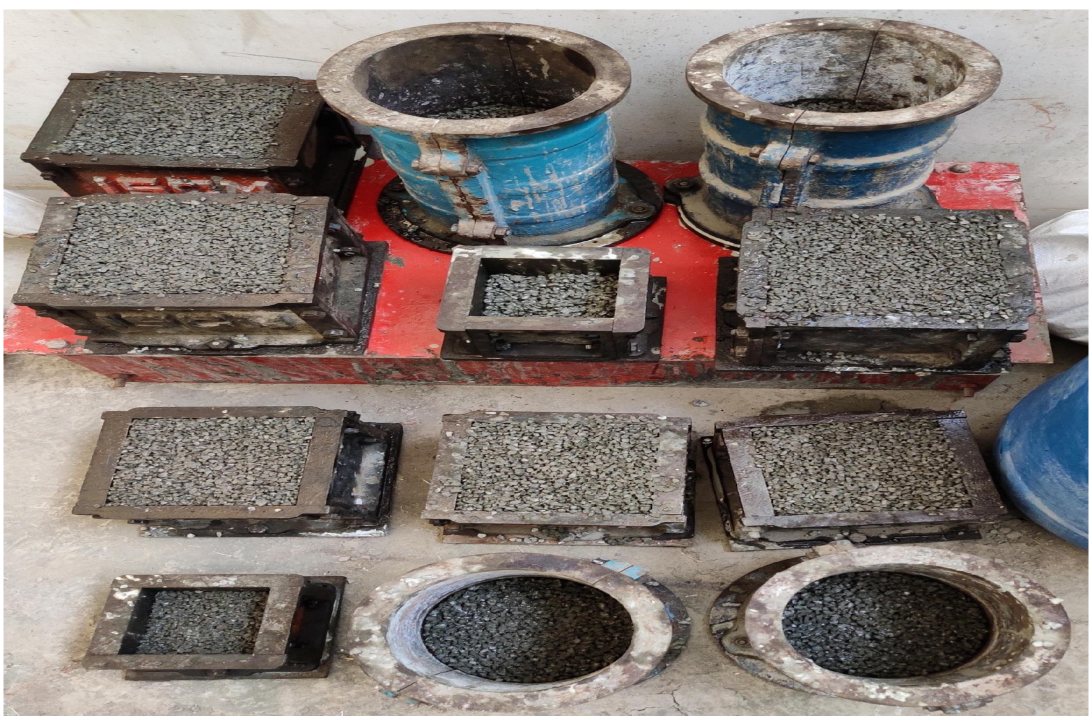
Behaviour of fly ash in concrete

In initial days strength of the concrete will be less but later days increases drastically.

Water:

Water to cementitious materials ratios between 0.27 to 0.30 are used routinely with proper inclusion of chemical admixtures, and those as high as 0.34 and 0.40 have been used successfully. The relation between strength and water to cementitious materials ratio is not clear for pervious concrete because unlike conventional concrete, the total paste content is less than the voids content between the aggregates. Therefore, making the paste stronger may not always lead to increased overall strength. Water content should be tightly controlled. The correct water content has been described as giving the mixture a sheen, without flowing off of the aggregate. A handful of pervious concrete formed into a ball will not crumble or lose its void structure as the paste flows into the spaces between the aggregates.

wet pervious concrete with different w/c ratio



Calculations:

1. 1:0.5:4

Total vol. of concrete for 6 cubes =(.15 × .15 × .15) × 6 × 1.05 = .022 $m3$

+5% extra

Weight of concrete = .0212625 × 1800 =41.4kg

Weight of cement = (1 ÷ 5.5)41.4 =7.527kg

Weight of coarse aggregate = (4 ÷ 5.5)41.4 =30kg

Weight of fly ash = (.5 ÷ 5.5)41.4 =3.76kg

w/c ratio =0.4

Quantity of water = $7.2 \times .4 = 2.88L$

2. 1:0.5:5

Total vol. of concrete for 6 cubes +5% extra =$(.15 \times .15 \times .15) \times 6 \times 1.05 = .022\ m3$

Weight of concrete = $.0212625 \times 1800 = 41.4kg$

Weight of cement = $(1 \div 6.5)41.4 = 6.36kg$

Weight of coarse aggregate = $(5 \div 6.5)41.4 = 31.84kg$

Weight of fly ash = $(.5 \div 6.5)41.4 = 3.18kg$

w/c ratio =0.4

Quantity of water = $6.36 \times .5 = 3.18L$

3. 1:0.5:6

Total vol. of concrete for 6 cubes +5% extra =$(.15 \times .15 \times .15) \times 6 \times 1.05 = .022\ m3$

Weight of concrete = $.0212625 \times 1800 = 41.4kg$

Weight of cement = $(1 \div 7.5)41.4 = 5.52kg$

Weight of coarse aggregate = $(5 \div 7.5)41.4 = 33.12kg$

Weight of fly ash = $(.5 \div 7.5)41.4 = 2.76kg$

w/c ratio =0.5

Quantity of water = $5.52 \times .5 = 2.76L$

4. 1:0.5:7

Total vol. of concrete for 6 cubes +5% extra = $(.15 \times .15 \times .15) \times 6 \times 1.05 = .022\ m3$

Weight of concrete = $.0212625 \times 1800 = 41.4kg$

Weight of cement = $(1 \div 8.5)41.4 = 4.87kg$

Weight of coarse aggregate = $(5 \div 8.5)41.4 = 34.09kg$

Weight of fly ash = $(.5 \div 8.5)41.4 = 2.435kg$

w/c ratio =0.5

Quantity of water = $4.87 \times .5 = 2.435L$

Determination of Compressive Strength of Cement.

Objective : To determine the compressive strength of pervious concrete cubes.

Theory : The compressive strength of hardened pervious concrete is the most important of all the properties. Therefore, it is not surprising that the concrete is always tested for its strength at the laboratory before the concrete is used in important works..

Apparatus : Compression testing machine

Procedure :

1. Preparation of test specimens - Clean appliances shall be used for mixing and the temperature of water and that of the test room at the time when the above operations are being performed shall be 27 ± 2°C. Potable/distilled water shall be used in preparing the cubes.

3. The water in which the cubes are submerged shall be renewed every 7 days and shall be maintained at a temperature of 27 ± 2°C. After they have been taken out and until they are broken, the cubes shall not be allowed to become dry.

4. Test three cubes for compressive strength for each period of curing mentioned under the relevant specifications (i.e. 3 days, 7 days, 28 days)

5. The cubes shall be tested on their sides without any packing between the cube and the steelplattens of the testing machine. One of the plattens shall be carried on a base and shall be self-adjusting, and the load shall be steadily and uniformly applied.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Determination of water permeability of concrete cover

Objective:

This standard specifies a method for the determination of the water permeability of concrete cover as a durability performance indicator.

Apparatus :

The apparatus comprises a pressure chamber with provisions for the accurate measurement of pressure, temperature and the volume of water permeating into the concrete cover to be tested for water permeability.

A computerised data acquisition system is preferred for the real-time display of the value of water permeability against time. A permanent record of the ambient air temperature, humidity and the water temperature is to be kept while the test is in progress.

Test specimens:

The test should preferably be performed on a 150 mm concrete cube. It is recommended that at least three test specimens be used in each test.

Test Procedure:

1. The test should preferably be conducted on test specimens of different age. Specimens of other ages may be chosen according to special conditions or requirements.
2. The density of the test specimens should be determined before the test.
3. Careful setting up of the apparatus is necessary to prevent any seepage of water from the concrete cover in contact with the pressure chamber. If water leakage occurs, the test shall be stopped.
4. The water pressure is recommended to be between 1.5 bar and 4 bar depending on the quality of concrete specimens to be tested.
5. The apparatus should be calibrated with a mature concrete test cube of known value of water permeability and conditioned for the calibration.

6. The duration of calibration test is preferably not less than 1 hour. However, the duration may be reduced if the calibration test results indicate that a steady flow condition has occurred.