ISSN: 0976-3031

Available Online at http://www.recentscientific.com

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 8, Issue, 4, pp. 16632-16640, April, 2017

International Journal of Recent Scientific Research

DOI: 10.24327/IJRSR

Research Article

ENHANCMENT OF GREEN BUILDING WITH POROUS CONCRETE AS A PAVING MATERIAL

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DOI: http://dx.doi.org/10.24327/ijrsr.2017.0804.0187

ARTICLE INFO

Article History:

Received 18th January, 2017
Received in revised form 10th February, 2017
Accepted 06th March, 2017
Published online 28th April, 2017

Key Words:

GHGS-Green House Gases, IPCC - Intergovernmental Panel on Climate Change, GRS-Green Rating System, TERI-The Energy & Research Institute, USGBC-United State of Green Building Council , LEED- Leadership in Energy and Environmental Design, CASBEE- Comprehensive Assessment System for Building Environmental Efficience

ABSTRACT

Pervious concrete is pretty bright and its major implication will be to obtain the sufficient groundwater discharge and improving the quality of in filtered water. The water while percolating from pervious slab gets naturally filtered from pollution but cannot be directly used for domestic purposes. Future research in this direction will improve tremendous input of labour, technology and funds. Also, future research on pervious concrete with reinforcement can be done. Porous concrete pavement is a very cost-effective and environmental friendly means to support green, sustainable growth. It is globally famous and used worldwide for parking lots, sideways etc. We performed two different trial mixes of various proportions of Gravels, cement, and water. After analysis of two trials and testing we selected the preferable trial mix of pervious concrete, which having well compressive Strength and percolation from which we concluded the following points. We perform the compressive strength, porosity and permeability test on all the sample that we are taking above and we are found that best result on the basis of this result we conclude. In this sample the strength is good but the porosity and permeability does not found which we expected.

INTRODUCTION

This chapter presents an overview of green buildings and is divided into three sections. The first section discusses what makes buildings green and gives several definitions of green building. The second section discusses the environmental impacts of traditional buildings and explains common green building practices with respect to energy efficiency, water efficiency, building materials, occupant health and well-being, and construction and demolition waste. The third section discusses the role of lawyers in the green building field. This chapter provides a brief overview of issues that are discussed in more detail in subsequent chapters. Citations to these later chapters are included where applicable. There are many definitions of what a green building is or does. Definitions may range from a building that is "not as bad" as the average building in terms of its impact on the environment or one that is "notably better" than the average building, to one that may even represent a regenerative process where there is actually an improvement and restoration of the site and its surrounding environment. The ideal "green" project preserves and restores habitat that is vital for sustaining life and becomes a net producer and exporter of resources, materials, energy and water rather than being a net consumer. A green building is one whose construction and life time of operation assure the healthiest possible environment while representing the most efficient and least disruptive use of land, water, energy and resources. The optimum design solution is one that effectively emulates all of the natural systems and conditions of the pre-developed site-after development.

Concept of green building

Green building concept, in broader terms involves a building, which is designed, built, operate, maintained or reused with objective to protect occupant health, improve employee

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productivity, use wisely natural resources and reduce the environmental impact. In other words the green building process incorporates environmental consideration into every stage of the building construction. This process focus on the design, construction, operation and maintenance phases and takes into account the lot design and development efficiency, energy and water efficiency, resource efficiency indoor environmental quality, building-owner maintenance and the buildings overall impact on the environment.

A few aspects of green building concept are outline below.

- Lot design, preparation and development- Thoughtful and efficient site design and improve the energy performance of new construction. The designs with a focus on saving trees, constructing onsite storm water retention/infiltration features and orienting the house to maximize solar power gain are basic aspects in a green building.
- Resource efficiency- It is fact that a green building is most successful when the concepts are incorporated and implemented at the design phase-the time at which material/product/system selection occurs. Creating resource efficient designs and using resource efficient materials can maximize function while optimizing the use of natural resources.
- Energy efficiency-The energy efficiency is weighted heavily in most green building program whole system approach will bring improve results. Further, a careful window selection, build envelope air sealing, duct sealing, proper placement of air and vapour barriers, use of solar power heating/cooling systems will contribute towards an energy efficient building.
- Water efficiency-Green home often focus on conserving water both indoor and out. Implementation more efficient water delivery system indoors and native and water retaining and drought resistance landscaping selection outdoors can aid preventing unnecessary waste of valuable water resources. Current research and practices have shown the natural processes can be a very successful method of filtering and removing contaminants from storm water and waste water which can then be reused successfully for irrigation purpose etc.

Green Rating Systems

The green building movement has led to the emergence of various green rating systems. The predominant ones are:

1. BREEAM -Building Research Establishment Environmental Assessment Method, which is widely used in the UK;
2. LEED- Leadership in Energy and Environmental Design, which was developed by the United state of Green Building Council (USGBC) and used in the US;
3. Green Star- developed by the Green Building Council of Australia and used in Australia. The New Zealand Green Building Council have also developed their own version of the Green Star tool;
4. CASBEE- Comprehensive Assessment System for Building Environmental Efficiency, which was developed by Japan Sustainable Building Consortium and is used in Japan;
5. Green Mark- used in Singapore and mandated by the Building & Construction Authority for all new development and retrofit works;
6. NABERS - National Australian Built Environment Rating System managed by the NSW (New South Wales) Department of Environment and Climate Change. The only rating system to measure ongoing operational performance.

Ranges	Credit required levels
LEED certified	23-27
LEED silver	28-33
LEED gold	34-44
LEED platinum	45-61

The green rating systems followed in India are:

- LEED India- administered by the Indian Green Building Council (IGBC);
- GRIHA -Green Rating for Integrated Habitat

Assessment developed by TERI (The Energy and Research Institute). These tools are relatively new and have not fully evolved. There is no doubt that more and more developers are resorting to these systems to get their buildings certified. Rating systems provide a tool to enable comparison of buildings on their sustainability credentials. Many occupiers and investors are using these tools as a guide to selecting properties for lease or acquisition.

Meanwhile, these systems are also being constantly improved. Therefore, the entire green building ecosystem is getting in place. Among all these rating systems, LEED has emerged as the most popular and is followed across 24 countries across the globe, including India.

LEED Rating System

The LEED rating system, developed by the USGBC, is a recognised and popular international green rating system. It has been adopted by the IGBC to suit Indian green building requirements. The LEED rating system broadly encompasses five environmental categories - sustainable sites, water efficiency, energy and atmosphere, materials and resources and Indoor Environmental Quality (IEQ). Additionally, it emphasises the innovation and design process to address sustainable building expertise and other design measures that are not already covered in the five environmental categories. The system is designed to be comprehensive in scope and simple in operation. There are credits for each criterion under the broad categories. These criteria credits are earned by addressing the specific environmental impact in design and construction. Different levels of green building certification are awarded based on the total credits earned. A total of up to 61 credits can be earned. The credit requirement for different levels of rating is as follows:

Table no. 1.1 LEED Indian certification level

LITERATURE REVIEW

The literature search included reviews of published and unpublished literature, field performance reports, and other published and unpublished documents. However, the literature on field performance remains limited.

Background Study and Related works

Delatte and Schwartz in observed that "Portland Cement Pervious Concrete (PCPC) is a material of increasing interest for parking lots and other applications. PCPC pavements greatly reduce the quantity of runoff and "first flush" pollution from parking areas, and can enhance groundwater recharge. Light colored paving materials such as PCPC can help mitigate urban heat island effects.

Tyner, Wright and Dobbs in states that "Pervious concrete is increasingly being installed to improve storm water quality and reduce runoff produced by urban settings (Graham *et al*., 2004; Bean *et al*., 2007). Pervious concrete systems can be grouped into two broad classifications:

1. Those that detain storm water (detention systems) in an underlying Gravel base until it is routed to a more conventional storm water drainage network, and
2. Those that retain storm water (retention systems) in the previous concrete and Gravel base until exfiltration into the underlying subgrade.

When designing a retention system, the permeability of the underlying soil subgrade can be a limiting factor of the design, especially if the pervious concrete rests upon a clay subgrade with low permeability. If a retention system cannot drain within a few days, the storage volume is less likely to be available for the next precipitation event.

Subramanian stated in that "Fresh water is a renewable resource, yet the world's supply of clean, fresh water is steadily decreasing. In case of pervious concrete, when water percolates into the ground, natural bacteria in soils break down organic pollutants. The main advantage of pervious concrete is it reduces (or even zero) peak storm water discharge from paved area."

P. Bentz in observed that "As the usage of pervious concrete continues to increase dramatically, a better understanding of the linkages between microstructure, transport properties, and durability will assist suppliers in mixture proportioning and design. He also presents various virtual pervious concrete micro structural models and compares their percolation characteristics and computed transport properties to those of real world pervious concretes. The demonstration of a virtual pervious concrete that captures the percolation and transport properties of the real in-place material will also allow an extension to computational-based durability studies of pervious concrete, considering issues relevant to freezing-and-thawing resistance and clogging. Obtain observed that "In pervious concrete fine Gravel is non-existent or present in very small amounts (<10% by weight of the total Gravel) So, concrete mixtures are typically designed for 20% void content in order to attain sufficient strength and infiltration rate. The water-cementations material ratio (w/cm) is an important consideration for obtaining desired strength and void structure in pervious concrete. A high w/cm reduces the adhesion of the paste to the Gravel and causes the paste to flow and fill the voids even when lightly compacted. Curing should begin within 20 minutes after final consolidation and continue through 7 days.

Leming in describes the hydrologic design elements of a pervious concrete paving system using the "stage storage discharge" approach, including selection of an appropriate design rainfall event, integration of site characteristics and specified runoff limits, and the effects of various soil horizons. Emphasis is on "active" mitigation applications where the intent is to capture a significant portion of the runoff from an entire site, including permeable, impermeable, and vegetated areas. Results of an example feasibility study found that by using pervious concrete for a nine-acre parking lot would act hydrologically as if it were grass. Schaefer summarized in the recent research efforts on pervious concrete mix designs for cold weather applications; reduction of road noise, storm water management and constructability issues is discussed. In addition, the efforts to develop a comprehensive and integrated study for full depth and wearing course applications under the auspices of the National Concrete Paving technology Center at Iowa State University are presented.

Mix design ingredients are as below.

1. Smaller Gravel produces higher strength
2. River gravel generally produces higher strength than limestone
3. The use of sand increases strength while slightly decreasing void ratio and permeability.
4. The use of fibers increases tensile strength and permeability without affecting other PCPC properties
5. Proper compaction is key to producing durable PCPC
6. Sand is required to produce freeze-thaw durable PCPC using the ASTM C666A procedure
7. Well designed pervious concrete can meet strength, permeability, and freeze thaw requirements for cold weather climates.

Part A: Porous Concrete

Pervious concrete pavement is one of the leading materials used by the concrete industry in affecting significant "GREEN" industry practices. Pervious concrete is a unique cement-based product whose porous structure permits free passage of water through the concrete and into the soil without compromising the durability or integrity of the concrete. Pervious concrete is a zero-slump, open graded material consisting of hydraulic cement, coarse Gravel, admixtures and water. Because pervious concrete contains little or no fine Gravel such as sand, it is sometimes referred to as "no-fines "concrete. The increased porosity due to no fines in the mix and 15-20% air voids allows for the flow of water through the material.

The advantages of pervious concrete surfaces include increased utilization of residential and commercial land, and direct replenishment of local aquifers. PC pervious pavements have been used in the past 20 years in areas of lower traffic loads such as parking lots, shoulders of roadways, airport taxiways and runways, street and local roads provided the subsoil conditions, drainage characteristics and groundwater location are suited.

- Pervious concrete is a kind of concrete that uses little or no sand in the mix, resulting in a concrete of high porosity.

- In recent years, the popularity of pervious concrete has grown among contractors, architects, planners and engineers.
- Slump of pervious concrete has no relation with its workability and hence not be specified as an acceptance criteria.
- Pervious concrete pavement is a unique and effective method towards environmental issues and support green, sustainable growth.
- Porous pavement gives the urban trees the rooting space they need to grow.
- Water infiltrates through the pervious concrete and helps in improving the ground water table and for the growth of trees by absorbing the water by root zone

Fig 2 Pervious concrete

Preferable Trial

While doing the sample trials by taking the different size of gravel. The strength as well as percolation from the trial sample B mix of pervious concrete was observed to be excellent.

1. Gravels= 6.0 kg (16mm-12.5mm)
2. Sand= 0kg
3. Water= 450 ml

Compressive strength of Concrete cube

Compressive strength of concrete is obtained by applying a compressive load on a cube of 150mm× 150mm ×150mm. The result obtained is according to the specific values obtained are shown

OBSERVATION AND RESULT

Table No 1 Compressive Strength of Concrete cube

Sample	Mix Design	Gravel Size	Curing Days	Compressive Strenght(N/mm^2)
A	M20	40mm-16mm	7DAYS	14.22
B	M10	16mm-12.5mm	7DAYS	4.44
C	M10	40mm-31.5mm	7DAYS	2.22
D	M1O	12.5mm-10mm	7DAYS	4.10
E	M1O	20mm-16mm	7DAYS	3.36

Analysis of preferable trial

We obtained a graph showing compressive Strength of 7 days of pervious concrete cubes. From which we analyzed that the compressive strength of 4.44N/mm^2 for 7 days for pervious concrete mix containing 16mm pass and 12.5mm retain Grave

Installation of Pervious Pavements

In order for the pervious concrete to drain properly, the base and subgrade materials must be permeable, even if highly compacted. It is important for the concrete and the base materials to have a greater permeability than the underlying soil.

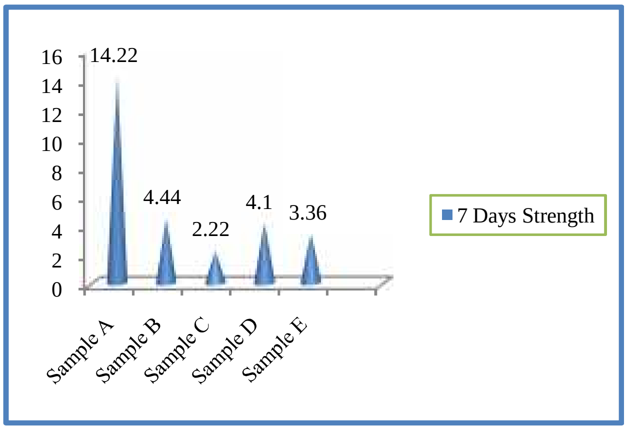

Fig 3 Compressive strength of different sample (7 days)

The concrete is usually placed over a base of course of clean, gap graded gravel or crushed rock (25mm maximum size) that acts like a reservoir to hold water until it can infiltrate the underlying soil. A geosynthetic liner may be placed below the stone reservoir to prevent preferential flow paths and to maintain a flat bottom. The thickness of the base materials can vary depending on the planned use of the pervious pavement. Parking area designs usually have six-inch (15.24 cm.) base thickness. If storm water volume storage needs demand it, then the base thickness may be more than six inches

Finishing

Typically, pervious concrete pavements are not finished in the same way as conventional concrete pavements. Normal floating and toweling operations tend to close up the top surface of the voids, which defeats the purpose (for most applications) of pervious concrete. For the majority of pervious pavements, the "finishing" step is the compaction. This leaves a rougher surface, but can improve traction.

Curing

Because of its low w/c and larger exposed surface area, pervious concrete requires aggressive curing techniques. ACI 522.1-08 recommends the following:

- The curing of pervious concrete must start within 20 minutes of placement. The short period of time limits the amount of finishing work that can be done, although some type of stamping can be done after the plastic sheet is placed.
- All exposed edges of the pavement should be covered with polyethylene sheet.
- The curing cover material should be secured without using dirt.
- The plastic should remain in place for not less than seven days.
- "Curing" for pervious slabs and pavements begins before the concrete is placed:

Engineering Properties

Fresh Properties

The plastic pervious concrete mixture is stiff compared to traditional concrete. Slumps, when measured, are generally less than 3⁄4 in. (20 mm), although slumps as high as 2 in. (50 mm) have been used. When placed and compacted, the Gravels are tightly adhered to one another and exhibit the characteristic open matrix.

For quality control or quality assurance, unit weight or bulk density is the preferred measurement because some fresh concrete properties, such as slump, are not meaningful for pervious concrete.

Conventional cast cylinder strength tests also are of little value, because the field consolidation of pervious concrete is difficult to reproduce in cylindrical test specimens, and strengths are heavily dependent on the void content. Unit weights of pervious concrete mixtures are approximately 70% of traditional concrete mixtures.

Concrete working time typically is reduced for pervious concrete mixtures. Usually one hour between mixing and placing is all that is recommended. However, this can be controlled using retarders and hydration stabilizers that extend the working time by as much as 1.5 hours, depending on the dosage. the principal of determining the degree of compaction achieved by standard amount of work done by allowing the concrete to fall through a standard height the degree of compaction factor is the ratio of weight partially compacted concrete the wt. of fully compacted concrete.

Compressive strength

Pervious concrete mixtures can develop compressive strengths in the range of 500 psi to 4000 psi (3.5 MPa to 28 MPa), which is suitable for a wide range of applications. Typical values are about 2500 psi (17 MPa). As with any concrete, the properties and combinations of specific materials, as well as placement techniques and environmental conditions, will dictate the actual in-place strength. Drilled cores are the best measure of in-place strengths, as compaction differences make cast cylinders less representative of field concrete.

PART B: METHODOLOGY

Material Requirement

Pervious concrete uses the same materials as conventional concrete, except that there is usually little to no fine Gravel. The quality, proportions and mixing techniques affect many of the properties of pervious concrete, in particular the void structure and the strength. Freshly mixed pervious should be plastic and capable of being shaped like modeling clay when squeezed by hand. It should hold its shape without slumping.

Gravels

In project we are using the river course gravel as a waste material. The size of the coarse Gravel used is kept varying with considering various sample. The use of the pervious concrete will dictate the size of the gravel used, and sizes can vary from 40mm to 10mm in size. Gravel can be rounded like crushed stone and still make for a good mixture. The decision about the best Gravel for any project is usually a joint decision between the producer and the contractor. It is good to remember that rounded Gravel requires less compactive effort than angular Gravel, and can produce higher strength pervious concrete.

Water

Water that is potable is generally fine for use in the mix. Coarse Gravel should be kept damp before batching, especially if the weather is very hot with low humidity in order to ensure consistency and uniformity from batch to batch of plastic pervious concrete. If the Gravel is too dry before being mixed, the mixture will not place or compact well. But excess free water on Gravels contributes to the overall mixing water and will create a wet, soupy mix in which the paste flows off, and the voids are filled. Water to cement ratios should be 0.45 not including any chemical admixtures. The relation between strength and water-to-cement ratios in regular concrete, the relationship for pervious is not as well defined. In pervious, the total paste content is less than the voids content between the Gravels, so making the paste stronger may not reliably lead to increased overall strength. Needless to say, the water content should be tightly controlled so that the mixture has seen to it without it being so soupy that it flows off the Gravel.

Cementations Materials

Portland cements and blended cements may be used in pervious concrete. Supplementary Cementitious Materials (SCMs) such as fly ash, pozzalans and blast-furnace slag may also be used. These added materials will affect the performance, setting time, strength, porosity and permeability of the final product. The overall durability of the pervious concrete is increased with the use of silica fume, fly ash and blast-furnace slag due to the decrease in permeability and cracking.

Admixtures

Some of the same admixtures used in regular concrete can be used with pervious concrete. Many of these admixtures are retarders, or hydration-stabilizing due to the quick setting time with pervious concrete. Some of these include water-reducing admixtures (WRA), retarders, hydration stabilizing admixtures (HSA), viscosity modifying admixtures (VMA) and internal curing admixtures (ICA). Air-entraining admixtures reduce freeze-thaw damage and are used in climates with cold wet winters.

One of the distinct and challenging characteristics of pervious concrete mixtures is its low water content that makes it stiffen up much faster than conventional concrete which has a higher slump. For this reason, the use of retarders to extend the setting time and allow for longer delivery and placement times is critical to a successful placement. It is also a consideration to facilitate the discharge from and prevent build-up in the mixer trucks.

Innovative Materials

Fly ash

Fly ash is one of the residues generated in combustion, and comprises the fine particles that rise with the flue gases. Ash which does not rise is termed bottom ash. In an industrial context, fly ash usually refers to ash produced during combustion of coal. Fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys of coal-fired power plants and together with bottom ash removed from the bottom of the furnace is in this case jointly known as coal ash. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline) and calcium oxide (CaO), both being endemic ingredients in many coal-bearing rock strata.

In the past, fly ash was generally released into the atmosphere, but pollution control equipment mandated in recent decades now requires that it be captured prior to release. In the US, fly ash is generally stored at coal power plants or placed in landfills. About 43 percent is recycled, often used to supplement Portland cement in concrete production. Some have expressed health concerns about this.

In some cases, such as the burning of solid waste to create electricity ("resource recovery" facilities a.k.a. waste-to-energy facilities), the fly ash may contain higher levels of contaminants than the bottom ash and mixing the fly and bottom ash together brings the proportional levels of contaminants within the range to qualify as nonhazardous waste in a given state, whereas, unmixed, the fly ash would be within the range to qualify as hazardous waste.

Granulated Blast Furnace Slag

GGBS cement is added to concrete in the concrete manufacturer's batching plant, along with Portland cement, Gravels and water. The normal ratios of Gravels and water to cementations' material in the mix remain unchanged. GGBS is used as a direct replacement for Portland cement, on a one-to-one basis by weight. Replacement levels for GGBS vary from 30% to up to 85%. Typically 40 to 50% is used in most instances. GGBS cement sets more slowly than concrete made with ordinary Portland cement, depending on the amount of GGBS in the cementitious material, but also continues to gain strength over a longer period in production conditions. This results in lower heat of hydration and lower temperature rises, and makes avoiding cold joints easier, but may also affect construction schedules where quick setting is required.

The use of GGBS cement in concrete in Ireland is covered in the new Irish concrete standard IS EN 206-1:2002. This standard establishes two categories of additions to concrete along with ordinary Portland cement: nearly inert additions (Type I) and pozzolanic or latent hydraulic additions (Type II). GGBS cement falls in to the latter category. As GGBS cement is slightly less expensive than Portland cement, concrete made with GGBS cement will be similarly priced to that made with ordinary Portland cement.

Use of GGBS significantly reduces the risk of damages caused by alkali–silica reaction (ASR), provides higher resistance to chloride ingress reducing the risk of reinforcement corrosion and provides higher resistance to attacks by sulfate and other chemicals. GGBS is also routinely used to limit the temperature rise in large concrete pours. The more gradual hydration of GGBS cement generates both lower peak and less total overall heat than Portland cement. This reduces thermal gradients in the concrete, which prevents the occurrence of micro cracking which can weaken the concrete and reduce its durability.

Tests on materials

Cement

Fineness of Cement

Fineness of the cement is the degree of grinding of cement. The rate of reaction depends on the fineness of grinding i.e. It increases with the fineness and vice versa causing early setting and greater heat which is the main cause of cracks due to expansion and contraction.

Standard Consistency Test

Result

The initial setting time of cement is found to be 43 minutes.

Soundness test

Observation table

Result

Distance between two indicator = 7 mm

Specific Gravity of Coarse Gravel

The following procedure is adopted for calculation of specific gravity of Gravel

SR No	1	2	3	4
Weight(gm)	Weight of empty pycnometre (W_1)	Weight of (pycnometre + Gravel) (W_2)	Weight of (pycnometre + Gravel + water) (W_3)	Weight of (clean water + pycnometre) (W_4)
Reading	628gm	880gm	1680gm	1556gm

Table No3 Specific Gravity

Sr. No	Material	Weight of material per mould	Unit
1	Cement	1 kg	Kg/m^3
2	Water	0.45 lit	Lit/m^3
3	Coarse Gravel	6.0 kg	Kg/m^3
4	Fine Gravel (Sand)	0kg	Kg/m^3

Specific Gravity = $\frac{(W2-W1)}{W2-W1-(W3-W4)} = \frac{(880-628)}{880-628-(1680-1556)} =$ 1.97

Result: The specific gravity is found to be **1.97**

Selection of Mix Design

We refer the nominal mix design M10 and M20 by IS 456-2000
Ratio of M10=1:3:6
Ratio of M20=1:1.5:3.
From the description shown in methodology about the material required such as Gravel, cement, we have taken trial one by using materials shown in table [3.4]

Analysis of sample A

Table No. 3.4 Trial sample A

From the table the compressive Strength of 7 days of pervious concrete cubes. From which we analyzed that the compressive strength of 14.22 N/mm^2 for 7 days containing 40mm pass 16mm retain Gravel.

From the description shown in methodology about the material required such as Gravel, cement, we have taken trial two by using materials shown in table [3.5]

Table No 5 Sample B

Sr. No	Material	Weight of material per mould	Unit
1	Cement	1 kg	Kg/m^3
2	Water	0.45 lit	Lit/m^3
3	Coarse Gravel	6.0 kg	Kg/m^3
4	Fine Gravel (Sand)	0kg	Kg/m^3

Sr. No	Material	Weight of material per mould	Unit
1	Cement	1 kg	Kg/m^3
2	Water	0.45 lit	Lit/m^3
3	Coarse Gravel	6.0 kg	Kg/m^3
4	Fine Gravel (Sand)	0kg	Kg/m^3

From the table compressive Strength of 7 days of pervious concrete cubes. From which we analyzed that the compressive strength of 4.44N/mm^2 for 7 days for pervious concrete mix containing 16mm pass 12.5mm retain Gravel.

Sample B

Analysis of sample C

From the description shown in methodology about the material required such as Gravel, cement, we have taken trial three by using materials shown in table [3.6]

From the table obtained a compressive Strength of 7 days of pervious concrete cubes. From which we analyzed that the compressive strength of 2.22 N/mm^{2}for pervious concrete mix containing 40mm pass and 31.5mm retain Gravel.

Sample C

Analysis of sample D

From the description shown in methodology about the material required such as Gravel, cement, we have taken sample D by using materials shown in table [3.7]

Table No 7 Sample D

Sr. No	Material	Weight Batching per mould (0.003375 m^3)	Unit
1	Cement	1kg	Kg/m^3
2	Water	0.45 lit	Lit/m^3
3	Coarse Gravel	6.0kg	Kg/m^3
4	Fine Gravel (Sand)	0kg	Kg/m^3

From the table obtained compressive Strength of 7 days of pervious concrete cubes. From which we analyzed that the compressive strength of 4.10 N/mm2 for 7 days for pervious concrete mix containing 12.5mm pass and 10mm retain Gravel.

Sample D

Analysis of sample E

From the description shown in methodology about the material required such as Gravel, cement. We have taken sample E by using materials shown in table [3.8].

Table No 8 sample E

Sr. No	Material	Weight of material per mould	Unit
1	Cement	1kg	Kg/m^3
2	Water	0.45 lit	Lit/m^3
3	Coarse Gravel	6.0kg	Kg/m^3
4	Fine Gravel (Sand)	0kg	Kg/m^3

Sample	Size of gravel	Mix design	Porosity
A	40mm - 16mm	M20	34.50%
B	16mm - 12.5mm	M10	40.74%
C	40mm - 31.5mm	M10	39.22%
D	12.5mm - 10mm	M10	44%
E	20mm - 16mm	M10	37%

Sample E

From the table the compressive Strength of 7 days of pervious concrete cubes. From which we analyzed that the compressive strength of 3.36 N/mm^2 for 7 days for pervious concrete mix containing only 20mm pass 16mm retain Gravel.

Porosity

Table no 4 Observation table of Porosity

Sample	Size of gravel	Mix design grade	Thickness of panel (m)	Volume of panel (m^3)	Time in sec	Permeability in %
Sample A	40mm-16mm	M20	0.07	0.001575	40	20
Sample B_1	16mm-12.5mm	M10	0.07	0.001575	11	83
Sample B_2	16mm-12.5mm	M10	0.09	0.002025	15	82.40
Sample B_3	16mm-12.5mm	M10	0.10	0.00225	21	95
Sample C	40mm-31.5mm	M10	0.07	0.001575	12	96
SampleD_1	12.5mm-10mm	M10	0.07	0.001575	15	97
SampleD_2	12.5mm-10mm	M10	0.10	0.00225	17.10	95
Sample E	20mm-16mm	M10	0.07	0.001575	16	92

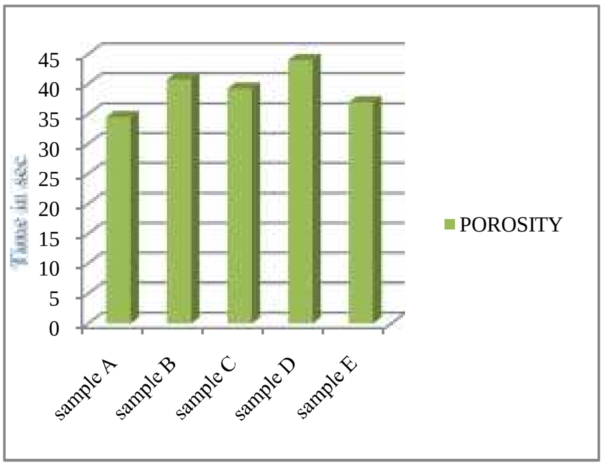

Fig 4 Relation between Porosity and Time

Permeability

The property of the soil mass which permits the seepage of water through its interconnecting voids, is called permeability. A soil having continuous voids is called permeable soil. The gravel are highly permeable while stiff clay is the least permeable and hence a clay is termed as impermeable soil for all practical purposes.

Environmental Benefits Checklist

- Allows storm water to infiltrate into the ground to replenish ground water aquifers.
- Retains storm water so that retention ponds are not needed for parking lots.
- Keeps pavement surfaces dry even in wet situations, such as greenhouses.
- Allows parking lots to be ice-free in freeze/thaw areas since snow melt immediately drains off the surface.
- Allows water and air to get to the roots of trees within a parking area.
- Aerobic bacteria that develop within the pavement and base can break down oil and remove other pollutants from the water that washes off the surface.
- Light reflectivity is higher than with asphalt surfaces, reducing any heat island effect.
- Allows a project to claim LEED ® points. (Leadership in Energy and Environmental Design is a rating system developed by the U.S. Green Building Council to evaluate the environmental performance of a building.)
- Can collect irrigation and retain water to be used for irrigation.

Economic Benefits of Pervious Concrete

A parking lot properly constructed from pervious concrete has a life span ten times as long as an asphalt lot, thereby providing excellent long term benefits. It is true that the initial costs for pervious pavement may be slightly higher due to the preparation of the sub-base, but those who look long term will realize the economic benefits. As far as the material goes, pervious concrete is installed in a thicker quantity than conventional concrete, usually six-inches (15 cm.) vs. four-inches (10 cm.). However, one must look beyond the costs per square foot, at the overall system. Pervious concrete is a sustainable product that saves money in the long run for the following reasons:

- Lower installation costs due to the elimination of costly curbs, gutters, storm drain outlets and retention basins that cost two to three times more to construct than pervious. Less money will be needed for labor, construction and maintenance of ponds, pumps, drainage pipes and other storm water management systems.
- Allows for the use of existing storm sewer systems for new developments.
- Increase land utilization since there is no need to purchase additional land for large retention ponds and other filtering systems. Land developers can get a better return on investment with efficient land use that does not have to allow for large detention ponds since the pavement itself acts as a detention area.

CONCLUSION

Porous concrete pavement is a very cost-effective and environmental friendly means to support green, sustainable growth. It is globally famous and used worldwide for parking lots, sideways etc.

We performed two different trial mixes of various proportions of Gravels, cement, and water. After analysis of two trials and testing we selected the preferable trial mix of pervious concrete, which having well compressive Strength and percolation from which we concluded the following points.
In first sample A we found that a strength 14.22N/mm^2, permeability 20%, time for percolation 40 sec. porosity 34.50% in this sample the strength is good but the porosity and permeability does not found which we expected.

In second sample B we found that a strength 4.44N/mm^2, permeability 86.8%, time for percolation 16 sec. porosity 40.74% in this sample the strength is good but the porosity and permeability does not found which we expected.

In third sample C we found that a strength 2.22N/mm^2, permeability 96%, time for percolation 12 sec. porosity 39.22% in this sample the strength is good but the porosity and permeability does not found which we expected.

In forth sample D we found that a strength 4.10N/mm^2, permeability 96%, time for percolation 14 sec. porosity 44% in this sample the strength is good and porosity and permeability also good found which we expected.

In fifth sample E we found that a strength 3.36N/mm^2, permeability 92%, time for percolation 15 sec. porosity 37% in this sample the strength is good but the porosity and permeability does not found which we expected.

We perform the compressive strength, porosity and permeability test on all the sample that we are taking above and we are found that best result in sample D on the basis of this result we conclude that the sample D is best as compared the other sample as a paving material.

Future Scope

Future of pervious concrete is pretty bright and its major implication will be to obtain the sufficient groundwater discharge and improving the quality of infiltered water. the water while percolating from pervious slab gets naturally filtered from pollution but cannot be directly used for domestic purposes. Future research in this direction will improve tremendous input of labour, technology and funds. Also, future research on pervious concrete with reinforcement can be done.

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How to cite this article:

Mahesh T. Ramteke.2017, Enhancment of Green Building with Porous Concrete as A Paving Material. *Int J Recent Sci Res.* 8(4), pp. 16632-16640. DOI: http://dx.doi.org/10.24327/ijrsr.2017.0804.0187

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