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A Project Report On "Water Absorbing Pavement Using Pervious Concrete"

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ABSTRACT
Water Absorbing pavement is a new technique in Pavement construction. Through this technique we can find a solution for the low ground water level, effective management of storm water runoff, Agricultural problems, etc. Pervious concrete can be introduced in low traffic volume areas, walk ways, sub base for concrete pavements, inter locking material etc. Pervious concrete as a paving material have the ability to allow water to flow through itself to recharge ground water level and minimize surface storm water runoff. This property of porous concrete reviews its applications and engineering properties, including environmental benefits, strength and durability. By replacing a part of cement with conplast SP430, then it results the more strength to the concrete. Hence it acts as an eco-friendly paving material.

KEYWORDS: Pervious Concrete, Storm Water, Ground water Recharging, Light Weight, Waste Material Management, Strength, Durability...

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I. INTRODUCTION

The natural processes of the water cycle have been fundamentally altered by human development and construction practices. In the natural state, rainwater falls to the earth and gets absorbed into the soil and vegetation where it is filtered, stored, evaporated, and re-dispersed into the ever-flowing cycle. However continuous urbanization driven by increasing motor vehicles is leading to the impervious covering of the earth's surface with bituminous or concrete pavements. By sealing the earth's natural filter, potential for excess runoff is increased which can lead to a number of problems such as downstream flooding, bank erosion and possibly transport of pollutants into potable water supplies.

The problems associated with impermeable surfaces are:

• Pollution of surface water: When storm water runs off impermeable surfaces, it picks up pollutants as it flows into storm drains. The contaminated water then flows directly into rivers, lakes, wetlands and oceans, generating problems for biodiversity as well as public health.

• Flooding of surface water and erosion of stream banks: During periods of heavy rainfall, large amounts of impermeable surfaces generate large amounts of runoff. This sudden influx of runoff into rivers can cause flash flooding and erosion of stream banks. Excess runoff also contributes to the rate of deterioration of pavements.

• Lowering of Ground Water Table: Impermeable surfaces send rainwater into storm drains rather than allowing it to percolate down to aquifers. Scientific studies on the groundwater revealed that excessive exploitation has been lowering the aquifer level, thus limiting natural recharge. Additionally, overexploitation for longer periods may account for several natural hazards such as unexpected landslides, sustained water logging, reduction in soil moisture, and changes in natural vegetation.

• Water Logging: On impermeable surfaces where runoff has no drainage route, storm water can puddle for long periods of time, causing water logging. Stagnate puddles can become breeding places for undesirable insects such as mosquitoes.

• Heat island effect: Due to the heat-absorbing quality of asphalt and other paving materials, sites with high ratios of impermeable surfaces increase ambient air temperatures and require more energy for cooling. Unlike the rural countryside, cities are largely paved-over or built on, so there is no vegetation or moisture to absorb heat and cool the landscape; asphalt, concrete and rooftops simply absorb the sun's energy during the day and re-release it at night. According to a 2009 American Meteorological Study, nighttime temperatures can be as much as 14 degrees hotter in built up urban areas than in rural areas.

Pervious concrete pavement systems are claimed to allow recharge of groundwater through infiltration, thus reducing or eliminating runoff, and help control the amount of contaminants in waterways. Such treatment occurs as a result of capturing initial rainfall and allowing it to percolate into the ground, thus allowing soil chemistry and biology to "treat" the polluted water naturally. It is also claimed that through collecting rainfall and allowing it to infiltrate, pervious pavements allows increased groundwater and aquifer recharge, reduction of peak water flow through drainage channels, and minimization of flooding. A pervious 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, thus serving as a mean of Sustainable Urban Drainage System (SUDS). Although pervious concrete systems can effectively solve the problems of urban drainage, there are issues regarding is behavior and mix designs. Its performance relies on two key characteristics; 'Strength' and 'Permeability'. The primary objective of this research is to understand the gradually varying properties of pervious concrete pavements by altering the mix design parameters. The lack of proper specifications and standard test methods make its design an arduous task, as different field conditions require different specifications. Therefore, a better understanding of the properties in order to determine an ideal mix design will ease the design and installation of pervious concrete pavements.

II. PERVIOUS CONCRETE

2.1 What is Pervious Concrete?

Porous pavement is a storm water drainage system that allows rain water and runoff to move through the pavements surface to storage layer below, with the eventually seeping into the underlying soil. Permeable pavement is beneficial to the environment because it can reduce storm water volume, treat the storm water quality, and replenish the ground water supply and lower air temperatures on hot days. Due to increased void ratio, water conveyed through the surface and allowed to infiltrate and evaporate, whereas conventional surfaces will not do so. A porous pavement surface therefore becomes an active participant in hydrological cycle: rain fall and snow melt are conveyed back through soil into ground water. And also this pavement technology creates more efficient land use by eliminating the need for retention ponds, swales, and other storm water management devices. In doing so, pervious concrete has the Ability to lower overall project costs on a first-cost basis. In previous concrete, carefully controlled amounts of water and cementations materials are used to create a paste that forms a thick coating around aggregate particles. A pervious concrete mixture contains little or no sand, creating a substantial void content. And that's why it is also known as No fines Concrete. Using sufficient paste to coat and bind the aggregate particles together creates a system of highly permeable, interconnected voids that drain quickly. For porous concrete, water permeability is the main specification requirement instead of its strength and continuity of the open pores is the main concern in the production of porous concrete. The high water permeability of porous concrete makes it to be considered as an environmentally friendly concrete. When the component materials of porous concrete, environmentally unfriendly Portland cement is partially replaced by supplementary cementations materials, such as fly ash, ground granulated blast furnace slag and coarse aggregates by recycled concrete aggregate, then the porous concrete could be considered as environmentally concrete for sustainable construction.

Porous concrete is a performance-engineered concrete made with controlled amounts of cement, coarse aggregates, water, and admixtures to create a mass of aggregate particles covered with a thin coating of paste. A pervious concrete mixture contains little or no sand, creating a substantial void content. Using sufficient paste to coat and bind the aggregate particles together creates a system of highly permeable, interconnected voids that drains quickly. For strength, and to keep the paste from flowing and filling the voids, a low water/cementations material (w/c) ratio is required. The w/c ratio is critical for the successful production.

A typical w/c ratio of about 0.4 is often employed. Both the low mortar content and high porosity also reduce strength compared to conventional concrete mixtures, but sufficient strength for many applications is readily achieved. "Porous concrete has also been referred to as pervious concrete, permeable concrete, no-fines concrete, gap-graded concrete, and enhanced- porosity concrete". Pervious concrete has a rough, open texture that has been compared to a rice cake. Color may be more pronounced because the rough texture reduces the glare associated with conventional concrete pavement. The size and shape (round or angular) of the coarse aggregate in a mixture are significant visual design variables. Pervious concrete is a structural concrete pavement with a large volume (15 to 35percent) of interconnected voids. Like conventional concrete, it's made from a mixture of cement, coarse aggregates, and water. However, it contains little or no sand, which results in a porous open-cell structure that water passes through readily. Pervious concrete by virtue of its nature of lay connected voids facilitates straightforward and water unfold of the natural resources becomes straightforward and easy as against PCC, RCC.

2.2 History of Pervious Concrete

Within the UK in 1852, the primary use of permeable concrete was with the growth of two homes that are residential and an ocean barrier. Price potency appears to possess the first motive for its original practice because of the restricted cement quantity used. Absolutely, it was not until 1923 once permeable concrete resurfaced as a feasible structure material. Now it absolutely was restricted to the development of two storey households in areas like European country, London, Liverpool and Manchester. Porous concrete usage in Europe redoubled steady, particularly within the war II generation. As permeable concrete utilize fewer cement than typical concrete for cement was scarce at this point. It appeared that porous concrete was the simplest suites material for that amount. Thus, it gained continued quality and it unfolds to areas like West Africa, Australia, Venezuela, Russia and the geographical region.

2.3 Benefits of Pervious Concrete

Benefits of pervious concrete include:

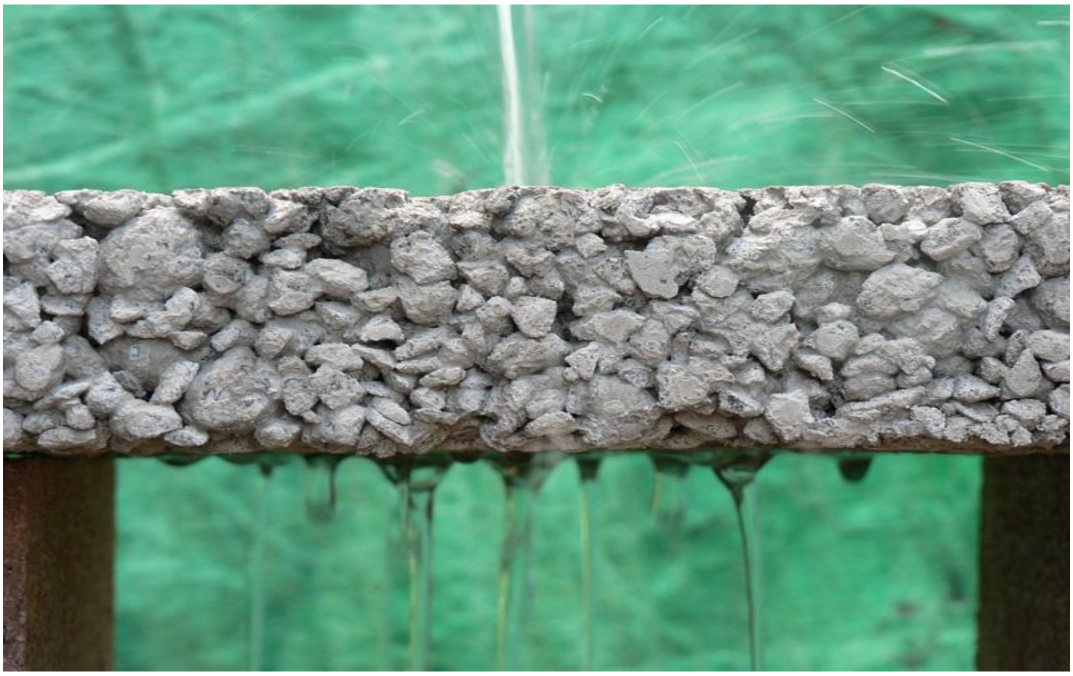
1. Reducing the rate of runoff.
2. Filtering pollutants out of runoff.
3. Infiltrating runoff into the ground.
4. Maintaining the natural hydrologic function of the site.
5. Native formation recharge.
6. Pollution removal and water budget retention.
7. Fewer would like for storm drain.
8. Green edifice different appropriate for several applications.
9. Normal run-off permits rain to empty on to sub surface.
10. Decreased edifice needs for voidance buildings.
11. Reduce contamination avoids conservational harm.
12. Defends lakes and streams and permits native foliage to flourish.

Pervious pavement is designed primarily to promote storm water infiltration and improve the quality of storm water runoff. It is typically designed to capture rainfall on the pavement surface area, but may also accept run-on from adjacent impervious areas and other landscapes (sidewalks, rooftops, or gutters). Another benefit of pervious pavement is the reduction of pollutants that enter storm water runoff by reducing the amount of splash and spray that wash pollutants from the underside of vehicles. This would be considered a form of source control and a useful component of storm water compliance. Pervious concrete infiltrate the water below the pavement surface and eliminate standing water issues. This will help to eliminate concerns of mosquito breeding. Some recent studies have also found that pervious pavement can help reduce temperatures on and around concrete which helps reduce urban heat island effect.

2.4 Literature Review

Many research works have been done on pervious concrete since 18th century. These researches have been proved to be helpful in understanding the behavior of pervious concrete. From these papers, this can be summarized that Europeans first used the porous concrete in 1800s for pavement surfacing and load bearing walls. It has been in use in United States since 1970s; in India it became popular in 2000. Its popularity has increased significantly since last 10 years since its usefulness in managing storm water runoff is realized.

At present research works are going on comparison of pervious concrete and porous asphalt pervious concrete mix design for wearing coarse applications and performance of pervious concrete pavement in cold weather climate serviceability of pervious concrete pavements and increasing infiltration from pervious concrete into the underlying clay soil etc. Future research needs on porous concrete are research on more applications and case studies of porous concrete such as on low volume streets, highway shoulders, medians and swales research on construction techniques to standardize the most effective placement technique (plate compactor, vibratory screed, roller, high density paver); methods to reduce ground water pollution durability and maintenance.



3) Benefits of Water Absorbing Pavement
1) Effective surface Runoff Management –
Pervious concrete pavement allows water to percolate through itself. This is effective in managing runoff from paved surfaces, thus providing local flood control.
2) Ground Water Recharge –
It solves the problem of ground water by constantly recharging groundwater through its paved surface.
3) The making of pervious concrete pavement is less costly.
4) The groundwater provided by this method can be used in a multiple ways.
5) It reduces the need for traditional storm water infrastructure, which may reduce the overall cost.
6) It can help to reduce temperatures on and around concrete which helps to reduce urban heat island effect.
7) Reducing the rate of runoff
8) Filtering pollutants out of runoff
9) Infiltrating runoff into the ground.
10) Maintaining the natural hydrologic function of the site.
11) Reduce contamination avoids conservational harm.
12) Defends lakes and streams and permits native foliage to flourish.
13) Pollution removal and water budget retention.
14) Fewer would like for storm drain.
15) Green edifice different appropriate for several applications.
16) Normal run-off permits rain to empty on to sub surface.

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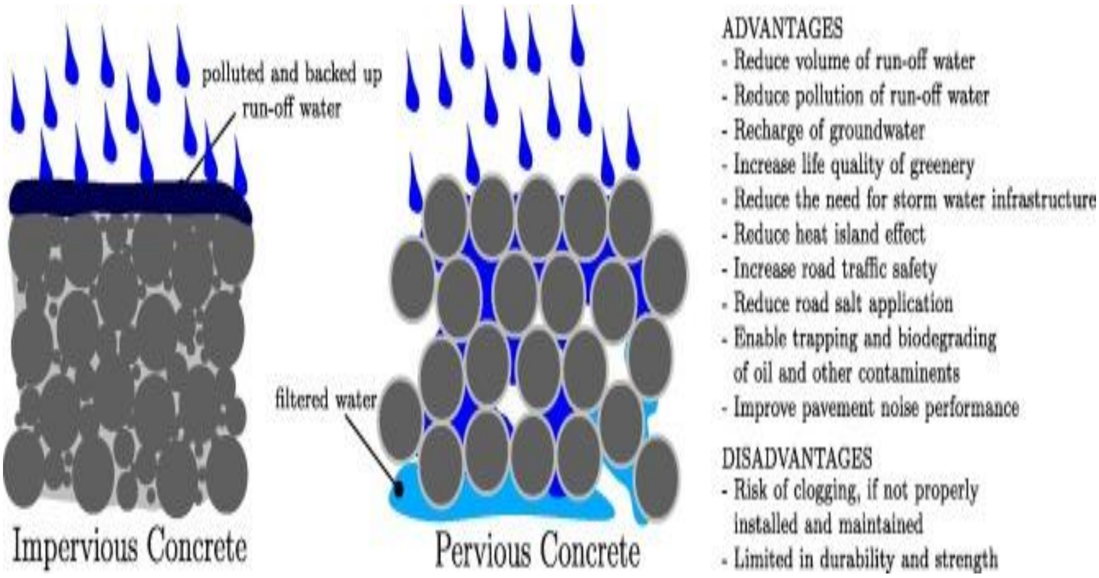
polluted and backed up
run-off water
Impervious Concrete
filtered water
Pervious Concrete
ADVANTAGES
- Reduce volume of run-off water
- Reduce pollution of run-off water
- Recharge of groundwater
- Increase life quality of greenery
- Reduce the need for storm water infrastructure
- Reduce heat island effect
- Increase road traffic safety
- Reduce road salt application
- Enable trapping and biodegrading
of oil and other contaminents
- Improve pavement noise performance
DISADVANTAGES
- Risk of clogging, if not properly
installed and maintained
- Limited in durability and strength

4) Case Study

Comparison of asphalt and pervious concrete surfaces in a case study from USA.

Water stagnant on asphalt surface while pervious concrete allows the water to flow through.

5) MATERIALS USED

5.1 Cement –

53 Grade OPC provides high strength and durability to structure because of its optimum particle size distribution and superior crystallized structure. Being high strength cement, it provides numerous advantages wherever concrete for special high strength application is required, such as in the construction of skyscrapers, bridges, flyovers, chimneys, runways, concrete roads and other heavy load bearing structures.

S.No	Property of Cement	Value
1	Fineness of cement(m^2/kg)	320
2	Specific gravity of cement	3.15
3	Standard consistency of cement	35%
4	Initial setting time	90 min
5	Final setting time	265 min
6	Grade of cement(OPC)	53 grade

Table 1: Physical properties of cement

5.2. Coarse Aggregate

Coarse aggregate was used as a primary ingredient in making the permeable concrete. Larger aggregates provide a rougher surface. Recent uses for pervious concrete have focused on parking lots, low-traffic pavements, and pedestrian walkways. For these applications, the smallest sized aggregate feasible is used for aesthetic reasons. Coarse Aggregates are those that are retained on the sieve of mesh size 4.75 mm. Their upper size is generally around 7.5 mm. Gravels from river bed are the best coarse aggregates in the making of Common Concrete.

5.3 Water

Water to cementations materials ratios between 0.34 and 0.40 are used routinely with proper inclusion of chemical admixtures, and those as high as 0.45 and 0.52 have been used successfully. The relation between strength and water to cementations 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.

5.4 Admixture

Chemical admixtures are used in pervious concrete to obtain special properties, as in conventional concrete. Because of the rapid setting time associated with pervious concrete, retarders or hydration-stabilizing admixtures are used commonly. Here we used conplast SP430. Conplast SP430 complies with IS: 9103:1999 and BS: 5075 Part 3 .Conplast SP430 conforms to ASTM-C-494 Type 'G. It is the high performance water reducing and super plasticizing admixture. Conplast SP430 is based on Sulphonated Naphthalene Polymers and is supplied as a brown liquid instantly dispersible in water. Conplast SP430 has been specially formulated to give high water reductions up to 25% without loss of workability or to produce high quality concrete. The main advantages of this admixture are improved workability, increased strength, improved quality, higher cohesion and chloride free.

5.4.1 Uses of conplast SP430

• To produce pumpable concrete
• To produce high strength, high grade concrete by substantial reduction in water resulting in low permeability and high early strength. • To produce high workability concrete requiring little or no vibration during placing.

5.4.2 Advantages of conplast SP430

• Improved workability - Easier, quicker placing and compaction.
• Increased strength - Provides high early strength for precast concrete if water reduction is taken advantage of.
• Improved quality - Denser, close textured concrete with reduced porosity and hence more durable.
• Higher cohesion - Risk of segregation and bleeding minimized.

6) EXPERIMENTAL WORK

6.1 Mix design of pervious concrete

6.1.1 Void Content

At a void content lower than 15%, there is no significant percolation through the concrete due to insufficient interconnectivity between the voids to allow for rapid percolation. So, concrete mixtures are typically designed for 20% void content in order to attain sufficient strength and infiltration rate.

6.1.2 Water – Cement Ratio

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 aggregate and causes the paste to flow and fill the voids even when lightly compacted. A low w/cm will prevent good mixing and tend to cause balling in the mixer, prevent an even distribution of cement paste, and therefore reduce the ultimate strength and durability of the concrete. W/cm in the range of 0.26 to 0.40 provides the best aggregate coating and paste stability. The conventional w/cm-versus-compressive strength relationship for normal concrete does not apply to pervious concrete. Careful control of aggregate moisture and w/cm is important to produce consistent pervious concrete.

6.1.3 Cement Content

The total cementations material content of a pervious concrete mixture is important for the development of compressive strength and void structure. Insufficient cementations content can result in reduced paste coating of the aggregate and reduced compressive strength. The optimum cementations material content is strongly dependent on aggregate size and gradation but is typically between 267 and 415 kg/m3. The above guidelines can be used to develop trial batches. ASTM C1688 provides the tests to be conducted in the laboratory to observe if the target void contents are attained.

6.2 Preparation of Cube Specimens

6.2.1 Mixing

➔ Mix the cement and coarse aggregate on a water tight none-absorbent platform until the mixture is thoroughly blended and is of uniform color.

➔ add the conplast SP430 in water and stir properly and pour into cement and coarse aggregate mixture.

➔Mix it until the concrete appears to be homogeneous and of the desired consistency.

6.2.2 Sampling

➔ clean the mounds and apply grease.

➔ Fill the concrete in the moulds in 3 equal layers.

➔ Compact each layer with not less than 35strokes per layer using a tamping rod (steel bar 16mm diameter and 60cm long, bullet pointed at lower end).

➔Level the top surface and smoothen it with a trowel.

6.2.3 Curing of the specimens

The test specimens are stored in moist air for 24hours and after this period the specimens are marked and removed from the moulds and kept submerged in clear fresh water until taken out prior to test.

6.3 Testing

6.3.1 Infiltration test

Infiltration test was carried out with reference of the test procedure given in ASTM C1701. Infiltration test was used for finding the water passing ability of pervious concrete panel which was casted and placed in field. Infiltration test has been carried out manually. The test consists of four main components: Installing the infiltration ring, prewetting the concrete, testing the concrete and calculating the results. For infiltration rate test of pervious concrete panel of 150mm x 150mm x 150mm were casted. The ring is then placed on the cleaned surface and secured in place with plumber's putty. Then water is poured onto the surface and measuring the time for the free water to disperse. With the help of measured volume of water, time required for draining out all the water and cross sectional area of cube Infiltration rate of Pervious Concrete is found out. In this experiment study infiltration rate carried out on panel with mud operation and without it.

6.3.2 Compression testing machine

Generally the compressive strength of the pervious concrete is less the conventional concrete to justify the various compressive strength of cube with different fine fractions this test is conducted. Compressive strength is the resistance of a material to breaking under compression.

• Remove the specimen from water after 7 days curing time and wipe out excess water from the surface
• Clean the bearing surface of the testing machine.
• Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.
• Align the specimen centrally on the base plate of the machine.
• Rotate the movable portion gently by hand so that it touches the top surface of the specimen.
• Apply the load gradually without shock and continuously at the rate of 140 kg/cm 2 /minute till the specimen fails.
• Record the maximum load and note any unusual features in the type of failure.

7) SCOPE FOR FUTURE

1) Since ground water scarcity is a major problem for the upcoming future this idea helps to increase ground water availability for the upcoming future, so that this water can be used in a multiple ways.

2) Since this idea is less costly and it is very effective in all the ways so that it has a very wide scope for the future.

3) By using the pervious concrete pavement we can able to recharge the ground water table and the storm water disposal can also be done. So, in future to tackle problems and to protect people from flood prone areas, the pervious concrete pavement is one effective solution.

Pervious pavement is designed primarily to promote storm water infiltration and improve the quality of storm water runoff. It is typically designed to capture rainfall on the pavement surface area, but may also accept run-on from adjacent impervious areas and other landscapes (sidewalks, rooftops, or gutters). Another benefit of pervious pavement is the reduction of pollutants that enter storm water runoff by reducing the amount of splash and spray that wash pollutants from the underside of vehicles. This would be considered a form of source control and a useful component of storm water compliance. Pervious concrete infiltrate the water below the pavement surface and eliminate standing water issues. This will help to eliminate concerns of mosquito breeding.

8) CONCLUSION

From the experimental results of investigation, Porous concrete allows water passes through it. It is not composed of fine aggregates. Aggregate having size more than 20mm cannot be used, because of larger voids cause settle down of cement slurry. And aggregates having size less than 10mm can give better results. Effective utilization of waste product (fly ash), and making it as a eco-friendly concrete. Lesser percentage of fly ash gives high strength than higher percentage. Higher percentage of fly ash weaker in cement bonding. Conplast Sp430 is good admixture, and it increases the strength and bonding between cement and aggregates.

Errors of the past will dictate designs of the future. Unfortunately there is not a precise recipe for pervious concrete that yields high compressive strength and porosity and neither do the existing test methods provide a clear understanding of the behavior of pervious concrete. Testing along with analysis of existing systems is the best method for developing a range of values which will lead to a functional design.

The compressive strength test performed on cylindrical samples does not provide an accurate measurement of the strength and durability of Pervious Concrete Pavements. Therefore other test parameters including flexural strength, splitting tensile strength, fresh density, and void ratio may provide a better understanding of the performance of pervious concrete pavements. Besides, the lack of standard procedures for compaction methods makes it an arduous task to design pervious concrete pavements for field use.

Based on the finding of the study, Pervious concrete, although not as strong as conventional concrete, may provide an acceptable alternative when used in low volume and low impact areas. It is normally used without any reinforcement due to high risk of corrosion because of the open pores in its structure. It can be gainfully used to some extent to allow ground water recharging and to control intensity of urban flooding as well as to keep thermal balance in buildup areas. Some applications include pervious pavement for parking lots, rigid drainage layers under exterior areas, greenhouse floors to keep the floor free of standing water, structural wall applications where lightweight or better thermal insulation characteristics, or both are required, elements where better acoustic absorption characteristics are desired, base course for roads, surface course for parking lots, tennis courts, zoo areas, animal barns, swimming pool decks, beach structures, seawalls, embankments, etc.