International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.10 No.8, pp 677-683, 2017

# Utilization of Pervious Concrete in Rainwater Harvesting with Partial Addition of Glass powder

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**Abstract :** Pervious concrete is a relatively new concept for rural road pavement, with increase into the problems in rural areas related to the low ground water level, agricultural problem pervious concrete as a paving material has seen renewed interest due to its ability to allow water to flow through itself to recharge groundwater level and minimize storm water runoff. This introduction to pervious concrete pavements reviews its applications and engineering properties, including environmental benefits, structural properties, and durability. In rural area cost consideration is the primary factor which must be kept in mind. So that in rural areas costly storm water management practices is not applicable. The project commences with the introduction about pervious concrete along with its involvement in making rainwater harvesting. It follows the preparation and specific mix proportion of pervious concrete with addition of glass powder, Pervious concrete cubes & Prism were casted for five different mixes with addition of glass powder and each cube is cured for 7 days & 28 days. Compression tests were conducted for each cube using compression testing machine. Permeability tests were conducted for each cylinder using permeability testing machine.

## 1.0 Introduction

Pervious concrete is a special type of concrete with a high porosity used for concrete flatwork applications that allows water from precipitation and other sources to pass directly through, thereby reducing the runoff from a site and allowing groundwater recharge. The high porosity is attained by a highly interconnected void content. Typically pervious concrete has little or no fine aggregate and has just enough cementitious paste to coat the coarse aggregate particles while preserving the interconnectivity of the voids. Pervious concrete is traditionally used in parking areas, areas with light traffic, residential streets, pedestrian walkways, and greenhouses. It is an important application for sustainable construction and is one of many low impact development techniques used by builders to protect water quality

## 2.0 Construction Techniques

An experienced installer is vital to the success of pervious concrete pavements. As with any concrete pavement, proper subgrade preparation is important. The subgrade should be properly compacted to provide a uniform and stable surface. When pervious pavement is placed directly on sandy or gravelly soils it is recommended to compact the subgrade to 92 to 96% of the maximum density. With silty or clayey soils, the level of compaction will depend on the specifics of the pavement design and a layer of open graded stone may have to be placed over the soil. Engineering fabrics are often used to separate fine-grained soils from the stone layer. Care must be taken not to over-compact soil with swelling potential [1]. The subgrade should be moistened prior to concrete placement, and wheel ruts from the construction traffic should be raked and re-compacted. Typically pervious concrete has a water to cementitious materials (w/cm) ratio of 0.28 to 0.40 with a void content of 15 to 25%. The mixture is composed of cementitious materials, coarse aggregate and water with little to no fine aggregates. Addition of a small amount of fine aggregate will generally reduce the void content and increase the strength, which may be desirable in certain situations. This material is sensitive to changes in water content, so field adjustment of the fresh mixture is usually necessary. The correct quantity of water in the concrete is critical [2]. Too much water will cause paste drain down, and too little water can hinder adequate curing of the concrete and lead to a premature ravelling surface failure. A properly proportioned mixture gives the mixture a wet metallic appearance or sheen. A pervious concrete pavement may be placed with either fixed forms or slip-form paver. A common approach to placing pervious concrete is in forms on grade that have a riser strip on the top of each form such that the strike off device is actually 3/8-1/2 in. (9 to 12 mm) above final pavement elevation. Strike off may be by mechanical or manual screeds, though mechanical screens are preferable. After striking off the concrete, the concrete is compacted to provide a strong bond between the paste and aggregate, and to create a smoother riding surface. Excessive pressure when rolling is avoided as it may cause the voids to collapse. Rolling is be performed immediately after strike off. Jointing pervious concrete pavement follows the same rules as for concrete slabs on grade, with a few exceptions. The rules of jointing geometry, however, remain the same [4]. Joints in pervious concrete are saw cut after the curing stage or tooled with a rolling jointing tool prior to curing. Proper curing is essential to the structural integrity of a pervious concrete pavement. Curing ensures hydration of the cement paste to provide the necessary strength in the pavement section to prevent ravelling. Curing should begin within 20 minutes of concrete discharge and continue through 7 days. Covering pervious concrete pavement with 6 mil. Plastic sheeting is the standard method of curing, however, this contributes to a substantial amount of waste sent to landfills. Alternatively, preconditioned absorptive lightweight aggregate as well as internal curing admixture (ICA) has been used to effectively cure pervious concrete without waste

### 3.0 Scope

The adverse effects of urban development on natural watercourses and associated infrastructure have been well documented. These impacts stem from the loss of natural infiltration, evaporation, and transpiration functions as pervious vegetated areas are replaced with impervious surfaces such as buildings and paved surfaces [5]. As less rain water infiltrates the ground or returns to the air through evaporation and transpiration, termed evapo-transpiration, more rain water flows over the pavement surface, carrying with it a variety of pollutants that ultimately contaminate river ecosystems. Additionally, the higher runoff volumes result in the erosion of stream channels, flooding, and damage to storm water infrastructure.

### 3.1 Properties f Pervious Concrete

- The water cement ratio of pervious concrete will ranges from 0.28 to 0.40.
- The amount of void content will be 15 to 25%.
- Slump value of fresh concrete will be 20 mm and the slumpobtained is a true slump.
- The density of pervious concrete will ranges from 1600 kg/m3 to 2000 kg/m3.
- The permeability rate will be 120 to 320 l/m2/min.
- The compressive strength of this concrete will be 3.5N/mm2 to 28N/mm2.
- The flexural strength will ranges from 1N/mm2 to 3.8N/mm2.

### 3.1.1 Advantages

- Allows water to drain into the subgrade naturally, like concrete wasn't even there.
- Does not increase the amount of impermeable surface on your lot. You can build a bigger house.
- Minimizes the infrastructure costs by reducing the amount of storm water released into the sewers.

### 3.2 Materials Used

- Cement – OPC 53 grade
- Fine aggregate
- Coarse aggregate
- Admixture – Glass Powder

- Water

### 3.3 Properties of Ordinary Portland Cement – 53 Grades

- Density of cement - 300kg/m3
- Fineness of cement - 7.5%
- Specific gravity - 3.15
- Initial setting time - 28 min
- Final setting time - 600 min

### 3.4 Properties of Fine Aggregate

- Fineness modulus - 2.65
- Specific gravity - 2.25

### 3.5 Properties of Coarse Aggregate

- Specific gravity - 2.70
- Fineness modulus - 5.96
- Size of aggregates - Passing through 12.5 mm IS
- Sieve and retaining in 4.75mm IS sieve

### 3.6 Glass Powder and its Properties

Glasses and its powder has been used as a construction material to decrease environmental problems. The coarse and fine glass aggregates could cause ASR (alkali-silica reaction) in concrete, but the glass powder could suppress their ASR tendency, an effect similar to supplementary cementations materials (SCMs). Therefore, glass is used as a ADDITION of supplementary cementitious materials.

| • MIX | • CEMENT | • G.P | • C.A | • W/C |
|---|---|---|---|---|
| • M1 | • 1.08 | • 0 | • 5.4 | • 0.45 |
| • M2 | • 0.972 | • 0.108 | • 5.4 | • 0.45 |
| • M3 | • 0.864 | • 0.216 | • 5.4 | • 0.45 |
| • M4 | • 0.756 | • 0.324 | • 5.4 | • 0.45 |
| • M5 | • 0.648 | • 0.432 | • 5.4 | • 0.45 |

- Specific Gravity: 2.58
- Chloride Content: Nil to IS:456
- Dosage : as per mix design

### 4.0 Mix Proportion For Cubes

**Mix M1: No Glass Powder (0% Addition of Glass Powder)**

- Cement = 1.08kg
- Glass Powder = 0
- Coarse aggregate = 4.5kg

**Mix M2:10% Addition of Glass Powder**

- Cement = 0.972kg
- GLASS POWDER = 0.108kg
- Coarse aggregate = 4.5kg

**Mix M3: 20% Addition of Glass Powder**

- Cement = 0.864kg
- Glass powder = 0.216kg
- Coarse aggregate = 4.5kg

**Mix M4: 30% Addition of Glass Powder**

- Cement = 0.756kg
- Glass Powder = 0.324kg
- Coarse aggregate = 4.5kg

**Mix M5: 40% Addition of Glass Powder**

- Cement = 0.648kg
- Glass Powder = 0.432kg
- Coarse aggregate = 4.5kg

**Table 1: Quantity of Materials for Casting Cubes**

| MIXES | Trial 1 ($N/mm^2$) | Trial 2 ($N/mm^2$) | Average strength ($N/mm^2$) |
|---|---|---|---|
| M1 | 11.50 | 11.50 | 10.63 |
| M2 | 14.80 | 13.33 | 14.12 |
| M3 | 14.60 | 16.00 | 15.60 |
| M4 | 20.00 | 20.40 | 19.73 |
| M5 | 24.20 | 22.70 | 23.63 |

**Mix Proportion For Cylinders**

**Mix M1: No Glass Powder (0% Replacement of Coarse Aggregate)**

- Cement = 2.16 kg
- Glass powder = 0%
- Coarse aggregate = 8.2 kg

**Mix M2 : 10% Replacement of Cement**

- Cement = 1.944kg
- Glass powder = 10% replacement of cement=0.216kg
- Coarse aggregate = 8.2 kg

**Mix M3: 20% Replacement of Cement**

- Cement = 1.728 kg
- Glass powder = 20% replacement of cement
  - =0.432 kg
- Coarse aggregate = 8.2 kg

**Mix M4: 30% Replacement of Cement**

- Cement = 1.512 kg
- Glass powder =30% replacement of cement=0.648 kg
- Coarse aggregate = 8.2kg

**Mix M5: 40% Replacement of Cement**

- Cement = 1.276 kg
- Glass powder = 20% replacement of cement
  - =0.864 kg
- Coarse aggregate =8.2 kg

**Table : 2 Quantity of Materials for Casting Cylinders**

| MIX | CEMENT(kg) | G.P(kg) | C.A(kg) | W/C |
|---|---|---|---|---|
| M1 | 2.16 | 0 | 8.2 | 0.45 |
| M2 | 1.944 | 0.216 | 8.2 | 0.45 |
| M3 | 1.728 | 0.432 | 8.2 | 0.45 |
| M4 | 1.512 | 0.648 | 8.2 | 0.45 |
| M5 | 1.276 | 0.864 | 8.2 | 0.45 |

## 4.0 Result and Discussions

### 4.1 Compressive Strength Test

Compressive strength is one of the important properties of concrete. Concrete cube of 150x150x150mm were cast. After 24hours the specimen were demoulded and subjected to water curing. After 7, 28 days of curing of 45 cubes were taken and tested in compression testing machine.

**Table 3: Compressive Strength of Pervious Concrete at 7days**

| MIXES | Trial 1 ($N/mm^2$) | Trial 2 ($N/mm^2$) | Average strength ($N/mm^2$) |
|---|---|---|---|
| M1 | 6.66 | 7.5 | 7.11 |
| M2 | 5.77 | 6.67 | 6.22 |
| M3 | 8.89 | 8.44 | 8.665 |
| M4 | 11.56 | 10.22 | 10.89 |
| M5 | 15.58 | 13.78 | 14.68 |

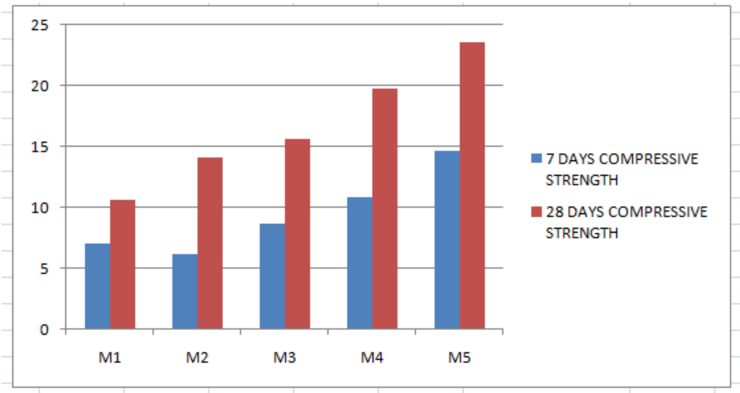


**Figure 1 Graph showing the Variation of Compressive Strength**

### 4.2 Permeability Test

Tests were carried out conforming to IS 3085 (1965) to obtain the permeability test of various concrete mixtures. Falling head method (FHM) and constant head method (CHM) are, respectively, used to test the water permeability of permeable concrete, using different water heads on the testing samples [8]. The results indicate the apparent permeability of pervious concrete decreasing with the applied water head. The results also demonstrate the permeability measured from the FHM is lower than that from the CHM. The fundamental difference between the CHM and FHM is examined from the theory of fluid flowing through porous media. The testing results suggest that the water permeability of permeable concrete should be reported with the applied pressure and the associated testing method.

**Table 4: Permeability test of Pervious Concrete at 28 days Constant head method**

| Head | Quantity of water | Time Taken | Discharge | Average |
|---|---|---|---|---|
| Q1 | 2000 | 180 | 11.11 | 0.019 |
| | 3900 | 360 | 10.83 | |
| | 5800 | 560 | 10.36 | |
| Q2 | 2100 | 180 | 11.66 | 0.02 |
| | 4000 | 360 | 11.11 | |
| | 6000 | 560 | 10.71 | |
| Q3 | 2250 | 180 | 12.5 | 0.022 |
| | 4300 | 360 | 11.9 | |
| | 6400 | 560 | 11.42 | |

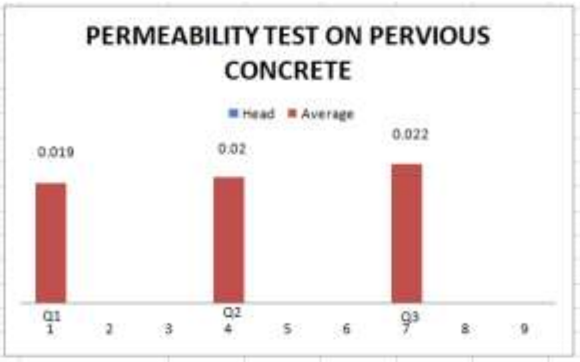


**Figure 2 Graph showing the Variation of Average Discharge**

## 5.0 Conclusions

From the above results, we came to know that, the mix M5 with 20 % fine aggregate yields good compressive strength and flexural strength. Whereas the permeability rate is higher for mix M1 with 0% fine aggregate. Therefore by reducing the fine aggregate content, the permeability rate can be increased. We prefer this pervious concrete for low loading areas like residential roads, Sidewalks, pathways, parking areas, parks, tennis courts, etc. So that it permits the entry of rain water to the ground efficiently and increases the ground water table. The smaller the size of coarse aggregate should be able to produce a higher compressive strength and at the same time produce a higher permeability rate. Finally, further study should be conducted on the pervious concrete pavement produced with these material proportions to meet the condition of increased abrasion and compressive stresses due to high vehicular loading and traffic volumes. We prefer this pervious concrete for low loading areas like residential roads, Sidewalks, pathways, parking areas, parks, tennis courts, etc. So that it permits the entry of rain water to the ground efficiently and increases the ground water table. Apart from this study we conclude that there is a considerable saving in amount about 29 Rs / m3 or 193 Rs / m2 or 18 Rs / feet2 for construction of 1m * 1m * 0.15m size pavement [10]. Pervious concrete is the relatively new concrete for the pavement construction in rural areas having cost benefits and pervious concrete extensively used worldwide because of their environmental benefits, hydraulic and durability properties[11].

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