International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 06 | June - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

Performance Evaluation of M_{30} grade Pervious Concrete Pavement

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ABSTRACT

Pervious concrete is a special type of concrete, which consists of cement, coarse aggregates, water and if required, admixtures and other cementitious materials. The pervious concrete is also called as permeable concrete and porous concrete. The void content is more which allows the water to flow through its body. As there are no fine aggregates used in the concrete matrix.

The compressive strength of pervious concrete is less when compared to the conventional concrete due to its porosity and voids. There is lot of research work is going in the field of pervious concrete. The usage of pervious concrete is limited even though it has lot of advantages. The pervious concrete eliminates surface runoff of storm water, facilitates the ground water recharge, and makes the effective usage of available land. For now, the usage of pervious concrete is mostly limited to light traffic roads only. If the properties are improved, then it can also be used for medium and heavy traffic rigid pavements. Also, the pervious concrete eliminates surface runoff of storm water, facilitates the ground water recharge, and makes the effective usage of available land.

Keywords: Pervious concrete, Mix proportion, Permeability

1: INTRODUCTION

Construction technology has seen a rapid change over time. Many typical structures can be constructed within a month of duration using advanced construction techniques. Through it is proven that no construction can be done economically without using concrete. Concrete solidifies and hardens after mixture and placement due to a chemical process known as hydration. The water reacts with cement, which bonds the other components together and eventually creating a stone material. It is used to make pavement, architectural structure, foundation, overpasses, parking structure etc. The strength of concrete mainly depends on water cement ratio. If the water cements ratio increases then too much the bleeding of concrete takes place and the strength of concrete also reduced. Pervious concrete is a special concrete in comparison to normal concrete as its high porosity for concrete flatwork applications that allow water from hydrologic cycle (precipitation) and other source to pass directly through there by reducing the runoff from a site and help full in recharging the ground.

A pervious concrete can be made from a mixture of cement, coarse aggregates, and water like normal concrete but it contains little or no sand, which make concrete in which water can pass. The reason behind pervious concrete absorb water is a pervious concrete have a large interconnection of voids and voids ratio help water conveyed through the surface and allowed to infiltrate

1.1: Objective of this Study

In this study, the effects of varying the components of pervious concrete on its compressive strength are investigated. The goal is to achieve a maximum compressive strength without inhibiting the permeability characteristics of the pervious concrete.

1.2: Scope of this Study

- ✓ To reduce the surface runoff of the storm water.
- ✓ Pervious concrete pavement is ideal for protecting trees in a paved environment.
- ✓ For collecting rainfall and allowing it to infiltrate, groundwater, aquifer recharge, water table level is increased.

1.3: The benefits from its use are its potential to:

- Reduce the quantity of runoff water
- Improve water quality
- Enhance pavement skid resistance,
- Reduce traffic-induced noise levels

2. LITERATURE REVIEW

Ravindra rajah Sri R. and Yukari A., (2010) they have studied the environmentally friendly pervious concrete for sustainable construction. It seems that porosity has significant effect on compressive strength and permeability of pervious concrete. Replacement of 50% cement by fly ash had no significant effect on water permeability but it was noted that there is a marginal strength effect of pervious concrete. It also found that pervious concrete maintains a porosity range of 15- 30%. Also, it is assuming that replacement of 50% of cement has no significant effect on water permeability. So, it is possible to prepare environment friendly pervious concrete with significantly reduced amount of Portland cement with fly ash

Hossain T et al. (2012) have studied the pervious concrete using brick chips as coarse aggregate-An experimental study. Pervious concrete made of brick chips performs well in respect of permeability. However, permeability of brick aggregate pervious concrete is higher than stone aggregate pervious concrete. Thus, brick aggregate can be used in pervious concrete in places where load is comparatively less and more permeability is required.

Darshan S. Shah et al. (2014) studied the hardened properties of pervious concrete. Compressive strength, split Tensile Strength and flexural Strength are included in hardened properties of pervious concrete. Test results indicates that smaller size of gravel (9.375 mm gravel) has more Compressive Strength (12.71 N/mm2) and Flexural Strength (1.91 N/mm2) with 1:6 concrete mix proportion and for OPC 53 Grade Cement.

Stephen.A.Arhin, Rezene, WasimKhan, (December2014),"Optimal Mix Design for Previous Concrete for Urban Area" In this paper they developed and tested five design mixes of previous concrete to identify the appropriate mix which provided the maximum compressive strength with acceptable permeability rate and flexural strength for the district of Colombia. They concluded that, the standard Proctor Hammer. Compaction method appears to be Optimum procedure for preparing the previous concrete and having compressive strength 3500psi and permeability in between the range of 57.8. And 299.5 in /hr.

Gesoglu M. et al. (2014) investigating the properties of pervious concretes containing waste tire rubber. Three types of rubber were used in the production of rubberized plain pervious concrete mixtures which obtained by partially replacing the aggregate with rubber. Here, water-cement (w/c) ratio, moist curing period, and rubber contents by

total aggregate volume were considered as experimental parameters. Finally, it is concluded that the use of rubber significantly improves the engineering properties and permeability.

Yeih W et al. (2015) have studied the engineering properties of pervious concrete made with air-cooling electric arc furnace slag as aggregates Apart from this porous concrete made with EAFS aggregates had a lower weight loss than that made with natural river gravels for the soundness tests. It is found that EAFS based pervious concrete has a higher water permeability and higher compressive strength than that made with gravels. The compressive strength is higher than 21 MPa and water permeability is 0.01 cm/s.

Jeet Yadu (2016)"Permeable Pavement & its application. A Case Study" He summarized literature on study of construction and application of such a pavement which is permeable in nature. The problem related to scarcity of water arriving due to increasing area of paved surfaces has been considered. Permeable pavement are not so complex and are easy to install, they have many advantages like ground water recharging, storm water management and applications of permeable pavement is depends on various aspects such as climate, area of application, traffic volume and load.

Ibrahim H.A and Razak H.A (2016) have studied the addition of palm oil clinker on properties of pervious concrete. In this study, Palm oil clinker is taken as the coarse aggregate in the fabrication of pervious concrete. Raw materials like Portland cement Type I,10 mm size coarse aggregate and fixed water-cement ratio of 0.3 are used. The compressive strength of the material lies between 3.43- 9.52 MPa. It is noted that loss in strength was about 65% is observed full replacement. However, replacement of Palm oil clinker at 25% shows better performance among all. As such, it has been identified as the best mix for optimum performance of the POCPC.

3. Materials and Methodology3.1: Materials

Cement: In this experimental investigation Portland pozzolana cement (PPC) was used for all concrete mixes, the cement used was fresh and without lumps. The testing of cement was done as per IS 8112-1989.The specific gravity ofcement was found to be 3.15.

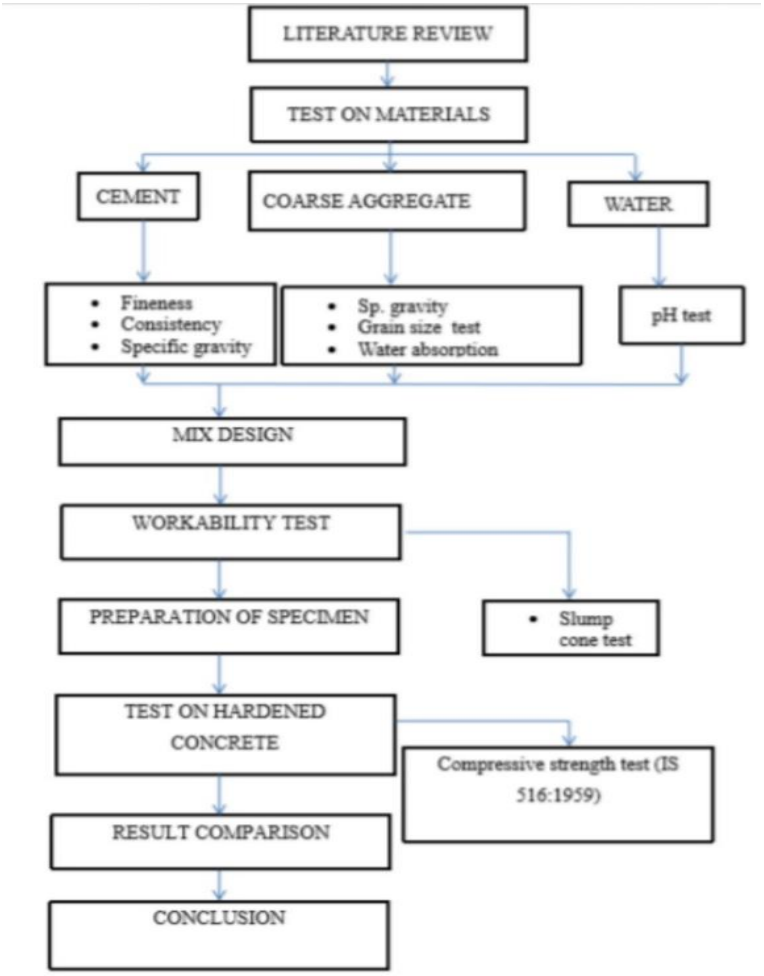
Water: Portable tap water is used for preparation of specimens and curing of specimens.

Fine aggregate: Fine aggregate was not used in this project.

Coarse aggregate: Locally available coarse aggregate passing from 20mm sieve and conforming IS 383-1970 were used in present work. The specific gravity of coarse aggregate was found to be 2.74.

3.2: Methodology

3.2.1: Flow Chart of Concrete Mix Design:



3.2.2: MIX DESIGN AS PER IRC-44-2017

Mix Proportions obtained as per mix design by IRC-44-2017:

Cement = 450 kg/m3,

Water = 197 kg/m3,

Coarse aggregate = 1050 kg/m3

Water cement ratio = 0.40,

Ratio = (1: 0: 2.33) (Cement: Sand: Coarse aggregate)

3.2.3: WORKABILITY TEST FOR FRESH CONCRETE

Slump Test:

Procedure

- Inner surface of the cone was thoroughly coated with oil after cleaning the inner surfaces.
- Slump cone was put on a rigid surface.
- Slump cone was filled by fresh concrete in four layers equally.
- Each layer was compacted by tamping rod twenty five times.
- Mould was raised vertically and lifted from concrete slowly.
- The maximum height of subsided concrete was determined.
- Difference between height of slump cone and subsided concrete was obtained.
- This difference was called slump value and was measured in mm.

Compaction Factor Test:

Procedure

- Weight W was calculated which is the weight of empty cylinder.
- Fresh concrete sample was taken and was filled into the upper hopper.
- After opening the trap door, the sample was allowed to fall into the hopper which is lower.
- Lower hopper was opened and the concrete dropped into the cylinder.
- Weight W_1 was calculated (weight of cylinder + weight of partially compacted concrete)
- Same fresh concrete was refilled in 4 equal layers into the cylinder after emptied the cylinder.
- By tamping rod each layer was twenty five times tamped for full compaction of concrete.
- Weight W_2 was calculated which weight of cylinder with fully compacted concrete.

  Compaction Factor = (W1-W) / (W2-W)

3.2.4: Compressive Strength Test

Cube casting

- The quantity of all the ingredients in concrete was calculated as per mix design.
- Water was added as per mix design and mixed well to get uniform concrete mix.
- Cube specimen was filled by fresh concrete and it was compacted by tamping rod to get full compaction of concrete.
- Cube sample was demoulded after twenty-four hours.
- Specimens were put into the water tank for curing.

Testing:

- For testing the concrete cube was placed into the compression testing machine and was placed correctly on the machine plate.
- Compressive load was gradually applied till the breaking of cube sample in the form of cracks.
- The breaking load was noted on which the mould breaks or cracks.

Compressive Strength = Breaking load / Area of Cross section of specimen

3.2.5: Flexural Strength of Concrete

Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam to resist failure in bending. It is measured by loading 150 x 150 mm concrete beams with a span length of 700 mm. This test is performed by three-point loading experiment. The beam is supported at two points from below near the ends. The bending moment is lower in a third point test than in a centre point test.

Calculation: Specimen:

Length (*l*): mm, Width (*b*): mm, Depth (*d*) : mm

Distance between the line of fracture and the nearer support (a) : mm
For 150 mm specimen If *a* > 200 mm: $\mathbf{f_b = (P \times l) / a \times d^2}$

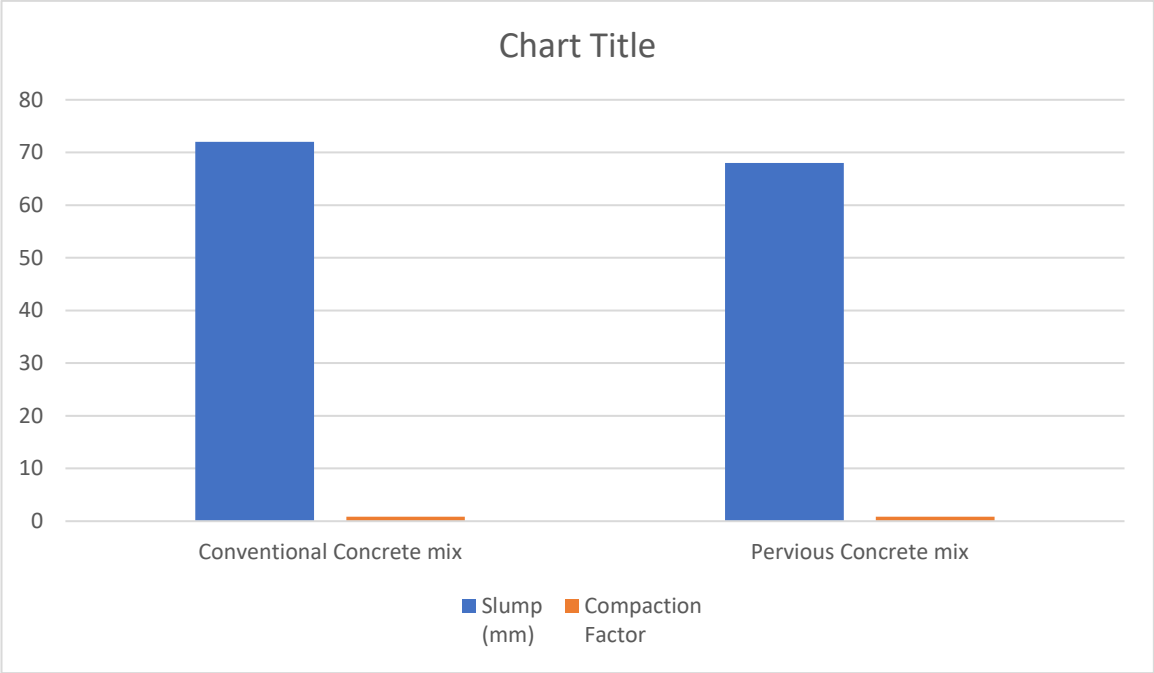
For 150 mm specimen If 200 > *a* > 170 mm: $\mathbf{f_b = (P \times l) / b \times d^2}$

4. RESULTS

4.1: Workability Test of Fresh Concrete:

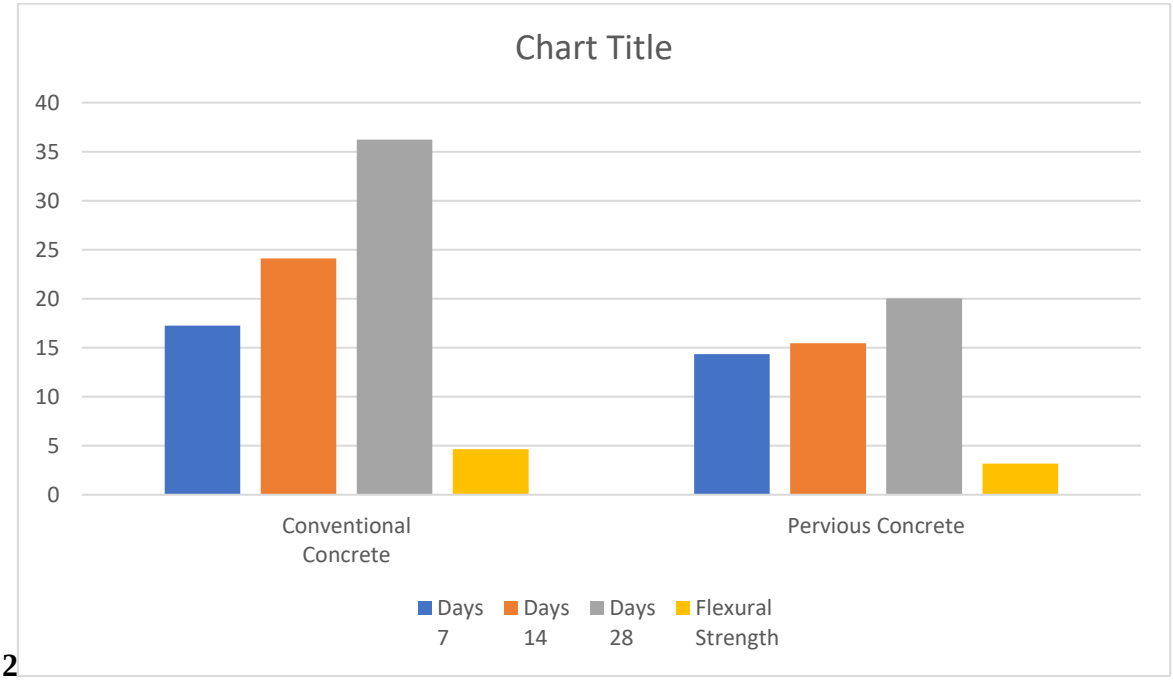
Specimen	Water Cement Ratio	Slump (mm)	Compaction Factor
Conventional Concrete mix(With fine aggregate)	0.40	72	0.86
Pervious Concrete mix (without fine aggregate)	0.40	68	0.83

Graph: 1



4.2: Hardened Pervious Concrete:

Compression Strength (N/mm^2)							Flexural Strength(N/mm^2)	
Mix	Days 7	Avg	Days 14	Avg	Days 28	Avg	Days 28	Avg
Conventional Concrete	17.14		24.9		35.9		4.42	
	17.5	17.25	23.48	24.10	36.6	36.21	4.63	4.65
	17.11		23.92		36.15		4.9	
Pervious Concrete	11.44		14.55		19.59		3.1	
	15.22	14.36	15.15	15.46	19.69	20.02	3.2	3.19
	16.44		16.69		20.80		3.27	



Graph: 2

5: CONCLUSION

Based on the experimental study of compressive and flexural strength of concrete the following conclusion can be drawn:

- Pervious concrete gives low compressive strength. Therefore, it is used for parking lots, sidewalks, highway shoulders and median.
- It can also be used in heavy rainfall areas where rain water penetrates into the ground.
- We concluded that aggregate of size 30 mm gives the good compressive strength and optimum porosity in pervious concrete.
- Following terms plays a crucial role in the strength of pervious concrete:
  a) Size of coarse aggregate
  b) Water-cement ratio
  c) Aggregate - cement ratio

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